REVISTA HYGEIA **ISSN: 1980-1726**
https://seer.ufu.br/index.php/hygeia DOI: https://doi.org/10.14393/Hygeia2174977

PERSISTENCE OF LEPROSY PREVALENCE RATES IN BRAZIL: A TEMPORAL AND SPATIAL APPROACH BETWEEN 2001 AND 2022

PERSISTÊNCIA DAS TAXAS DE PREVALÊNCIA DA HANSENÍASE NO BRASIL: UMA ABORDAGEM TEMPORAL E ESPACIAL ENTRE 2001 E 2022

Naanda Kaanna Matos de Souza
Universidade Regional do Cariri, Curso de Enfermagem, Iguatu, CE, Brasil
naanda.souza@urca.br

Fernanda Cassiano de Lima
Ministério da Saúde, Secretaria de Atenção Primária à Saúde, Brasilia, DF, Brasil
fernandacl@hotmail.com.br

Denis Fernandes Alves
Universidade Federal de Pernambuco, Núcleo de Gestão, Caruaru, PE, Brasil
denis.fernandes@ufpe.br

Luis Abel da Silva Filho
Universidade Regional do Cariri, Departamento de Economia, Crato, CE, Brasil
luis.abel@urca.br

Viviane Martins da Silva
Universidade Federal do Ceará, Departamento de Enfermagem, Fortaleza, CE, Brasil
viviane.silva@ufc.br

ABSTRACT
This study aimed to identify the areas of concentration of leprosy cases in Brazil through an ecological approach with space/time analysis of notification data in Brazilian municipalities between 2001 and 2022. The case prevalence rate was constructed, and then a spatial analysis was conducted using the Moran Global and Local Indexes. A reduction in prevalence rates and significant variations in the negative direction were observed. In spatial terms, the results reveal a strong positive spatial autocorrelation and significance at 5%, demonstrating that space plays a key role in explaining the contagion and prevalence of the disease. High-High clusters were formed in the North and Midwest regions, while Low-Low clusters were found in nearly the entire South and parts of the Southeast. Furthermore, it is possible to observe a decrease in the number of hyperendemic municipalities, which are regionally concentrated in endemic areas, especially in municipalities in the North, Northeast, and Midwest. Consequently, these findings may support the implementation of measures for identifying, monitoring, treating, and controlling the disease in areas with high leprosy concentration.

Keywords: Leprosy. Population studies in public health. Spatial-temporal analysis. Cluster analysis.

RESUMO

Este estudo teve como objetivo identificar as áreas de concentração de casos de hanseníase no Brasil por meio de uma abordagem ecológica com análise espaço/temporal de dados de notificação em municípios brasileiros entre 2001 e 2022. A taxa de prevalência de casos foi construída e, em seguida, realizou-se uma análise espacial utilizando os Índices Moran Global e Local. Observou-se uma redução nas taxas de prevalência, além de variações significativas na direção negativa. Em termos espaciais, os resultados revelam uma forte autocorrelação espacial positiva e significância de 5%, indicando que o espaço desempenha um papel crucial na explicação do contágio e da prevalência da doença. A formação de aglomerados High-High foi observada nas regiões Norte e Centro-Oeste, enquanto aglomerados Low-Low foram registrados em quase todo o Sul e partes do Sudeste. Além disso, é possível notar uma diminuição no número de municípios hiperendêmicos, concentrados regionalmente em áreas endêmicas, especialmente nas regiões Norte, Nordeste e Centro-Oeste. Dessa forma, esses achados podem subsidiar a implementação de medidas para identificação, monitoramento, tratamento e controle da doença em áreas com elevada concentração de hanseníase.

Palavras-chave: Hanseníase. Estudos populacionais em saúde pública. Análise espacial-temporal. Análise de clusters.

Recebido em 08/08/2024
Aceito para publicação em: 28/05/2025.

INTRODUCTION

Leprosy is a neglected chronic infectious disease with high disability, particularly affecting socially and economically vulnerable populations. Despite advances in diagnosis and treatment, Brazil ranks among the three countries with the highest number of cases globally, along with India and Indonesia, responsible for 79% of global notifications in 2021 (WHO, 2021). Its persistence reflects biomedical challenges and deep-rooted social and structural inequalities, including housing conditions, access to health services, and low socioeconomic status (Nery et al., 2019; Feather et al., 2022).

Public health strategies have been developed globally and nationally in response to this scenario. The World Health Organization launched the Global Leprosy Strategy 2021–2030, which aims to interrupt transmission, reduce disabilities, and eliminate stigma and discrimination. In Brazil, the National Strategy to Combat Leprosy 2024–2030 incorporates similar goals: interrupt transmission in 99% of municipalities, eliminate leprosy in 75% of them, reduce new grade 2 disability cases by 20%, and respond to 100% of discrimination complaints registered in the SUS (BRASIL, 2021). However, the COVID-19 pandemic significantly disrupted health surveillance and care networks, delaying diagnoses and compromising the achievement of these goals (BRASIL, 2023).

Although the epidemiological scenario was introduced initially, it is important to emphasize that regional disparities persist. Brazil's North, Northeast, and Midwest regions concentrate most of the new cases and are characterized by limited access to health services and chronic socioeconomic challenges (Rocha et al., 2020). These structural issues - geographical, logistical, and management-related barriers - contribute to the endemicity of the disease in these areas. Primary Health Care (PHC), although a key component of early case detection and control strategies, still face limitations in coverage and capacity to act proactively in these vulnerable territories.

Several operational issues also hinder the effectiveness of surveillance, such as case underreporting, diagnosis delays, and insufficient service integration. Although current policies seek to address these limitations, the system's fragmentation and resource distribution disparities continue to be obstacles (Silva et al., 2016).

From a scientific perspective, few studies still evaluate the distribution of leprosy in Brazil, considering both space and time at the national level. Most of the literature prior to 2020 focuses on local contexts or regional analyses and does not address the impacts of the COVID-19 pandemic. A search using descriptors such as “leprosy,” “spatial distribution,” “temporal trend,” and “Brazil” in databases like Scopus, PubMed, and SciELO reveals a limited number of studies that adopt municipalities as the unit of analysis over long time periods.

The present study contributes to filling this gap by applying spatial statistical methods, specifically, techniques that account for spatial autocorrelation, capable of identifying patterns of concentration and disease persistence. Among various epidemiological indicators, prevalence was chosen for its sensitivity to incidence and case duration, which is especially relevant in chronic diseases with delayed diagnosis like leprosy.

By integrating spatial and temporal dimensions, this research advances the understanding of the epidemiological behavior of leprosy in Brazil, offering evidence to support more targeted and equitable public policies.

Objective: To identify spatial clusters and persistent areas of leprosy cases in Brazil through an ecological analysis based on prevalence data, with spatial and temporal components, using municipalities as units of analysis from 2001 to 2022.

METHOD

With historical series data, this ecological study uses a descriptive quantitative approach to analyze leprosy in 5,570 municipalities. Data was obtained from the Ministry of Health through the Notifiable Diseases Information System - Sinan Net and collected on 11/06/2023. Software R version 4.3.3 was used for data processing and analysis.

Inclusion and exclusion criteria

This study included all cases of leprosy notification by municipality of residence and year of diagnosis from 2001 to 2022, since the prevalence indicator was constructed according to the guidelines of the Ministry of Health (2018). All records not classified in any municipality were excluded, thus appearing as cases in unknown municipalities. These cases were discarded since it is impossible to perform spatial analysis with information not georeferenced by a unit of analysis.

Prevalence rate

This index aims to measure the magnitude of the disease, and in this study, it was calculated for the 5,570 Brazilian municipalities. For spatial representation of the information on maps, the annual cases were added at five-year intervals (2001-2005; 2006-2010) for the first two maps and every six years (2011-2016; 2017-2022) for the last two, and then the mean of the period was obtained for the construction of the prevalence rate, as described below:

$$TP_{h,i} = \frac{\bar{X}_{h,i}}{\overline{Pop_i}} * 10{,}000 \tag{1}$$

Where $TP_{h,i}$ represents the leprosy prevalence rate in municipality I; X represents the mean number of leprosy cases in each of the analyzed areas on 12/31 of each year ($\bar{X}_{h,i}$ 2001-2005; 2006-2010, 2011-2016; 2017-2022); $\overline{Pop_i}$ represents the mean population of each period of the cut-off in municipality i; multiplied by 10,000, according to the Ministry of Health (2018). Its interpretation is as follows: low < 1.00/10,000 inhabitants; medium 1.00 to 4.99/10,000 inhabitants; high 5.00 to 9.99/10,000 inhabitants; very high 10.00 to 19.99/10,000 inhabitants; hyperendemic ≥ 20.00 /10,000 inhabitants (MS, 2018).

Justification for the stratification into four periods (2001–2005; 2006–2010; 2011–2016; 2017–2022): The study was divided into four periods based on data availability and key political and economic shifts that influenced health outcomes in Brazil. This grouping ensures consistent data analysis and reduces year-to-year variability. Each interval reflects distinct phases in health policy and governance: the expansion of primary care (2001–2010), political and economic instability (2011–2016), and recent challenges such as fiscal austerity and the COVID-19 pandemic (2017–2022). These contextual changes directly affect leprosy surveillance and service delivery, justifying the temporal stratification.

Exploratory Analysis of Spatial Data (AEDE)

To achieve objectives, the present study used spatial analysis techniques. The analysis goes back to Exploratory Analysis of Spatial Data (AEDE). According to Anselin (1988), it is a method to describe the distribution and spatial association of a particular variable among the units evaluated, perceive patterns and forms of spatial instability, and identify outliers. It should be noted that the exploratory analysis is more suitable for intensive variables, that is, variables divided by some intensity indicator, such as variables per capita or by area (Almeida, 2012), thus justifying the proposed analysis in the study.

To perform an AEDE, it is first necessary to adopt a spatial weighting matrix (W). Contiguity matrices are binary spatial weights that can be constructed by neighborhood based on contiguity, distance matrices, and the distance weight matrix criterion (Anselin, 1988; Lesage, 1999). Given the characteristics of disease transmission associated with spatial patterns, the Queen contiguity matrix was used in the present article.

Moran's I statistics observe the existence of global spatial regimes in the data. However, Anselin (1988) proposed the LISA (Local Indicators of Spatial Association) statistic, which needs to satisfy two criteria: I) for each observation, LISA must offer an indication of significant spatial clusters of similar values around the observation; II) the sum of the LISAs for all observations is proportional to the indicator of global spatial association. Below are the descriptions of each index.

Moran's Index (Global)

Using Moran's global I, a single value of all polygons is obtained, which refers to the index's spatial association measure. In this study, this index represents the linear spatial correlation of leprosy prevalence rates among Brazilian municipalities in the years under observation (Moran, 1948), as defined below.

$$\mathrm{I_{i,t}} = \frac{\mathrm{n}}{\sum_{\mathrm{i}}\sum_{\mathrm{j}}\mathrm{w_{ij}}} \frac{\sum_{\mathrm{i}}\sum_{\mathrm{j}}\mathrm{w_{ij}z_iz_j}}{\sum_{\mathrm{i}}\mathrm{z_i^2}} \tag{2}$$

Where, $\mathrm{I_{i,t}}$ it is defined as the one calculated for the municipality i in the period t; I-Moran Global it is defined as the number of spatial units (Brazilian municipalities); $\mathrm{z_iz_j}$ these are the values (prevalence rate) of the indicator in each of the immediate municipalities (I and J); $\mathrm{w_{ij}}$ includes the spatial weights of the municipalities

(i and j) of the matrix W of spatial weights; Furthermore, the W matrix of space weights were defined by the "boundary neighborhood", that is, the queen matrix. Thus, the municipality that borders another municipality is a neighbor. When two municipalities are neighbors, you have. Otherwise, you have.

Positive and statistically significant spatial correlation indicates the presence of spatial correlation captured by the. Therefore, the municipalities with a high concentration of leprosy cases are close to other municipalities with a high concentration of cases. On the other hand, municipalities with low values tend to be grouped with those with low values, with similar municipalities approaching each other and distancing themselves.

Moran's Index (Local)

Anselin (1995) proposed statistics Local Indicators of Spatial Association – LISA, called I-Moran Local. This statistic provides individual value for each region (municipalities analyzed), enabling a significant spatial grouping of observed individuals. Identifying the clusters resulting from LISA occurs using Moran's scatter plot and the cluster map of individuals (municipalities). The mathematical definition can be presented, as shown below,

$$\mathrm{I}_{\mathrm{i,t}} = \frac{\mathrm{z_i}}{\sigma^2} \sum_{\mathrm{j}} \mathrm{w_{ij}} \mathrm{z_j}, \sigma^2 = \frac{\sum_1 \mathrm{z_i^2}}{\mathrm{n}} \tag{2}$$

$\mathrm{I}_{\mathrm{i,t}}$ is defined as that of the municipalities in each of the periods analyzed in this study; σ^2 is the representation of the variance of the distribution of values of the variable under consideration, being; $z_i = y_i - \bar{y} w_{ij}\ n_t$, it is defined as the weight of the spatial matrix w, considered in this study; and, it is the number of observations (municipalities) analyzed in each time.

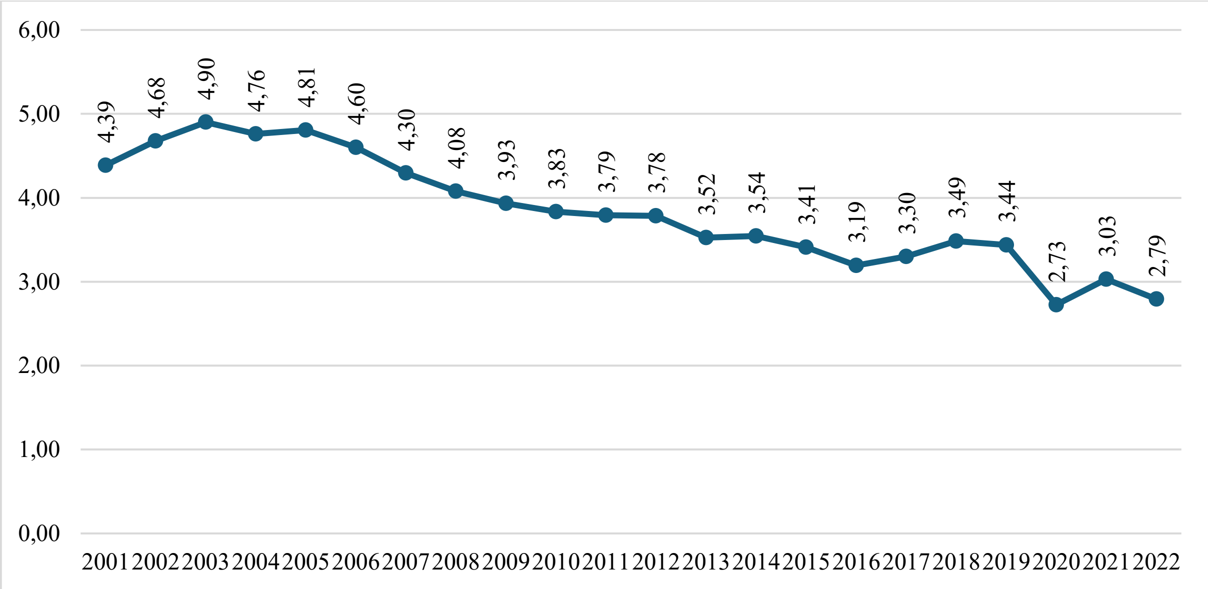
The results presented in the cluster map present the significance of the measures of local association, informing the dispersion of the Moran diagram of the observations. Moran's scatter plot, on the other hand, presents the measures of global linear association high-high, low-low, high-low, and low-high, separated by the linear regression line, which agglomerates the type of each linear association for each individual (municipality) of the analysis. Thus, it can be stated that it enables the identification of local patterns of linear association that present statistical significance. Its calculation is applied to each of the observations (municipalities) assigned a value (coefficient) that allows for the identification of its degree of similarity or dissimilarity with neighboring spatial units. The following section will present the comprehensive set of results from the statistical and spatial analysis conducted as a fundamental part of this study.

FINDINGS

Spatial Analysis

Figure 1 contains Brazil's annual leprosy prevalence rate from 2001 to 2022. At the beginning of the series, in 2001, a prevalence rate of 4.93 was recorded, which is considered of medium magnitude according to the Ministry of Health (2018). The highest prevalence rate was recorded in 2003, with 4.90 per 10,000 inhabitants.

Figure 1 – Leprosy prevalence rate in Brazil – 2001-2022



Source: Devised by the authors based on data from the Ministry of Health/SVSA—Notifiable Diseases Information System—Sinan Net.

The lowest prevalence rate in the series was recorded in 2020, with 2.73 cases per 10,000 inhabitants, which is considered of medium magnitude. The last year of the series recorded a prevalence rate of 2.79 cases per 10,000. Throughout the series, the prevalence rate decreased by 36.33%.

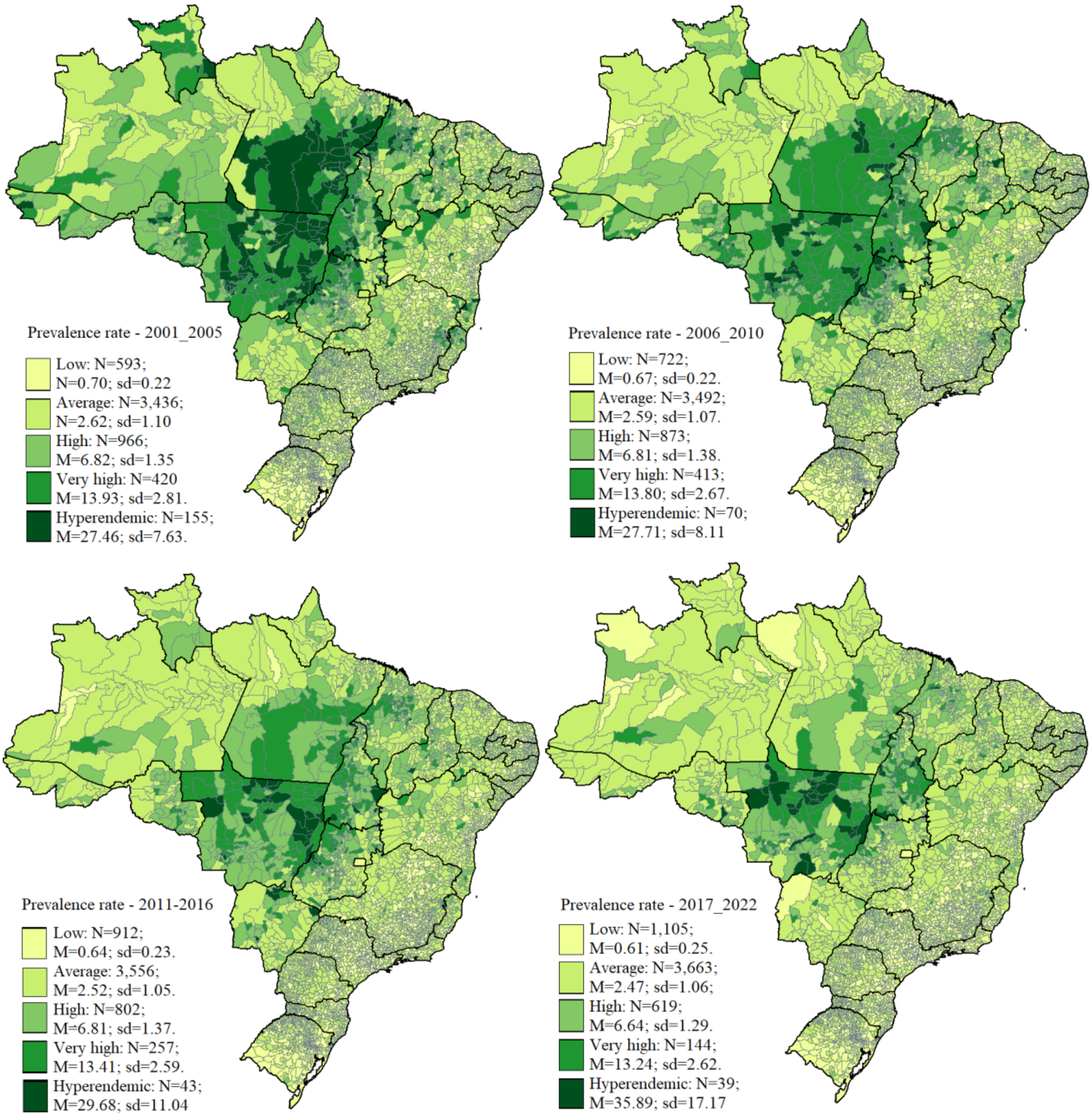
Figure 2 presents data on the mean prevalence rates across the four defined periods: 2001–2005, 2006–2010, 2011–2016, and 2017–2022. For analytical consistency, the first two periods correspond to five-year and the last two to six-year intervals, as defined by the author's data treatment approach.

In the first period (2001–2005), 593 municipalities registered low prevalence rates, with a mean of 0.70 cases per 10,000 inhabitants. Most municipalities (3,436) presented mean prevalence rates, with an average of 2.62 per 10,000 inhabitants and a standard deviation of 1.10. A total of 965 municipalities exhibited high prevalence, with a mean of 6.82 and a standard deviation of 1.35. Additionally, 965 municipalities were classified with very high prevalence (meaning 13.41; SD = 2.81), and 156 municipalities were considered hyperendemic, with a mean rate of 29.68 per 10,000 inhabitants (SD = 9.34).

In the second period (2006–2010), an improvement in epidemiological indicators began to emerge. The number of municipalities with low prevalence rates increased from 593 to 722, with a slight reduction in the mean (from 0.70 to 0.67) and the maintenance of the same standard deviation (0.22). Meanwhile, municipalities with mean prevalence remained numerous (3,492), although their average rate slightly decreased to 2.59, with a lower standard deviation of 1.07, suggesting reduced variability.

Notably, the number of municipalities with high, very high, and hyperendemic prevalence declined in this second interval. The most significant reduction was observed in hyperendemic areas: while 156 municipalities fell into this category in the first period, only 70 were registered between 2006 and 2010. This shift suggests early progress in controlling the disease's territorial intensity and severity (see Figure 2).

Figure 2 – Prevalence rates per 10,000 population accumulated for selected periods



Note 1 – The data are presented in the maps by prevalence rate (low, medium, high, very high, and hyperendemic). The number of municipalities in each cut-off, with their mean prevalence rate of the group and its standard deviation, was also made available, where N represents the number of municipalities of each scale, M represents the mean of the prevalence rate, and *sd* represents the standard deviation of the mean on each of the scales.

Source: Devised by the authors with research data, 2023.

Between 2011–2016 and 2017–2022, the data indicated a continuous increase in municipalities with low and medium prevalence rates, accompanied by a reduction in the number of municipalities classified as high, very high, or hyperendemic.

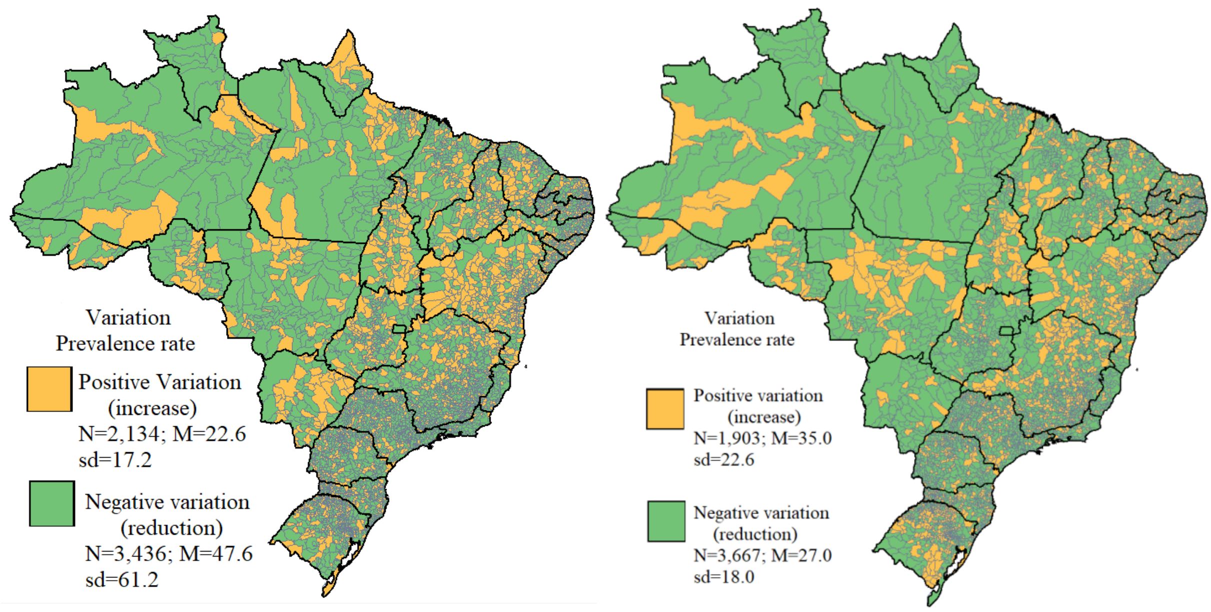
From 2011 to 2016, 912 municipalities recorded low prevalence rates, with a mean of 0.64 per 10,000 inhabitants and a standard deviation of 0.23. In the same period, 3,556 municipalities presented medium prevalence rates (meaning 2.52; SD = 1.05), while 802 were classified as high prevalence (mean of 6.81; SD = 1.37). Additionally, 257 municipalities presented very high prevalence rates, and 43 were identified as hyperendemic, with mean rates of 13.41 and 29.68 per 10,000 inhabitants, and standard deviations of 2.59 and 11.04, respectively.

In the subsequent period (2017–2022), this pattern persisted. The number of municipalities with low prevalence increased to 1,105, with a mean of 0.61 and a standard deviation of 0.25. For medium prevalence, 3,665 municipalities were recorded (meaning 2.75; SD = 1.06). Meanwhile, the number of municipalities classified as high, very high, and hyperendemic declined to 619, 144, and 40, respectively. The corresponding mean prevalence rates were 6.64, 13.24, and 41.55 per 10,000 inhabitants.

These data, summarized in Figure 2, show a shift in the distribution of leprosy prevalence across municipalities over time, with a decrease in the number of high and hyperendemic areas and a relative increase in those with medium and low prevalence.

Figure 3 presents percentage variations in the number of leprosy cases. The first map displays the variation between the cumulative values of 2006–2010 and 2001–2005. The second map illustrates the variation between 2017–2022 and 2011–2016.

Figure 3 – Percentage variation in the mean leprosy prevalence rate by selected periods



Note 2 – *N* represents the number of municipalities, *M* represents the mean change in the group of municipalities, and *sd* represents the standard deviation of the mean of the municipalities.
Source: Devised by the authors with research data, 2023.

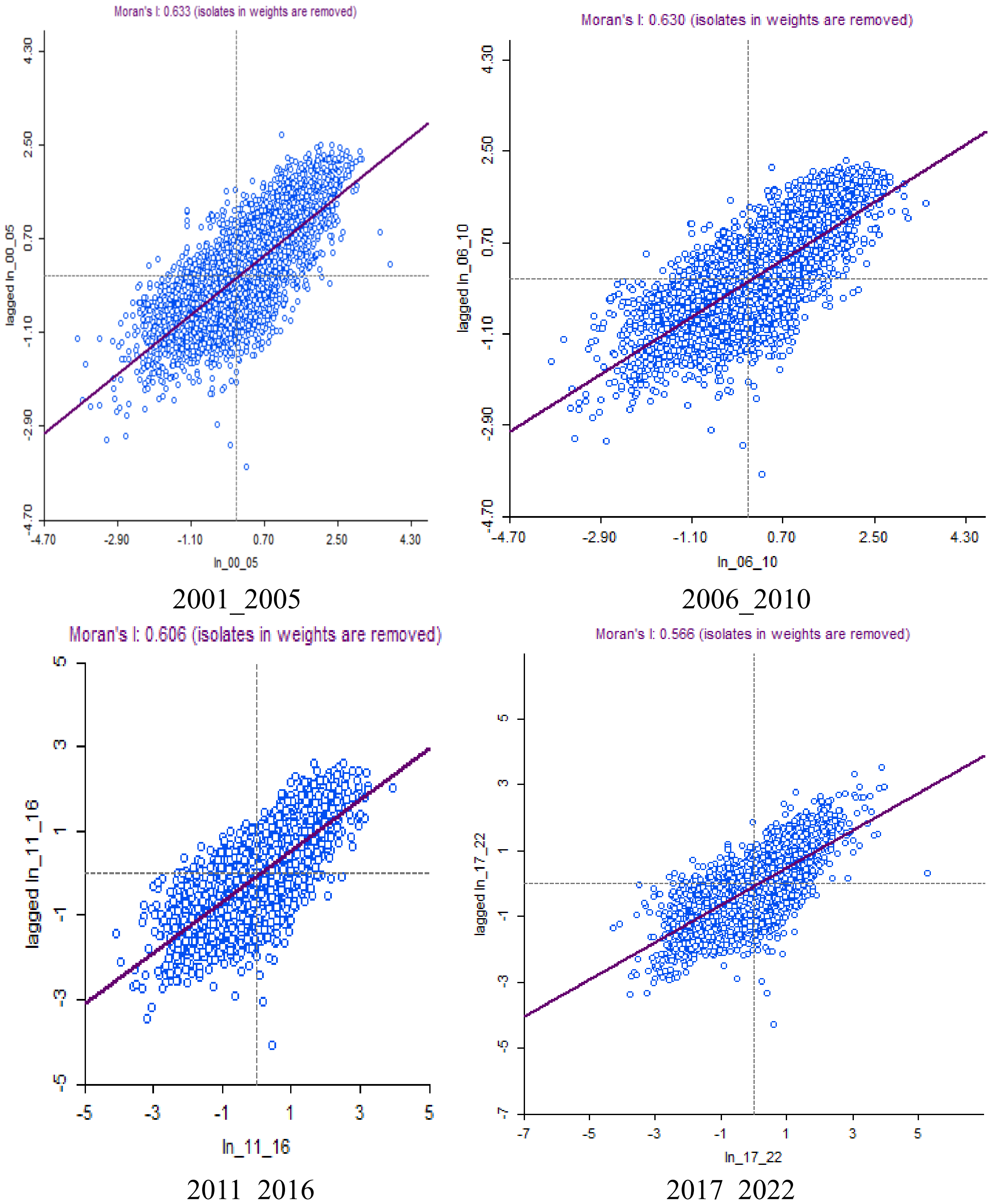
According to the records, 2,134 municipalities showed a positive variation in accumulated leprosy cases during the first period analyzed, with a mean increase of 22.61% and a standard deviation of 17.15. Conversely, 3,436 municipalities registered a negative variation, with a mean reduction of 47.57% in the number of cases and a standard deviation of 61.20. The second map (Figure on the right) presents the variation in cumulative values between 2017–2022 and 2011–2016. In this period, 1,903 municipalities recorded an increase in cases (mean = 35.8%; SD = 22.6), while 3,667 municipalities showed a reduction, with a mean percentage decrease of 27.0% and a standard deviation of 18.0.

When considering spatial factors, the results indicate positive and statistically significant spatial autocorrelation in all four time periods analyzed, as measured by Moran's I. Figure 4 presents the Moran scatter plots, where the first quadrant (high-high) contains most municipalities, including some outliers. This quadrant represents municipalities with high leprosy prevalence surrounded by others exhibiting high prevalence rates.

The Moran's I values indicate increasing spatial autocorrelation in the first three periods (Figures 4A, 4B, and 4C), suggesting a stronger spatial association between municipalities and the presence of spatial spillover effects. However, in the final period (2017–2022), Moran's I was reduced, reaching

0.206—the lowest value among the intervals analyzed. This suggests a weakening spatial dependence in the distribution of leprosy prevalence across municipalities in the most recent period.

Figure 4 – Moran's scatter plot for the variable means of leprosy prevalence rate in the four time frames



Source: Devised by the authors with research data, 2023.

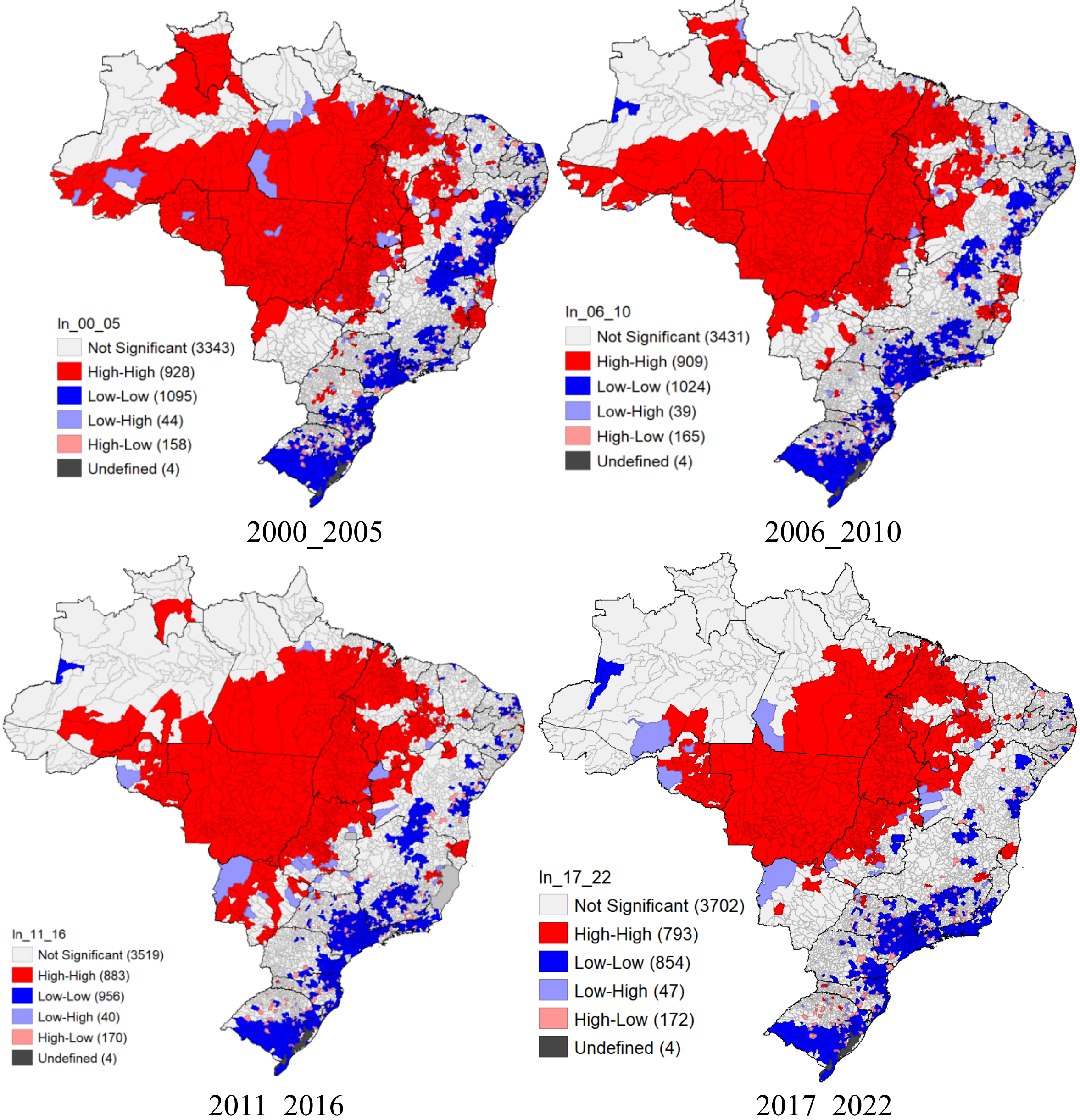
As Almeida (2012) described, the cluster map includes four statistically significant categories, integrating local significance with Moran's scatter plot. In this study, the analysis of the Local Indicators of Spatial Association (LISA) was conducted in a univariate context, with the objective of identifying spatial patterns and locating statistically significant clusters based on Moran's Local I.

The results show a consistent presence of high-high clusters in the northern and midwestern regions. Over time, the number of municipalities forming these clusters increased - from 269 in the initial period to 323 in the most recent one - indicating a spatial concentration of municipalities with high prevalence surrounded by others with similarly high rates.

In contrast, the South region exhibited the lowest concentration of clusters, followed by the Southeast, reinforcing the observed regional disparities in leprosy distribution across the country.

Figure 5, which showcases the univariate LISA cluster maps, is crucial in visualizing these spatial patterns. These maps significantly contribute to a deeper understanding of the disease's prevalence in the country's regions, thereby aiding the formulation of effective health policies and interventions.

Figure 5 – Univariate LISA cluster map for the variable leprosy prevalence rate in the four-time frames



Source: Devised by the authors.

DISCUSSION

The results of this study show a reduction in leprosy prevalence in Brazil over the analyzed period, a trend also observed in other countries that previously recorded a high disease burden, such as India (Sasidharanpillai et al., 2014), Mexico (Larrea; Carreño; Fine, 2012), Japan (Koba et al., 2009), South Korea (Lee et al., 2015), and Saudi Arabia (Assiri et al., 2014). Despite the WHO's goal of eliminating leprosy as a public health problem (WHO, 2021), Brazil continues to report a significant number of cases, including persistent rates of grade 2 physical disability and infections among children under 15. These indicators suggest the ongoing circulation of *Mycobacterium leprae* in the population, considering its long incubation period (Brazil, 2023).

In 2018, the last year before the COVID-19 pandemic, 28,660 new cases were diagnosed in Brazil. Of these, 2,109 were accompanied by physical disability, and 1,705 occurred in children under 15 (Brazil, 2023). The pandemic context introduced additional challenges: social isolation policies, fear of contamination in health units, and the prioritization of respiratory illnesses may have led to delays in diagnosis and underreporting, affecting the visibility of leprosy cases in official records (Mahato; Bhattarai; Singh, 2020). Consequently, apparent reductions in case numbers during this period should be interpreted cautiously.

This downward trend may reflect epidemiological advances and operational performance limitations, including failures in active case finding, contact tracing, and communication strategies aimed at early detection and public awareness. Moreover, stigma and fear of institutional discrimination hinder treatment adherence and access to care, especially within Primary Health Care services (Lima et al., 2018).

The spatial analysis revealed that the North, Northeast, and Midwest regions presented the highest mean prevalence rates. The North, in particular, stood out for its high incidence and persistence over time. Previous studies (e.g., Rodrigues et al., 2020) identified high-risk clusters in these regions, including Rondônia, Mato Grosso, and Acre.

A minority of municipalities showed growth in prevalence despite national efforts to reduce transmission. These cases raise concerns about underdiagnosis and surveillance gaps, especially in socioeconomically vulnerable areas where precarious living conditions increase transmission risk. Studies have shown that areas with worse social indicators tend to maintain higher disease burdens (Brazil, 2010; WHO, 2016; Assis et al., 2018).

Leprosy is primarily transmitted through prolonged contact in crowded or poorly ventilated environments, which are more common in low-income areas. These structural conditions make early detection through contact investigation a key control strategy.

In addition to poverty and social vulnerability, weaknesses in local health care networks also contribute to the persistence of the disease. Barriers to diagnosis, treatment, follow-up, and health education remain relevant in these regions (Reis et al., 2019). The persistence of endemic pockets suggests that routine health services, particularly PHC, are not sustaining adequate surveillance and intervention actions over time.

Spatial analysis revealed that hyperendemic municipalities are often adjacent to others with similar prevalence levels, forming High-High clusters in the North, Midwest, and parts of the Northeast. This pattern reinforces the association between regional socioeconomic inequalities, territorial isolation, and limitations in the reach of public health programs (Penna et al., 2009; França, Duarte, Garcia, 2017; Assis et al., 2018; WHO, 2021).

Internalizing economic activities – especially agribusiness – and related migratory flows may contribute to disease expansion in these regions. Rapid urbanization and agricultural frontier expansion without proportional improvements in infrastructure and public service provision are also associated with increasing leprosy incidence in certain municipalities (Andersen; Reis, 1997; Magalhães et al., 2011; Monteiro et al., 2015).

Finally, it is important to acknowledge some limitations of this study. The use of secondary data is subject to inconsistencies in reporting and classification, particularly during periods of health system stress such as the COVID-19 pandemic. Additionally, although spatial statistical methods were employed, the analysis was limited to a univariate approach. Future studies may explore multivariate spatial models to investigate the relationship between socioeconomic variables, health infrastructure, and disease patterns. Despite these limitations, the findings provide robust evidence of regional disparities in Brazil's persistence and intensity of leprosy.

FINAL CONSIDERATIONS

This study aimed to analyze whether there is temporal and spatial persistence of leprosy prevalence rates in certain municipalities in Brazil. This contributes to mapping areas with a higher concentration of prevalence, which consequently transmits the disease faster and with less effective control.

The study presents a body of evidence that shows a reduction in prevalence rates over time. However, in spatial terms, a growing cluster of the High-High type prevails in the North and Midwest, regions with high case means, with the Northeast region in an intermediate position since cases of disease concentration are promptly registered in some municipalities of some states in this region. On the other hand, the South and part of the Southeast predominantly have clusters of the Low-Low type.

The results found are essential for literature on the subject, and the evaluation and implementation of the national policy to combat leprosy, since it contributes to empirical evidence that there is a need to combat leprosy. Clusters persist temporally with the High-High formation in all the sections analyzed in this study. However, other operational indicators should be correlated with the analyses in this study to reflect on the reasons for the downward trend. It is necessary to analyze data related to the degree of physical disability diagnosed, modes of case detection, new cases in children, the proportion of contacts examined, primary surveillance strategy for the disease, new multibacillary cases, and the infectious form of the disease.

An important contribution of the study is related to spatial issues. Geospatially, evidence shows that the North, Northeast, and Midwest regions may serve as epicenters for public health policies focused on leprosy notification, health communication, information, treatment, and control to eliminate the disease in the country.

REFERENCES

ALMEIDA, Eduardo. **Econometria Espacial Aplicada**. Campinas, São Paulo: Alínea, 2012.

ANDERSEN L. E, REIS E. J. **Deforestation, development, and government policy in the brazilian amazon: an econometric analysis** [Internet]. Rio de Janeiro: Ipea. 1997. Available from: https://portalantigo.ipea.gov.br/agencia/images/stories/PDFs/TDs/ingles/dp_69.pdf

ANSELIN, L. Local indicators of spatial association—LISA. **Geographical analysis**, v 27, n 2, p 93-115. 1995. Available from: https://doi.org/10.1111/j.1538-4632.1995.tb00338.x

ANSELIN, L. **Spatial econometrics: methods and models**. Boston: Kluwer Acamic, 1988. https://doi.org/10.1111/j.1538-4632.1995.tb00338.x

AQUINO, D. M. C. D.; CALDAS, A. D. J. M.; SILVA, A. A. M. D.; COSTA, J. M. L. Perfil dos pacientes com hanseníase em área hiperendêmica da Amazônia do Maranhão, Brasil. **Revista da Sociedade Brasileira de Medicina Tropical,** v 36, n 1, p 57-64, janeiro de 2003. https://doi.org/10.1590/S0037-86822003000100009

ASSIRI, A.; YEZLI, S.; TAYEB T.; ALMASRI M.; BAMGBOYE A. E.; MEMISH Z. A. Eradicating leprosy in Saudi Arabia: outcome of a ten-year surveillance (2003–2012). **Travel Medicine and Infectious Disease**, v 12, n 6, pt B, p 771-777. 2014. https://doi.org/10.1016/j.tmaid.2014.10.002

ASSIS I. S; ARCOVERDE M. A. M.; RAMOS A. C. V.; ALVES L. S.; BERRA T. Z.; ARROYO L. H.; QUEIROZ, A. A. R.; SANTOS, D. T.; BELCHIOR, A. S.; ALVES, J. D.; PIERI, F. M.; SILVA-SOBRINHO, R. A.; PINTO, I. C.; TAVARES, C. M.; YAMAMURA, M.; FRADE, M. A. C.; PALHA, P. F.; CHIVARAVALLOTI-NETO, F.; ARCÊNCIO, R. A. Social determinants, their relationship with leprosy risk and temporal trends in a tri-border region in Latin America. **PLoS Neglected Tropical Diseases**, v 12, n 4, e0006407. 2018. https://doi.org/10.1371/journal.pntd.0006407

BRASIL. Ministério da Saúde. Se**cretaria de Vigilância em Saúde Departamento de Doenças de Condições Crônicas e Infecções Sexualmente Transmissíveis – DCCI**. Boletim Epidemiológico 2021, Brasília. Ed 1, 2023. Available from: https://bvsms.saude.gov.br/bvs/publicacoes/estrategia_nacional_enfrentamento_hanseniase_2019.pdf

BRASIL. Ministério da Saúde. **Secretaria de Vigilância em Saúde Departamento de Doenças de Condições Crônicas e Infecções Sexualmente Transmissíveis – DCCI**. Boletim Epidemiológico 2023, Brasília. Número especial, Jan/ 2023. Available from:: https://www.gov.br/saude/pt-br/centrais-de-conteudo/publicacoes/boletins/epidemiologicos/especiais/2023/boletim_hanseniase-2023_internet_completo.pdf/view

BRASIL, Ministério da Saúde. **Estratégia Nacional para o Enfrentamento da Hanseníase – 2024-2030**. Available from: https://www.gov.br/saude/pt-br/centrais-de-conteudo/publicacoes/svsa/hanseniase/estrategia-nacional-para-enfrentamento-a-hanseniase-2024-2030/view

CAKINER, T.; YÜKSEL, A.; EĞÏT, A. S.; CAĞRI, G.; KARAÇORLU, M.; KÜLTÜR, A. The extent of leprosy-related disabilities in Istanbul Leprosy Hospital, Turkey. **Leprosy review**, v 68, n 1, p 43-49. 1997. https://doi.org/10.5935/0305-7518.19970007

FREITAS, L. R. S. D.; DUARTE, E. C.; GARCIA, L. P. Analysis of the epidemiological situation of leprosy in an endemic area in Brazil: spatial distribution in the periods 2001 - 2003 and 2010 - 2012. **Revista Brasileira de Epidemiologia**, v 20, n 4, p 702-713. 2017. https://doi.org/10.1590/1980-5497201700040012

KOBA A.; ISHII N, MORI S, FINE PE. The decline of leprosy in Japan: patterns and trends 1964-2008. **Leprosy Review**, v 80, n 4, p 32-40. 2009. https://doi.org/10.47276/lr.80.4.432

LARREA M. R.; CARRENO M. C.; FINE P. E. Patterns and trends of leprosy in Mexico: 1989-2009. **Leprosy Review**, v 83, n 2, p 184-194. 2012. https://doi.org/10.47276/lr.83.2.184

LEANO, H. A. M.; ARAUJO, K. M. F. A.; RODRIGUES, R. N.; BUENO, I. C.; LANA F. C. F. Indicators related to physical disability and diagnosis of leprosy. **Revista Rene**, v 18, n 6, p 832-839, 2017. https://doi.org/10.15253/2175-6783.2017000600018

LEE J.; KIM J. P.; NISHIKIORI N.; FINE P. E. The decline of leprosy in the Republic of Korea: patterns and trends 1977-2013. **Leprosy Review**, v 86, n 4, p 316-327. 2015. https://doi.org/10.47276/lr.86.4.316

LESAGE, J. P. The theory and practice of spatial econometrics. University of Toledo. **Toledo, Ohio**, v 28, n 11, p 1-39. Available from: https://www.spatial-econometrics.com/html/sbook.pdf

LIMA F, C.; ALENCAR O. M.; PEREIRA, T. M.; DAYANE L. Aspects that difficult the decentralization of Hanseniasis control actions in a Municipality of the Cariri-CE Region. Cadernos ESP – **Revista científica da Escola de Saúde Pública do Ceará**, v 7, n 2, 2018.

MAGALHAES M. C. C.; SANTOS E. S.; QUEIROZ M. L.; LIMA M. L.; BORGES R. C. M.; SOUZA M. S.; RAMOS A. N. Migration and Hansen's disease in Mato Grosso. **Revista Brasileira de Epidemiologia**, v 14, n 3, p 686-697, 2011. https://doi.org/10.1590/S1415-790X2011000300004

MAHATO, S.; BHATTARAI, S.; SINGH, R. Inequities towards leprosy-affected people: A challenge during COVID-19 pandemic. **PLOS Neglected Tropical Diseases**, v 14, n 7, e0008537, 2020. https://doi.org/10.1371/journal.pntd.0008537

MIRANZI, S. D. S. C.; PEREIRA, L. H. D. M.; NUNES, A. A. Epidemiological profile of leprosy in a Brazilian municipality between 2000 and 2006. **Revista da Sociedade Brasileira de Medicina Tropical**, v 43, n 1, p 62-67, 2010. https://doi.org/10.1590/S0037-86822010000100014

MONTEIRO L. D.; MARTINS-MELO F. R.; BRITO A. L.; ALENCAR C. H.; HEUKELBACH J. Spatial patterns of leprosy in a hyperendemic state in Northern Brazil, 2001-2012. **Revista de Saúde Pública**, v 49, p 84-91, 2015. https://doi.org/10.1590/S0034-8910.2015049005866

MONTEIRO, L. D.; MARTINS-MELO, F. R.; BRITO, A. L.; LIMA, M. D. S.; ALENCAR, C. H.; HEUKELBACH, J. Leprosy trends in Tocantins, a hyperendemic State in the North of Brazil, 2001-2012. **Cadernos de Saúde Pública**, v 31, n 5, p 971-980, 2015. https://doi.org/10.1590/0102-311X00075314

Moran, P. A. P. Rank correlation and product-moment correlation. **Biometrika**, v 35, n 1/2, 203-206, 1948. https://doi.org/10.2307/2332641

NERY, J. S.; RAMOND, A.; PESCARINI, J. M.; ALVES, A.; STRINA, A.; ICHIHARA, M. Y.; PENNA, M. L. F.; SMEETH, L.; RODRIGUES, L. C.; BARRETO, M. L.; BRICKLEY, E. B.; PENNA, G. O. Socioeconomic determinants of leprosy new case detection in the 100 Million Brazilian Cohort: a population-based linkage study. **The Lancet Global Health**, v 7, n 9, e1226-e1236, 2019. https://doi.org/10.1016/S2214-109X(19)30260-8

PENNA, G. O.; PONTES, M. A. D. A.; NOBRE, M. L.; PINTO, L. F. National Health Survey reveals high percentage of signs and symptoms of leprosy in Brazil. **Ciência & Saúde Coletiva**, v 27, n 6, p 2255-2258, 2022. https://doi.org/10.1590/1413-81232022276.18322021

PENNA, M. L. F.; OLIVEIRA M. L. W.; PENNA, G. Spatial distribution of leprosy in the Amazon region of Brazil. **Emerging Infectious Diseases**, v 15, n 4, p 650-652, 2009. https://doi.org/10.3201/eid1504.081378

REIS, A. D. S. D., SOUZA, E. A. D., FERREIRA, A. F., SILVA, G. V. D., MACEDO, S. F. D., ARAÚJO, O. D. D.; CRUZ, J. R; GARCÍA, G. S. M.; CARNEIRO, M. A. G.; BARBOSA, J. C. RAMOS JR, A. N. Overlapping of new leprosy cases in household contact networks in two municipalities in North and Northeast Brazil, 2001-2014. **Cadernos de saúde pública**, v 35, n 10, e00014419, 2019. https://doi.org/10.1590/0102-311X00014419

ROCHA, M. C. N.; LIMA, R. B.; STEVENS, A.; GUTIERREZ, M. M. U.; GARCIA, L. P. Deaths with leprosy as the underlying cause recorded in Brazil: use of data base linkage to enhance information. **Ciência & Saúde Coletiva**, v 20, n 4, 2015https://doi.org/10.1590/1413-81232015204.20392014

ROCHA, M. C. N.; NOBRE, M. L.; GARCIA, L. P. Epidemiological characteristics of leprosy in elderly Brazilians and comparison with other age groups (2016-2018). **Cadernos de Saúde Pública**, v 36, n 9, 2020. https://doi.org/10.1590/0102/311X00048019

RODRIGUES, R. N.; LEANO, H. A. D. M.; BUENO, I. D. C.; ARAÚJO, K. M. D. F. A.; LANA, F. C. F. High-risk areas of leprosy in Brazil between 2001-2015. **Revista Brasileira de Enfermagem**, v 73, n 3, 2020.: https://doi.org/10.1590/0034-7167-2018-0583

SANTOS, A. R.; IGNOTTI, E. Prevention of physical disabilities due to leprosy in Brazil: a historic analysis. **Ciência & Saúde Coletiva**, v 25, n 10, p 3731-3745. 2020. https://doi.org/10.1590/1413-812320202510.30262018

SASIDHARANPILLAI, S.; BINITHA, M. P.; RIYAZ N.; AMBOOKEN, B.; MARIYATH, O. K.; GEORGE, B.; JANARDHANAN, A. K.; SHERJEENA, P. V. B. Children leprosy: a retrospective descriptive study from Government Medical College, Kozhikode, Kerala, India. **Leprosy Review**, v 85, n 2, p 100-110, 2014. https://doi.org/10.47276/lr.85.2.100

SILVA, C. L. M.; FONSECA, S. C.; KAWA, H.; PALMER, D. O. Q. Spatial distribution of leprosy in Brazil: a literature review. **Revista Sociedade Brasileira de Medicina Tropical**, v 50, n 4, p 439-49, 2017. https://doi.org/10.1590/0102-311X00075314

WORLD HEALTH ORGANIZATION (WHO). **Estratégia Global de Hanseníase 2021–2030 – "Rumo à zero hanseníase"**. New Delhi: OMS; 2021. Available from: file:///D:/Dados/Downloads/9789290228424-por.pdf