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Exploratory analysis of health-related indicators contained in the Sustainable Development Goals for the State of Mexico

Summary

The health-related Sustainable Development Goals (SDGs) serve as pivotal benchmarks for gauging the health, well-being, and overall development of a nation's populace. This study aims to meticulously scrutinize the available SDG indicators for the State of Mexico at the municipal level, employing sophisticated techniques rooted in exploratory spatial data analysis. The primary objective is to comprehensively grasp the interplay between these indicators and their geographic distribution. This analytical approach will unveil discernible patterns encompassing clustering, dispersion, spatial self-correlation, and other geographical trends within the selected indicators. Spatial autocorrelation, notably, plays a pivotal role in discerning similarities or disparities in values and their potential correlation with geographic proximity. This analysis serves to ascertain the existence of significant spatial patterns. To accomplish this, graphical tools like maps and diagrams will be utilized. These visual representations effectively convey geographical information, thereby facilitating the communication of findings. This methodology will be particularly invaluable in pinpointing vulnerable populations. Anticipated outcomes include robust findings that can substantially inform the development agendas and guide the implementation of public health policies within the Mexican entity.

Keywords: State of Mexico; Geoinformatics; health-related indicators; Sustainable Development Goals.

Abstrakt

Cele zrównoważonego rozwoju związane ze zdrowiem (SDGs) stanowią kluczowe wskaźniki do oceny zdrowia, samopoczucia i ogólnego rozwoju populacji danego kraju. Niniejsze badanie ma na celu szczegółowe zbadanie dostępnych wskaźników SDGs dla stanu Meksyk na poziomie gminnym, wykorzystując zaawansowane techniki zakorzenione w eksploracyjnej analizie przestrzennej danych. Głównym celem jest wszechstronne zrozumienie wzajemnych zależności tych wskaźników i ich geograficznego rozkładu. Ten podejście analityczne ujawni widoczne wzorce obejmujące skupiska, rozproszenie, przestrzenną samokorelację i inne tendencje geograficzne w wybranych wskaźnikach. Samokorelacja przestrzenna odgrywa kluczową rolę w wykrywaniu podobieństw lub rozbieżności w wartościach oraz ich potencjalnej korelacji z bliskością geograficzną. Analiza ta służy ustaleniu istnienia istotnych wzorców przestrzennych. Aby to osiągnąć, wykorzystane zostaną narzędzia graficzne, takie jak mapy i diagramy. Te wizualne reprezentacje efektywnie przekazują informacje geograficzne, ułatwiając komunikację wyników. Metoda ta będzie szczególnie wartościowa w identyfikacji podatnych grup ludności. Przewidywane rezultaty obejmują solidne wyniki, które znacząco mogą wpłynąć na agendy rozwojowe i wytyczanie polityki zdrowotnej w meksykańskim regionie.

Słowa kluczowe: Stan Meksyk; Geoinformatyka; wskaźniki związane ze zdrowiem; Cele Zrównoważonego Rozwoju.

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Introduction

In September 2015, the United Nations General Assembly endorsed the Sustainable Development Goals (SDGs), comprising 17 overarching objectives, 169 specific targets, and 232 indicators (UN, 2020). Notably, a substantive segment of these—12 goals, 33 targets, and 57 indicators—directly pertain to health considerations (SDG Collaborators, 2016; WHO, 2020; Asma et al., 2020; Novillo-Ortiz et al., 2021; Wilson et al., 2021). These metrics predominantly encompass health outcomes, healthcare services, and environmental risk factors (Asma et al., 2020). The fundamental purpose of these globally applicable goals is to ensure the promotion of sound health and well-being across all age groups (UN, 2022).

The capacity to measure, analyze, and visually represent these indicators is of utmost importance. In this context, one highly effective tool is the exploratory analysis of spatial data (EASD). EASD facilitates the examination of geographic patterns, relationships, and distributions inherent in these health-related indicators, enabling a comprehensive understanding of spatial variations and associations critical to informed decision-making in health policy and intervention strategies.

Theoretical aspects

Health and territory

Health constitutes a comprehensive state encompassing physical, mental, and social dimensions, influenced by multifaceted factors. In 1946, the World Health Organization broadened the health concept, emphasizing not only disease but also promoting healthy lifestyles, disease prevention, and addressing mental and social well-being aspects.

Breilh (2003) posits health and disease within individuals or describing epidemiological patterns in social groups as intricate processes interlinking history, society, biology, and ecology. These factors interact within individuals, social groups, and society itself. Meanwhile, the concept of territory in geographical analysis spans beyond mere geographical extension, encompassing physical, political, cultural, and social characteristics, including aspects like administration, borders, property, and cultural identity.

Porto-Gonçalves (2002) asserts that territory embodies a complex concept influencing the formation of identities or territorialities. These identities evolve dynamically, molded by historical events and shaping specific territorial orders across different historical periods, consequently impacting the health conditions of populations.

Iñiguez and Barcellos (2003) emphasize understanding health processes through the lens of territory. They advocate for comprehending the ethical dialogue between materiality and the significance of processes to foster the well-being of individuals and communities.

The intersection of health and territory entails a multidisciplinary exploration, probing how geographical and spatial factors impact population health. This intricate relationship spans various dimensions, encompassing disease geographical distributions and the accessibility of health services.

Exploratory analysis of spatial data (EASD) comprises techniques delineating and visualizing spatial distributions to identify outliers, spatial associations, cluster groupings, hot/cold spots, and spatial heterogeneity (Anselin, 1999). It involves analyzing geographical distribution patterns of each database indicator associated with maps, employing measures like mean, median, mode, variance, deviation, and kurtosis.

Spatial self-correlation, a technique within EASD, gauges the similarity between neighboring geographical observations, elucidating if variable values in one place relate to nearby locations. Statistical tools such as the Moran index quantify global spatial self-correlation, with positive values indicating positive spatial association, negative values indicating negative spatial correlation, and values near zero signaling lack of spatial autocorrelation (Siabato W. and Guzmán J., 2019).

Local Spatial Association Analysis (LISA), a facet of Exploratory Spatial Data Analysis (EASD), identifies patterns of local spatial correlation within geographic data. Using Moran's local statistics, LISA discerns whether high or low values tend to cluster together in specific locations, revealing significant correlations with neighboring locations (Anselin, 1995).

Methodological aspects

(a)Study area

The State of Mexico is situated in the southern-central region of the country, sharing borders with Querétaro to the north, Hidalgo to the northeast, Tlaxcala to the east, Puebla to the southeast, Morelos and Mexico City to the south, Guerrero to the southwest, and Michoacán to the west. It is administratively divided into 125 jurisdictions and covers an extensive territory spanning 22,357 square kilometers (refer to Figure 1). As per the 2020 Population Census and Housing data, the state boasts a populace of 16,992,418 inhabitants, making it the most densely populated entity in the country and representing approximately 13.5% of the national population. (INEGI, 2020).

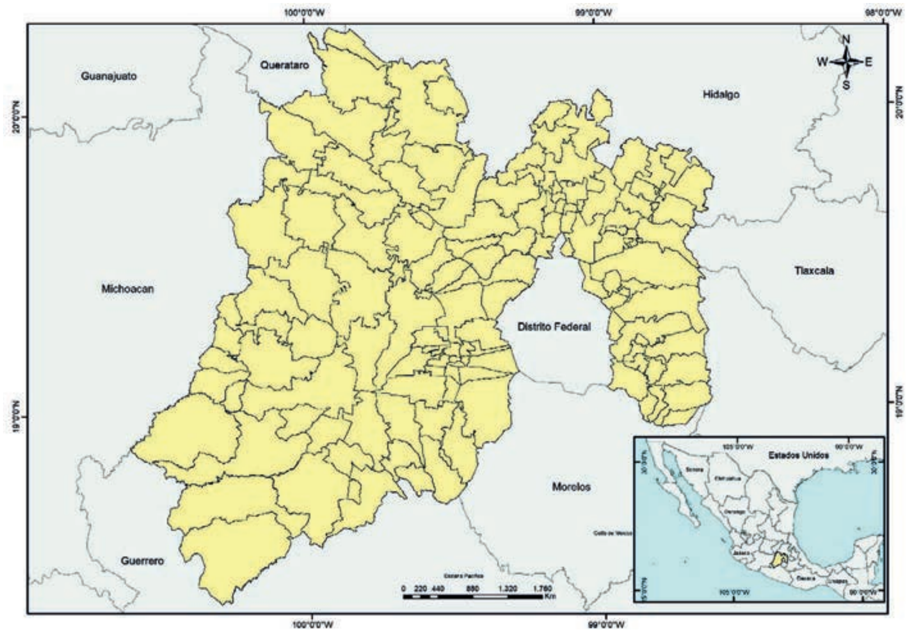

Figure 1. Geographic location of the State of Mexico.

Source: authors.

In 2020, the economic output of the Mexican territory accounted for 9.1% of the national gross domestic product (GDP), ranking it as the second-largest economy within the country. The state's GDP is predominantly structured, with 28% contributed by industries encompassing manufacturing, machinery and equipment, electronics, automotive, textiles, and maquiladora operations. The services sector makes up 22% of the GDP, while commerce, hotels, and restaurants collectively contribute 20%. Additionally, financial services and real estate activities account for 15% of the state's GDP. (INEGI, 2021).

b) Sources of information and variables.

The variables utilized in this study were sourced from official repositories such as the 2020 Population and Housing Census, administered by the National Institute of Statistics and Geography. Additionally, data was acquired from the Health Information System (SINAIS) operated by the Ministry of Health.

The database comprises information from 125 municipalities and is limited to 10 key indicators at its alphanum level:

1. Underage mortality rate per 100,000.
2. Mortality rate among individuals over 65 years per 100,000.
3. Maternal mortality rate per 100,000.
4. Mortality rate of infants under 28 days old per 100,000.
5. Mortality rate due to cardiovascular diseases within the age group of 30–70 years, per 100,000 population within a specified time frame.

6. Mortality rate due to diabetes within the age group of 30–70 years, per 100,000 population during a specific period.
7. Mortality rate due to chronic respiratory diseases within the 30–70 age group, per 100,000 population within the same timeframe.
8. Birth rate among teenage mothers (typically aged 15 to 19 years) within a given period, per 100,000 population.
9. Rate of accessibility to essential healthcare services for the population (health units) per 100,000.
10. Rate of women aged 15 years or older who have encountered intimate partner violence within a specified period (gender-based violence), per 100,000 population.

These indicators serve as crucial metrics in evaluating various aspects of demographic health, mortality patterns, access to healthcare services, and occurrences of intimate partner violence among women within the specified region.

c) Techniquesof analysis

To achieve the primary objective of the research, a sequence of processes was undertaken, outlined as follows:

The initial step involved computing mortality rates to unveil the ratio of deaths within a particular area. To accomplish this, the following formula was employed:

$$Mortality\ Rate = \frac{Number\ of\ Deaths\ in\ a\ Year}{Population\ in\ a\ Year} \times 100{,}000\ Population.$$

Upon computing the rates, the remaining variables were transformed into index values by computing percentages. Subsequently, the variables underwent standardization utilizing the Z-score method. The Z-score indicates the number of standard deviations a value is positioned from the mean. This process involved the application of the following formula:

$$Z\ score = \frac{x - \mu}{\sigma}$$

Where x represents the variable data, μ the mean of the data, and σ the standard deviation of the data.

Upon standardizing the variables, the alphanumeric dataset was linked with the cartographic dataset of the State of Mexico, facilitated by the GeoDa software. This software, developed by the University of Chicago since 2003, enabled the integration of the two datasets.

Subsequently, to conduct the exploratory analysis of spatial data, the GeoDa software was utilized. The primary techniques employed within GeoDa included frequency histograms, scatter plots, and box plots aimed at identifying outliers. Additionally, Moran scatter plots and LISA charts were utilized.

Moran's I statistic and Moran's dispersion graph are methodologies employed to examine spatial dependence or self-correlation at a global level. These methods do not specifically identify hotspots or cold zones deviating from the overall trend of a variable or ascertain the presence of spatial concentrations. For this purpose, LISA graphs were employed to analyze local spatial dependence (Santana G. and Aguilar A.G., 2019).

The computation involved generating a spatial weights matrix using the Queen criterion for spatial dependence, encompassing all observations sharing an edge or vertex (refer to figure 2) for Moran scatter plots (I Moran test) and LISA graphs. Following the matrix creation, the Moran dispersion graph, cluster map, and significance map were derived using the available tools.

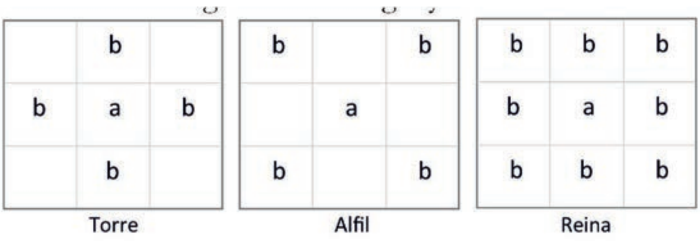

Figure 2. Contiguity matrix

Source: Authors.

To ascertain the presence or absence of significant spatial autocorrelation, a hypothesis test is conducted to determine if the spatial distribution of each variable occurs randomly.

The null hypothesis (H0) assumes that the spatial distribution is random, while the alternative hypothesis (H1) rejects this assumption, suggesting that the spatial distribution is non-random. Therefore, global and local spatial autocorrelation are framed within a system of hypotheses. This discussion aims to reject the null hypothesis of spatial randomness in favor of an alternative hypothesis indicating either clustering or dispersion. A positive autocorrelation implies a clustered distribution pattern, whereas a negative autocorrelation suggests a scattered distribution pattern.

Defining the level of significance, typically denoted by the symbol alpha (α), is crucial. Alpha represents the probability of rejecting the null hypothesis. If the probability of a specific value obtained in a test equals or is less than α, the null hypothesis (H0) is rejected in favor of the alternative (H1) (Buzai & Baxendale, 2012). Conventionally, the significance level is set at 0.05; if the p-value, the probability value, is less than or equal to 0.05, the null hypothesis is rejected in favor of the alternative hypothesis.

The p-value represents a probability and signifies numerical estimates of the area under a known distribution curve. Within analytical tools, the p-value assesses the likelihood that the spatial pattern of a variable stems from some non-random process (Mitchell, 2005). A p-value of 0.05 denotes 95% confidence, while 0.01 and 0.001 indicate 99% and 99.9% confidence, respectively, that the observed autocorrelation is not the result of random chance.

Accompanying this analysis is the Local Spatial Association Index (LISA), which identifies local spatial association patterns and evaluates individual locations' influence on global statistics through Geographic Information Systems (GIS) (Anselin, 1995).

This combined information allows the classification of significant locations into clusters (HH and LL) or spatial dispersions (HL, LH) as follows:

- High-High (HH): Signifies locations with high values surrounded by neighboring locations with significant high values, indicating the presence of a high-valued cluster in that area.
- Low-Low (LL): Represents locations with low values surrounded by neighboring locations with significant low values, suggesting the presence of a low-valued cluster in that area.
- High-Low (HL): Reflects locations with high values neighboring locations with significant low values, indicating a discrepancy between that area and its close neighbors.
- Low-High (LH): Denotes locations with low values surrounded by neighboring locations with significant high values, also indicating a spatial discrepancy.

Results

The graphical methods employed in the exploratory analysis of spatial data offer an initial insight into understanding the sociospatial information structure concerning the health-related variables aligned with the Sustainable Development Goals (SDGs) within the State of Mexico.

a) Underage death rateper 100,000

The under-five mortality rate stands as a critical metric signifying the health status of a population. Globally, this rate has shown a consistent decline in recent decades, attributable to advancements in medical care, expanded access to vaccinations, enhanced living conditions, and increased education regarding maternal and child health. However, it's crucial to acknowledge the considerable variability in under-five mortality rates across countries and within distinct socioeconomic strata within a given nation.

In the State of Mexico, the under-five mortality rate recorded for 2020 stood at 174.69 per 100,000 infants within this age bracket. The calculated Moran's I statistic reveals a value of -0.066, indicating a negative and statistically insignificant spatial correlation. The obtained p-value of 0.166 exceeds the conventional significance level of 0.05, leading to the acceptance of the null hypothesis. Consequently, the analysis indicates a spatial randomness in the under-five mortality rate across the region (figure 3).

b) Death rate over 65yearsper 100,000

This rate serves as a common metric to evaluate mortality among the elderly population, offering a crucial indicator for gauging the quality of healthcare services and other factors linked to population aging.

In the State of Mexico, the mortality rate among individuals aged over 65 in 2020 stood at 5346.26981 per 100,000 inhabitants within this age cohort. Notably, the municipality of Toluca recorded the highest number of deaths, while Jilotzingo exhibited the lowest mortality rate.

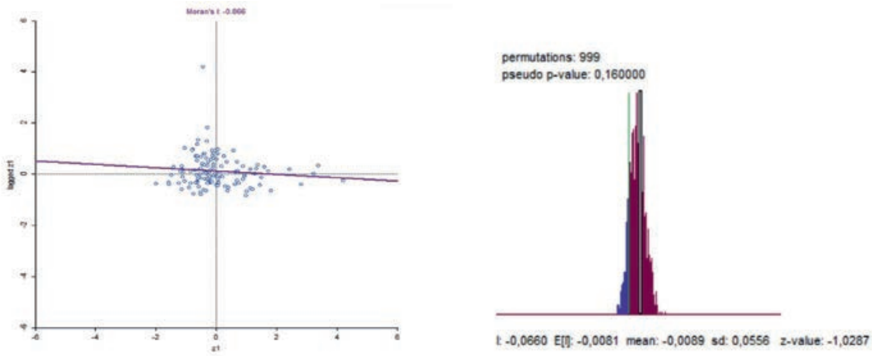

Figure 3. I Moran scatter plot.

Source: own elaboration in Geode

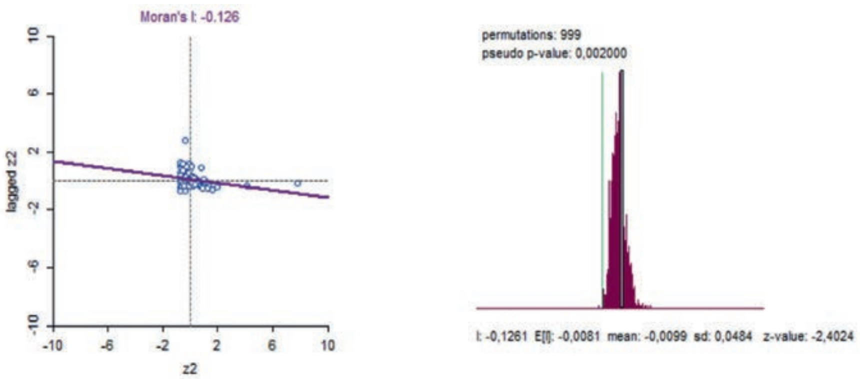

Figure 4. I Moran scatter plot.

Source: own elaboration in Geode

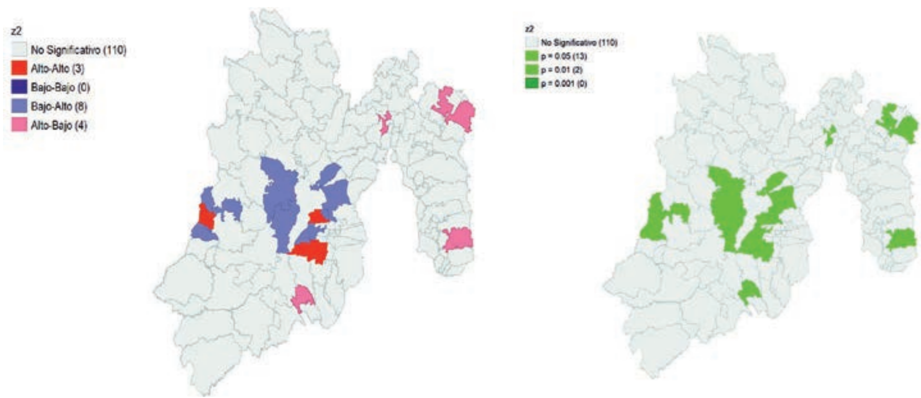

Figure 5.LISA analysis: cluster and statistical significance

Maternal death rate per 100,000

ource: own elaboration in Geode

The computed Moran's I statistic reflects a value of -0.126, indicating a negative spatial correlation. The obtained p-value of 0.002, less than 0.05, leads to the rejection of the null hypothesis, supporting the acceptance of the alternative hypothesis, suggesting that the observed autocorrelation is not a result of randomness (refer to Figure 4).

Local spatial autocorrelation (LISA) analysis identified 15 municipalities as significant in the model, with 13 having a 95% confidence interval. Notable municipalities within this classification include Zinacantepec, Tenango del Valle, Calimaya, Axapusco, and Amecameca. The cluster map highlights three municipalities with high-high values (Metepec, Tenango del Valle, and Ixtapan del Oro), while four municipalities exhibit high-low values, suggesting possible adjacency to locations with significantly lower values.

Moreover, the predominant concentration lies within the low-high classification, wherein municipalities exhibit low values while being surrounded by areas with significant high values. Noteworthy municipalities in this classification include Almoloya de Juárez, Zinacantepec, and Lerma (refer to Figure 5).

c) Maternal deaths

Maternal deaths encompass the fatalities of women during pregnancy, childbirth, or within 42 days of the pregnancy's termination, regardless of its duration or the site of pregnancy. These deaths occur due to causes related to or exacerbated by pregnancy or its management, excluding accidental or incidental factors. Hence, maternal deaths serve as a pivotal indicator reflecting the state of maternal health and the efficacy of the medical care system within a country (Villerías and Santana, 2021).

In the State of Mexico, the maternal mortality rate recorded for 2020 stood at 70.94 per 100,000 live births. Notably, the municipalities of Cuautitlán and Toluca exhibited the highest maternal mortality rates, while Zacazonapan and Jilotzingo demonstrated the lowest rates within that year.

The calculated Moran's I statistic revealed a value of 0.031, indicating a positive but statistically insignificant spatial correlation. The obtained p-value of 0.168 exceeds the standard significance level of 0.05, leading to the acceptance of the null

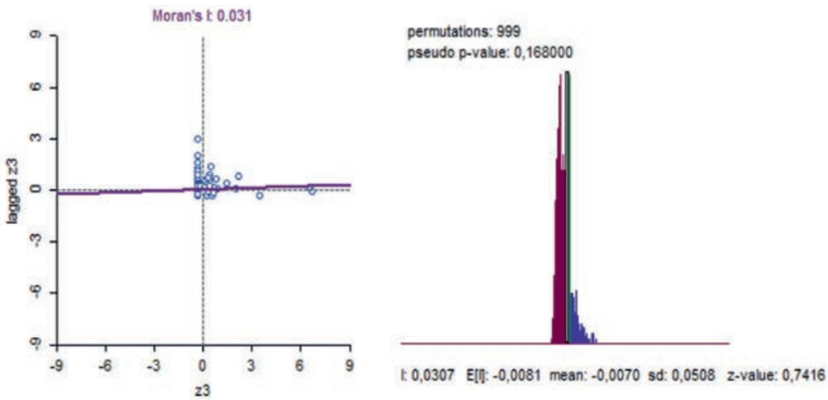

Figure 6. I Moran scatter plot.

Source: own elaboration in Geode

hypothesis. Consequently, the analysis suggests a state of spatial randomness concerning maternal mortality across the region (refer to Figure 6).

d) Under-28 death rateper 100,000

The mortality rate within the neonatal age group, referred to as the neonatal mortality rate, stands as a pivotal indicator assessing the quality of antenatal care, delivery practices, and neonatal healthcare services within a region.

In the State of Mexico, the neonatal mortality rate for the specified period was 890.32 per 100,000 births. The municipalities of Toluca, Cuautitlán, and Valle de Bravo reported the highest rates of neonatal mortality. Conversely, 44 municipalities documented no deaths within this age group, including Nopaltepec, Melchor Ocampo, Cocotitlán, Ecatzingo, and Otzoloapan.

The calculated Moran's I statistic revealed a value of -0.143, indicating a negative spatial correlation. The obtained p-value of 0.002, below the standard

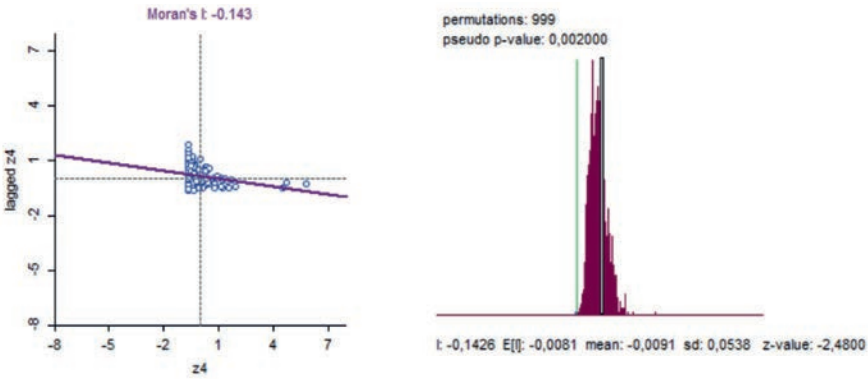

Figure 7. I Moran scatter plot.

Source: own elaboration in Geode

threshold of 0.05, led to the rejection of the null hypothesis and the acceptance of the alternative hypothesis. This implies that the observed autocorrelation is not a consequence of randomness, indicating the presence of spatial autocorrelation (refer to Figure 7).

Local Spatial Autocorrelation (LISA) analysis identifies 10 municipalities as statistically significant in the model at a confidence level of 95%. Notable municipalities within this classification include Valle de Bravo, Tenango del Valle, and Ixtapan de la Sal.

The cluster map highlights distinct patterns: Zumpango displays high-high values, signifying a concentrated cluster of high rates. Meanwhile, Valle de Bravo, Chalco, and Ixtapan de la Sal fall into the high-low category, indicating potential proximity to areas with significantly lower rates. Additionally, municipalities like Tenango del Valle, Nopaltepec, Teloyucan, Cuautitlan, Nezahualcoyotl, and San Mateo Atenco exhibit low-high values, suggesting adjacency to areas with notably higher rates (refer to Figure 8).

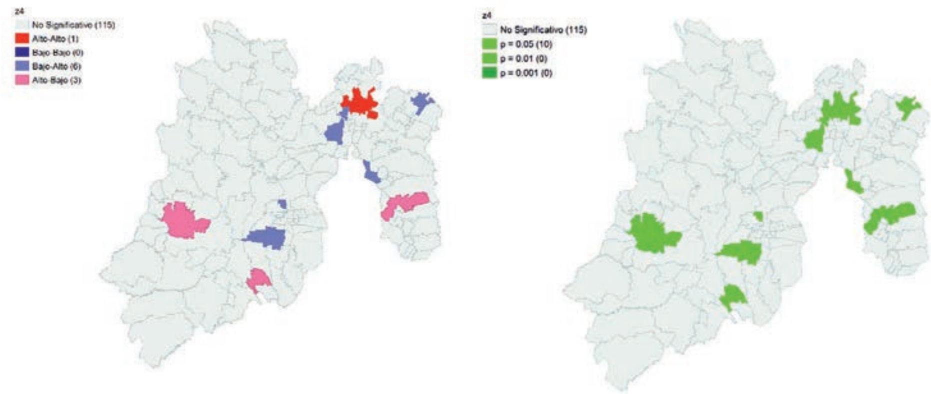

Figure 8.LISA analysis: cluster and statistical significance

Source: own elaboration in Geode

e) Rate of deaths due to cardiovascular disease and diabetes mellitus in the age group 30 to 70yearsin a given periodper 100,000.

Chronic diseases and diabetes mellitus pose a burgeoning global public health challenge. These persistent ailments not only inflict considerable human suffering but also exert a substantial burden on healthcare systems and national economies due to their impact across all age groups and social strata (Villerias and Juárez, 2020).

In the State of Mexico, the municipalities of Isidro Fabela, Toluca, and Capulhuac exhibited the highest mortality rates due to cardiovascular diseases, recording values of 253.0, 244.8, and 221.5 per 100,000 inhabitants, respectively. Concerning diabetes mellitus, the municipalities of Xalatlaco, Atizapán, and Tepetlixpa reported rates of 443.3, 400.9, and 389.7 per 100,000 inhabitants, respectively.

The computed Moran's I statistics for cardiovascular diseases and diabetes mellitus stood at 0.134 and 0.210, respectively, indicating a positive spatial correlation. The derived p-values of 0.012 and 0.002, both below the significance threshold of 0.05, resulted in the rejection of the null hypothesis and acceptance

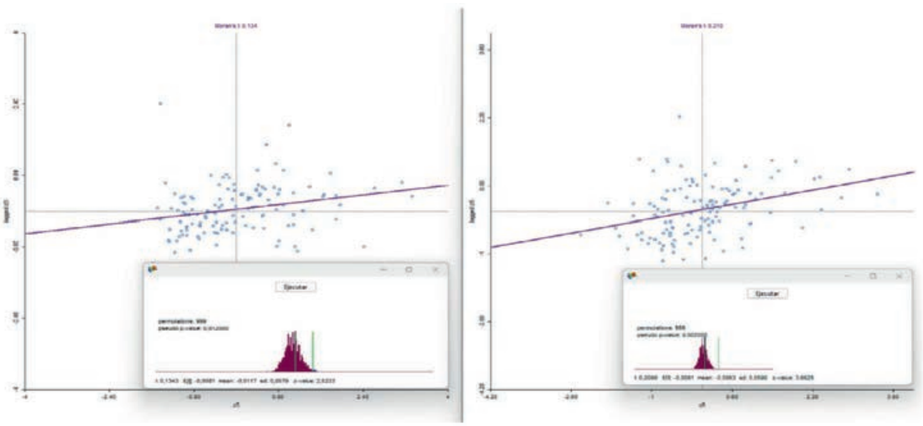

Figure 9. I Moran scatter plots

Source:own elaboration in Geode

of the alternative hypothesis. This signifies that the observed autocorrelation is not due to randomness but rather indicates the presence of spatial autocorrelation (refer to Figure 9).

Local Spatial Autocorrelation (LISA) analysis identifies 21 municipalities as statistically significant within the model, presenting a 95% confidence interval. High-high values for cardiovascular diseases are concentrated in municipalities

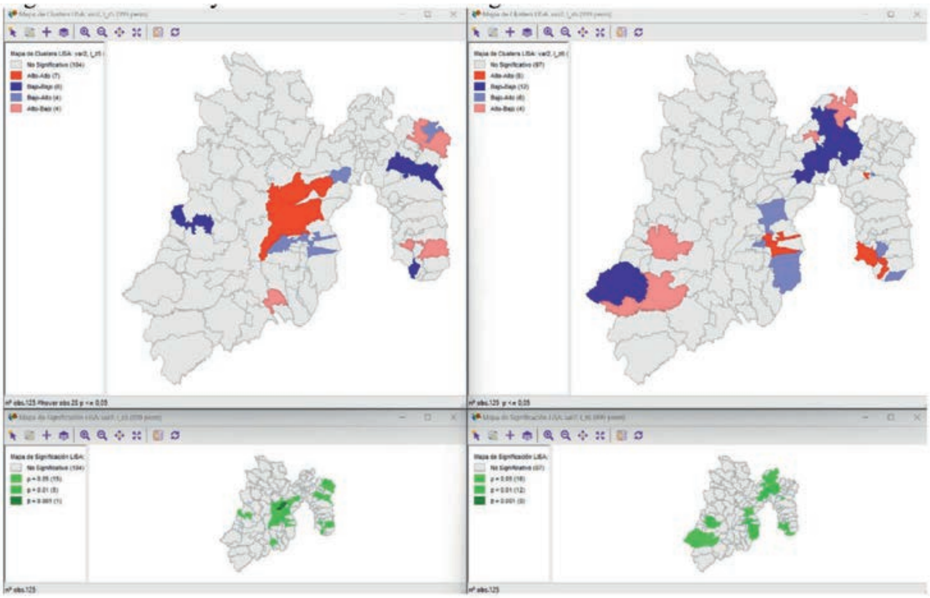

Figure 10. LISA analysis: cluster and statistical significance

Source: own elaboration in Geode

situated at the central region of the State of Mexico. Conversely, for diabetes mellitus, these high-high values are observed in smaller municipalities located toward the southeast and east of the region (refer to Figure 10)

f) Rate of deaths due to chronic respiratory diseases in the 30–70 age group in thesame periodper 100,000

The mortality rate attributed to chronic respiratory diseases in the State of Mexico stood at 168.8 per 100,000 individuals aged 30 to 70 years. Notably, municipalities such as Luvianos, Tianguistenco, Temoaya, Otzolotepec, and Lerma exhibited the highest mortality rates from chronic respiratory diseases. Conversely, 108 municipalities reported no deaths from these causes in the given year, including San José del Rincón, San Felipe del Progreso, Ixtlahuaca, Almoloya de Juárez, and Zinacantepec.

The computed Moran's I statistic yielded a value of 0.052, indicating a very weak positive spatial correlation. The derived p-value of 0.002, falling below the significance threshold of 0.05, led to the rejection of the null hypothesis and acceptance of the alternative hypothesis. This indicates that the observed autocorrelation

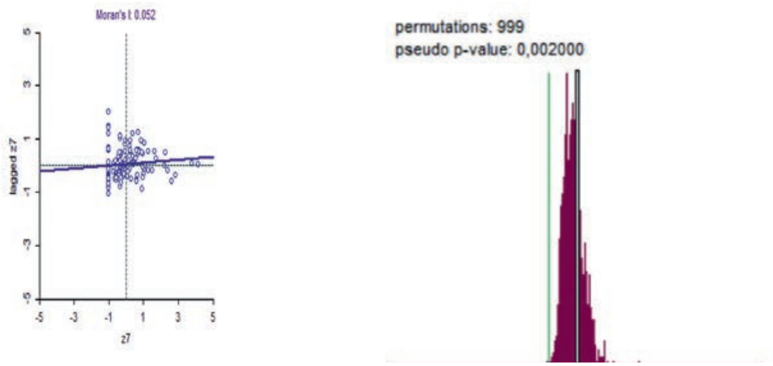

Figure 11. I Moran scatter plot.

Source: own elaboration in Geod

is not a consequence of randomness but rather suggests the presence of spatial autocorrelation (refer to Figure 11).

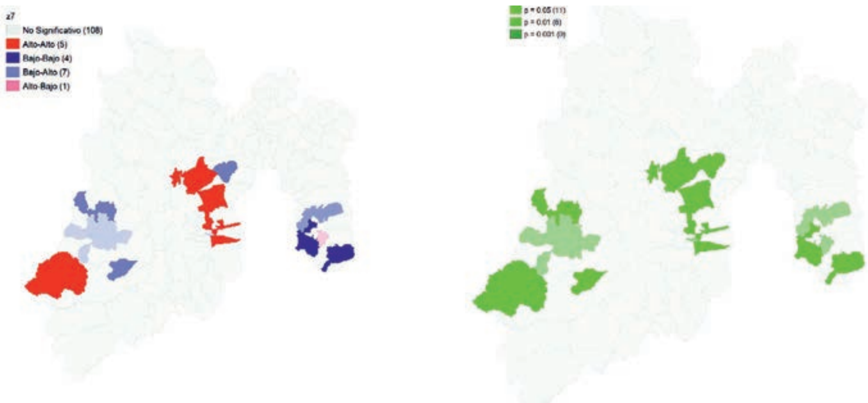

Figure 12. LISA analysis: cluster and statistical significance

Source: own elaboration in Geode

Local Spatial Autocorrelation (LISA) analysis identifies a subset of 11 municipalities as statistically significant within the model, bearing a 95% confidence interval. For instance, municipalities such as Luvianos, Tianguistenco, Temoaya, Temamatla, San Simón Guerrero, Otzolotepec, Lerma, Juchitepec, Jilotzingo, Donato Guerra, and Atlautla exhibit low-high values (refer to Figure 12).

g) Birth rate to teenage mothers (usually in the age range of 15 to 19years) in a given periodper 100,000

The birth rate among teenage mothers aged 15 to 19 years in the State of Mexico amounted to 6238.86553 per 100,000 inhabitants within the same age group. Municipalities such as Luvianos, Santo Tomas, and Otzoloapan exhibited the highest rates of births among adolescent mothers. Conversely, 101 municipalities reported no births among adolescent mothers in the given year, including Toluca, Zinacantepec, Temoaya, Villa Victoria, and Metepec.

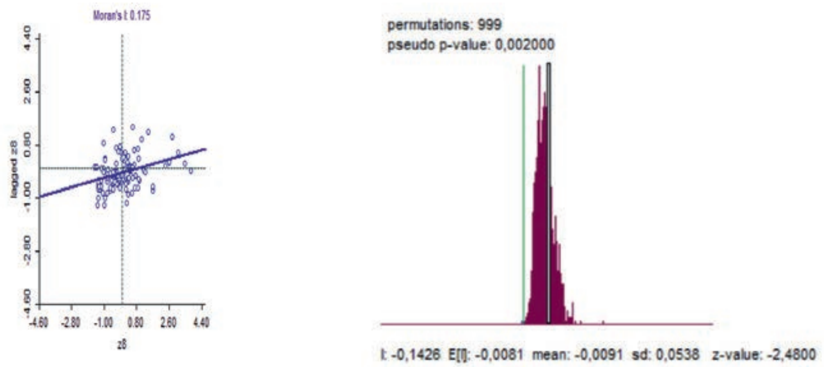

Figure 13. I Moran scatter plot.

Source: own elaboration in Geode

The computed Moran's I statistic resulted in a value of 0.175, indicating a positive spatial correlation. The derived p-value of 0.001, below the significance threshold of 0.05, led to the rejection of the null hypothesis and acceptance of the alternative hypothesis. This suggests that the observed autocorrelation is not due to randomness but rather indicates the presence of spatial autocorrelation (refer to Figure 13).

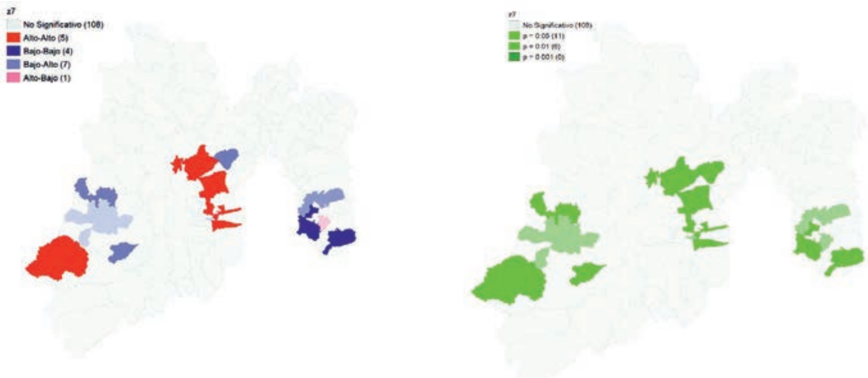

Figure 14. LISA analysis: cluster and statistical significance

Source: own elaboration in Geode

The analysis of Local Spatial Autocorrelation (LISA) reveals that merely 18 municipalities exhibit statistical significance within the model at a 95% confidence interval. Notable municipalities such as Tlalnepantla de Baz, Valle de Bravo, Cuautitlán Izcalli, Naucalpan de Juárez, Ecatepec de Morelos, Coacalco de Berriozábal, Melchor Ocampo, Lerma, Atenco, and Acolman demonstrate low-high values (refer to Figure 12).

h) Coverage rate of essential health services for the population(health units) per 100,000

The health services coverage rate in the State of Mexico reached 253,653.003 per 100,000 population. Notably, municipalities such as Luvianos, Tejupilco, Zacualpan, Valle de Bravo, and Temascaltepec demonstrated the highest coverage

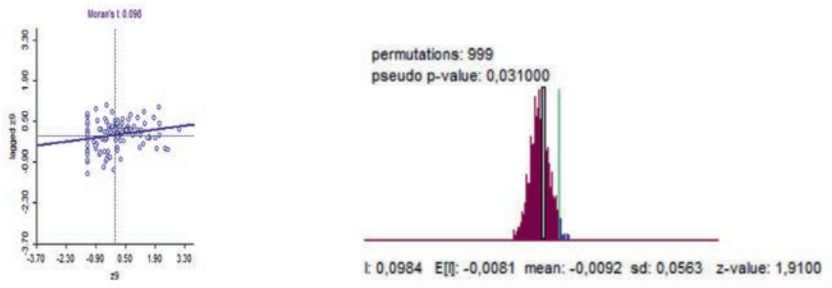

Figure 15. I Moran scatter plot.

Source: own elaboration in Geode

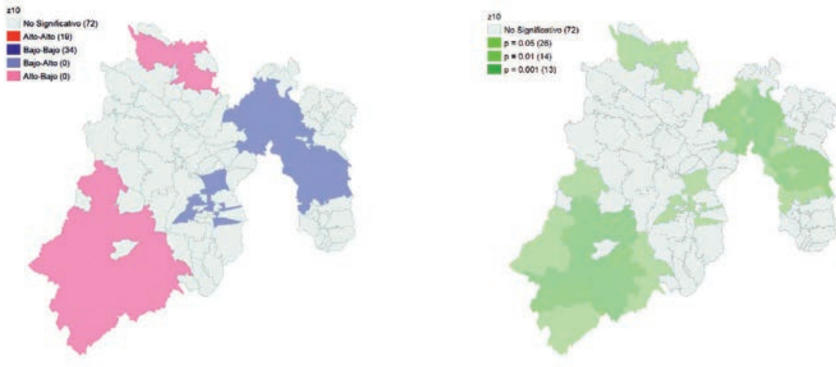

Figure 16. LISA analysis: cluster and statistical significance

Source: own elaboration in Geode

rates. Conversely, 72 municipalities did not report any coverage rate, including Otumba, Morelos, Tonatico, Tezoyuca, and Temamatla.

The computed Moran's I statistic indicated a value of 0.669, signifying a positive spatial correlation. The resulting p-value of 0.001, below the significance threshold of 0.05, led to the rejection of the null hypothesis in favor of the alternative hypothesis. This suggests that the observed autocorrelation is not a consequence of randomness but indicates the presence of spatial autocorrelation (refer to Figure 15).

The analysis of Local Spatial Autocorrelation (LISA) indicates significance in solely 26 municipalities within the model, maintaining a 95% confidence interval. For instance, municipalities such as Luvianos, Villa Guerrero, Valle de Bravo, Tianguistenco, Donato Guerra, Zumpango, Tultitlan, Temascaltepec, Sultepec, and Jaltenco exhibit low-high values (refer to Figure 16).

i) Rate of women aged 15yearsor olderwho have experienced intimate partner violence in each period (gender-based violence) per 100,000

The incidence rate of women aged 15 years who have experienced intimate partner violence in the State of Mexico was 151,086.009 per 100,000 inhabitants. Notably, the municipality with the highest rate of affected women is Atizapán. Conversely, 114 municipalities did not report any cases of women violated, including Aculco, Polotitlan, Soyaniquilpan de Juárez, Temascalcingo, and Acambay.

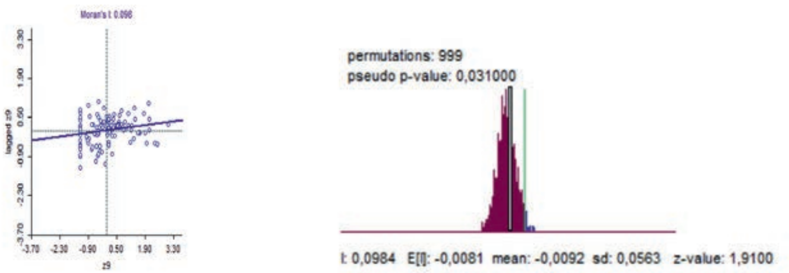

Figure 17. I Moran scatter plot.

Source: own elaboration in Geode

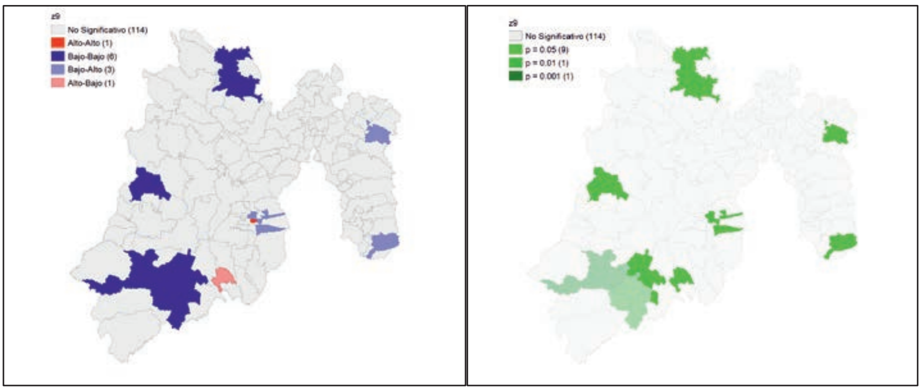

Figure 18. LISA analysis: cluster and statistical significance

Source: own elaboration in Geode

Moran's I statistic computed at 0.098 indicates a positive spatial correlation. However, the resulting p-value of 0.031 exceeds the significance threshold of 0.05. Consequently, the null hypothesis is rejected, and the alternative is accepted, suggesting that the observed autocorrelation is not due to randomness but indicates spatial autocorrelation (refer to Figure 17).

The analysis of Local Spatial Autocorrelation (LISA) reveals that only nine municipalities demonstrate significance within the model, maintaining a 95% confidence interval. For instance, municipalities such as Jilotepec, Ixtapan de la Sal, Atlautla, Atizapán, and Otumba display low-high values (refer to Figure 18).

Conclusions and Reflections

The Exploratory Analysis of Spatial Data (EASD) serves as a statistical method for investigating patterns and relationships within geographic data. Employing diverse tools such as density maps, spatial autocorrelation indices, and interpolation techniques, EASD enables the visualization and comprehension of variable spatial distributions within a specific geographical region. This in-depth analysis of spatial and data elements unveils clustering or dispersion patterns, offering crucial territorial insights essential for informed decision-making.

Regarding the specific indicators:

The indicators concerning deaths of children under 5 years and those under 28 days show notably higher rates in municipalities like Toluca and Valle de Bravo, primarily urban areas with high mobility. Other municipalities in the east and south of the State of Mexico display similar characteristics.

The indicator for deaths of individuals over 65 years exhibits higher values in municipalities such as Axapusco, Metepec, Temamatla, Texcoco, and Toluca, mainly urban areas located in the central and eastern parts of the state. Similarly, indicators related to cardiovascular diseases, diabetes, and chronic respiratory diseases in the 30 to 70 age group showcase elevated values in urbanized municipalities, particularly in the central and surrounding areas of Mexico City. This could be linked to more sedentary lifestyles and dietary variations compared to predominantly rural municipalities.

A distinct pattern is evident between deaths attributed to diabetes and chronic respiratory diseases, with the former's higher values concentrated in central municipalities and the latter's higher values located in the northeast and east of the state.

Births to adolescent mothers, exhibiting elevated values in remote municipalities to the south and southwest, are characterized by scattered rural localities.

The indicator measuring health service availability, counted by the number of health units, necessitates consideration of each service's specifics to accurately gauge its real coverage, encompassing factors such as the number of medical professionals, nursing staff, laboratory facilities, and pharmacies.

Lastly, the indicator assessing intimate partner violence against women aged 15 years or older, denoted as gender-based violence, showcases higher values in central and metropolitan areas near Mexico City, displaying a more clustered pattern attributed to enhanced economic activity and mobility. In contrast, lower values are prevalent in the southwestern regions mainly.

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