Magnitude of social determinants in high risk areas of leprosy in a hyperendemic city of northeastern Brazil: An ecological study

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Accepted for publication 29 October 2019

Summary

Objective: To investigate the association of certain social determinants with areas at high-risk for leprosy in a hyperendemic city in northeastern Brazil.

Methods: An ecological study was carried out in Imperatriz, a hyperendemic municipality of northeastern Brazil. The units of analysis were urban census tracts, in which variables related to the number of dwellers per domicile, literacy and per capita monthly income were selected for the construction of the social determinants

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dimensions, by means of the Principal Components Analysis (PCA) technique. Spatial scan statistics were applied to identify areas of elevated leprosy risk and binary logistic regression was performed, considering the high-risk areas as the dependent variable and the social determinants dimensions as the independent variable. The Odds Ratios (ORs) were calculated with its 95% Confidence Intervals (CIs). The Receiver Operating Characteristic (ROC) Curve was applied to verify the discriminative power of the model. Type I error was set at 5% ($p < 0.05$).

Results: 2,552 leprosy cases were georeferenced and the scan statistic identified high-risk areas. The logistic model showed that social determinants were associated with high-risk areas (OR = 1.25, 95% CI = 1.07–1.49, $p = 0.006$). The area under the ROC curve value confirmed the discriminatory capacity for the model at 65%, which was considered sufficient.

Conclusions: The high-risk areas for leprosy are associated with social determinants of low household per capita income, low educational levels and high numbers of residents per household.

Keywords: Leprosy, spatial analysis, social determinants

Introduction

Leprosy is a chronic infectious disease caused by *Mycobacterium leprae*, which predominantly affects the skin and the peripheral nervous system, resulting in neuropathies and long-term associated consequences, including deformities and physical disabilities.¹

Despite the elimination of the disease in some countries of the world (prevalence <1 case per 10,000 inhabitants) leprosy persists in developing countries as a public health issue, as part of the Neglected Tropical Diseases group.^{2–4}

The World Health Organization (WHO) published the Global Leprosy Strategy 2016–2020: Accelerating towards a leprosy-free world,⁵ the goals of which are to reduce the global and local burden of leprosy, with the reduction of cases of children with deformities, reduction of new cases diagnosed with Grade 2 disability to less than one case per 1 million inhabitants and revision of all laws that lead to discrimination of patients with leprosy.⁵

While a global detection rate of 2.77 cases per 100,000 inhabitants was estimated in 2017, the countries with the highest number of cases are India, Brazil and Indonesia, with 80.2% of reported cases.⁶ Brazil presented a rate of detection of new cases of 12.94 cases per 100,000 inhabitants, in which it was responsible for 92.3% of the cases reported in the Americas,^{6,7} also showing a Grade 2 disability rate of 8.30 cases per 1 million inhabitants, and detection in children under 15 of 3.72 cases per 100,000 children. Some Brazilian states have already achieved the goal of eliminating leprosy; however, the northern, central-western and northeast regions of the country still have high rates of leprosy.

A spatial analysis study carried out in 2009 in Brazil identified that the states of Mato Grosso, Tocantins, Rondônia, Pará and Maranhão comprise high-risk areas for the persistent transmission of the disease.⁸ Maranhão, defined as hyperendemic for leprosy, had a detection rate of 44.34 new cases per 100,000 inhabitants in 2017, well above the global and Brazilian means.⁹

Considering that the treatment for leprosy is available and free of charge worldwide, it is assumed that the main barrier to elimination of the disease is related to the social determinants, such as situations of poverty, unhealthy environments and difficulties of leprosy patients in accessing to the health care services.

Spatial analysis studies conducted in Indonesia,^{10,11} India,¹² Nigeria,^{13,14} Bangladesh¹⁵ and Brazil^{16–25} present evidence that leprosy presents focal behavior, with the formation of clusters, and that the disease has an association with social determinants, such as precarious housing conditions, high numbers of residents per household, low levels of education, rural exodus and difficulties in access and accessibility to health services.

Among the studies reporting association of the disease with social determinants, the authors did not identify any that studied the association of high-risk areas of leprosy with social determinants, as well as developing a predictive model of this association. Such predictive studies may be helpful in the planning actions in health and in prioritizing areas for promoting equity of access and elimination of the disease. Therefore, the study aimed to investigate the association of certain social determinants with areas at high-risk for leprosy in a hyperendemic city in northeastern Brazil.

Methods

STUDY DESIGN AND RESEARCH SCENARIO

This was an ecological study,²⁶ conducted in the city of Imperatriz, Maranhão state, which is located in the northeastern region of Brazil (Figure 1), 626 km from the state capital, São Luís, being the second largest population, economic, political and cultural center of Maranhão. Imperatriz has a population of 247,505 inhabitants, with a population density of 180.79 inhabitants/km² and a territorial area of 1,368,988 km².²⁷ Regarding the Health Care Network, it has 102 health facilities registered in the Brazilian Nation Health System (*Sistema Único de Saúde* - SUS) and is divided into four health districts: 1. Vila Nova, 2. Vila Lobão, 3. Bacuri and 4. Santa Rita, with each district being composed of a variable number of neighborhoods, according to their populations.²⁸ Concerning socioeconomic indicators, the city has an illiteracy rate of 9.7%, life expectancy at birth of 73.2 years, Human Development Index (HDI) of 0.73, social exclusion index of 0.6, incidence of poverty of 55.28% and Gini Index of 0.46. Considering basic sanitation, 23% of the city has a sewage network and 86% a supply of drinking water.^{27,28} From 2006 to 2016, the rate of detection of new cases of leprosy in the state of Maranhão was 59.03 cases per 100,000 inhabitants, with it being the third most endemic disease in Brazil.⁷ In Imperatriz, in the same period, the detection rate was 109.03 cases per 100,000 inhabitants, which places it in a situation of hyperendemicity.⁷

STUDY POPULATION AND INFORMATION SOURCES

All cases of leprosy (ICD 10 - A30.0 to A30.8) reported in the Notifiable Disease Information System (SINAN) between 2006 and 2016 were considered. The SINAN is the Brazilian information system responsible for registering and processing information on notifiable diseases throughout Brazil, providing information, bulletins and reports on morbidity, making it an important Brazilian epidemiological database.²⁹ The selected variables were: date of notification, date of diagnosis, date of birth, sex, education, operational classification (Paucibacillary and Multibacillary leprosy), clinical form, assessment of the degree of physical disability at diagnosis, and residence address. Data were collected from the Health Surveillance Service of the Imperatriz Regional Health Management Unit, of the state government of Maranhão in May 2018. In the collection process, the information was tabulated in spreadsheets using the Microsoft Excel[®] 2013 software, performing the process of validating the database and removing duplicate notifications.

Figure 1. Map of the location of the Imperatriz, Maranhão, Brazil. Source: Brazilian Institute of Geography and Statistics.

The ecological analysis units of the study were the 218 urban census tracts of Imperatriz. The digital map of census tracts was acquired free of charge through the Brazilian Institute of Geography and Statistics (*Instituto Brasileiro de Geografia e Estatística - IBGE*). The census tract is the smallest territorial unit formed by a continuous area, located in an urban or rural area, with size, number of households and number of residents defined, and is used for the main Brazilian statistical enquires and surveys.³⁰

The socioeconomic variables were: number of residents of the household, literacy and household income, collected from the results of the IBGE Demographic Census, aggregated by census tracts.³¹ The selection of variables was based on the leprosy determinants framework of Chapitini and Marshman (2015),³² which considers socio-economic/behavioral, location and environmental dimensions. Table 1 presents the variables considered for the construction of the social determinants.

STATISTICAL ANALYSIS

A descriptive analysis of the clinical and sociodemographic variables of the cases was carried out, with the calculation of absolute frequencies, relative frequencies and rates according to the subgroups of each variable. In the calculation of the rates, for the age and sex variables, the denominator was the municipal population for each subgroup. For the education, operational classification, clinical form and evaluation of the degree of physical disability at diagnosis variables, the denominator was the total population of the municipality. The values were divided by the number of years of study (11 years) and multiplied by 100,000. For the age

Table 1. Variables selected from the 2010 Demographic Census (IBGE) for the construction of the social determinants, Imperatriz, Maranhão, Brazil

Dimension	Variables	Variable code
People per household	Proportion of permanent private households with 1 to 3 residents	V01
	Proportion of permanent private households with 4 to 5 residents	V02
	Proportion of permanent private households with 6 to 8 residents	V03
Literacy	Proportion of men without schooling	V04
	Proportion of women without schooling	V05
Household income	Proportion of households with permanent residents with nominal monthly income per capita of between 1/2 to 1 minimum wage	V06
	Proportion of households with permanent residents with nominal monthly income per capita of between 1 to 2 minimum wages	V07
	Proportion of households with permanent residents with nominal monthly income per capita of between 2 to 3 minimum wages	V08

Source: Brazilian Institute of Geography and Statistics.

variable, the measures of position (mean and median) and dispersion (Standard Deviation) were calculated using the R version 3.3.2 software (<https://www.r-project.org/>). Proportions for the proximal socioeconomic variables of the social determinants were calculated, taking into account the number of households or people with a certain characteristic in each census tract, divided by the total number of households or total number of people in each area, multiplied by 100.

The cases of leprosy were georeferenced from the geographical coordinates (latitude and longitude) of the residential addresses of each case. The Google Earth[®] free access software (<https://www.google.com/earth/>) and the Google Maps[®] tool (<https://www.google.com/maps/>) were used to identify geographical coordinates and the ArcGis[®] 10.6 software (<https://www.esri.com/en-us/arcgis/about-arcgis/overview>) for georeferencing, with the construction of a file containing the geographical coordinates of each case (represented by points) in SIRGAS 2000 projection. Cases of leprosy were spatially distributed on the digital map of urban census tracts, available from the IBGE website (<https://www.ibge.gov.br/geociencias-novoportal/downloads-geociencias.html>).³⁰ Cases with an address in a rural area (84 cases), without an address (316 cases) and/or with an incomplete address (260 cases) were excluded. It was opted to exclude the cases originating from the rural zone due to the impossibility of locating the geographical coordinates in these areas, considering the programs used.

After georeferencing, clusters of leprosy were identified using the scan statistic technique proposed by Kulldorff and Nagarwalla.³³ This technique is based on the maximum likelihood ratio statistic, based on a Poisson probability distribution (for discrete quantitative variables), adopting the geographical non-overlap of the clusters, circular shaped clusters, and Monte Carlo replication with 999 replications as the parameters.

The scan statistic technique requires a maximum spatial window size defined based on the size of the population or the geographic area of the study. The maximum spatial window size is often defined to be less than or equal to 50 % of the total population at risk. When using a large maximum window size, the maximum likelihood is obtained for a large cluster that contains several smaller clusters, and it is not always clear whether it is better to report one large cluster or several smaller ones.³⁴

Therefore, to reduce the formation of excessively large clusters with small Relative Risk (RR), Gini Cluster is a methodological option to evaluate the degree of the heterogeneity of the collection of clusters, explaining how well the cluster collection reveals the underlying true cluster patterns. This way, the population at risk indicated by this technique was 8%, which is considered the specification to identify the most important cluster to be reported in the scenario studied.³⁴ For this analysis, SaTScan software version 9.6 (<https://www.satscan.org/>). We defined high-risk areas as those included in clusters with RR greater than 1.

For the construction of the social determinants from the sociodemographic variables, the Principal Component Analysis (PCA) technique was applied using the Statistica® version 10.0 software (<http://www.statsoft.com/products/statistica-features>). Principal Component Analysis is a statistical approach used to analyze interrelations between a set of variables and explain these variables around their common inherent dimensions, aiming to condense the information contained in the original variables into a smaller set of statistical variables (components) with a minimum loss of information.³⁵

In the first stage of the technique, the data were standardized, so that each attribute contributed with the same weight in the calculation of the coefficient of similarity among the objects. After this step, the variables had zero mean and unit variance. Next, the components with total explained variance >70% that met the Kaiser criterion, with eigenvalues above 1, were selected.³⁵ Then, the scores for each census tract were calculated by multiplying the eigenvectors by the value of the variables of each census tract.

Following this, binary logistic regression was performed, considering the risk areas of leprosy identified from the spatial scan statistic as the dependent variable, classified as 1 when RR higher than 1 ($RR > 1$) and 0 when RR is lower than 1 ($RR < 1$), and the dimensions of the social determinants constructed through the PCA technique as the independent variable. The Odds Ratios (ORs) were calculated along with their respective 95% Confidence Intervals (95% CIs) for each PCA covariate. The Hosmer–Lemeshow test was applied to estimate the quality of fit of the model and the Receiver Operating Characteristic (ROC) Curve was applied to verify the discriminative power of the model, and its result was classified according to the criterion of Šimundić.³⁶ Type I error was set at 5% ($p < 0.05$). The analyses were performed using the R version 3.3.2 software.

The study was approved by the Research Ethics Committee of the University of São Paulo at Ribeirão Preto College of Nursing (EERP/USP) under Certificate of Presentation for Ethical Assessment (CAAE) No. 44637215.0.0000.5393. Signing of a consent form was not necessary as secondary data were used and the participants were not identified. The data were analyzed anonymously.

Results

A total of 3,212 cases of leprosy were reported in Imperatriz during the period investigated. Table 2 shows the descriptive statistics of the cases, where it is possible to observe that highest numbers were observed for age range 30 and 59 years (1,566; 48.76%; rate = 166.46 per 100,000 inhabitants), males (1,850; 57.60%; rate = 141.06 per 100,000 inhabitants) and subjects with incomplete elementary education (1,687; 52.52%; rate = 61.96 per 100,000 inhabitants). Regarding the clinical variables, the main operational classification was multi-bacillary (1,966; 61.21%; rate = 72.21 per 100,000 inhabitants), with Grade 1 disability (515; 16.03%; rate = 18.91 per 100,000) and Grade 2 disability (205; 6.38%; rate = 7.52 per 100,000 inhabitants) at diagnosis.

Table 2. Main characteristics of the leprosy cases and respective rates per 100,000 inhabitants, Imperatriz, Maranhão, Brazil (2006–2016).

Variable	Absolute frequency (<i>n</i> = 3,212)	Relative frequency (%)	Rates (100,000 inhabitants)
Age			
Under 15 years	296	9.21	40.26
15 to 29 years	773	24.07	93.98
30 to 59 years	1,566	48.76	166.46
>60 years	577	17.96	257.42
Minimum value	3 years		-
Maximum value	95 years		-
Mean	40.4 years		-
Median	39 years		-
Gender			
Male	1,850	57.60	141.06
Female	1,362	42.40	96.52
Education			
No schooling	356	11.08	13.07
Incomplete elementary education	1,687	52.52	61.96
Complete elementary education	184	5.73	6.75
Incomplete high school education	295	9.19	10.83
Complete high school education	379	11.80	13.92
Incomplete higher education	40	1.25	1.46
Complete higher education	88	2.74	3.23
Declined to answer	29	0.90	-
Not applicable	46	1.43	-
Did not answer	108	3.36	-
Clinical form			
Undetermined	556	17.31	20.42
Tuberculoid	696	21.67	25.56
Borderline	1,331	41.44	48.88
Lepromatous	609	18.96	22.36
Not classified	13	0.40	-
Did not answer	7	0.22	-
Operational classification			
Paucibacillary	1,245	38.76	45.72
Multibacillary	1,966	61.21	72.21
Did not answer	1	0.03	-
Assessment of the degree of physical disability at diagnosis			
Grade 0	2,087	64.97	76.65
Grade 1	515	16.03	18.91
Grade 2	205	6.38	7.52
Not evaluated	381	11.87	-
Did not answer	24	0.75	-

Regarding the spatial distribution of the leprosy cases, of the total number of cases (3,212), 84 cases were from the rural area of the municipality and were therefore excluded, according to the study criteria. Of the remaining total (3,128), a further 316 were excluded because the address was blank and 260 because the address was incomplete, leaving 2,552 (81.59%) for georeferencing.

Figure 2. Leprosy high risk areas, Imperatriz, Maranhão, Brazil (2006–2016). Source: Brazilian Institute of Geography and Statistics.

Through the scan statistic it was possible to identify three high-risk clusters statistically significant for leprosy cases (Figure 2). The high-risk areas included the census tracts located in districts 2. Vila Lobão, 3. Bacuri and 4. Santa Rita, located in the northeast and southwest regions of the city of Imperatriz.

Table 3 shows the dimensions of the social determinants identified from the PCA, according to the criteria described in the methods. Dimension 1 presented an eigenvalue of 4.47, with a total explained variance of 55.92%. Dimension 2 presented an eigenvalue of 1.23, with a total explained variance of 15.45%. Together, the two dimensions explained 71.38% of the variability of the data.

The variables that contributed positively in dimension 1, in order of importance, were: Proportion of men without schooling, Proportion of women without schooling, Proportion of private permanent households with 6 to 8 residents, Proportion of permanent private households with 4 to 5 residents, and Proportion of permanent private households with nominal monthly income per capita between 1/2 to 1 minimum wage.

Table 3. Matrix of the original variables and the dimensions of the social determinants, Imperatriz, Maranhão, Brazil

Variable code	Variables	Social Determinants	
		Dimension 1	Dimension 2
V01	Proportion of permanent private households with 1 to 3 residents	-0.401	0.179
V02	Proportion of permanent private households with 4 to 5 residents	0.281	-0.439
V03	Proportion of permanent private households with 6 to 8 residents	0.359	0.253
V04	Proportion of Men without schooling	0.393	0.295
V05	Proportion of women without schooling	0.378	0.209
V06	Proportion of permanent private households with nominal monthly income per capita of between 1/2 to 1 minimum wage	0.075	-0.725
V07	Proportion of permanent private households with nominal monthly income per capita of between 1 to 2 minimum wages	-0.409	-0.108
V08	Proportion permanent private households with nominal monthly income per capita of between 2 to 3 minimum wages	-0.398	0.201

Table 4. Predictive analysis of the social determinants associated with the areas at risk of leprosy, Imperatriz, Maranhão, Brazil (2006–2016)

	Social Determinants	Coefficient	Odds Ratio	(95% CI)	<i>p</i>	ROC
Model 1	Dimension 1	0.23	1.25	1.07–1.49	0.006	0.65
Model 2	Dimension 2	-0.08	0.97	0.72–1.30	0.876	-

In dimension 2, the variables that contributed positively in order of importance were: Proportion of men without schooling, Proportion of private permanent households with 6 to 8 residents, Proportion of women without schooling, Proportion of permanent private households with nominal monthly income per capita between 2 to 3 minimum wages, and Proportion of permanent private households with 1 to 3 residents.

The dimensions of the social determinants were tested for the areas at high-risk for leprosy, observing the results of the statistics in Table 4. The final model showed that dimension 1 (greater number of residents, education deficits and low income) was associated with high-risk areas (OR = 1.25; 95% CI = 1.07–1.49; $p = 0.006$).

The area under the ROC curve value for dimension 1 showed that its discriminatory capacity for the high-risk areas of leprosy was 65%, the discriminatory power of the model was classified as sufficient.³⁶ The value of Nagelkerke's R^2 coefficient was 0.05, the model can explain about 5% of the variations registered in the dependent variable. The Hosmer–Lemeshow test showed a value of $p = 0.529$, showing a good model fitness. The diagnosis of the logistic regression model indicated its adequacy and the non-violation of assumptions.

Discussion

The results of the study indicate that areas at high-risk for leprosy are associated with certain social determinants in a hyperendemic city of northeastern Brazil. The ROC demonstrated the sufficient prediction capacity of the model to explain the high-risk areas in Imperatriz.³⁶ The findings also show an overall detection rate of 108.76 cases per 100,000 inhabitants, confirming the hyperendemic profile according to the parameters of the Brazilian Ministry of Health.⁹ The municipality has shown rapid demographic growth, being the second economic center of

the state of Maranhão, receiving a large number of migrants from northern and northeastern Brazilian states due to its influence in the local economy, which may be causing an increase of the bacillus circulating in the studied region.^{37,38}

The age group most affected in the period investigated was that of 30 to 59 years, an age group that includes the economically active Brazilian population. The involvement of people in this age group can hinder the development of work activities, which can lead to its interruption, early retirements and a decrease in the quality of life of workers.^{17,39,40}

There was a high rate of cases in males, corroborating the literature,^{16,17,24,41} with the higher incidence in this sex possibly being related to longer exposure to the bacillus and less care for the health, leading to late diagnosis and increased risk for the development of physical disabilities.⁴² Regarding the educational level, the majority of cases had incomplete primary education, corresponding to less than five years of schooling (incidence of 61.96 cases per 100,000 inhabitants), with low educational levels having been described in the literature as a risk factor for leprosy.^{16,32} According to some authors, people with low levels of education have difficulty understanding the pathophysiological mechanisms and clinical manifestations of the disease and also tend to present greater difficulty in seeking health services and access to them.^{12,16,23,43}

Regarding the clinical profile of the disease, there were high rates among the multibacillary patients with a borderline clinical form (incidence of 48.88 cases per 100,000 inhabitants). High rates of Grades 1 and 2 disability at diagnosis were also observed, being 18.91 and 7.52 cases per 100,000 inhabitants, respectively, which may have occurred as a result of the delayed diagnosis. In the literature, the predominance of the borderline and lepromatous clinical forms and degrees of physical disability in the general distribution of cases suggests the occurrence of active transmission of the disease and late diagnosis, since, given the long latency period of *Mycobacterium leprae*, the immune system of the individuals is already compromised, with the development of more severe forms.^{44,45}

The study suggests that the areas at high-risk for leprosy are associated with the social determinants of low income, low schooling and high number of residents per household. The areas of leprosy high risk include census tracts located in districts 2. Vila Lobão, 3. Bacuri and 4. Santa Rita, located in the northeast and southwest of the municipality. A common characteristic of these three districts is that they are peripheral regions, far from the urban center of the city, and due to the rapid occupation of these regions, some pockets of poverty have been formed, with a consequent increase in situations of social inequality.³⁸

A study carried out in the city, evaluating the incidence of leprosy in children under 15 years of age, found that the highest occurrence of cases was located in health district 4. Santa Rita, in the northeast of the city. This district is characterized by a high population density, low socioeconomic level and deficits in basic sanitation,²⁸ which corroborates the present investigation, in which the areas of risk included this district.

In Brazil, previous analyses identify 10 clusters with the highest-transmission of leprosy, of which the highest relative risk was located in the municipalities from north and northeast of the country, including the states of Maranhão, Pará, Tocantins and Piauí.¹⁸ According to the authors, social determinants that include high number of residents per household, low income may be associated with the high transmission of leprosy, aspects identified in the present study.

Penna *et al.*,⁸ in 2009, analyzed the spatial distribution of leprosy in Brazil and verified an increase in detection rates in some areas, with the formation of clusters. According to the authors, this can be explained by two causes. First, the improvement of access to health services may be favoring the increase of this detection. Second, local context factors may be

contributing to the delimitation, maintenance and circulation of the bacillus in these clusters, due to the occupation of urban space, housing characteristics, family aggregation habits, and increased flow of people (migration) motivated by economic conditions.

The literature highlights that municipalities with high rates of people with low levels of education, greater population size, higher proportions of households with inadequate sanitation, higher rates of urbanization, higher average number of people per household and per room, and higher income inequality present higher rates of leprosy.^{21,23,46}

Social determinants that include lack of education and low income were favorable to the high incidence of the disease in the municipality of Imperatriz. The degree of economic inequality was the variable most associated with the incidence of leprosy in Imperatriz, demonstrating that the more heterogeneous the income distribution of a municipality, the greater the probability of this disease being an important public health problem.^{21,47}

Another variable that is associated with the increased risk of transmission of leprosy is related to the interregional migratory flow present in Brazil. The state of Maranhão is one of the states of the northeast with greater emigration and immigration, especially with the neighboring states, which may explain the maintenance of high detection rates of leprosy.³⁷ In addition, Maranhão is one of the states with the largest rural exodus, where rural migration to urban centers, such as the municipality of Imperatriz, is a common solution to reduce poverty. This process of urbanization, however, is accompanied by precarious housing and living conditions, with the formation of pockets of poverty, which maintains the circulation of the bacillus.³⁷ Thus, explanations for the persistence of leprosy in clusters described in the study and by other authors may be a consequence of the persistence of pockets of poverty and the precarious living conditions of these populations. Accordingly, coping strategies should include measures of income distribution, social inclusion and improvements in general living conditions, in particular, the implementation of social protection measures.⁴⁶

One measure to reduce social inequalities adopted in Brazil concerns the Brazilian conditional monetary transfer program, called the *Programa Bolsa Família* (PBF). The PBF is intended for extremely poor families and poor families, with children or adolescents up to the age of 17 or for pregnant or breast feeding women.⁴⁸⁻⁵⁰ A study that verified the association between leprosy detection rate and PBF coverage evidenced an increasing tendency in the mean coverage of the PBF and a reduction in the detection rates of leprosy in children under 15 years of age in municipalities with high risk of transmission of the disease, revealing a protective effect of this program.⁵¹ Although the present study did not measure PBF coverage, it should be emphasized that income transfer and social protection policies in general are strategic and important for reducing social inequalities, and such actions should be valued, especially in the risk areas identified in the study. Based on the present study and the literature evidence found, the main measures for the elimination of leprosy as a public health problem in Brazil should be directed toward reducing social inequalities (in which Brazil is one of the world leaders) and strengthening health systems and services in relation to early diagnosis, prevention of physical disabilities, active case search, intradomiciliary contact evaluation and stigma reduction.

Among the limitations of the study, the use of secondary information sources, with the presence of unavailable and incomplete data, should be highlighted. Another limitation was the difficulty in selecting the variables of the IBGE related to social determinants, due to the lack of information from some census tracts.

In conclusion, the study provides evidence that the areas at high-risk for leprosy are associated with social determinants of low household per capita income, low educational levels and high numbers of residents per household. Considering the results of the ROC curve,

which the discriminatory capacity of the final model was classified as sufficient, it is worth mentioning that there are other determinant factors for the occurrence of the leprosy that need different methodological approaches to be identified. However, the verification of the association of the disease with social determinants, as showed in this study, is useful for the planning of actions addressed to the reduction in these inequalities, and may contribute to the reduction of leprosy transmission in municipalities with high endemicity of leprosy.

Acknowledgements

The authors would like to thank the Health Surveillance Service of the Imperatriz Regional Health Management Unit, of the state government of Maranhão for making the data available.

Funding information

This study was financed in part by the Coordenação de Aperfeiçoamento de Pessoal de Nível Superior - Brasil (CAPES) - Finance Code 001.

Contributions of each author

ACV Ramos, RA Arcêncio was involved in Conceptualization, Formal analysis, Investigation, Methodology, Writing – original draft, Writing – review & editing.

M Santos Neto, FM Pieri was involved in Investigation, Writing – original draft, Writing – review & editing.

M Yamamura, LH Arroyo, IS Assis, MAM Arcoverde was involved in Formal analysis, Methodology.

JD Alves, LS Alves, TZ Berra, JF Martoreli Júnior was involved in Writing – original draft, Writing – review & editing.

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