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Spatial-temporal analysis of leprosy in a priority Brazilian northeast municipality for disease control

Análise espaço-temporal da hanseníase em município do Nordeste brasileiro prioritário para o controle da doença

Análisis espacio-temporal de la lepra en municipio del noreste brasileño prioritario para el control de la enfermedad

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ABSTRACT

Objectives: to analyze the spatial-temporal distribution of leprosy in a priority municipality for leprosy control. **Methods**: ecological study, conducted in a city in the Northeast of Brazil, whose analysis units were census sectors. The study used compulsory notification data for cases registered between 2008 and 2017. TerraView software and the Batch Geocode tool was used for geocoding. The detection of spatial-temporal agglomerations of high relative risks was done by scanning statistics. **Results**: the spatial-temporal distribution of cases was heterogeneous, creating four agglomerations of high relative risks in the urban area of the municipality between the years 2008 and 2012; and annual prevalence rates classified from high to hyperendemic. **Conclusions**: areas of higher risk and concentration of the disease in space-time were linked to the characteristics of high population density and social vulnerability of these spaces, raising the prioritization of health professionals' actions, systems, and services for control, and monitoring the disease.
Descriptors: Leprosy; Spatial-Temporal Analysis; Geographic Information Systems; Health Information Systems; Residence Characteristics.

RESUMO

Objetivos: analisar a distribuição espaço-temporal da hanseníase em município prioritário para controle da doença. **Métodos**: estudo ecológico, realizado em município do Nordeste brasileiro, cujas unidades de análise foram setores censitários. Utilizaram-se dados de notificação compulsória relativos aos casos registrados entre 2008 e 2017. Para geocodificação, utilizaram-se o *software* TerraView e a ferramenta Batch Geocode. A detecção de aglomerados espaço-temporais de altos riscos relativos foi feita por estatística de varredura. **Resultados**: a distribuição espaço-temporal dos casos foi heterogênea, com formação de quatro aglomerados de altos riscos relativos na zona urbana do município entre os anos de 2008 e 2012; e taxas de prevalência-ano classificadas de altas a hiperendêmicas. **Conclusões**: áreas de maior risco e concentração da doença no espaço-tempo estiveram atreladas às características de alta densidade demográfica e de vulnerabilidade social desses espaços, suscitando a priorização de ações dos profissionais, sistemas e serviços de saúde para controle e vigilância da doença.
Descritores: Hanseníase; Análise Espaço-Temporal; Sistemas de Informação Geográfica; Sistemas de Informação em Saúde; Características de Residência.

RESUMEN

Objetivos: analizar distribución espacio-temporal de lepra en municipio prioritario para control de la enfermedad. **Métodos**: estudio ecológico, realizado en municipio brasileño, cuyas unidades de análisis fueron sectores censuales. Utilizaron datos de notificación obligatoria relativos a casos registrados entre 2008 y 2017. Para geocodificación, utilizaron el software TerraView y herramienta Batch Geocode. Detección de aglomerados espacio-temporales de altos riesgos relativos realizada por estadística de barredura. **Resultados**: distribución espacio-temporal de los casos fue heterogénea, con formación de cuatro aglomerados de altos riesgos relativos en la zona urbana del municipio entre 2008 y 2012; y tasas de prevalencia año clasificadas de altas a hiperendémicas. **Conclusiones**: áreas de mayor riesgo y concentración de la enfermedad en el espacio-tiempo estuvieron relacionadas a las características de alta densidad demográfica y de vulnerabilidad social de esos espacios, suscitando la priorización de acciones de los profesionales, sistemas y servicios de salud para control y vigilancia de la enfermedad.
Descriptores: Lepra; Análisis Espacio-Temporal; Sistemas de Información Geográfica; Sistemas de Información en Salud; Características de Residencia.

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INTRODUCTION

Leprosy is a chronic, infectious disease caused by *Mycobacterium leprae*, which is highly disabling and persists a worldwide public health problem[1]. Its occurrence is higher in impoverished countries[2], where unfavorable socioeconomic, living, and poor health conditions make feasible the contamination and spread of the bacillus[3-4].

Global data announced that in 2018, 208,619 new cases of the disease were detected in 161 countries, with a rate of 2,74 cases/100,000 inhabitants and a prevalence of 0,29/10,000[1]. In comparison with the previous year, the global prevalence rate decreased by 4%. However, countries in the Americas, the Mediterranean, and the Western Pacific showed increases in detection rates, reaching 0,58 cases/10,000 inhabitants[1], highlighting that the disease still remains neglected[4-6]. Leprosy is capable of causing physical and social limitations to its carriers, increasing the costs of health services, and contributing to the stagnation of the inequalities scenery, representing an obstacle to the socioeconomic growth of these countries[5-6].

Considering the register of cases in the world, Brazil is in second place, after India, and presented between the years 2014 and 2018 an average incidence rate of 13.64 new cases/100,000 inhabitants. In this same period, the state of Maranhão revealed a rate of 48,23 new cases/100 thousand inhabitants[2]. Among the municipalities of Maranhão, Imperatriz presents itself as an important *cluster* of leprosy, with a high number of cases per year, in which cases are dispersed throughout the municipality in areas of greater population density[7].

The heterogeneous distribution of the disease in the national territory, especially observed in the North, Northeast and Midwest Regions[2], requires the utilization of spatial and spatial-temporal analysis techniques that, through the geoprocessing of georeferenced data, make it possible to identify areas of accumulation and juxtaposition of transmissible diseases[8]. Thus, it is possible to have a more comprehensive view of individuals' health in the different contexts in which they are inserted, as well as to facilitate the management of the population's diseases[8-9].

Scientific investigations have been stimulated regarding the use of geoprocessing as a set of theoretical and computational techniques and methods aimed at the collection, entry, storage, treatment, and processing of data intended for the generation of new data and/or spatial or georeferenced information on transmissible diseases such as leprosy[10-12]. This vast field of geoprocessing includes techniques of space analysis, spatial-temporal and Geographic Information Systems (GIS)[13-14].

Geoprocessing and its spatial and spatial-temporal analysis interfaces constitute tools for planning surveillance actions, health-care and social policies, minimize existing inequities by targeting health actions specifically to vulnerable populations[14] and contribute to the control of leprosy transmission, being considered decision-support systems[10,12].

In turn, GISs are computational tools used to apprehend, accumulate, manage and expose geographic information, allowing visualization and characterization of the space and spatial-temporal distribution of health events through thematic maps[13-14]. Consequently, it is possible to study the occurrence of the event associated with local determining factors and the development of etiological hypotheses, allowing the analysis of the health situation at the local level[15].

Among the various analysis techniques, the detection of *clusters* employing spatial scanning, also known as *scanning* statistics[16], has been explored more recently in Brazil in the context of spatial analysis of leprosy, using the municipalities of the twenty-seven Federal Units as ecological analysis units between the years 2001 and 2015[12]. Twenty-six *clusters* were identified, with a detection rate of 59.19/100,000 inhabitants, with a higher proportion in the Legal Amazon, and was highlighted the need to intensify disease control and surveillance actions in these locations[12].

It is worth mentioning that, in addition to ensuring spatial analysis, scanning statistics also incorporates the temporal factor, highlighting the identification of clusters of events, simultaneously in space and time[17], and brings awareness to the affected territories and populations at imminent risk of illness in a given period[12].

In Imperatriz, leprosy distribution occurs in areas with precarious sanitary conditions and easy spread of the notifiable diseases[7]. In this sense, there is a need to develop studies that bring new contributions about the fragilities found in that territory emerges, considering its spatial distribution and the variations presented in space-time, pointing out areas exposing the population to the highest risk of contracting the disease.

Therefore, considering leprosy endemicity in the state of Maranhão[2] and the high number of cases in the municipality of Imperatriz[7], the geographical disparities of the territory and factors associated with the disease, along with the scarcity of studies addressing the space and time analysis concomitantly, this research sought, using spatial-temporal scanning statistics, to reveal areas vulnerable to the occurrence of the disease in a decade, given the operational variations that may occur over time.

OBJECTIVES

To analyze the spatial-temporal distribution of leprosy in a priority municipality for disease control.

METHODS

Ethical aspects

The Research Ethics Committee of the Federal University of Maranhão (UFMA) approved the research, with seem issued on October 17, 2018.

Design, period, and place of study

An ecological study of the spatial-temporal analysis of leprosy, according to cases notified to the National System of Notifiable Disorders (SINAN) between 2008 and 2017, in Imperatriz, located in southwest Maranhão, 626 km from the capital São Luís, Northeast Brazil (Figure 1). The municipality has 1,368,988 km2 and an estimated population of 258,016 inhabitants, of which over 94% reside in the urban area[18]. It is considered the state's second-largest population center and commercial and services

hub[19]. The 246 census sectors in the municipality defined by the Brazilian Institute of Geography and Statistics (IBGE)[20] were units of ecological analysis of this investigation.
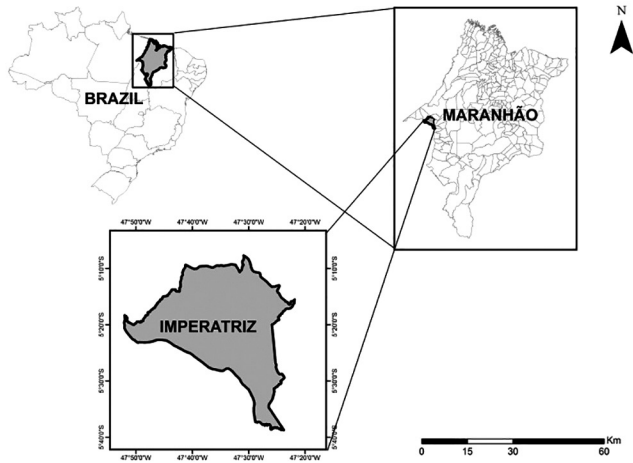
Source: Adapted from Brazilian Institute of Geography and Statistics (IBGE)[20].

Figure 1 - Map of Brazil, outlining the state of Maranhão and the city of Imperatriz

Population of study: criteria of inclusion

All reported leprosy cases (ICD10:A30) in the course of treatment on December 31 of each year of assessment were included in this study[21], using residence address, and excluding duplicate registrations.

Study protocol

The residence data, such as an address, number, neighborhood, zip code, and zone, in addition to the operational classification and clinical forms of the cases, were obtained through the SINAN in the Health Monitoring Service from the Imperatriz Regional Health Management Unit (UGRSI) and collected in February 2019. The population data under the public domain were obtained from the last demographic census results in 2010.

For the geocoding of the events, besides the individual notification form's residence data, researchers used the cartographic base of Imperatriz municipality. The maps followed the Shape file formatting, composed of three files with *shp, shx* and *dbf* extensions, in *Universal Transverse Mercator* (UTM) projection and regional geodetic system for *South American Datum* (SAD 69).

The addresses of the cases were standardized and assimilated to the cartographic base of Imperatriz and the geocofication process was carried out using the TerraView software version 4.2.2, from the interpolation of the case to its specific street segment. Thus, the geocoding of the data consisted of associating the tabular data that did not present explicit spatial reference of leprosy cases, transporting them to a map (cartographic base of the municipality) already incorporated in a GIS environment.

Besides, the Batch Geocode tool (available at http://batchgeo. com/br/) was used to search for records of leprosy cases not located in the cartographic base. This tool searches Google Earth for the coordinates of addresses. The geocoded cases were distributed by urban and rural census sectors of the municipality to carry out spatial-temporal scanning statistics.

Data analysis and statistics

The spatial-temporal scanning analysis technique was employed in order to detect agglomerations in space and time[16]. On that occasion, it was assumed as a null hypothesis (H_0) that there was no agglomeration in the regions or areas in the municipality of Imperatriz in a given time interval (all individuals in the population would have the same probability of presenting leprosy). As an alternative hypothesis (H_1), that region z was an agglomeration (individuals in a given area and period would have a higher probability of contracting the disease than others).

The SaTScan 9.3 program and Poisson's discrete model were used for the identification of agglomerations in space-time. It is noteworthy that the geographical non-overlap of the conglomerates, their maximum sizes of 50% in the analyzed period of time, circular format with 999 replications and the time interval in day, month and year between the years 2008 and 2017 were the criteria used for this analysis. Still, it is important to highlight that the space-time scanning technique was processed taking into account the distribution of cases according to the population, age distribution and sex of the census sectors, as well as envisioning the identification of agglomerations of high and low relative risks.

The detection of statistically significant agglomerations (p <0.005) was based on the comparison between the likelihood ratio test statistics against a null distribution, according to the Monte Carlo simulation[16]. The relative risk (RR), on the other hand, can present information from different areas, removing the effects of different population groups to demonstrate the intensity of the phenomenon studied in a given study area[17]. The ArcGIS 10.5 program created all thematic maps.

The annual prevalence rate was determined for every 10,000 inhabitants, for each identified spatial-temporal agglomeration, taking into account all existing cases, considering the population of the same location and period, according to IBGE population estimates, divided by the corresponding number of years in each agglomeration.

It was used endemicity parameters as expressed in Indicators for Monitoring the Progress of Leprosy Elimination as a public health problem for the classification of prevalence findings, which usefulness is to measure the endemic magnitude[21]. It considers as low endemicity localities with less than 1 case/10 thousand inhabitants; medium, between 1 and 4,9/10 thousand inhabitants; high, between 5 and 9,9/10 thousand inhabitants; very high, between 10 and 19,9 cases/10 thousand inhabitants; and hyperendemicity, 20 or more cases/10 thousand inhabitants.

RESULTS

In the period analyzed, 2,550 leprosy cases were reported to SINAN in the municipality of Imperatriz. Seventy-four were excluded due to duplicity, resulting in 2,476. Among these, according to operational classification, 1,667 (67.33%) were classified as multibacillary (MB), 809 (32.67%) paucibacillary (PB). We emphasize the borderline clinical form, as the majority, with 1,175 (70.49%) of reported cases.

Table 1 - Characterization of spatial-temporal agglomerations of leprosy cases, according to the population of the census tracts, distributed by sex and age, Imperatriz, Maranhão, Brazil, 2008-2017

Spatial-temporal Agglomeration and period of detection	Census sectors	Cases	Population (inhabitants)	RR (CI95%)	Prevalence rate (cases/10,000 inhabitants per year)	p value	Neighborhoods
1 (January 1, 2008 to December 31, 2011)	33	219	56,340	1.74 (0.55-2.19)	9.72	p < **0.001**	Vilinha, Jardim São Luís, Vila Nova, Parque Santa Lúcia, Vila Nova, Vila Lobão*, Vila Redenção, Alto da Boa Vista, Parque Amazonas, Jardim Tropical, Parque da Palmeiras, Vila Esmeralda e Vila Cafeteira
2 (January 1, 2008 to December 31, 2009)	3	29	14,757	3.81 (1.33-5.49)	9.82	p < **0.001**	Santa Inês*, Santa Rita e Bom Sucesso
3 (January 1, 2008 to December 31, 2010)	3	26	5,336	4.18 (1.43-6.14)	16.24	p < **0.001**	Centro
4 (January 1, 2008 to December 31, 2012)	1	21	1,852	6.95 (1.94-10.63)	22.68	p < **0.001**	Beira-Rio e Bacuri*

Note: * Central district of the agglomeration; RR - relative risk; CI95% - 95% confidence interval.

According to the geocoding process of the events under study, of the 2,476 cases of leprosy, 2,105 (approximately 85%) were geocoded. Of these, 2,000 cases (95%) used TerraView software and 105 (5%) cases using Batch Geocode. It was not possible to geocode 371 (15%) cases, which presented inconsistencies in the addresses informed - 105 (5%) blank addresses and 266 (10%) incomplete. About cases distribution according to census sectors, the absolute majority, 2,096 (about 99.6%), occurred in the urban area of the municipality.

The spatial-temporal scanning analysis revealed four spatial-temporal agglomerations of statistically significant leprosy cases (p < 0.005), controlled by age, gender, and population size of each census sector, exclusively within the urban perimeter of the municipality. Characteristics such as case numbers, number of census sectors, population, RR (95% confidence interval - CI95%), annual prevalence rate, and neighborhoods involved in the spatial-temporal agglomerations detected are presented in Table 1. Spatial-temporal agglomerations were detected between 2008 and 2012, with annual prevalence rates ranging from 9,72 to 22,60 cases/10,000 inhabitants.

In the spatial-temporal agglomerations' locations, RR ranged from 1.74 (RR Agglomeration 1 - detected between January 1, 2008, and December 31, 2011) to 6.95 (RR Agglomeration 4 - detected between January 1, 2008, and December 31, 2012). Also, the population living in the census sectors belonging to the Central District, Beira Rio, and Bacuri neighborhoods presented a higher risk of leprosy than the populations of other census sectors in the municipality (Figure 2).

DISCUSSION

Initially, we emphasize the importance of the studies to evaluate existing leprosy cases in space-time, especially those affected by clinical forms of MB, which have a high number of leprosy bacilli, constituting major sources of infection and transmitters of the disease until specific treatment is started[22].

In this scenario, it was observed an significant number of MB clinical forms, with a predominance of the borderline form, a finding consistent with several investigations[23-26] and with the epidemiological panorama of 26% increase in these clinical forms over a decade in the country, reaching, in 2018, 77.2% of the detected cases[2]. Such results demonstrate that the bacillus transmission is active and refers to a critical node to be overcome by healthcare services, considering late diagnosis and treatment of the disease[22]. There is a need for investments in training healthcare professionals working in Family Health Strategy (FHS) to provide early diagnosis of the disease, in addition to the implementation of healthcare education strategies aimed at the population about stigma and prejudice, pointed out as factors that hinder the search for healthcare services for diagnosis[24].

About 85% of cases investigated were geocoded, a number similar to other studies[27-28], which founded rates of 81.4% to 87.4%. Regarding the non-geocoded cases, 15% presented inconsistencies in the addresses reported, even using the TerraView software and Batch Geocode, showing 10% with incomplete addresses and 5% blank.
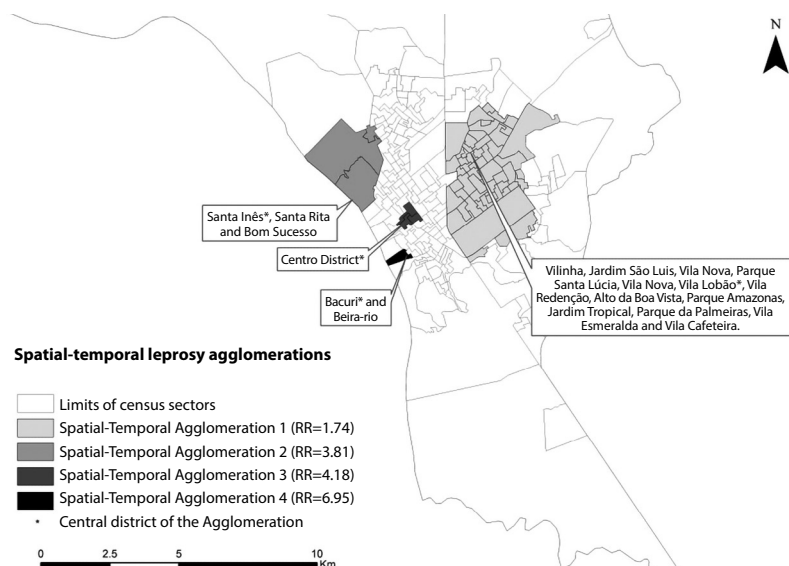

Figure 2 – Spatial-temporal agglomerations of leprosy cases, according to the population of the census tracts, distributed by sex and age, Imperatriz, Maranhão, Brazil, 2008-2017

Although "address" information is not a required field in the leprosy notification form, it is necessary to investigate the case or the calculation of an epidemiological or operational indicator[29]. Consequently, this information favors the identification of patterns of disease occurrence and the mapping of vulnerable territories. The quality of the data fed into the information systems is directly related to the efforts of the municipalities and regions in providing reliable data, in addition to the proper filling out of the notification form by the health professionals involved in patient care[30].

The adequate filling out of the data requires a special look of the professionals responsible for the notification since it guides the decision making and the direction of the actions to monitor the disease. Furthermore, investments in cadastral mapping, which are a State responsibility, are necessary and map areas with recent growth, especially those with disharmonious growth, typically seen in favelas and irregular settlements. An efficient georeferencing of cases depends primarily on the quality of the address data[31].

In recent decades, the intensification of leprosy urbanization in the Brazilian national territory has been observed, associated with the deficient life situations of the population and the restriction of access to collective goods and services. These characteristics are related to the fragile urban space, characterized by high levels of population agglomerations and socioeconomic vulnerability that enable a framework of convalescence and death[32]. In this sense, this socio-spatial reality can increase exposure to conditions that favor disease transmission or reduce detection and notification. Besides, poorer localities, because they have less detection and monitoring capacity, may have lower than expected annual detection rates of new cases and favor underreporting[33].

It was possible to detect through scanning analysis statistically significant spatial-temporal agglomerations that presented a high relative risk for leprosy. These were concentrated mainly in the urban area's central region, with dispersion to the northeast, northwest, and southwest of the municipality. It was possible to find the districts with the highest number of records of the disease, configuring its heterogeneous distribution. The census sectors belonging to the Central, Bacuri, and Beira Rio neighborhoods (Agglomerations 3 and 4) presented higher RR values and signaled these inhabitants' susceptibility to contract and develop the disease.

The results of this investigation are in line with another study conducted in Imperatriz, which used the technique of spatial analysis of data by area and revealed non-random distribution of the disease, demonstrating the easy dissemination of disease among the four health districts, especially in areas of higher population agglomeration and poor sanitary conditions[7]. Furthermore, the heterogeneous behavior of leprosy found in Imperatriz was also identified in other scenarios[25,34-35], confirming the hypothesis of association of the disease with the geographical, cultural and socioeconomic conditions in which certain populations live[36]. Actions in these regions must be planned and carried out according to the deficiencies and local preferences[34].

The distribution of leprosy concentrated in the municipality's urban area can be partially explained by the deficiency in its urban planning. There was no concern, from public management and the society of Imperatriz, with the municipality's urban planning, which causes it to grow in a disorderly and chaotic way[37]. Such expansion, without previous planning, also determined the appearance of areas considered subnormal, lacking essential public services in their majority, such as those evidenced mainly in the spatial-temporal Agglomerations 1 and 2, belonging to the urban zone, more distant from the central district.

Corroborating these findings, agglomerations of leprosy cases were identified in hyperendemic municipalities of Ceará, mostly in locations characterized by mostly deficient socioeconomic conditions, and with longer periods of fixed housing[8]. A disorderly growth of the urban area, as occurred in the scenario under investigation, usually without infrastructure, favors the emergence of precarious housing and poor sanitation conditions that, associated with household agglomeration, have direct interference in the occurrence of leprosy and maintain the possible persistence of endemic diseases in pockets of urban poverty, enabling the maintenance of the bacillus in the environment for a longer time[38-39].

It is emphasized that Imperatriz's basic sanitation services do not attend to all the city population, and less than half of the households (48,3%) presents adequate sanitary exhaustion[18]. Moreover, other factors may be related to the disease's greater urbanization, such as the rural population's difficulty of access to healthcare services and the greater offer of these services in the urban area[40].

The creation of spatial-temporal agglomerations in Imperatriz demonstrates that there are population groups vulnerable to leprosy in space-time. Thus, tools that identify spatial-temporal agglomerations contribute to developing strategies more specific to the areas of highest occurrence[11].

About the annual prevalence rates seen in spatial-temporal agglomerations between 2008 and 2012, it was noted that such locations were considered of high endemicity (Agglomerations 1 and 2), very high endemicity (Agglomerations 3), and hyperendemic (Agglomerations 4)[21]. It is essential to consider underestimating such an epidemiological indicator, considering the non-geocoding of 15% of reported cases.

The results of this investigation did not follow the epidemiological panel of the prevalence presented in the national scenario, considered to be decreasing over the years, and, along with scenarios such as Mato Grosso (in the Midwest Region) and Tocantins (in the North Region)[30], Imperatriz still reveals an heterogeneous spatial distribution and maintains the endemic area with high bacillary loads in the state and the Northeast Region. The sizeable territorial extension of the municipality and the socioeconomic inequalities provide this disparity of high levels of endemicity, notably expressed in census sectors belonging to the most vulnerable neighborhoods, from the housing and socioeconomic point of view.

Moreover, demographic density is among the factors contributing to hyperendemic areas for leprosy[15], as occurred in Agglomeration 4, which had the smallest population, but 21 cases distributed over a small territorial area may have contributed to the higher prevalence rate detected. Furthermore, keeping in mind the municipal socioeconomic indicators, this demographic indicator deserves to be highlighted when dealing with

communicable diseases because, when associated with social and economic inequalities, it favors the occurrence of diseases such as leprosy[15].

Likewise, the supply of health services also influences the endemicity and heterogeneous distribution of this disease[15]. Until December 2017, this municipality had 58.43% coverage of the Family Health Strategy (FHS)[41], and the two agglomerations with higher prevalence were in areas covered by the FHS, with Health Basic Units (UBS) of reference for the nearby regions configured as discovered areas. It is known that the more significant coverage by FHS favors the detection of leprosy cases since it increases the interaction of individuals with the health services; however, when the supply and conditions of services are precarious for early diagnosis, treatment, and monitoring of cases, there is an increase in the number of cases and, as a result, the possibility of formation of Agglomerations[8].

Thus, the present investigation findings call for prioritization of actions by health professionals, systems, and services for disease control and monitoring, based on the reduction of social inequities related to access to healthcare. Therefore, there is a way to achieve the purpose of the National Strategy to Eliminate Leprosy[22] to avoid disabilities and reduce the transmission of infection in the community

Study limitations

The use of secondary data occasionally presents absence and/or inconsistency of information, especially regarding addressing, causing losses in the geocoding process of events and subsequent underreporting. Therefore, it is necessary to rigorously fill out the required notification forms with complete information to subsidize the population's health status and decision-making evaluation. Inherent to ecological studies, the "ecological fallacy" also stands out, a limitation that occurs when it is not possible validate, at the individual level, statements made at a more aggregate level[42].

Contributions to Nursing and Public Policy

This research has generated subsidies for administrators and healthcare professionals to realize an important scenario in the Northeast of Brazil characterized as high and extremely high endemicity, besides being hyperendemic, regarding the evaluation of health actions for the planning and implementation of strategies aimed at the control and surveillance of leprosy.

From this perspective, the spatial-temporal visualization of the areas at greatest risk for the disease's occurrence may contribute to interventions aimed at improving the socio-environmental and economic conditions of the population living in vulnerable territories, aiming at controlling and eliminating the disease. Additional investigations that explain leprosy's connection to such conditions are needed to establish a dimension of possible causal factors.

The study highlights the importance of the methodological approach used here, which helps evaluate the geographic space to plan, monitor, and evaluate healthcare actions, facilitates the management of diseases that affect the population, and directs interventions to the most vulnerable regions.

CONCLUSIONS

Through spatial-temporal analysis, it was possible to understand leprosy's behavior in the municipality of Imperatriz, identify the areas of the highest concentration of the disease between the years 2008 and 2012 and visualize, in a more comprehensive way, the health of individuals in their environment. We detected agglomerations of high relative risk and annual prevalence rates of high endemicity to hyperendemicity in the urban area, linked to the characteristics of social vulnerability of these spaces. We emphasize the importance of new studies to help to understand explanatory factors for the spatial distribution of the disease, as well as to understand how healthcare services organize themselves in the face of the social reality of their communities.

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