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Leprosy and social deprivation: Definition of priority areas in an endemic state Northeastern Brazil

Hanseníase e carência social: definição de áreas prioritárias em estado endêmico do Nordeste brasileiro

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ABSTRACT: ***Introduction:*** Leprosy is a disease that reserves close relation with social and economic conditions. Brazil is the only country that has not yet reached the goal of eliminating the disease as a public health problem. ***Objective:*** This study aimed to analyze social deprivation in the municipalities of Bahia and its relation with the detection of new cases of leprosy in the population. ***Methods:*** It is an ecological study conducted in the state of Bahia, from 2001 to 2015. Variables analyzed: detection rate of new cases, social deprivation index (SDI) and Hansen's disease in children under 15 years of age. The SDI was built on four variables: socioeconomic performance index, *per capita* income, proportion of extremely poor, and household density. For spatial analysis, local empirical bayesian modeling and global and local Moran statistics were used. Statistical analysis used multivariate, spatial and logistic regression, odds ratio calculation and analysis of variance. ***Results:*** Leprosy showed heterogeneous distribution in the state, with concentration in the north-west and south axis. 60.4% (n = 252) of the municipalities presented very low life conditions. An association was observed between living conditions and the detection of leprosy, with higher coefficients in the municipality group with better living conditions ($p < 0.001$). ***Conclusion:*** It was concluded that the worst conditions acted as an impediment to the diagnosis, while increasing the risk of illness. Good conditions have the opposite effect.

Keywords: Leprosy. Poverty. Social Conditions.

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RESUMO: ***Introdução:*** A hanseníase é uma doença que guarda estreita relação com as condições sociais e econômicas. O Brasil é o único país que ainda não alcançou a meta de eliminação da doença como problema de saúde pública. ***Objetivo:*** Este trabalho teve como objetivo analisar a associação entre a carência social dos municípios baianos e a detecção de casos novos de hanseníase na população, como instrumento para a definição de áreas prioritárias para intervenção. ***Metodologia:*** Trata-se de um estudo ecológico realizado no estado da Bahia, no período de 2001 a 2015. Variáveis analisadas: coeficiente de detecção casos novos, índice de carência social (ICS) e hanseníase em menores de 15 anos. O ICS foi construído com base em quatro variáveis: índice de *performance* socioeconômica, renda *per capita*, proporção de extremamente pobres e densidade domiciliar. Na análise espacial, foram utilizadas modelagem bayesiana empírica local e estatística de Moran global e local. Na análise estatística, foram empregados regressão multivariada, espacial e logística, cálculo do *odds ratio* e análise de variância. ***Resultados:*** A hanseníase apresentou distribuição heterogênea no estado, com concentração no eixo norte-oeste e sul. Dos municípios, 60,4% (n = 252) apresentaram muito baixa condição de vida. Observou-se associação entre as condições de vida e a detecção da hanseníase, com maiores coeficientes no grupo de município com melhor condição de vida ($p < 0,001$). ***Conclusão:*** As piores condições atuaram como um impeditivo ao diagnóstico, ao mesmo tempo que ampliaram o risco de adoecimento. As boas condições possuem efeito inverso.

Palavras-chave: Hanseníase. Pobreza. Condições Sociais.

INTRODUCTION

In the world, only Brazil has not yet reached the goal of eliminating leprosy as a public health problem, agreed in less than one case per 10,000 inhabitants. Currently, the country has the second highest number of new diagnoses of the disease, second only to India. Over 90% of all occurrences are concentrated in the Americas[1-3].

In the epidemiological scenario of leprosy in the Northeast, considering 2016, the state of Bahia occupied the second position in absolute number of new cases (2,077 diagnoses) and in the active registry (2,143 patients under treatment) and the sixth position in detection coefficients in the general population and in those under 15 years of age and of prevalence. Endemic was classified as high in both the general population (13.6/100 thousand inhabitants) and in people under 15 years old (3.16/100 thousand inhabitants). The prevalence observed was of 1.4/10 thousand[2].

In the last decades, with the discussion about the influence of socioeconomic and cultural conditions on the morbidity and mortality profile of the population, research on the theme has gained space in the global scientific universe[4,5]. Although the association between leprosy transmission and the social and economic conditions in which people live is not a recent subject in science, studies still differ regarding the findings observed[6-8]. This scenario legitimizes the conduction of regional investigations that allow the identification of priority municipalities for intervention, especially in endemic areas[9].

In 1994, the United Nations Children's Fund (UNICEF) developed the survival conditions index[10] to identify groups of children in poorer survival conditions to contribute to

the development of intervention strategies. Since then, many researchers have adapted the proposed methodology to understand the social dynamics of different health problems[8], adopting a new interpretation for the term, which is now recognized as a social deprivation index (SDI).

This study assumes that the relationship between leprosy and the level of social deprivation of the population is neither linear in nature nor in cause and effect. The initial hypothesis is that this socioeconomic context acts as a determinant of both the diagnosis of the disease and the risk of illness itself, although in different contexts and interpretations.

Thus, this study aimed to analyze the association between the social needs of Bahia municipalities and the detection of new cases of leprosy in the population, as a tool for defining priority areas for intervention.

METHODS

This is an ecological study conducted in Bahia between 2001 and 2015. Composed of 417 municipalities, the state is the largest in the Northeast Region and the fifth largest in the country in territorial extension, representing 36.33% of the Northeast area and 6.63% of the Brazilian territory. Of its territory, 69.31% is in the semiarid. It is also the fourth largest population in Brazil and the first in the Northeast, surpassing 15.2 million inhabitants[11] (Figure 1).

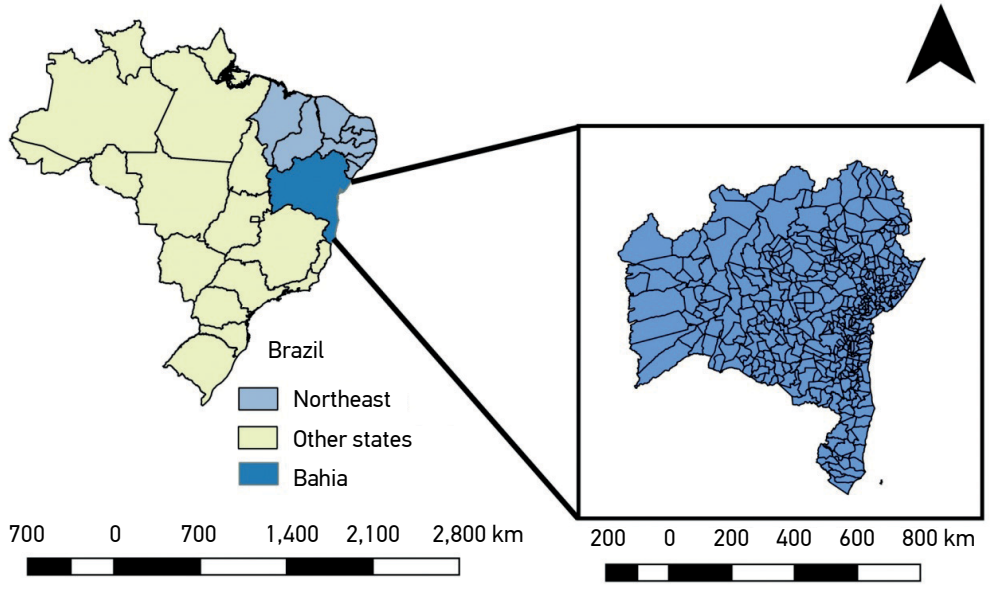


Figure 1. Map of geographical location of the study area.

Three variables were selected for the study:

- coefficient of detection of new leprosy cases in the general population / 100 thousand inhabitants;
- SDI;
- number of leprosy cases in children under 15 years of age.

The dependent variable was the detection rate of new leprosy cases in the general population in the period. Data regarding the disease cases were obtained from the Notification Disease Information System (*Sistema de Informação de Agravos de Notificação* – SINAN), and population data from the Brazilian Institute of Geography and Statistics (*Instituto Brasileiro de Geografia e Estatística* – IBGE). The following equation was adopted: mean new leprosy cases in the period / mid-period population in the place × 100 thousand.

The independent variable was the SDI. For its construction, the methodology proposed by Unicef[10] was adopted. Initially the municipalities were ranked according to each variable selected for its composition, establishing the score of each one (Si). The municipality with the highest value (Vmax) was assigned Si = 1 and the one with the lowest value (Vmin) Si = 0. For the other municipalities, Si was defined by the equation Si = (Vobserved - Vmin) / (Vmax - Vmin). The SDI of each municipality was then determined by the simple arithmetic mean of Si.

Four variables were selected for the composition of the SDI:

- socioeconomic performance index — economy and finance (IPESE-EF); índice de *performance* socioeconômica — economia e finanças (IPESE-EF);
- mean monthly value of *per capita* income (RENDAPERCAPIT);
- proportion of extremely poor people (% EXTRPOBRES);
- number of households with density greater than three people per dormitory (DOM3PPDOR).

For the variables RENDAPERCAPIT and IPESE-EF, a formula for the inversion of values (1-Si) was applied in order to maintain the same sense of the other variables (the higher the value, the greater the social deprivation). The IPESE-EF was obtained from the Bahia Department of Economic and Social Studies, and the other variables from the 2010 IBGE census.

After calculating the SDI, the following criteria were adopted to classify the municipalities in quartiles:

SDI = 0.142 to 0.259: low social deprivation;

SDI = 0.260 to 0.369: medium social deprivation;

SDI = 0.370 to 0.479: high social deprivation;

SDI = 0.480 to 0.699: very high social deprivation.

It should be noted that these variables were selected after exhaustive analysis of the literature and elaboration of models, which took place in three stages.

Stage I was characterized by the selection of variables that could be associated with leprosy detection. Based on a broad literature review[9,12-23], the following variables were selected: municipal human development index and its dimensions (longevity, education and income), Gini and Theil-L indexes (income inequality), vulnerability index and its dimensions (urban

infrastructure, human capital and income and work), Firjan municipal development index and its dimensions (education, health and employment and income) and socioeconomic performance index and its dimensions (education, health, economy and finance, demographic density, proportion of urban population, collective household with resident, proportion of individuals aged 60 years old or older in the population, proportion of illiterate individuals aged 15 years old or older, proportion of households with inadequate sanitation, average monthly *per capita* income, proportion of extremely poor people, number of households with a density greater than three people per bedroom, occupancy of individuals aged 10 years old or older, households without income, family composed of six or more people living in the household, responsible person and spouse without income, proportion of single person households, number of permanent private households connected to the general water supply network, number of permanent private households without restrooms for exclusive use of the household and number of permanent private households with garbage collected).

In step II, these variables were submitted to multivariate regression in order to identify those that were associated with leprosy detection coefficient. The existence of multicollinearity between the independent variables was not observed, which was evaluated according to the tolerance and the variance inflation factor. The backward method was used.

Stage III consisted of applying spatial regression with global effects (mixed autoregressive model and spatial error model). This last step was necessary because the residues of both classical regression models showed spatial dependence, verified by Moran statistics. The choice between the mixed autoregressive model or the spatial error model was based on the application of Lagrange multiplier tests.

After the elaboration of the database containing the studied variables, the statistical treatment of the data was carried out in three stages:

- exploratory spatial analysis;
- association study;
- identification of priority municipalities.

EXPLORATORY SPATIAL ANALYSIS

Initially, the detection coefficient was smoothed by the local empirical Bayesian model in order to reduce the random fluctuation of the data[24]. Then, both the smoothed detection coefficient and the SDI were subjected to exploratory spatial analysis using Moran global and local statistics to assess spatial dependence and to identify spatial clusters. The model was validated by applying the pseudo-significance test[24,25].

Once the global spatial autocorrelation was found, local index of spatial association was applied. Each area was given a significance value and was allocated in a quadrant of the Moran scattering diagram:

- Q1: high/high;
- Q2: low/low;

- Q3: high/low;
- Q4: low/high.

Then, Moran-type maps were generated for both indicators[24,25].

ASSOCIATION STUDY

In the second stage of the modeling, an association between the detection coefficient and the SDI was sought. To this end, the indicators were dichotomized: for the leprosy detection coefficient, we adopted 0 for the low and medium endemicity categories and 1 for the high, very high and hyperendemia categories. For SDI, we adopted 0 for low and medium social deprivation and 1 for high and very high social deprivation. The association was tested using logistic regression and *odds ratio* (OR) calculation. In addition, the analysis of variance was applied to compare the means of the general coefficient between the SDI strata. Significance of 5% was adopted.

IDENTIFICATION OF PRIORITY MUNICIPALITIES

Finally, we sought to identify the areas considered priority for intervention. To define these areas, a severity variable was also adopted: the number of cases in children under 15 years of age in the study period, with a value set at 5. This value was defined by characterizing the average of one case for every three years of the study series and for its ability to evidence the maintenance of the disease transmission chain.

Then, three priority groups were established:

- group I: municipalities with high and very high SDI and, at least, five cases in children under 15 years of age during the study period;
- group II: municipalities with high and very high SDI, high/very high/hyperendemic detection coefficient (10 or more cases/100 thousand inhabitants) and no cases in children under 15 registered in the period;
- group III: municipalities with high and very high SDI, no cases in children under 15 years old and low endemic in the general population (< 2 cases/100 thousand inhabitants).

Group I highlights the need for interventions aimed at the general population (adults and children), group II includes silent municipalities for children under 15 and reinforces the need for active search in this population, and group III identifies the totally silent municipalities.

TerraView 4.2.2, QGIS 2.14.11, GeoDa 1.8.10 and Statistical Package for Social Sciences (SPSS) 22.0 were used for the analyses. The territorial meshes needed to make the maps were obtained from IBGE.

The study was approved by the Research Ethics Committee of *Universidade Federal de Alagoas*, Presentation Certificate for Ethical Appraisal (CAAE) No. 70943617.5.0000.5013, and Approval Opinion No. 2.212.723, of August 10th, 2017.

RESULTS

From 2001 to 2015, 42,227 new leprosy cases were diagnosed in residents of the state of Bahia, 3,430 (8.1%) in individuals under 15 years of age. Of the 417 municipalities, 15 (3.6%) were classified as silent, 27 (6.5%) as of low endemicity, 182 (43.6%) as of medium, 119 (28.5%) as of high, 35 (8.4%) as very high endemicity, and 39 (9.4%) as hyperendemic, as shown in Figure 2. It was also observed that the highest coefficients were in the northwest axis of the state and in the southern region.

Regarding the SDI, it was found that only 12 municipalities had low social deprivation (SDI 0.142 to 0.259). The leprosy detection coefficient in this group was quite heterogeneous, ranging from 8.26/100 thousand in Pojuca to 103.3/100 thousand in Barreiras. The municipalities of Barreiras, Eunápolis, Teixeira de Freitas, and Luís Eduardo Magalhães were classified as hyperendemic (Figure 2).

At the other extreme are municipalities with very high social deprivation, which accounted for 60.4% (n = 252) (Figure 2). Of this total, 26 (10.3%) were classified as of low endemicity, 11 of them totally silent in the period, and 18 (7.1%) as hyperendemic. Of the 10 municipalities with the highest SDI, four of them were classified as hyperendemic for leprosy.

Additionally, Moran statistics showed spatial dependence of the SDI (I = 0.589; p = 0.01), with a large area with high and very high social deprivation. The municipalities with the highest SDI were located in the northeast to central-north axis of the state, totaling 77 municipalities. Of this total, only three (3.9%) had low endemicity, 41 (53.2%) medium endemicity, 16 (20.8%) high, five (6.5%) very high, and 12 (15.6%) were hyperendemic. The three municipalities with the highest SDI are also hyperendemic for leprosy: Pilão Arcado (SDI = 0.669 and detection coefficient of 65.38 cases/100 thousand), Barra (SDI = 0.671 and coefficient of 64.49/100 thousand) and Buritirama (SDI = 0.699 and coefficient of 48.96/100 thousand).

Comparison of the detection coefficient and the SDI maps (Figure 2) showed that the west and south regions, which are priority for leprosy, have a lower social deprivation. At the same time, part of the northern and central-northern municipalities has high and very high SDI while they are hyperendemic, with spatial overlap of 12 municipalities in the Moran map.

Still according to Figure 2, the spatial distribution of the number of cases in children under 15 years of age showed that 164 (39.3%) municipalities did not diagnose any individuals in the period, and only 15 (3.6%) reported 51 or more cases. These 15 municipalities together accounted for 1,994 cases, which corresponded to 58.1% of all diagnoses. In addition, nine of them had low and medium SDI and six high and very high SDI.

Logistic regression analysis (Table 1) showed that the lowest SDI acted as a risk factor (OR = 0.129 and p <0.001). When repeating the analysis considering the priority municipalities,

according to their position in the Moran scattering diagram, this same association was not observed (OR = 0.844 and p = 0.446).

Additionally, according to Table 2, the average overall detection coefficient increased as the SDI decreased, showing a statistically significant difference between the average detection coefficients of municipalities classified as low and medium SDI when compared with those with high and very high SDI.

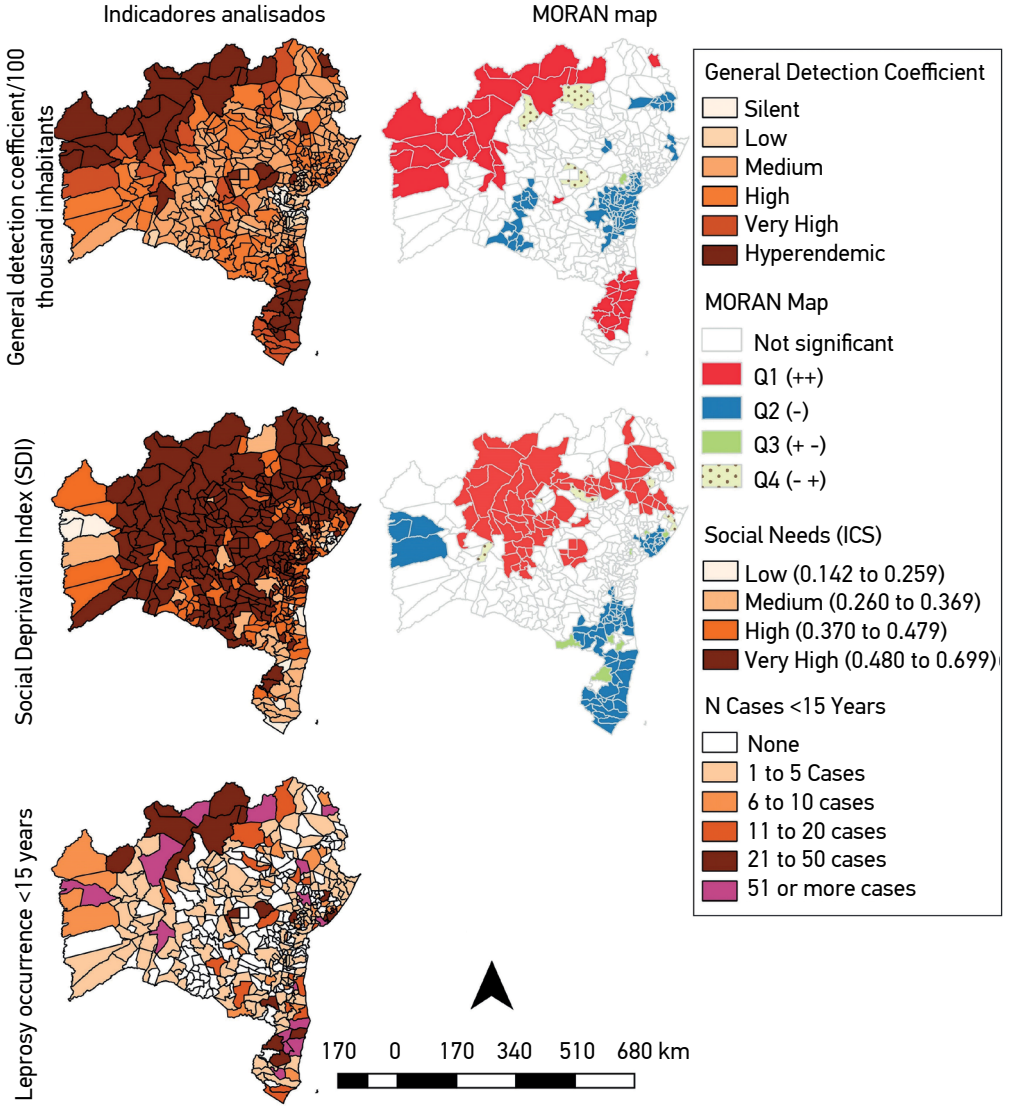


Figure 2. Spatial analysis of the detection rate of new leprosy cases in the general population, social deprivation index and leprosy occurrence in children under 15 years of age. Bahia, Brazil, 2001–2015.

Priority group I consisted of 56 municipalities, most notably in the north-west axis, group II comprised 100 municipalities, and group III 37 municipalities (Figure 3).

DISCUSSION

This study analyzed the association between the social needs of Bahia municipalities and the detection of new leprosy cases in the population, as an instrument for defining priority areas for intervention. The findings presented show the complexity of the relationship between leprosy and the SDI of the municipalities.

Table 1. Logistic regression with the dependent variable the degree of endemicity. Bahia, Brazil, 2001–2015.

Variable	Degree of endemicity		p	OR	95%CI
	High to hyperendemia (n = 193)	Low to medium (n = 224)			
SDI					
High and very high social deprivation (n = 366)	150 (41.0%)	216 (59.0%)	0.001*	0.129	0.059 – 0.283
Medium and low social deprivation (n = 51)	43 (84.3%)	8 (15.7%)			
Moran Quadrant					
Q1 (n = 77)	33 (42.9%)	44 (57.1%)	0.446	0.844	0.512 – 1.39
NS, Q2, Q3 and Q4 (n = 340)	160 (47.1%)	180 (47.1)			

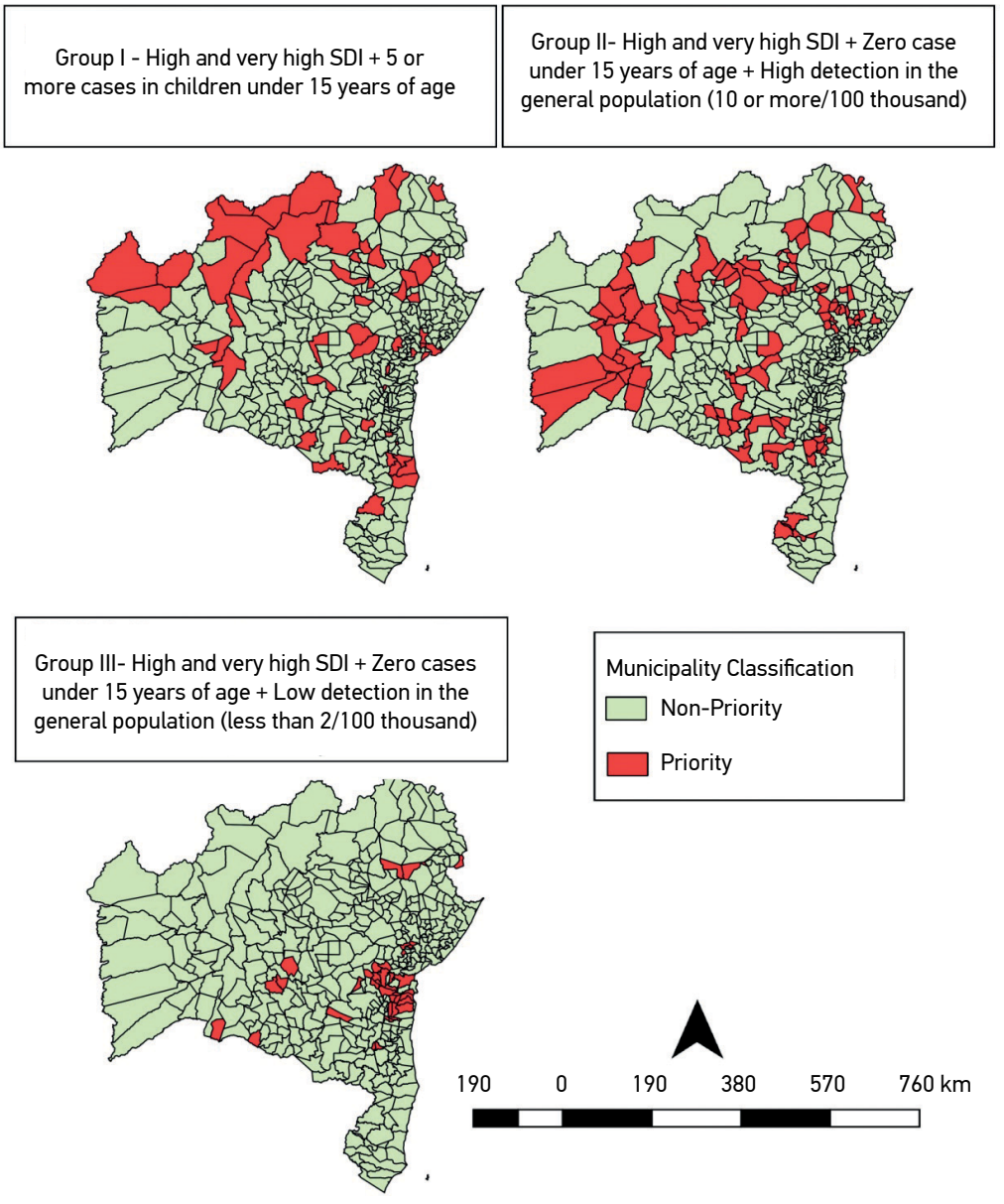
OR: *odds ratio*; 95%: 95% confidence interval; SDI: social deprivation index; Q1: Moran quadrant 1; NS: not significant; Q2: Moran quadrant 2; Q3: Moran quadrant 3; Q4: Moran quadrant 4; * statistical significance.

Table 2. ANOVA of the general leprosy detection coefficient according to social deprivation stratum. Bahia, Brazil, 2001–2015.

Variable	SDI				ANOVA	Groups with statistical significance
	Low (1) *(n = 12)*	Medium (2) *(n = 39)*	High (3) *(n = 114)*	Very High (4) *(n = 252)*		
Overall detection coefficient	34.1 ± 30.1	25.7 ± 23.2	13.6 ± 17.7	13.5 ± 23.0	p = 0,01*	1 *vs.* (3,4) 2 *vs.* (3,4)
	27.7 ± 24.9		13.5 ± 21.5		p < 0.001*	-

SDI: social deprivation index; *statistical significance.

The low detection coefficients in a significant portion of the municipalities most deprived may be evidence of underreporting of leprosy in these areas, as a result of the interaction of different factors, such as poor availability of health services, poor access by the population, disability of services in diagnosing new cases and failures in surveillance systems, with greater damage to



SDI: social deprivation index.

Figure 3. Spatialization of municipalities according to leprosy priority group. Bahia, Brazil, 2001–2015.

smaller municipalities[26-29]. All these reasons increase the hidden prevalence of the disease and keep many municipalities silent or with few diagnosed cases[26-29], making leprosy invisible in these places.

On the other hand, the organization of health services, characterized by network decentralization, provision of ancillary examinations, contact surveillance, health promotion actions and active case tracking[30-32], has been pointed by many studies as a determinant of diagnosis and, therefore, of the increase in the coefficients, at least in the short term. In the long term, a real and sustainable reduction of the endemic disease is expected[33]. None of the 12 low-income Bahia municipalities were classified as silent during the study period, which may reflect the impact of better municipal social conditions on the detection of new leprosy cases.

The scientific literature has pointed out that the availability and quality of municipal health services are influenced by local economic and managerial conditions. Most developed municipalities and those with the greatest wealth are those that are most likely to offer their population a more qualified health network[34,35]. In this study, disease detection coefficients increased toward lower social deprivation, reinforcing the importance of these better social conditions in the diagnosis of disease in endemic areas, which results in an increase in the detection coefficient.

It should be noted that access to health services encompasses multidimensional understanding, including political, social, economic and cultural aspects[36], which is why the idea is only raised in this text. In addition, the methodological framework adopted in the study is unable to address this issue, and research is needed to analyze the influence of access on leprosy detection rate in endemic areas.

Because of this complex web of mediation around the dynamics of leprosy transmission, we introduced the term pseudo-risk to define the results of logistic regression, where lower social need was associated with higher disease burden. Pseudo-risk because it is not a real risk of the individual becoming ill, but because it facilitates the diagnosis of the disease, especially in endemic areas. This condition, which Nsagha et al.[37] called ambiguity in the relationship between leprosy and socioeconomic conditions, has become less inaccurate according to our interpretation.

In addition, we present important evidence that the risk of becoming ill is associated with greater social deprivation, not appearing in the regression model possibly due to underreporting in these areas. Among the evidences, we highlight the spatial overlap of 12 municipalities located in the Q1 quadrant of the SDI Moran diagram and the detection coefficient, the fact that many municipalities with greater social need are also hyperendemic, and the heterogeneous distribution of both disease and poverty, although the latter occupies a large territorial extension.

A study by Cabral-Miranda et al.[19] conducted in the state of Bahia reinforces these findings. According to the authors, socioeconomic and environmental conditions are linked to the permanence of the leprosy transmission chain. Thus, the presence of geographic areas with high social deprivation and which also have high leprosy detection coefficients explains the influence of the fragile socioeconomic conditions of the population on the maintenance of the *Mycobacterium leprae* transmission chain[38-42]. As a result of all the investigations conducted here, the central element chosen for the definition of priority areas was high/very

high social deprivation. Based on this element, three priority intervention groups were listed, each requiring specific interventions. For group I, we recommend intensifying actions to interrupt the epidemiological chain of transmission; for group II, we suggest intensifying the active search for cases in this child population; and for group III, studies that may explain whether these areas are in fact free from leprosy or correspond to underreporting gaps.

Finally, even considering the robustness of the statistical methods adopted in this study, it is pertinent to highlight that it has important limitations[8,24,25]:

- use of secondary data from information systems, which may not express health reality;
- influence of random data fluctuation due to the existence of many municipalities with small populations;
- Influence of the size of the geographical units analyzed, once that, by looking at municipal indicators, we could not capture the differences intralocally.

CONCLUSION

Three conclusions were drawn. The first concerns the fact that the disease does not occur randomly in Bahia territory, being concentrated in important areas of development as well as in areas of poverty. In more developed areas, it is suggested that lower social deprivation acts as a determinant of the diagnosis.

The second conclusion refers to the determinants of the disease itself. In this case, social deficiency influences the disease process. With the neglect of the disease, the epidemiological chain of transmission is maintained and the hidden prevalence increases. This whole context places a veil over these areas that masks reality.

The third explains the importance of defining priority areas for intervention according to different epidemiological aspects, especially in such an unequal state, reinforcing the challenge of studying leprosy and putting in focus the need to particularize each region.

In addition, it was possible to show that reflecting the process of elimination of the disease is more than thinking about the economic situation of individuals and families, but pondering the need for a broader development that can reach both the distal and the proximal factors of illness and diagnosis.

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