REFERÊNCIA

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ORIGINAL ARTICLE / *ARTIGO ORIGINAL*

Analysis of the epidemiological situation of leprosy in an endemic area in Brazil: spatial distribution in the periods 2001 – 2003 and 2010 – 2012

Análise da situação epidemiológica da hanseníase em uma área endêmica no Brasil: distribuição espacial dos períodos 2001 – 2003 e 2010 – 2012

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ABSTRACT: ***Introduction:*** In Brazil, the spatial distribution of leprosy is heterogeneous. Areas with high transmission of the disease remain in the North, Center-west and Northeast. Areas with high transmission of the disease remain in the Northern, Central-Western and Northeastern regions of the country. ***Objective:*** to describe the spatial distribution of leprosy in municipalities with high risk of transmission, in the periods from 2001 – 2003 and 2010 – 2012. ***Methods:*** This was an ecological study using data from the Notifiable Diseases Information System (SINAN). They included all municipalities in the states of Mato Grosso, Tocantins, Rondônia, Pará and Maranhão. The following leprosy indicators were calculated per 100,000 inhabitants: incidence rate of leprosy, incidence rate in children aged less than 15 years and rate of new cases with grade 2 disabilities. The spatial scan statistic was used to detect significant clusters ($p \leq 0.05$) in the study area. ***Results:*** In the period 2001 – 2003, the scan spatial statistics identified 44 significant clusters for the leprosy incidence rate, and 42 significant clusters in the period 2010 – 2012. In the period 2001 – 2003, it was possible to identify 20 significant clusters to the incidence rate in children aged less than 15, and 14 significant clusters in the period 2010 – 2012. For the rate of new cases with grade 2 disability, the scan statistics identified 19 significant clusters in the period 2001 – 2003, and 14 significant clusters in the period 2010 – 2012. ***Conclusions:*** Despite the reduction in the detection of leprosy cases, there is a need intensify disease control actions, especially in the clusters identified.

Keywords: Leprosy. Ecological studies. Spatial analysis. Epidemiological surveillance. Cluster analysis. Communicable diseases.

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RESUMO: ***Introdução:*** No Brasil, a distribuição espacial da hanseníase é heterogênea. Áreas com alta transmissão da doença permanecem nas regiões Norte, Centro-Oeste e Nordeste do país. ***Objetivo:*** Descrever a distribuição espacial da hanseníase em municípios brasileiros com alto risco de transmissão, nos períodos 2001 – 2003 e 2010 – 2012. ***Métodos:*** Trata-se de um estudo ecológico com dados do Sistema de Informação de Agravos de Notificação (SINAN). Foram incluídos todos os municípios localizados nos Estados de Mato Grosso, do Tocantins, de Rondônia, do Pará e do Maranhão. Os seguintes indicadores de hanseníase foram calculados por 100.000 habitantes: taxa de incidência de hanseníase, taxa de incidência em menores de 15 anos e a taxa de casos novos com grau 2 de incapacidade (por 100.000 habitantes). A estatística espacial *scan* foi usada para detectar *clusters* significativos ($p \leq 0,05$) na área de estudo. ***Resultados:*** No período 2001 – 2003, a estatística espacial *scan* identificou 44 *clusters* significativos para a taxa de incidência da hanseníase, e 42 *clusters* significativos no período 2010 – 2012. No período 2001 – 2003, foram identificados 20 *clusters* significativos para a taxa de incidência em menores de 15 anos, e 14 *clusters* significativos no período 2010 – 2012. Para a taxa de casos novos com grau 2 de incapacidade, a estatística *scan* identificou 19 *clusters* significativos no período 2001 – 2003, e 14 agrupamentos significativos no triênio 2010 – 2012. ***Conclusão:*** Apesar da redução na detecção de casos de hanseníase, há uma necessidade de intensificar as ações de controle da doença, especialmente nos *clusters* identificados.

Palavras-chave: Hanseníase. Estudos ecológicos. Análise espacial. Vigilância epidemiológica. Análise por conglomerados. Doenças transmissíveis.

INTRODUCTION

Leprosy is a chronic disease caused by the bacillus *Mycobacterium leprae*, which affects mostly the skin and the peripheral nerves[1,2], and represents a public health issue in some parts of the world, including Brazil. According to a report by the World Health Organization (WHO), in 2014, 213,899 new cases of leprosy were notified in the world. In Brazil, in the same year, 31,064 new cases of leprosy were notified. Of these, 2,341 (7.5%) new cases corresponded to people aged less than 15 years, and 2,034 (6.5%) patients presented grade 2 disabilities[3].

To intensify the strategies of intervention and control of leprosy in specific geographic zones, the spatial analysis has been used by identifying the distribution of the condition in a national, regional and local level[4-8].

In Brazil, the spatial distribution of leprosy is heterogeneous: the States that are more socioeconomically developed in the South Region reached the goal of eliminating leprosy as a public health issue — prevalence of less than 1 case per 10,000 inhabitants. However, pockets of high load of the disease remain in the North, Center-West and Northeast regions of Brazil, considered the areas where the disease is mostly transmitted in the country[1,8-10].

A cluster analysis conducted in 2009 by the Ministry of Health showed that the States of Mato Grosso, Tocantins, Rondônia, Pará and Maranhão are still areas with high risk of persistent transmission of leprosy[10]. Recently, systems of geographic information and spatial analysis became important tools for the epidemiology, helping to understand the dynamics of transmission of several diseases. These results may be used as guides to elaborate programs to control leprosy, aiming at directing the intervention for high-risk areas[6,8,11]. Therefore, getting to know the spatial and temporal patterns of the disease in the cities of these States is essential to provide subsidies to plan for surveillance actions and to control the disease.

Therefore, the objective of this study was to describe the spatial distribution of leprosy in a group of Brazilian cities with high risk of transmission of this disease.

METHODS

An ecological study, with spatial analysis, was conducted using data from the Notifiable Diseases Information System (SINAN)[12], in the years 2001 – 2003 and 2010 – 2012. The units of study analysis were the 692 cities in the States of Mato Grosso, Tocantins, Rondônia, Pará and Maranhão. This group is located in the central area of Brazil (Figure 1). The study area occupies 2,998,569 km^2 and, according to the Demographic Census 2010, its total population was 20.1 million inhabitants, which represents 10.6% of the Brazilian population.

In the years 2001 – 2003 and 2010 – 2012, the following epidemiological indicators of leprosy were calculated for the cities in the group: incidence rate of leprosy/100,000

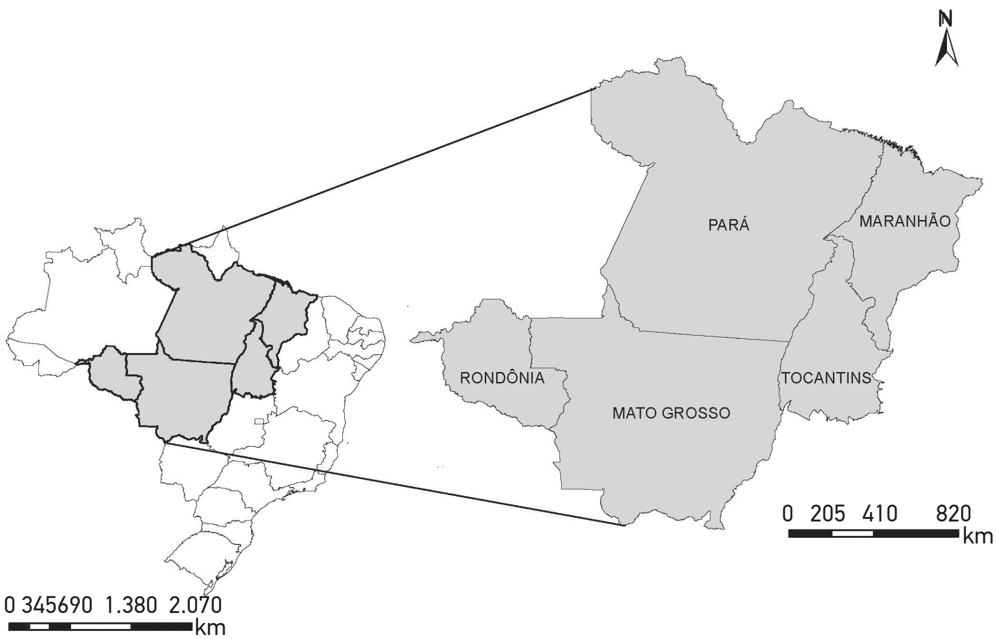

Figure 1. Study area: all municipalities in the States of Mato Grosso, Tocantins, Rondônia, Pará and Maranhão.

inhabitants, incidence rate in people aged less than 15 years/100,000 inhabitants, and rate of new cases with grade 2 disabilities/100,000 inhabitants. The size of the resident population in 2010, used as a denominator, came from Census 2010, and the other years used in this study were obtained from intercensal projections produced by the Brazilian Institute of Geography and Statistics (IBGE)[12,13].

The spatial statistics scan was used to detect significant clusters inside the study area in the analyzed period. This technique is defined by a circular geographic window that moves around the area of interest[14,15]. The method identifies one region, formed by all areas with the respective centroids inside the circle, and tests the constant risk null hypothesis *versus* the alternative hypothesis that there is high risk of occurrence of events inside the window, in comparison to the outside. The model with the Poisson distribution was used. This model is based on a number of events (cases of leprosy) distributed according to a known population at risk[16,17]. The statistical significance was evaluated considering $p \leq 0.05$ (likelihood ratio test). The *clusters* were identified using a purely spatial analysis[14], with a search radius of up 100 km[7].

The analyses were conducted with the softwares *SatScan* 9.3[18] and *ArcGis* 9.2 (*Environmental Systems Research Institute*, *Redlands*, CA, USA)[19].

This study was approved by the Research Ethics Committee in the School of Health Sciences of Universidade de Brasília, CAAE 20249613.9.0000.0030 and Report n. 392.809, issued on September 10, 2013. This study was conducted exclusively with secondary data, of public access, without identification of subjects, and its procedures are in accordance with the principles of ethics in research involving human beings.

RESULTS

From 2001 – 2012, 176,929 cases of leprosy were notified in the group of cities, which is equivalent to 34.6% of all cases in Brazil. In the cluster, from 2001 – 2003, 404 (58.4%) cities were classified as hyperendemic (mean annual incidence rate higher than 40 cases/100,000 inhabitants), with maximum value of 538.5 cases per 100,000 inhabitants. On the other hand, from 2010 – 2012, 402 (58.1%) cities were classified as hyperendemic, with maximum value of 314.5 cases per 100,000 inhabitants.

From 2001 – 2003, the spatial statistics scan identified 44 significant clusters for the incidence rate of leprosy. Of these, 30 are located in the States of Pará (12) and Mato Grosso (18). On the other hand, from 2010 – 2012, 42 significant clusters were identified for the incidence rate of leprosy. Of these, 28 are located in the States of Pará (11) and Mato Grosso (17) (Table 1). Also, 20 significant clusters were identified for the incidence rate of leprosy in adolescents aged less than 15 years, from 2001 – 2003, of which 7 are located in the State of Pará. From 2010 – 2012, the spatial statistics scan identified 14 significant clusters for the incidence rate in adolescents aged less than 15 years.

For the rate of new cases with grade 2 disabilities, the spatial statistics scan identified 19 significant clusters from 2001 – 2003, of which 7 are located in the State of Pará. From 2010 – 2012, the spatial statistics scan identified 14 significant clusters for this rate, with homogeneous concentration among the 5 Brazilian states belonging to the group (Table 1).

Table 1. Clusters most significant statistically* defined by using the spatial scan statistic, according to indicators and periods.

2001 – 2003				2010 – 2012			
Cluster – Central municipality (FU)	N. of municipalities	Annual rate	Relative risk	*Cluster* – Central municipality (FU)	N. of municipalities	Annual rate	Relative risk
Taxa de incidência							
1. Canaã dos Carajás (PA)	8	292.5	3.20	1. Marituba (PA)	1	221.6	3.76
2. Açailândia (MA)	15	201.6	2.23	2. Nova Guarita (MT)	12	155.1	2.63
3. Jacundá (PA)	9	267.2	2.92	3. Itinga do Maranhão (MA)	4	141.7	2.40
4. Brejo de Areia (MA)	29	230.1	2.49	4. Bom Jardim (MA)	11	110.1	1.87
5. Conceição do Araguaia (PA)	14	156.5	1.72	5. Sinop (MT)	5	129.4	2.19
Taxa de incidência em < 15 anos							
1. Canaã dos Carajás (PA)	8	104.4	4.15	1. Dom Eliseu (PA)	5	53.7	3.16
2. Açailândia (MA)	15	65.6	2.63	2. Conceição do Lago.Açu (MA)	34	31.8	1.91
3. Jacundá (PA)	9	76.9	3.05	3. Canaã dos Carajás (PA)	8	44.9	2.63
4. Brejo de Areia (MA)	29	49.4	1.96	4. Jacundá (PA)	9	35.2	2.05
5. Conceição do Araguaia (PA)	14	76.3	2.97	5. Jacareacanga (PA)	1	96.5	5.54
Taxa de casos novos com grau 2 de incapacidade							
1. Monte Negro (RO)	5	20.1	5.40	1. Marituba (PA)	1	22.3	7.01
2. Marituba (PA)	1	21.8	5.79	2. Bela Vista do Maranhão (MA)	2	33.3	10.28
3. Açailândia (MA)	15	8.8	2.38	3. Carlinda (MT)	9	10.8	3.35
4. São Luís Gonzaga do Maranhão (MA)	5	12.5	3.33	4. Ruronópolis (PA)	1	20.2	6.23
5. São João dos Patos (MA)	1	34.2	8.97	5. Rolim de Moura (RO)	3	14.8	4.58

*Significant clusters with $p < 0.05$, FU: Federation Unit; PA: Pará; MA: Maranhão; RO: Rondônia; MT: Mato Grosso.

Figure 2 shows the 15 most significant clusters for the incidence rate of leprosy, from 2001 – 2003 and 2010 – 2012. Of these, the overlapping of three clusters with the same main municipality stands out (Marituba, Altamira and Paragominas), located in the State of Pará, and the city of Araguaiana, in Mato Grosso, which are among the 15 most significant clusters. From 2001 – 2003, the most significant cluster included eight municipalities in Pará. On the other hand, from 2010 – 2012, the most significant cluster included only the city of Maratuba, located in the Metropolitan region of Belém.

Figure 3 shows the 15 most significant clusters for the incidence rate of leprosy in adolescents aged less than 15 years from 2001 – 2003 and 2010 – 2012. Of these, the overlapping of three clusters with the same main city stands out (Itaituba, Marituba and São João do Araguaia), located in the State of Pará, and the city of Ariquemes, in Rondônia. From 2001 – 2003, the most significant cluster included eight cities in Pará. On the other hand, from 2010 – 2012, the most significant cluster included five cities, also located in Pará.

Figure 4 shows the 14 most significant clusters for the rate of new cases with grade 2 disabilities, between 2001 – 2003 and 2010 – 2012. Of these, the overlapping of only one cluster with the same main municipality stands out, located in the city of Marituba (Pará). From 2001 – 2003, the most significant cluster included five cities of Rondônia. On the other hand, from 2010 – 2012, the most significant cluster included only the city of Marituba (Pará).

Figure 2. Most significant clusters for the incidence rate of leprosy (per 100,000 inhabitants) defined by using the spatial scan statistics, according to periods 2001 – 2003 and 2010 – 2012. Brazil, 2001 – 2012.

Figure 3. Most significant clusters for the incidence rate in adolescents aged less than 15 years (per 100,000 inhabitants), defined by using the spatial scan statistics, according to periods 2001 – 2003 and 2010 – 2012. Brazil, 2001 – 2012.

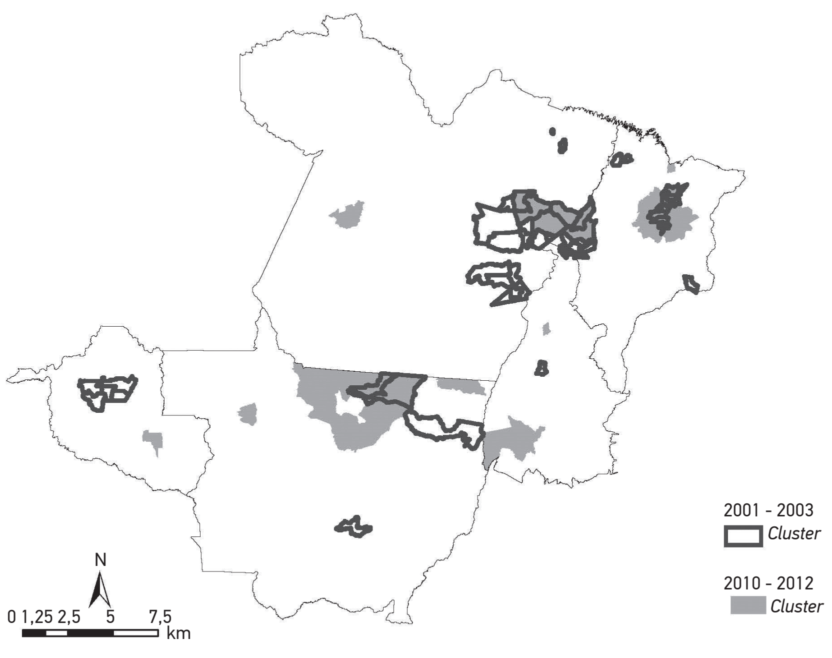

Figure 4. Most significant clusters for the rate of new cases with grade 2 disabilities (per 100,000 inhabitants), defined by using the spatial scan statistics, according to periods 2001 – 2003 and 2010 – 2012. Brazil, 2001 – 2012.

There was an overlap of 17 clusters with the same main municipality for the 3 indicators in the period of 2010 – 2012. The States of Mato Grosso, Maranhão and Pará stand out, which, together, concentrated 13 of these clusters. On the other hand, among the indicators incidence rate and rate of new cases with grade 2 disabilities, there was an overlap of 11 clusters with the same main municipality in the period of 2010 – 2012.

DISCUSSION

This study analyzed the group of Brazilian municipalities that concentrates 34.6% of all cases of leprosy notified in the country, from 2001 – 2012. In this group, 58% of the cities were classified as hyperendemic, in both analyzed periods. The spatial analysis allowed to identify the statistically significant clusters for the three indicators analyzed. In this analysis, the States of Pará and Mato Grosso stood out, which, together, presented the highest number of clusters for the incidence rate of leprosy, in both periods. Besides, some clusters were identified (n = 17) in which there were overlaps of high rates for the three indicators analyzed.

Studies have been showing the tendency of temporal reduction of different indicators of leprosy in Brazil. The prevalence rate in Brazil fell from 4.52 to 1.42 per 10,000 inhabitants between 2003 and 2013[20]. Besides, Freitas et al.[9], studying the same group of municipalities in this study, described a temporal trend of reduction in the incidence rate of leprosy, from 89.10 to 56.98 per 100,000 inhabitants, between 2001 and 2012[9]. The temporal reduction of some leprosy indicators is not coherent with the fact that the disease persists with high magnitude, and as a relevant public health issue in Brazil. In fact, the pace of reduction of leprosy indicators in Brazil, although relevant, seems to not be sufficient to reach the goal of eliminating the disease as a public health issue (prevalence < 1 case per 10,000 inhabitants), as proposed by the WHO[20,21]. Besides, leprosy presents geographic distribution that is also persistent in some geographic áreas of the Centerwest, North and Northeast regions of the country[9,20]. In fact, this study showed the overlapping of the clusters in both periods temporally separated in ten years, which reinforces the idea of temporal and geographic persistence of the indicators of the analyzed condition. Other authors have shown the persistence of the geographic distribution of leprosy and its spatial concentration[7,8,10,16,22-24]. For example, the clusters identified for the incidence rate of leprosy and for the incidence rate in adolescents aged less than 15 years are in areas similar to those mentioned in previous studies[7,10,22]. Alencar et al.[7], by using the same methodology of analysis and the same indicators of this study — however, in different geographic area and period (2001 – 2009) — identified 23 significant clusters for the incidence rate of the disease. In the common geographic área between the present study and that by Alencar et al.[7], concerning the incidence rate (with the same main municipality), it was observed that, in the period of 2001 – 2003, nine clusters were coincident, whereas three clusters were coincident in the period of 2010 – 2012. Besides, it is worth to mention the overlapping of clusters with high rates for the three indicators analyzed in this study, showing high risk of incidence of leprosy, active transmission of the disease and late diagnosis.

Several explanations can be given for these findings. Among them, some stand out:

1. the ones connected with the social vulnerabilities of the geographic areas;
2. those related with quality of health care;
3. the ones related with the quality of information in health as an element of distortion of the results analyzed.

As to the social vulnerabilities of the population, several studies have been pointing out to its association with the risk of leprosy[6,9,25-31]. In particular, Freitas et al.[9], in a recent national study, mention some ecological aspects significantly associated with higher incidence rates of leprosy among the cities in Brazil. In this matter, the authors highlight higher rate ratios between cities with high levels of illiteracy, larger population, higher proportion of households with inadequate sanitation, higher levels of urbanization, higher mean number of people per rooms in the households, and more income inequality, measured by the Gini Index[9]. Besides, Silva et al.[32], in an ecological study carried out in the Brazilian Amazon, describe there is evidence of association between intensive deforestation and high incidence rates of leprosy, also highlighting the precarious social conditions of the cities analyzed[32]. Therefore, according to this reference, the explanations for the persistence of leprosy in statistically significant clusters for decades, described in this study and by other authors, may be a consequence of the persistence of poverty pockets and precarious life conditions of these populations. Therefore, the initiatives to face that should include actions of income distribution, social inclusion and improvement of life conditions in general.

As to the explanations related with the quality of health care, it is important to consider that, even though there is not an effective vaccine, leprosy is treatable, and the treatment is free in the entire country. When associated with other control measurements, it strongly limits the transmission potential of the disease[33]. Therefore, it is plausible to assume that qualified health care, guided by equity, has the potential to increase the healing chances and to minimize the exposure of the population to the sickness. The early diagnosis of the condition, adherence to treatment (followed by non-abandonment) and the strengthening of prevention actions and disease control are certainly relevant elements that can contribute with the control of leprosy in the more vulnerable Brazilian populations. The lack of these elements may, in a way, explain the persistence of leprosy for at least ten years in some clusters identified in this study and by other authors[7,10,22].

The explanations related with the quality of information in health as an element of distortion of the results analyzed, as well as other limitations related with the use of secondary surveillance data, are worth of consideration. The under-notification of cases may be associated with the existence of asymptomatic or oligosymptomatic cases, with the precariousness in surveillance services to identify and notify the cases, and with the areas that are geographically difficult to access, therefore making it difficult to reach the health services. Freitas et al.[9] observed a gradient increment in the incidence rates of leprosy (attenuated) in the Brazilian cities when the proportion of coverage of the Family Health Program (PSF) units increased, and when the percentage of examinated contacts increased[9,34]. This fact may point to the existence of under-notification of cases, which, gradually, may be overcome when the basic care services improve their ability and quality. Even though this study adopted the term "incidence rate" for the new notified cases, these findings reinforce the idea that this measure reflects both the incidence of the disease and the ability of detecting new cases. The motivation was used to give relevance to these outcomes, such as population morbidity load, ad not only statistics of notified cases. On the other hand, it is important to notice that the "incidence rate" of leprosy estimated here is an underestimation of the real incidence rate, since it is based only on the notified cases[33]. Besides, Richardus and Habbema[35] warn us that the trends in the detection rates of new cases of the disease only reflect the trend in the incidence rates, unless there is not any major change in the probability of detecting cases throughout the studied years.

Other limitations may be related with the methodological options of this study, which used the municipality as the smallest unit of analysis. It is worth to remember that, even inside the Brazilian municipalities, important variations of the leprosy indicators can be found and require an analysis. In fact, a study conducted in the municipality of Castanhal (Pará) identified an intra-municipal heterogeneity in the distribution of leprosy, with significant clusters of high and low rates of disease detection[8]. Therefore, an intra-municipal description of the clusters identified as significant in this study should be approached in further analyses. Besides, the interpretation of the "persistence" of a specific cluster should be seen considering that clusters are defined based on a main municipality. Another limitation, related with the scan spatial statistics, is that clusters are always defined as circles or ellipses. In this sense, an area with low frequency of cases surrounded by areas with a higher number of cases can be included in a cluster, even though their characteristics may be different[17]. Besides, the scan spatial statistics uses the geographic coordinates of the municipality as a geographic reference, which may not reflect the real distribution of cases inside the cities[7].

Some of the limitations can be minimized by the conduction of more detailed analysis in the cities involved in the identified clusters, therefore allowing identifying the profile of the disease and defining more specific control strategies.

CONCLUSION

The geographic and temporal persistence of leprosy described in this study points to the need to search for new control strategies in these areas, where there is a risk of overlapping. In this study, as well as in others with intra-municipal approaches, it is possible to guide the detection of priority areas, with higher vulnerability for the diseases, recommending more effective interventions. The dissociation between the three indicators analyzed allows reflecting about the quality of information and surveillance systems, and points to new strategies of investigation in this theme.

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REFERENCES

1. Brasil. Ministério da Saúde. Portaria Conjunta nº 125, de 26 de março de 2019, que define ações de controle da hanseníase. Brasília: Ministério da Saúde; 2009.
2. Walker SL, Lockwood DNJ. The clinical and immunological features of leprosy. Br Med Bull 2006; 77-78(1): 103-21. DOI: 10.1093/bmb/ldl010
3. World Health Organization (WHO). Global leprosy update, 2014: need for early case detection. Wkly Epidemiol Rec 2015; 90(36): 461-76.
4. Bakker MI, May L, Hatta M, Kwenang A, Klatser PR, Oskam L, et al. Genetic, household and spatial clustering of leprosy on an island in Indonesia: a population-based study. BMC Med Genet 2005; 6: 40. DOI: 10.1186/1471-2350-6-40
5. Fischer EAJ, Pahan D, Chowdhury SK, Richardus JH. The spatial distribution of leprosy cases during 15 years of a leprosy control program in Bangladesh: an observational study. BMC Infect Dis 2008; 8: 126. DOI: 10.1186/1471-2334-8-126
6. Queiroz JW, Dias GH, Nobre ML, Dias MCDS, Araújo SF, Barbosa JD, et al. Geographic information systems and applied spatial statistics are efficient tools to study Hansen's disease (leprosy) and to determine areas of greater risk of disease. Am J Trop Med Hyg 2010; 82(2): 306-14. DOI: 10.4269/ajtmh.2010.08-0675
7. Alencar CH, Ramos Jr AN, Santos ES, Richter J, Heukelbach J. Clusters of leprosy transmission and of late diagnosis in a highly endemic area in Brazil: focus on different spatial analysis approaches. Trop Med Int Health 2012; 17(4): 518-25. DOI: 10.1111/j.1365-3156.2011.02945.x
8. Barreto JG, Bisanzio D, Guimarães LS, Spencer JS, Vazquez-Prokopec GM, Kitron U, et al. Spatial analysis spotlighting early childhood leprosy transmission in a hyperendemic municipality of the Brazilian Amazon region. PLoS Negl Trop Dis 2014; 8(2): e2665. DOI: 10.1371/journal.pntd.0002665
9. Freitas LR, Duarte EC, Garcia LP. Leprosy in Brazil and its association with characteristics of municipalities: ecological study, 2009-2011. Trop Med Int Health 2014; 19(10): 1216-25. DOI: 10.1111/tmi.12362
10. Penna ML, Oliveira ML, Penna GO. The epidemiological behaviour of leprosy in Brazil. Lepr Rev 2009; 80(3): 332-44.
11. Brasil. Ministério da Saúde. Saúde Brasil 2013: uma análise da situação de saúde e das doenças transmissíveis relacionadas à pobreza. In: Distribuição espacial das doenças relacionadas à pobreza no Brasil. Brasília: Ministério da Saúde; 2014. p. 287-324.
12. Brasil. Ministério da Saúde. DATASUS; Portal da Saúde 2014. [Internet]. Disponível em: http://tabnet.datasus.gov.br (Acessado em 20 março de 2014).
13. Brasil. Instituto Brasileiro de Geografia e Estatística (IBGE). Sinopse do Censo Demográfico 2010. Brasília: IBGE; 2011.
14. Kulldorff M, Nagarwalla N. Spatial disease clusters: detection and inference. Stat Med 1995; 14(8): 799-810.
15. Kulldorff M. A spatial scan statistic. Commun Stat Theory Methods 1997; 26(6): 1481-96. DOI: 10.1080/03610929708831995
16. Scheelbeek PFD, Balagon MVF, Orcullo FM, Maghanoy AA, Abellana J, Saunderson PR. A retrospective study of the epidemiology of leprosy in Cebu: an eleven-year profile. PLoS Negl Trop Dis 2013; 7(9): e2444. DOI: 10.1371/journal.pntd.0002444
17. Brasil. Ministério da Saúde. Secretaria de Vigilância em Saúde. Departamento de Vigilância Epidemiológica. Sistema de Informação de Agravos de Notificação–Sinan: normas e rotinas. Brasília: Ministério da Saúde; 2006.
18. Kulldorff BM. SaTScan User Guide for version 9.3. [Internet]. Disponível em: http://www.satscan.org (Acessado em 14 de maio de 2014).
19. ArcGis 9.2. [computer program]. Redlands (CA): ESRI; 2010.

20. Radis comunicação e saúde. Problema persistente. Revista Radis 2015. [Internet]. Disponível em: http://www6.ensp.fiocruz.br/radis/revista-radis/150/reportagens/problema-persistente (Acessado em 22 de outubro de 2015).
21. World Health Organization (WHO). Weekly epidemiological record. Geneva: WHO; 2010; 85(35): 337-48.
22. Alencar CH, Ramos AN, Barbosa JC, Kerr LR, Oliveira ML, Heukelbach J. Persisting leprosy transmission despite increased control measures in an endemic cluster in Brazil: the unfinished agenda. Lepr Rev 2012; 83(4): 344-53.
23. Cury MRCO, Paschoal VDA, Nardi SMT, Chierotti AP, Rodrigues AL, Chiaravalloti-Neto F. 2012. Spatial analysis of leprosy incidence and associated socioeconomic factors. Rev Saúde Pública 2012; 46(1): 110-8. DOI: 10.1590/S0034-89102011005000086
24. Duarte-Cunha M, Souza-Santos R, Matos HJ, Oliveira ML. Aspectos epidemiológicos da hanseníase: uma abordagem espacial. Cad de Saúde Pública 2012; 28(6): 1143-55. DOI: 10.1590/S0102-311X2012000600013
25. Ponnighaus JM, Fine PE, Sterne JA, Bliss L, Malema SS, Kileta S. Incidence rates of leprosy in Karonga District, northern Malawi: patterns by age, sex, BCG status and classification. Int J Lepr Other Mycobact Dis 1994; 62(1): 10-23.
26. Kerr-Pontes LR, Barreto ML, Evangelista CM, Rodrigues LC, Heukelbach J, Feldmeier H. Socioeconomic, environmental, and behavioural risk factors for leprosy in North-east Brazil: results of a case-control study. Int J Epidemiol 2006; 35(4): 994-1000. DOI: 10.1093/ije/dyl072
27. Imbiriba EN, Silva AL, Souza WV, Pedrosa V, Cunha M G, Garnelo L. Desigualdade social, crescimento urbano e hanseníase em Manaus: abordagem espacial. Rev Saúde Pública 2009; 43(4): 656-65. DOI: 10.1590/S0034-89102009005000046
28. Sales AM, Ponce de Leon A, Duppre NC, Hacker MA, Nery JA, Sarno EM, et al. Leprosy among patient contacts: a multilevel study of risk factors. PLoS Negl Trop Dis 2011; 5(3): e1013. DOI: 10.1371/journal.pntd.0001013
29. Suzuki K, Akama T, Kawashima A, Yoshihara A, Yotsu RR, Ishii N. Current status of leprosy: epidemiology, basic science and clinical perspectives. J Dermatol 2012; 39(2): 121-9. DOI: 10.1111/j.1346-8138.2011.01370.x
30. Moura ML, Dupnik KM, Sampaio GA, Nóbrega PF, Jeronimo AK, Miranda Dantas RL, et al. Active surveillance of Hansen's Disease (leprosy): importance for case finding among extra-domiciliary contacts. PLoS Negl Trop Dis 2013; 7(3): e2093. DOI: 10.1371/journal.pntd.0002093
31. Cabral-Miranda W, Chiaravalloti Neto F, Barrozo LV. Socio-economic and environmental effects influencing the development of leprosy in Bahia, north-eastern Brazil. Trop Med Int Health 2014; 19(12): 1504-14. DOI: 10.1111/tmi.12389
32. Silva DR, Ignotti E, Souza-Santos R, Hacon SSouza. Hanseníase, condições sociais e desmatamento na Amazônia brasileira. Rev Panam Salud Publica 2010; 27(4): 268-75. DOI: 10.1590/S1020-49892010000400005
33. Noordeen SK. Elimination of leprosy as a public health problem: progress and prospects. Bull World Health Organ 1995; 73(1): 1-6.
34. Nery JS, Pereira SM, Rasella D, Penna ML, Aquino R, Rodrigues LC, et al. Effect of the Brazilian conditional cash transfer and primary health care programs on the new case detection rate of leprosy. PLoS Negl Trop Dis 2014; 8(11): e3357. DOI: 10.1371/journal.pntd.0003357
35. Richardus JH, Habbema JD. The impact of leprosy control on the transmission of M. leprae: is elimination being attained? Lepr Rev 2007; 78(4): 330-7.

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