Article

Analysis of public management in Colombian municipalities. Spotlight on the performance of education, health, public services and security

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Abstract: This paper focuses on the performance of public management in Colombian municipalities by the methodology of performance measurement proposed by The National Planning Department by using outcome indicators from this methodology and matching them with key signs from the education, health, public services, and security sectors, based on databases from 2016 to 2022. The main goal is to analyze temporal performance patterns in these sectors across Colombian municipalities, considering their categorization under Law 617 of 2000. The study is methodologically based on a quantitative approach with correlational descriptive statistical indicators, which allows for analyzing the relationship between different variables without controlling them. The analysis combines statistical and visualization tools by using Google Colab and Python, enabling the evaluation of municipal performance in Colombia and identifying trends, regional disparities, and opportunities for improvement in public management. To finish, the security and health sectors, in that order, show the best performance at the national level, while access to education and public services are the most lagging. This study shows significant disparities in municipal performance across Colombia, highlighting the urgent need for specific public policy interventions. While the health and security sectors show fairly strong performance, enduring challenges remain in access to education and public services, especially in rural areas.

Keywords: public management; education; health; services; security; indicators

1. Introduction

Regional public management in Colombia plays a pivotal role in the planning and execution of resources aimed at directly influencing territorial development. Within a decentralized framework, local governments have taken on broader responsibilities in service provision, infrastructure investment, and the promotion of socio-economic development. However, regional performance is notably heterogeneous, highlighting the need to review trends, territorial performance levels, and intersectoral relationships within public management.

This analysis seeks to identify behavioral patterns in local governance, assess territorial performance, and figure out the degree of integration between strategic sectors. By examining these dimensions, the study aims to decide which sectors exhibit efficient governance and jointly positive outcomes and which ones fail in order to show positive correlations, potentially signaling deficiencies in public planning and sectoral coordination, as well as misalignments among key welfare indicators.

Using a data-driven approach, the analysis provides substantive insights for developing strategies that enhance regional and territorial integration in municipal

running, thus promoting more equitable and sustainable development all over the country. Specifically, analyzing the trends, correlations, and territorial comparisons, drawing upon datasets from key Colombian institutions, including performance indicators from the municipal performance measurement (MPM) methodology and TerriData (a DNP tool presenting key territorial governance indicators). Given the inherently limited nature of public resources, policy planning must focus on their optimization through cross-sectoral integration. In Colombia, resource allocation often introduces inefficiencies, with investments targeting individual sectors failing to improve related sectoral indicators. This phenomenon is evident in education, health, public services, and security.

Studies by Marriner and Menjura [1] and Rodríguez [2] point out the local and uncoordinated design of public policies as a major impediment to efficient governance, often leading to redundancy or the neglect of potentially synergistic actions. Conceptual and methodological gaps hinder the identification of intersectoral relationships, though the National Planning Department [3] highlights the promise of data analytics in improving decision-making and strategic resource allocation. This study thus explores public management through MPM results and outcome indicators in critical welfare sectors, using data analytics to reveal which sectors are well-aligned with jointly positive outcomes and which aren't.

Evidence-based decision-making emerges as crucial for designing coordinated actions with cross-sectoral impact. The findings may support planning and policy frameworks aligned with sectoral objectives to enhance public management efficiency and optimize investment for territorial well-being. This research contributes to public administration literature by addressing coordination deficiencies in governance and advocating planning approaches that ensure decisions targeting one sector positively influence others. The MPM methodology [4], evaluates changes in citizen access to education, health, public services, and security, indicating whether local governance has improved quality of life. Frequently, outcomes suggest inefficacy or inadequacy in administrative actions. Reports from regulatory entities in these sectors provide general insights but lack in-depth territorial analyses accounting for variables like population size and fiscal dependence.

Authors such as Ariza Téllez, Ruidiaz Arias and Sánchez Castañeda [5] attribute citizens' mistrust in public management to inefficiencies, low civic participation, and a lack of quality frameworks in local governance. For example, a report by Bank of the Republic [6] identifies lower education performance in rural municipalities and recommends efficient resource use and differentiated policy approaches [7]. Meanwhile, The National Planning Department [8] highlights health as a key driver in municipal performance, despite deficits in departments like Bolívar, Guainía, and Vaupés—regions with high fiscal dependency and small populations. The 2023 Superintendency stands out. The public utilities stress disparities in water and sanitation coverage between rural and urban areas, calling for integrated infrastructure and efficiency investments.

Internationally, public management studies reflect similar challenges. Fernando et al. [9] point out governance gaps in Sri Lanka's public-private partnerships and advocate service co-creation with citizens; Van der Waldt [10] emphasizes Africa's

sociopolitical dynamics; and Jean [11] stands up for multi-actor governance frameworks in global institutions. Few studies in Colombia focus on public management issues; however, international research such as Sampaio-Lemos and Romero-Fernández [12] in Brazil identifies strict failings in small municipalities due to lack of policy integration and administrative capacity. Zambrano Barrios [13] evaluates Latin America's reliance on imported management models that often misalign with regional realities. Caballero-Lozada and Nieto-Gómez [14] base educational workforce precocity on broader issues in New Public Management under Colombia's higher education reforms.

Drawing on this literature, the study synthesizes critical findings, identifying Colombia's municipal performance across key sectors as its main concern, alongside theoretical gaps in governance research. Accordingly, the study poses the research question: What are the behavioral patterns of municipal performance in Colombia between 2016 and 2022 in education, health, public services, and security among municipalities with freely disposable current income? The hypotheses proposed that municipalities with lower freely disposable income exhibit poorer performance across all sectors by limiting developmental and welfare outcomes. The study's main goal is to analyze temporal performance patterns in these sectors across Colombian municipalities, considering their categorization under [15].

2. Theoretical framework

2.1. Public management

Generally speaking, public management refers to the set of processes and actions that local governments carry out in order to ensure effective administration, rooted in the identification of needs, strategic decision-making, and the generation of public value. According to Alarcón [16], its effectiveness is evaluated based on four key dimensions: strategic, economic, operational, and social. Alarcón [16] also highlighted the importance of evaluating these dimensions through performance signs, allowing for the measurement of the degree of efficiency and effectiveness of public management. A concept of public management, based on an approach that contrasts in some respects with traditional public administration, is presented by Cejudo [17] in his book entitled "The New Public Management". He suggests introducing greater competition in the public area in order to achieve better results. In this context, he mentions performance measurement in public management as a key element, emphasizing the use of ex-post controls based on performance measures to evaluate officials, institutions, and programs in order to ensure that established goals are met.

A key concept of public management related to the measurement of municipal performance is management by rankings. This approach is based on the evaluation of the performance of public administrations through external comparative measurements. It is supported by indicators and evaluation methodologies developed by independent institutions, which allow for the establishment of rankings on efficiency, transparency, competitiveness, and quality in government management. These rankings not only diagnose the state of public administration but also generate

incentives for continuous improvement and the pursuit of legitimacy and prestige in public management [18].

The contemporary concept of public management is presented as a dynamic evolution of traditional administration, incorporating processes aimed at creating public value through the identification of citizen needs, strategic decision-making, and the continuous improvement of institutional efficiency. A comprehensive approach to evaluating its effectiveness, based on strategic, economic, operational, and social dimensions, is measured through performance indicators that reveal both achievements and areas for improvement. This emphasis on performance evaluation finds a more radical development, which, from the New Public Management perspective, advocates the introduction of competition mechanisms and ex post controls, implying a paradigm shift toward a market-based logic in state management. This perspective seeks to ensure the achievement of goals through the rigorous evaluation of officials and institutions, thus promoting a culture of results. In turn, management by rankings reinforces this evaluative approach by allowing external comparisons based on indicators designed by independent entities, raising standards of transparency, efficiency, and quality. However, while this model promotes continuous improvement and institutional legitimacy, it also poses risks such as oversimplifying administrative complexity or encouraging practices aimed solely at improving rankings rather than solving underlying public problems. Taken together, these approaches reflect a shift toward more results-oriented public management, but they require robust analytical and ethical frameworks to ensure that performance measurement translates into real and sustainable improvements for citizens.

2.2. Municipal performance measurement (MPM)

This concept in Colombia is introduced by El Departamento Nacional de Planeación as a methodology that seeks to assess municipal management and results through an index, focusing on efficiency and equity in public administration. It seeks to promote results-oriented public management, making it easier to formulate differentiated policies according to the capacities and needs of each municipality. It also allows for the identification of opportunities for improvement and the design of strategies to strengthen the fiscal and administrative autonomy of local governments [19].

According to Álvarez [20], the MPM index allows local governments to measure their capacity for resource mobilization, budget execution, openness, and territorial planning, in addition to evaluating the impact of their actions in areas such as education, health, services, and security. Its implementation responds to the need to reduce socioeconomic gaps and improve public management, promoting results-based administration and informed decision-making. The MPM index allows local governments to measure their capacity for resource mobilization, budget execution, transparency, and territorial planning, in addition to evaluating the impact of their actions in areas such as education, health, services, and security. Its implementation responds to the need to reduce socioeconomic gaps and improve public management by promoting results-based administration and informed decision-making.

The introduction of the Municipal Performance Index (MPM) by the National Planning Department (DNP) in Colombia represents a significant step toward results-based public management, focused on territorial efficiency and equity. This instrument not only allows for the evaluation of local government performance but also facilitates the formulation of differentiated policies adapted to the specific capacities and needs of each municipality, thus promoting more contextualized and effective governance [21]. The MPM measures key elements such as resource mobilization, budget execution, transparency, and territorial planning, in addition to assessing the impact of public policies in essential sectors such as education, health, services, and security. This methodology responds to the urgent need to close socioeconomic gaps through more technical, data-driven management that prioritizes informed decision-making and continuous improvement. By positioning performance as the central axis of government action, the MPM contributes not only to identifying critical areas for intervention but also to strengthening the fiscal and administrative autonomy of municipalities. However, for this approach to have a truly transformative impact, it is crucial to accompany it with institutional strengthening strategies, technical assistance, and citizen participation so that the results are not limited to improved indicators but also translate into tangible well-being for the population. In short, the MPM represents a powerful tool for modernizing local administration and moving toward more equitable and efficient public management, provided it is implemented with a comprehensive and sustained approach.

2.3. Component results of municipal performance measurement

The component results of municipal performance measurement strengthen the elements of population well-being as the ultimate goal of public policy. This component seeks to incentivize interventions focused on social well-being and considers key dimensions such as health, education, public services, and security. It is based on the idea that good municipal management should enhance these results and reduce socioeconomic gaps in the territory. Furthermore, these results are measured using standardized indicators that allow for year-over-year comparisons and facilitate the identification of areas with the greatest gaps [22].

The results component of the Municipal Performance Index (MPM) represents a strategic shift in the evaluation of local public management, focusing the analysis on the well-being of the population as the ultimate objective of territorial development. This component incorporates five fundamental dimensions—education, health, public services, security, and coexistence—which, when weighted equitably, guarantee a comprehensive view of the impact of municipal administration on citizens' quality of life [23]. Standardizing the indicators used not only allows for year-over-year comparisons but also enables the precise identification of territorial gaps, which aids in the formulation of targeted and more effective public policies. The relevance of this approach lies in its capacity to transform the logic of public management, shifting it from a process-centered model to one oriented toward concrete results in terms of social well-being. Furthermore, by translating performance into a quantitative scale from 0 to 100, a clear metric is introduced that

can be understood and used by both decision-makers and citizens, promoting transparency and accountability. However, the success of this model depends largely on the quality of the data, the institutional capacity to implement evidence-based changes, and the continuity of public policies that ensure long-term sustainability. In short, this component not only measures the impact of municipal actions but also becomes a governance instrument that articulates strategic planning with the objectives of equity and territorial development.

2.4. Categorization of municipalities in Colombia

The categorization of municipalities in Colombia is a classification procedure that enables the allocation of competencies, resources, and management tools to be tailored to the specific characteristics of each territorial entity. This system is based on criteria such as population size, fiscal capacity, administrative complexity, and socioeconomic conditions in order to organize municipalities into different categories [24].

This classification is aligned with the processes of administrative and budgetary decentralization, aiming to ensure a more equitable distribution of resources and decision-making that reflects the realities of each municipality. Therefore, this classification seeks to strengthen local governance and facilitate local development through the assignment of responsibilities and financial support that correspond to the specific capacities and needs of each entity [24].

The categorization of municipalities in Colombia refers to the classification of territorial entities according to their population size and current revenues with unrestricted use. This classification, established by Law 617 of 2000, aims to rationalize public spending and define the limits of operating expenses by setting fiscal management criteria for each municipal category.

Under this concept, municipalities come together into seven categories, ranging from the special category (those with the highest population and revenue) to the sixth category (those with the lowest fiscal and administrative capacity). Categorization is essential for deciding the elements such as the expenditure budget, the amount of resources that can be allocated to operational costs, and the transfers that can be made to local bodies such as municipal councils and ombudsman offices. It also influences the planning and implementation of investment projects within the Municipal Development Plan (Law 617 of 2000). Overall, municipal categorization is not only a technical criterion but also a tool for territorial planning and budgetary management, designed to ensure that municipalities operate within sustainable financial margins and with sound fiscal planning [25].

The categorization of municipalities in Colombia is a key instrument for aligning administrative and budgetary decentralization with the diverse reality of the national territory. Based on criteria such as population size, fiscal capacity, administrative complexity, and socioeconomic conditions, this classification seeks to allocate powers, resources, and management tools proportionally to the capabilities of each territorial entity. Legally established by Law 617 of 2000, the categorization divides municipalities into seven groups, from the special category to the sixth, allowing for the definition of operating expenditure limits and fiscal management

criteria tailored to the magnitude of freely allocated current revenues. This stratification not only rationalizes public spending but also guides local development planning, directly influencing budget design, the viability of investment projects, and the allocation of transfers to local bodies such as municipal councils and ombudsmen's offices. By aligning with territorial development objectives, categorization strengthens local governance by allowing for more autonomous and effective management tailored to the specificities of each municipality. However, its effectiveness depends on periodic updating of the criteria as well as institutional strengthening that guarantees the efficient use of allocated resources. Thus, categorization is consolidated not only as a technical measure but also as a territorial planning strategy that promotes fiscal sustainability, equity in resource distribution, and the consolidation of local capacities for autonomous and responsible development.

3. Materials and methods

The study employed a quantitative research approach, specifically by using correlational descriptive statistics. According to Hernández Sampieri, Fernández Collado and Baptista Lucio [26], this type of research is characterized by the observation and analysis of relationships between two or more variables without manipulating them. The primary objective is to identify patterns of association that enable the establishment of statistical correlations while acknowledging that such correlations do not imply causation. This methodological choice is appropriate when the aim is to determine the strength and direction of relationships among variables, using numerical data to support the analysis. The use of a correlational design is particularly valuable in contexts where understanding these associations can inform decision-making or policy development, even in the absence of experimental control.

3.1. Study databases

The databases analyzed in the study are provided by the National Planning Department (DNP), a public entity that oversees planning through the consolidation of databases that serve as a tool to strengthen public management based on statistics and surveys conducted at the municipal, departmental, and regional levels in Colombia. The website that consolidates the databases for the dimensions (health, economy, education, finance, peace, tourism, investment, among others) is located at (https://terridata.dnp.gov.co/). It also aims to introduce and promote the use of standardized and comparable signs that tell us the results in various dimensions across all Colombian territorial entities.

The methodological choice of this study is based on the use of databases consolidated by the National Planning Department (DNP), whose official nature and national scope guarantee the reliability, validity, and comparability of the data used. The TerriData platform provides standardized information on multiple dimensions of territorial development—such as health, economy, education, finance, tourism, peace, and investment—allowing for robust quantitative analyses based on verifiable and comparable indicators across municipalities. This methodological choice is aligned with a correlational quantitative approach, as it facilitates the exploration of

statistical relationships between variables based on previously systematically collected secondary data. The use of this source strengthens the objectivity of the analysis and helps avoid biases inherent in primary data collection, especially in large-scale territorial studies. Furthermore, access to historical data allows for year-over-year comparisons and the construction of trends, which enriches the understanding of the analyzed phenomena and supports informed decision-making for the design of public policies based on empirical evidence.

3.2. Steps of the descriptive correlational analysis

The descriptive correctional analysis was developed using the next steps:

Step 1: Select the relevant databases from the National Planning Department (DNP), focusing on the key dimensions of health, education, public services, and security. The datasets were filtered to retain only the pertinent variables for each dimension, and all missing or non-numeric (NaN) values were removed to ensure data quality.

Step 2: Import the cleaned datasets into the Google Colab environment to facilitate Python-based analysis. The filtered databases were imported into the Google Colab environment, a platform that allows Python code to run in the cloud. This choice facilitates collaborative work and access to advanced statistical libraries. Data integration in this environment ensures efficient and secure manipulation. The files were prepared for subsequent automated analysis.

Step 3: Develop Python scripts to conduct descriptive statistics and correlational analysis across the selected dimensions. Python scripts were developed using libraries such as Pandas, NumPy, and SciPy. These codes allowed for automated descriptive and correlational statistical analyses. The programming included functions to calculate means, medians, standard deviations, and correlation coefficients. This automation increased the accuracy and reproducibility of the analysis.

Step 4: Generate graphical representations to visualize the distribution of variables and identify patterns within the data. Distribution graphs such as histograms, box plots, and scatter plots were generated. These visualizations facilitated the identification of patterns, trends, and anomalies in the data. They also helped understand the variability within each dimension. The graphs were key to intuitively interpreting the statistical results.

Step 5: Conduct comparative statistical analysis across dimensions to highlight key differences or similarities. The statistical results were compared across the different dimensions (health, education, services, and security). This comparison made it possible to identify which areas presented the greatest overall weaknesses or strengths. The analyses included central and dispersion measures for each dimension. This provided an initial assessment of territorial performance.

Step 6: Compare the performance of departments within each dimension to assess regional disparities. The differences in performance among Colombian departments in each of the assessed dimensions were analyzed. This regional analysis allowed for the identification of territorial inequalities and gaps. Averages

by department were calculated and visualized using maps or comparative graphs. This served to identify priority areas for intervention.

Step 7: Perform correlation analysis to explore the relationships between variables within and across dimensions. Correlation tests were applied to identify significant relationships between variables within and between dimensions. Coefficients such as Pearson and Spearman were used depending on the nature of the data. This analysis allowed for the detection of associations relevant to the design of public policies. It also demonstrated whether improvements in one dimension could influence others.

Step 8: Identify outliers that may indicate exceptional cases or data anomalies. Municipalities with extreme values were identified using techniques such as the interquartile range and z-score analysis. These outliers were analyzed to determine whether they reflected data errors or exceptional situations. Detecting them helped refine the statistical analysis. They also provided valuable case studies for territorial assessment.

Step 9: Analyze intermunicipal differences to understand local-level performance variation. The results obtained by the municipality in each dimension were compared. This allowed for observing differences at the local level and evaluating municipal public management. The comparison included both general statistics and visual analysis. This step was essential for developing differentiated profiles by territory.

Step 10: Examine time-based trends to assess changes over the years and understand the evolution of each dimension. Data were analyzed over time to identify significant trends and changes. This analysis allowed us to assess the evolution of municipal performance in recent years. Ascending, declining, or stable patterns were observed for each dimension. These trends provide evidence for measuring the impact of implemented public policies.

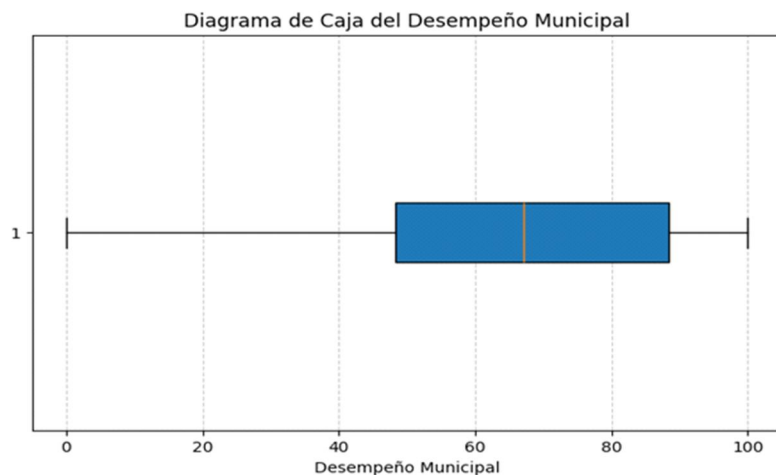### 3.3. Municipal performance analysis

The following histogram (**Figure 1**) shows the distribution of municipal performance in Colombia, based on data from the results component according to the "municipal performance measurement" (MPM) methodology, which consists of evaluating the change in outcomes related to access to education, health, public services, and security. Looking at the graph, it can reasonably be asserted that the distribution could be bimodal or dispersed, meaning that a large portion of Colombia's municipalities are at a medium level in terms of municipal performance (48); another large number are at a high level (88). Small groups at the extremes can also be seen, highlighting groups with very low performance and others with higher performance.
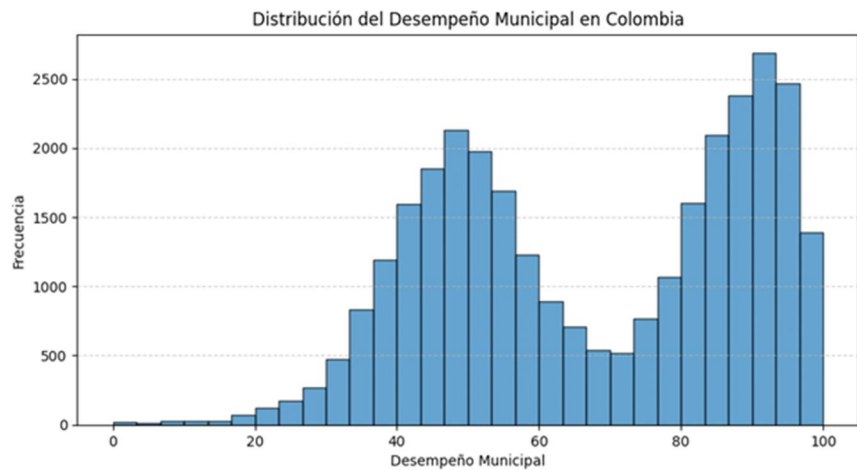
Figure 1. Distribution of municipal performance in Colombia.

Source: Prepared by the authors, taking into account data simulated by Python, by using the Matplotlib library [27].

Another perspective of the analysis shows that 25% of municipalities have a performance below 40 (see **Figure 2**). This group portrays the municipalities with the lowest performance results. On the other hand, 50% have a performance level between 40 and 80, defining the typical range of municipal performance. This suggests that the vast majority of municipalities in Colombia have acceptable performance (MPM: medium, high). However, a few municipalities have high performance, while others have low performance.

Figure 2. Distribution of municipal performance in Colombia.

Source: Prepared by the authors, taking into account data simulated by Python, by using the Matplotlib library [27].

Following the analysis, the following **Figure 3** compares the performance averages for each of the dimensions of the MPM outcome component (access to education, health, public services, and security). It is displayed that each of the dimensions presents different distributions, with security having the highest average at 89.73, followed by health at 83.87, while access to public services at 46.91 and education at 49.23 have the lowest averages.
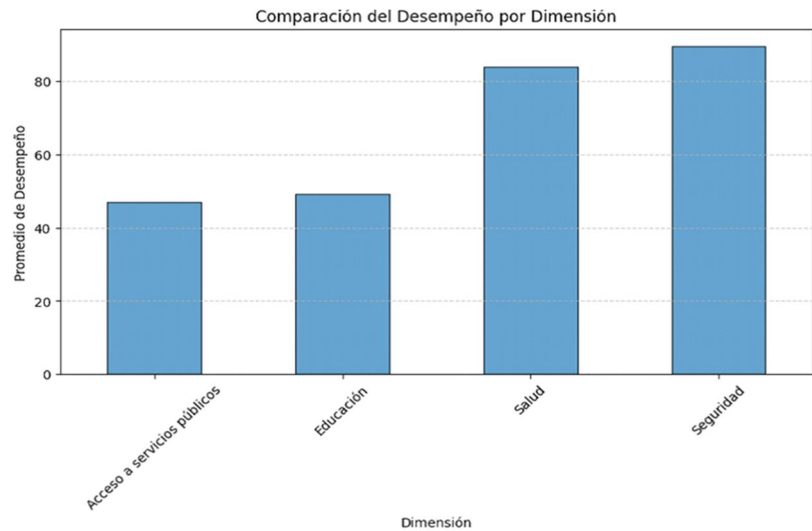
Figure 3. Municipal performance in Colombia per dimension.

Source: Prepared by the authors, taking into account data simulated by Python, by using the Matplotlib library [27].

From a departmental perspective, the results in health (83.87) and security (89.73) are striking, which, in general (see **Figure 4**), display the highest averages in most departments. Meanwhile, access to education (49.23) and public services (46.91) registers lower averages.
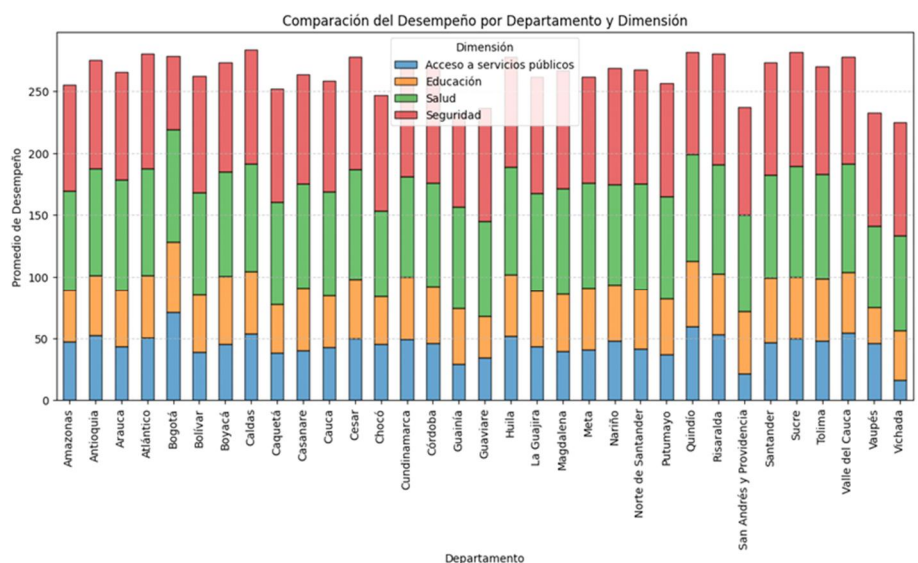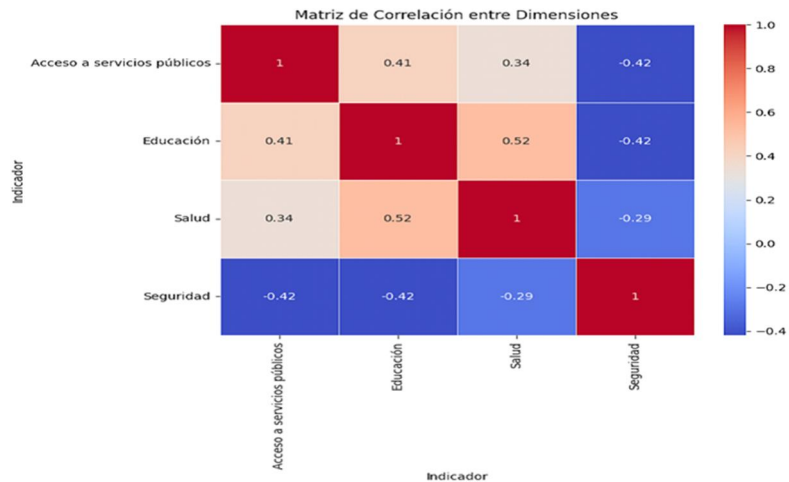

Figure 4. Efficiency per department and dimension in Colombia.

Source: Prepared by the authors, taking into account data simulated by Python, by using the Matplotlib library [27].

It must be said, the Capital District of Bogotá and the Department of Antioquia show a more balanced performance, searching for high scores in all dimensions (education, health, access to public services, and security). In contrast, the Departments of Guainía, Vaupés, Vichada, and Chocó have the lowest scores in each of their dimensions, suggesting the development of targeted public policies to address their structural deficiencies.

The matrix presented below (**Figure 5**) measures the relationship between the different dimensions of municipal performance, such as education, health, access to public services, and security. Each value in the matrix ranges between −1 and 1; 1 means a perfectly positive correlation, meaning the variables analyzed increase together; the latter also applies to values close to 1. On the other hand, negative values indicate that as one variable increases, the other decreases (or vice versa).

Figure 5. Correlation matrix between the dimensions of education, health, access to public services, and security.

Source: Prepared by the authors, taking into account data simulated by Python, by using the Matplotlib library [27].

Thus, the matrix shows a moderate correlation between access to education and health, while access to public services and security has very little correlation. This allows us to determine which actions taken in the area of education benefit health or the opposite, and that, furthermore, efforts regarding access to public services do not result in improvements in security.
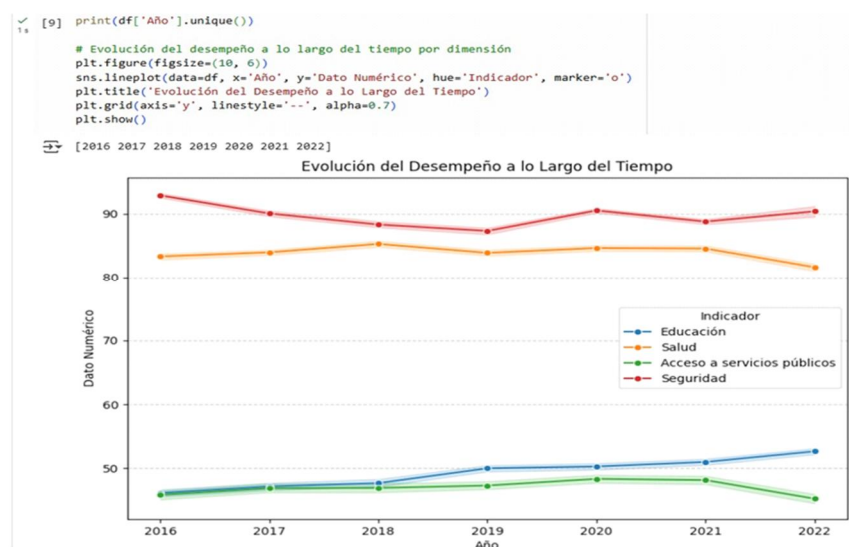
Figure 6. Evolution of municipal performance in Colombia by dimension, 2016–2022 series.

Source: Prepared by the authors, taking into account data simulated by Python, by using the Matplotlib library [27].

In **Figure 6**, the evolution of the performance of the four dimensions—education, health, access to public services, and security—over seven years (2016 to 2022) is shown. The highest scores during the aforementioned time horizon belong to security, with averages above 90. Regarding its dynamics, a downward trend is observed between 2016 and 2019, then it is improved in 2020 and drops again in 2021 and 2022.

Continuing with the trend analysis of the dimensions, stable behavior is observed in the health dimension, with values of 83 and 85 across the four dimensions. A slight increase is noted in 2018 and 2020, but a decline is observed in 2022. Meanwhile, the education and access to public services dimensions show lower scores, reflecting average performance. However, education performance is trending upward, rising from values close to 45 in 2016 to over 50 in 2022. Like education, access to public services shows a progressive increase until 2021; however, a decline is observed in 2022, which could indicate recent problems in the provision of basic services. Khan, Laghari and Baqasah [28] suggested a new architecture that combines machine learning with SVM (Support Vector Machines) and blockchain technology in order to improve data processing on the Internet of Medical Things (IoMT). The approach seeks to ensure strength and security in the handling of sensitive medical information, using SVM for efficient data analysis and blockchain to provide transparency, integrity, and resistance to cyberattacks. The proposal addresses key challenges in IoMT, such as patient privacy and cybersecurity, offering a scalable and reliable solution for connected medical environments. Thus, it is shown that the proposed structure be implemented as an architecture that models internet data but from the public sector.

4. Results

An analysis of key indicators in key sectors for the well-being of the beneficiary population is conducted. This analysis is about uploading and creating Python codes that allow for a statistical and comparative analysis of indicators from databases (obtained from: https://terridata.dnp.gov.co/) by specializing in indicators related to education, health, access to public services, security, and coexistence. The goal of this analysis is to compare the results of the local performance measurement, specifically with regard to the component results, according to which municipal management is evaluated based on the results in these same key sectors for the well-being of the territories.

4.1. Education: Gross coverage in transition.

Figure 7 is presented below, which leads the trend in gross coverage in transition. This indicator measures the relationship between the total number of students enrolled in transition grade (compulsory preschool for children approximately 5 years old) and the population of theoretical age to attend that grade. There is no stable trend over time; rather, there are peaks and valleys during the periods considered.
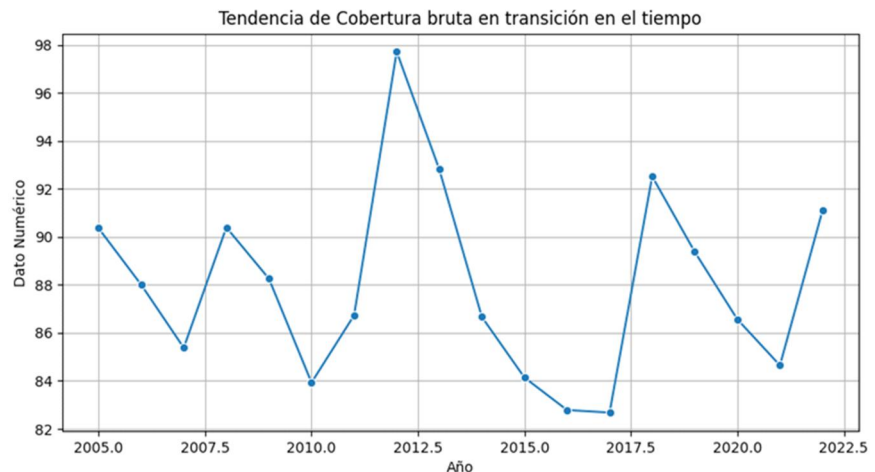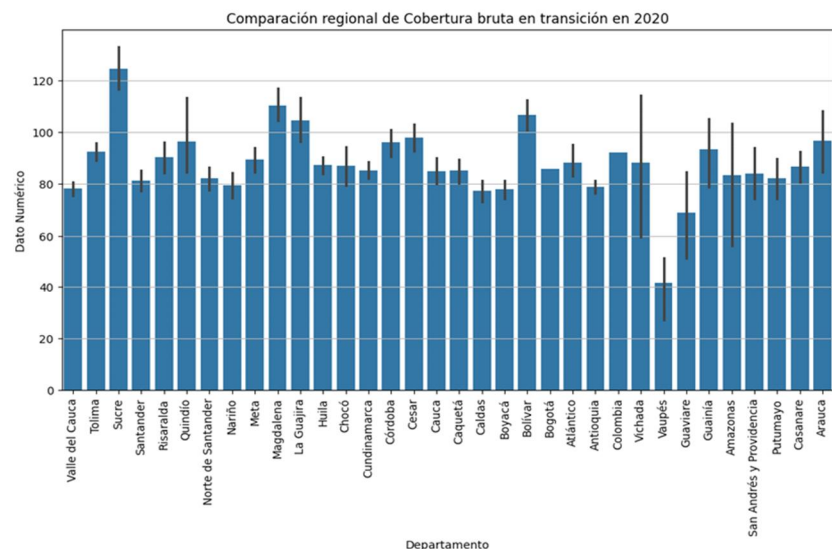
Figure 7. Trend in gross transition coverage in Colombia, 2005–2022 series.

Source: Prepared by the authors, taking into account data simulated by Python, by using the Matplotlib library [27].

In 2012, it was highlighted as the highest point for gross transition coverage, indicating that during that period, there was greater enrollment in transition grade among the population of age to attend it. However, a prolonged decline followed, reaching its lowest peak in 2017. Overall, gross transition coverage in Colombia has been cyclical, with periods of improvement and decline, although the most recent trend shows signs of improvement.

Significant differences from departments:

The following graph (**Figure 8**) displays data on gross transition coverage per department in Colombia in 2020. Some departments have coverage above 100%, which could mean good student absorption into the education system, but also the existence of students below the theoretical age for transition, that is, children who enter late or who repeat this school level. On the other hand, there are departments with values below 80%, which may reflect problems with access to transition education.

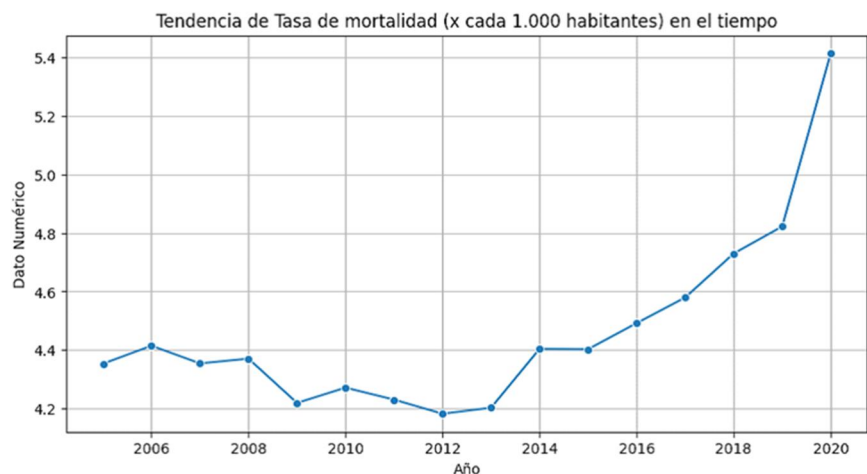**Figure 8.** Gross coverage in transition per department of Colombia, 2020 series.

Source: Prepared by the authors, taking into account data simulated by Python, by using the Matplotlib library [27].

Among the departments with the highest coverage, the following stand out: Valle del Cauca, Bogotá, and Antioquia, where coverage exceeds 100%. Conversely, some departments, such as Vaupés and Guaviare, have coverage below 50%. The graph also highlights inequalities in gross transition coverage between municipalities within the same department (black bar, which represents the standard deviation); thus, the departments of Vichada and Amazonas show the greatest variability in the data, identifying these inequalities within these departments.

Finally, and according to **Figure 8**, it is important to note that in 2020, gross coverage in transition showed significant differences among Colombian departments. On the one hand, the main cities and more developed departments showed high levels of coverage; on the other, some rural and remote areas faced difficulties in ensuring equitable access to education.

4.2. Health: Maternal mortality rate per 1000 inhabitants

In terms of health, **Figure 9** shows the trend in the mortality rate in Colombia per 1000 inhabitants from 2005 to 2020. It must be said that between 2005 and 2012, the mortality rate remained relatively stable, with slight fluctuations around values between 4.2 and 4.4 deaths per 1000 inhabitants. Since 2013, the trend has shown a slight increase, with a rising mortality rate year after year. In 2020, there was a sharp and significant increase in the mortality rate, reaching over 5.4 deaths per 1000 inhabitants (due to the COVID-19 pandemic).
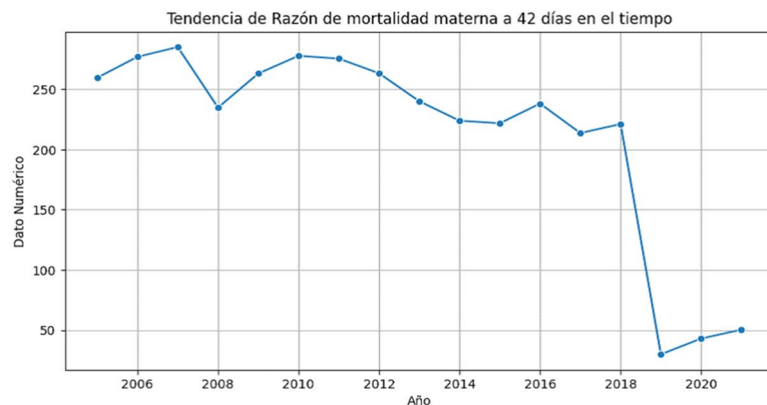

Figure 9. Mortality rate per 1000 inhabitants in Colombia, 2005–2020 series.

Source: Prepared by the authors, taking into account data simulated by Python, by using the Matplotlib library [27].

Continuing with the health field, we analyze the 42-day maternal mortality indicator, whose data trends are represented in the following graph (See **Figure 10**). Specifically, the 42-day maternal mortality ratio trend in Colombia indicates the number of maternal deaths per 100,000 live births. It can be seen that between 2005 and 2012, the maternal mortality ratio fluctuated, with generally high values, close to 250–280 deaths per 100,000 live births.

Then, from 2012 to 2018, a progressive decline in maternal mortality was evident with some variations. Starting in 2018, there was a drastic decline in the maternal mortality ratio, reaching an extremely low value in 2019. Between 2020

and 2021, there was a slight increase in mortality, but it remained significantly lower than in the years prior to 2018.
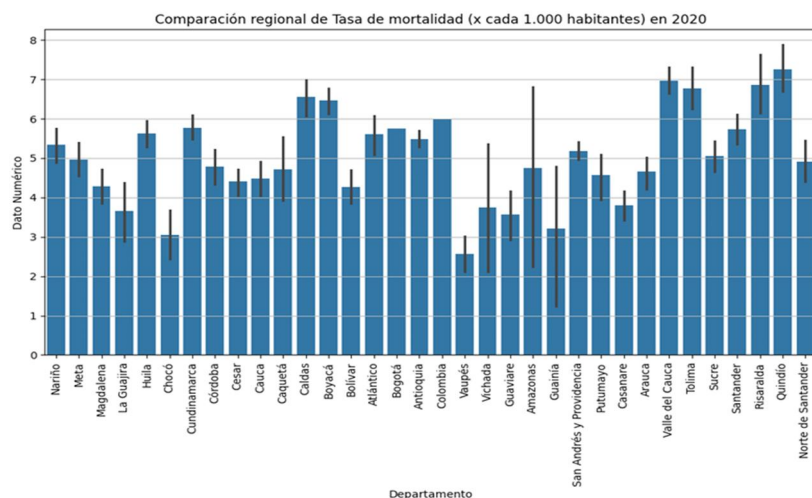

Figure 10. Trend in the 42-day maternal mortality ratio in Colombia, 2005–2021 series.

Source: Prepared by the authors, taking into account data simulated by Python, by using the Matplotlib library [27].

For comparative purposes, the mortality rate in Colombia's departments over 2020 was analyzed, expressed in deaths per 1000 inhabitants. Regarding this number, there is wide variability in mortality rates across departments. Some departments have relatively low rates, around 3 deaths per 1000 inhabitants, while others have high rates, exceeding 7 deaths per 1000 inhabitants.

Among the others with the highest mortality rates are Norte de Santander, Santander, Risaralda, and Boyacá, which have the highest rates, with values exceeding 7 deaths per 1000 inhabitants (See **Figure 11**). On the other hand, departments such as Vaupés, Guaviare, Amazonas, and San Andrés y Providencia have lower mortality rates, close to 2–3 deaths per 1000 inhabitants. The reason for the latter may be associated with the fact that these departments tend to have younger populations and are also less densely populated.
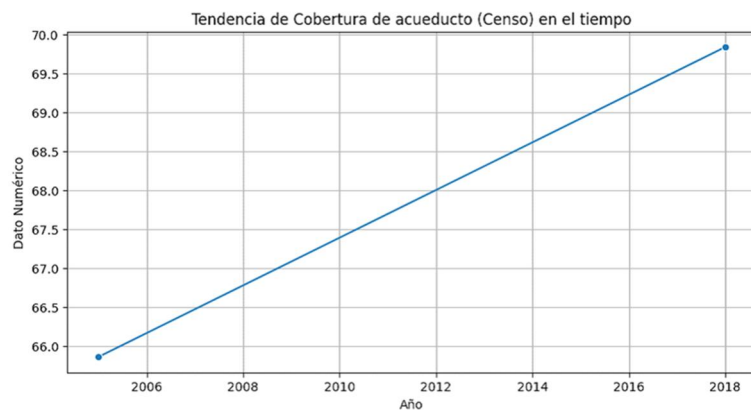

Figure 11. Trend in the 42-day maternal mortality ratio in Colombia, 2005–2021 series.

Source: Prepared by the authors, taking into account data simulated by Python, by using the Matplotlib library [27].

Regional inequality: There are significant differences in mortality between departments, influenced by demographic, socioeconomic, and healthcare access factors.

### 4.3. Access to public services: Water, sanitation, sewage system and electricity coverage

Regarding access to public services, the following graphs show the evolution of water, sanitation, sewage systems, and electricity coverage. **Figure 12** displays the trend in water supply coverage across Colombia's departments from 2005 to 2018, based on census data.

Figure 12. Trend in water supply coverage in Colombian departments, 2005–2018 series.

Source: Prepared by the authors, taking into account data simulated by Python, by using the Matplotlib library [27].

Within this trend, it can be seen that water supply coverage across Colombia's departments has increased from 66% in 2005 to 70% in 2018, an absolute change of 4 percentage points. Based on the above, and taking into account the positive linear trend in the graph, it could be said that water supply coverage across Colombia's departments has increased by 0.31 percentage points per year; however, this growth has been moderate.
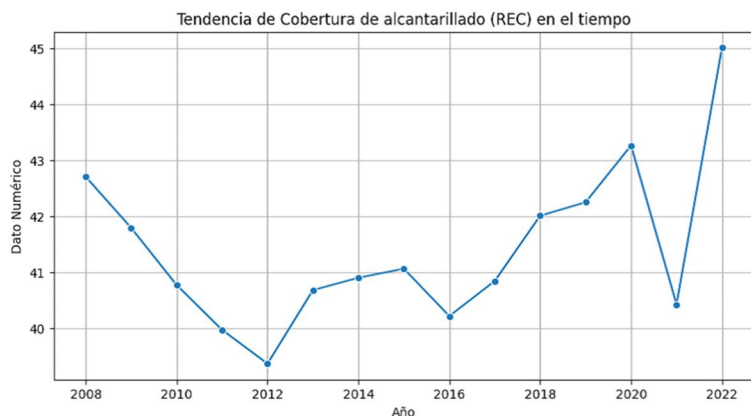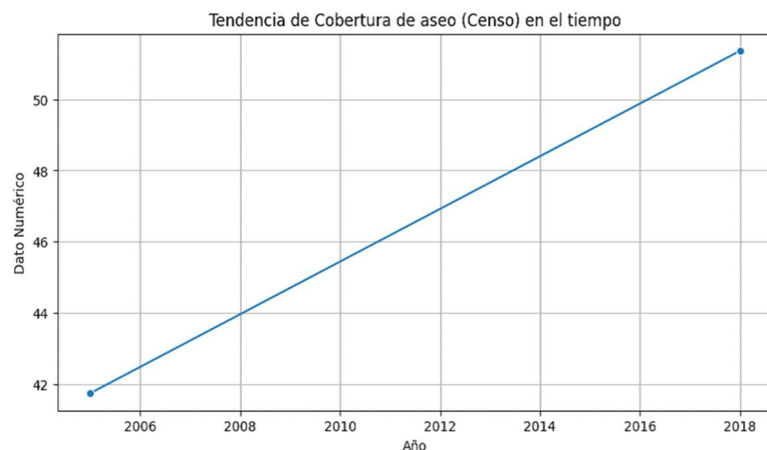

Figure 13. Sewerage system coverage trend in Colombian departments, 2008–2022 series.

Source: Prepared by the authors, taking into account data simulated by Python, by using the Matplotlib library [27].

In turn, the trend in sewerage system coverage across Colombian departments shows significant fluctuations over the considered period, with declines in some years and improvements in others. Specifically, between 2008 and 2022, coverage grew from 43% to 45%, or 2 percentage points; however, the most abrupt change occurred between 2021 and 2022 (see **Figure 13**).

Despite the above, it is worth noting that the growth in sewerage coverage across Colombian departments has not been constant, as there were periods of decline and stagnation before the recent improvement in 2022, especially between 2008 and 2012 (approximately more than 10%). Furthermore, despite periods of growth, this coverage remains low in absolute terms, suggesting that challenges remain in accessing this service in many departments (see **Figure 13**).

Finally, the access to sanitation services has improved over time in Colombia's departments, showing sustained growth between the years analyzed, as seen in **F**igure **14**. This graph shows a linear trend with a positive slope, indicating that sanitation service coverage has steadily increased between 2005 and 2018. This trend suggests that, if the current growth rate continues, much broader coverage could be achieved in the coming years, improving the country's quality of life.

Figure 14. Trend in sanitation system coverage in Colombia's departments, 2005–2018 series.

Source: Prepared by the authors, taking into account data simulated by Python, by using the Matplotlib library [27].

Regarding comparative analysis, the graphical behavior of the electricity coverage data across Colombian departments for 2018 is shown (**Figure 15**). The graph shows vertical bars indicating the coverage percentage in each department, with an error bar reflecting the variability of the data. High coverage is evident in most departments, above 90%. However, some departments have significantly lower coverage, suggesting inequality in access to energy services.
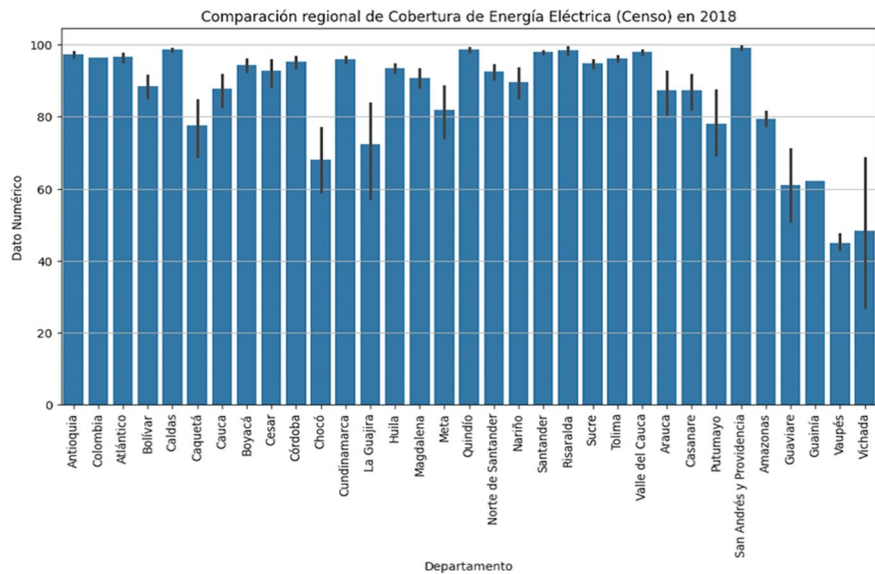
Figure 15. Electricity system coverage trend across Colombian departments, 2005–2018 series.
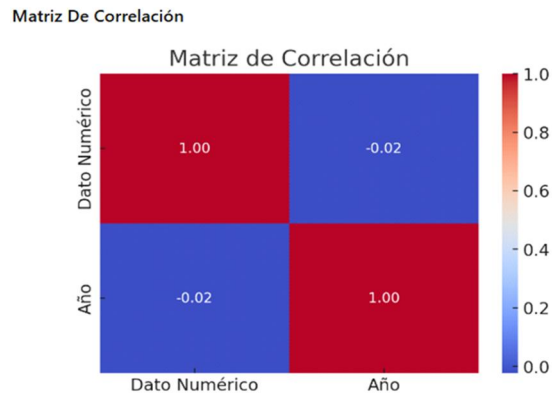
Source: Prepared by the authors, taking into account data simulated by Python, by using the Matplotlib library [27].

Some departments with lower coverage can be identified, especially in the Amazon and Orinoquía regions, such as Guainía, Vaupés, Vichada, and Amazonas, where values are below 70%. Furthermore, the error bars in some departments suggest greater uncertainty in the data, which could reflect differences within the same departments (urban vs. rural areas).

Departments such as Antioquia, Cundinamarca, Santander, Valle del Cauca, and San Andrés show coverage close to or equal to 100%. Others show medium or low coverage, such as Chocó, Guaviare, Vaupés, Guainía, and Vichada, with Vaupés standing out as having the lowest electricity coverage. However, Vichada, La Guajira, Chocó, and Guaviare present inequalities in coverage within their territories, with large differences between urban and rural areas, as evidenced by the error bars, which indicate the standard deviation of the data.
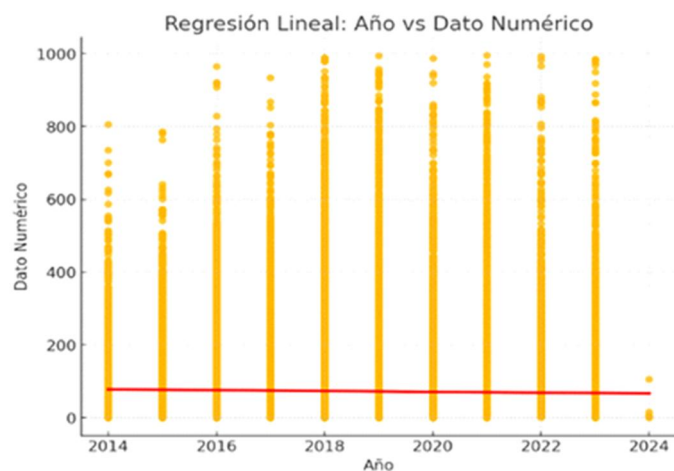
4.4. Security

Security, on the other hand, has not shown a direct temporal trend, although it is expected that incidents will increase or decrease over the years; that is, the data do not show a direct relationship (−0.02, according to the correlation matrix, **Figure 16**). Since there is no correlation with the year, it is possible that other variables not included, such as geographic location, type of incident, social context, etc., are more relevant in explaining the variation in the numerical data. In this sense, the number of incidents may be influenced by external factors associated with security policies and social phenomena, and not just by the calendar year (see **Figure 17**).

Matriz De Correlación

Figure 16. Correlation matrix security vs. years.

The following graph shows the data on the number of security-related incidents recorded each year (yellow dots) and the general trend between the years and the number of incidents (red line). It can be seen that, although there are variations, the data have a similar dispersion pattern for all years between 2014 and 2024; that is, there are no years with clearly fewer or more extreme records. The red line represents the linear regression, which is practically horizontal, pointing out that, on average, the number of security-related events or incidents hasn't changed significantly over the years.

Figure 17. Lineal regression year vs. numerical data (security).

5. Discussion

The analysis given in this study on municipal performance in Colombia shows significant differences in the quality and coverage of essential public services, analyzed through different methodologies and varying levels of depth in the indicators. Conclusively, it is emphasized that the security and health sectors show the best performance at the national level, although they aren't free from fluctuations and regional inequalities. On the contrary, the education and public services sectors are the most lagging, especially in terms of access and coverage. This general overview highlights territorial disparities and the existence of municipalities with

critical performance, which demands a specific and focused approach in public policies directed toward these areas.

The comparison of methodological approaches confirms the structural deficiencies in access to education and public services, with averages that do not exceed 50% coverage in many territories. In education, gross transition coverage shows a fluctuating trend, peaking in 2012 and experiencing a significant drop in 2017, reflecting not only access problems but also issues linked to retention and educational quality. Likewise, internal differences between departments and between urban and rural areas show persistent inequities that affect the comprehensive development of the population and limit growth opportunities for the most vulnerable municipalities.

Regarding public services, the results are worrying; with a national average of just 46.91 in access, this sector has the poorest municipal performance. Although modest progress can be noticed in water supply coverage, with an annual growth of only 0.31% between 2005 and 2018, the lag remains significant, especially in rural areas and small municipalities. The lack of suitable access to drinking water, basic sanitation, and electricity directly affects the quality of life and well-being of communities and constitutes a major problem for the economic and social development of these regions.

In contrast, the security sector shows relatively high performance, with a national average of 89.73. However, the declines observed during the periods 2016–2019 and 2021–2022 highlight instability in security management and public perception. Although correlation analysis reveals an almost null relationship between the years and the incidence of security events (−0.02), suggesting the absence of a clear trend, it also shows other strategies implemented haven't achieved a sustained impact on reducing incidents. This reinforces the need to rethink security policies, integrating them with social development processes and institutional strengthening to achieve more lasting effects [29].

Finally, the evidence of positive, albeit moderate, correlations between the education and health sectors suggests that investments in education could have favorable impacts on the general well-being and health of the population. On the contrary, the weak relationship between public services and security indicates that improving basic infrastructure doesn't automatically translate into better citizen security conditions, which calls out for an integrated approach to public policies. Therefore, it is recommended to design strategies that prioritize the expansion of educational coverage in municipalities with less than 80%, the strengthening of health systems, the acceleration of drinking water and sanitation projects in areas with less than 50% coverage, and the promotion of coexistence and civic culture programs. In addition, specialized research is required to formulate coordinated and comprehensive actions, with investments in infrastructure and institutional strengthening, aimed at reducing inequalities and improving the quality of life throughout the national territory.

6. Conclusions

The analysis given in this paper addresses municipal/local performance in Colombia by using different methodological approaches along with varying levels of depth in the indicators observed. The first is based on the analysis of data from the results component signs from the Municipal Performance Methodology (MPM), and the second one on key signs in the sectors of education, health, access to public services, security, and social coexistence. In short, it is relevant to note the security and health sectors, in that order, show the best performance nationwide, while access to education and public services are the most lagging. Regional disparities and municipalities with critical performance are also highlighted.

A comparison of the two methodological analysis approaches confirms the low coverage in access to public services and education (**Table 1**), with fluctuations and trends seen over the period analyzed. Furthermore, notable differences in coverage are evident between departments and within departments (urban vs. rural areas).

Table 1. A summary of the most relevant aspects of the indicators for each methodology.

MPM Variable	(Averages and Distribution) Specific Indicators	Summary: Indicators by methodological approach (Time Series)
Education (access and coverage)	Overall average of 49.23	Gross coverage in transition varies between 50% and 100% depending on the department (peak in 2012, drop in 2017)
Health (mortality)	Overall average of 83.87 in performance.	Overall mortality was stable (4.2–4.4 per 1000 until 2012); increasing since 2013, peaking in 2020.
Public Services (aqueduct)	Low average of 46.91 in access	Coverage went from 66% (2005) to 70% (2018) (+0.31% annually)
Security	Higher performance (89.73) but with drops in 2016–2019 and 2021–2022	Correlation, security-related incidents vs. years = −0.02, indicating a practically non-existent or null relationship

Source: Prepared by the authors.

According to the summary found in the chart above, the fluctuating trend in school coverage confirms the sector's low rating in the MPM, highlighting problems with access, retention, and educational quality. The health sector, on the other hand, has performed well; however, trends have shown vulnerability to health crises and regional inequality in access to services.

The public services sector is the worst-performing municipal sector, with slow progress and regional inequalities, especially in rural areas. This is confirmed by the coverage indicators for water supply, sewage system, electricity, and sanitation. Regarding security, it is concluded that, although overall performance is higher in this area, with a notable score of 89.73, there are significant declines in the 2016–2019 and 2021–2022 periods, which suggests significant fluctuations in the management or perception of security. However, when analyzing the correlation between security-related incidents and years, a value of −0.02 is obtained, indicating a practically nonexistent or null relationship. This suggests that, despite efforts to improve security performance, these have not translated into a sustained decrease in incidents over time or that other external factors could be affecting the occurrence of these incidents. Overall, these findings reflect the need to strengthen security strategies to achieve more consistent and lasting impacts.

The analysis, in turn, identifies positive, albeit moderate, correlations between the education and health sectors, which could mean that investing in education has a positive impact on the population's health. In contrast, indicators of access to public services and security show a weak relationship, making it possible to assert that greater availability of basic services such as drinking water, electricity, and sewage systems does not necessarily imply a direct improvement in the municipality's security. Based on the analysis of municipal performance and specific indicators for education, health, public services, and security, strategies are recommended within public policies that prioritize access to early childhood education in areas with coverage below 80%; strengthen health prevention programs, accompanied by greater investment in the hospital network, especially in municipalities with high mortality rates and low coverage; accelerate water and sewage projects, prioritizing municipalities with coverage below 50%; and promote programs aimed at improving coexistence and civic culture, integrating security policies with social development.

Generally speaking, specialized research is recommended on coordinated actions in education, health, public services, and security, with special attention to municipalities with critical indicators. In addition, comprehensive strategies should be developed with investment in infrastructure, institutional strengthening, and a territorial focus to reduce inequalities and improve the quality of life in all regions of the country.

Data availability statement: The original data presented in the study are openly available in [repository of terridata] at [https://terridata.dnp.gov.co/].

Institutional review board statement: Not applicable.

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Conflict of interest: The authors declare no conflict of interest.

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