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Original Article

Spatial Distribution of Leprosy Cases Notified in a Reference Center in the Municipality of Várzea Grande – MT, Brazil

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The spatial distribution can be mapped and analyzed for a better understanding of any disease's involvement with any/ Brazilian population. The objective of this study was to analyze the spatial distribution of leprosy cases reported in a reference center in the city of Várzea Grande - MT from 2016 to 2019. This is an observational and descriptive epidemiological study, with an ecological distribution nature. The information was extracted from the SINAN form. For the epidemiological profile, annual leprosy detection rates and proportions were calculated according to clinical form, neighborhood, mode of entry, smear, operational classification, number of affected nerves and skin lesions and degree of disability. In the spatial analysis, the empirical Bayesian model of global smoothing was used, established with the aid of the software GeoDa 1.20. A municipal detection rate of 38.4 per 100 thousand inhabitants was observed, with a predominant borderline clinical form with 70.8%, 62.4% cases with more than 6 skin lesions, 45.2% without neural involvement, 36.3% with disability degree 0, 85.4% were new cases registered and 50.7% did not undergo smear microscopy. The spatial distribution of leprosy cases in Várzea Grande has been associated with a low population quality of life, which includes basic sanitation and access to basic units.

Key words : Demographic Analysis, Leprosy, Basic Sanitation, Brazil

Introduction

Leprosy is a chronic, slow-progressing infectious disease caused by *Mycobacterium leprae*, which has high infectivity and low pathogenicity, i.e. it infects many people, but only a few develop clinical symptoms. The agent is an obligate intracellular bacterium with tropism for skin macrophages and Schwann cells in peripheral nerves, which can cause neural damage. As a result of this involvement, there are thermal, painful and tactile sensitivity disorders, atrophies and paresis that can progress to physical disabilities (Kubota et al 2014). The main form of transmission is believed to be mainly through the upper respiratory tract, with probable propagation of aerosols from oral or nasal secretions of infected and untreated individuals, through the uptake of the respiratory mucosa (Marks 2014).

In Brazil, leprosy is classified according to its clinical form as: Indeterminate, tuberculoid, borderline and lepromatous. Operationally, the

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first two are called paucibacillary (PB), when there are few bacilli present. The others are classified as multibacillary (MB), when there is a high amount of bacillary and the presence of more accentuated lesions. Leprosy is a public health problem, its treatment is performed exclusively in the Unified Health System (SUS), treatment is based on multidrug therapy, introduced in Brazil in 1991 by the Ministry of Health (Tavares et al 2013).

In Brazil, in the years between 2014 and 2018, 140,578 new cases of leprosy were reported, totaling an average detection rate of 13.7/100,000 inhabitants. In Mato Grosso, the indicators show only in the year 2018, it obtained a rate of 62.08/100 thousand inhabitants (Ministry of Health Brazil 2018).

The spatial distribution of diseases can be mapped and analyzed through the Geographic Information System (GIS) which is capable of containing geographic information, containing graphic analysis of epidemiological indicators, and its use is recommended by the World Health Organization (WHO) in all endemic countries (WHO 2005).

As spatial distribution of cases is useful to understand the epidemiology of any disease including leprosy (source, possible factors responsible/ associated with endemicity), such studies have local, regional, national and international relevance. the objective of this study was to analyze the spatial distribution of leprosy cases reported in a reference center in the city of Várzea Grande - MT.

Materials and Methods

This is an observational and descriptive epidemiological study, with an ecological basis, with a spatial distribution of new cases of leprosy diagnosed in the outpatient clinic of the secondary health care network in the municipality of Várzea Grande, between the years 2016 to 2019. The municipality of Várzea Grande is located in the state of Mato Grosso, in the mesoregion of Center-South Matogrossense, with an estimated population of 287,526 inhabitants in the year 2020. According to the Brazilian Institute of Geography and Statistics (IBGE), it is the second largest city in the state (BR-IBGE). In recent years, there has been a high number of new cases detected. The annual detection rate of the municipality has been growing in a disorderly way, being possibly influenced by operational factors, such as the number of trained professionals working in infectious diseases.

Data collection related to the cases was based on the notification forms of the Notifiable Diseases Information System (SINAN). New cases diagnosed at the Health Specialties Center (CES) from January 2016 to December 2019 were included. dermatology and infectious diseases, which reports around 70% of the total annual cases of leprosy in the city. Cases with failure to fill in the address information, and/or cases whose diagnosis had not been performed at the CES were excluded from the study.

Population, socioeconomic data and digital mesh for the municipality of Várzea Grande were obtained from the IBGE. The extracted population corresponds to the year 2010, aggregated by census sectors. In order to obtain the population by neighborhood, the population information of the sectors corresponding to each neighborhood was added. The socioeconomic variables also correspond to the last sense (Census) carried out (2010), and the following variables were included: proportion of households without water distribution through the network; proportion of households that do not have a bathroom; proportion of households without garbage collection service; proportion of households with 7 or more residents; proportion of literate people aged 60 or over. The digital mesh obtained from the IBGE is aggregated by neighborhood

and it has 52 registered neighborhoods. For the analyses, the neighborhoods of residence of the cases were redistributed according to the mesh available in the year 2010 (BR-IBGE 2010).

For the epidemiological profile, annual leprosy detection rates were calculated, per 100,000 inhabitants, and the proportions according to: according to the Madrid classification (Azulay 1954), clinical form (indeterminate, tuberculoid, borderline and lepromatous), neighborhood of residence, mode of entry (new case, re-admission, other municipality, same municipality), skin smear tests (negative, positive, not performed), operational classification (paucibacillary and multibacillary), number of affected nerves (0, 1, 2, 3, more than 3, not informed), number of skin lesions (0 to 5, above 6) and degree of physical disability (Ministry of Health Brazil 2016) in diagnosis (0, 1, 2, not evaluated). The detection rate was classified according to the parameters adopted by the Ministry of Health: low (<2.0/100,000 inhabitants), medium (2.0 - 9.99/100,000 inhabitants), high (10.00 – 19.99 / 100,000 inhabitants), very high (20.00 – 39.99 / 100,000 inhabitants) and hyperendemic (> 40.0 / 100,000 inhabitants) (Ministry of Health Brazil 2016).

For spatial distribution of detection rates, the empirical Bayesian model of global smoothing was used, taking a neighborhood pattern, defined by adjacency and established with the aid of the GeoDa 1.20 software, which points, for each municipality, the vector of neighboring municipalities. The use of the Bayesian technique reduces random fluctuation, caused mainly by the large differences in the populations of the analyzed neighborhoods (Souza et al 2007). In this case, the use of the technique aims to build maps of the average detection rates of the municipalities. Rates were calculated using a 2-year moving average (2016-2017, 2017-2018, 2018-2019). Maps were also constructed showing the spatial distribution of the proportions of multibacillary cases, and the proportion of reported cases with some physical disability at the time of diagnosis (1 or 2).

In the spatial analysis, the SCAN spatial scanning technique was used, on the hypothesis that leprosy cases would form clusters in space. For this, the program SatScan version 9.6[11] was used (Kulldorf 2018). In addition to identifying the spatial conglomerates, the Relative Risk (RR) method, which represents how much an area is more or less likely to have the presence of the event in relation to other areas of the entire territorial extension studied. For the present study, high-risk clusters for the occurrence of leprosy were analyzed. To perform the statistics, at the neighborhood level, using the Discrete Poisson Distribution model, points with plane coordinates (X, Y) of the centroids of each neighborhood were used. And to evaluate the significance, the Monte Carlo simulation was performed.

For the distribution and spatial analysis, new cases were grouped according to the neighborhood of residence, including all neighborhoods in the urban area of Várzea Grande, and redistributed according to the IBGE's digital grid. For the construction of the maps, the ArcGis 10.5 software was used.

At SINAN there was a record of 1,104 patients in the analyzed period, with 773 reported cases only in the CES. Of these, 63 forms were excluded because they were incomplete. The other 331 notification forms registered in other health units were not used in this study.

Results

Epidemiology of leprosy in Várzea Grande

Between 2016 and 2019, 1104 Leprosy cases were identified in the municipality, obtaining a

detection rate for this period of 38.4 / 100,000 inhabitants, being classified according to the Ministry of Health as a very high municipality in relation to the detection rate.

In the present study, the predominant clinical form in total in years is borderline with 503 (70.8%) of the cases, followed by tuberculoid with 125 (17.6%), lepromatous with 73 (10.3%) and indeterminate with 9 (1.3%) (Table 1).

It was also observed that 443 (62.4%) of the patients had more than 6 lesions at the time of diagnosis and 267 (37.6%) of the cases had 0 to 5 lesions. In this context, 134 (18.9%) of the cases were treated with a PB polychemotherapy (multi-drug treatment MDT using 6 supervised monthly doses of rifampicin and self-administered dapsone) regimen and 576 (81.1%) with MB – MDT (MDT using 12 monthly supervised doses of rifampicin, clofazimine and dapsone, in addition to the self-administered dose of clofazimine and dapsone) (Table 1).

Regarding the total number of affected nerves in years, 341 (45.2%) of the patients had no nerve involvement and 195 (25.8%) of them were not evaluated (Table 1).

Regarding the degree of disability, there was a predominance of 258 (36.3%) cases classified as 0, followed by 205 (28.9%) with grade 1 and 34 (4.8%) grade 2. However, 213 (30%) of the patients were not evaluated to obtain their degree of disability, there is a predominance of this fact in the years 2018 and 2019, with 116 (57.7%) and 67 (47.5%) of the cases, respectively (Table 1).

As for the mode of entry of reported patients, it is clear that most, 607 (85.4%) were new cases, followed by 53 (7.5%) re-entry, 23 (3.3%) transferred from other units to the CES outpatient clinic, 22 (3.1%) were not informed and 5 (0.7%) were transferred from other municipalities (Table 1).

Most patients (360, 50.7%) did not undergo smear microscopy. However, among the patients who underwent it, 278 (79.4%) had a negative result and 72 (20.6%) had a positive result. Among the positives, 36 (50%) had a borderline clinical form and 36 (50%) were lepromatous (Table 1).

In the municipality, there is the intermediate report with content relevant to the revision of the guidelines and the desired scenario for the elaboration of the municipal master plan of Várzea Grande. This report aims to present the main points of the diagnosis in a condensed way to facilitate the dissemination of main points of the municipality in the analysis of several factors. Among them, sociocultural aspects can be observed, especially in urban areas such as education, culture and regions where there is greater coverage of health care, with heterogeneous distribution for education and more homogeneous (centralized) for health units. In terms of infrastructure, emphasis is placed on regions with urban paving and water supply in the municipality (Fig. 1, State of Mato Grosso 2021).

In Brazil, 46.3% of the sewage generated is treated. The 2018 SNIS (National Sanitation Information System) showed that in Várzea Grande (MT) the total sewage service rate makes up 29.14% of the population, and the total water service rate is 89.29%. The water system serves 93% of the population, with a loss of 75% and only 25% of the hydrometer with effective operation. The sanitary sewage system serves 13.93% of the households and the rest of the population is conditioned to the use of septic tanks or sedimentary cesspools (Fig. 2, Ministry of Regional Development 2021).

Distribution and spatial analysis

For distribution and spatial analysis, cases residing in rural areas or with failure to fill in the address neighborhood were excluded,

Table 1 : Annual supplementary data on the variables collected.

Variable	2016	2017	2018	2019	Total Years
Notifications	163 (23%)	205 (28.9%)	201 (28.3%)	141 (19.8%)	710 (100%)
Clinical form	-				
Tuberculoid	45 (27.6%)	30 (14.6%)	29 (14.4%)	21 (14.9%)	125 (17.6%)
Borderline	106 (65%)	150 (73.2%)	152 (75.6%)	95 (67.4%)	503 (70.8%)
Virchowiana	12 (7.4%)	25 (12.2%)	13 (6.5%)	23 (16.3%)	73 (10.3%)
Undetermined	0	0	7 (3.5%)	2 (1.4%)	9 (1.3%)
Skin lesions					
0 to 5 lesions	64 (39%)	71 (35%)	87 (43%)	45 (32%)	267 (37.6%)
more than 6	99 (61%)	134 (65%)	114 (57%)	96 (68%)	443 (62.4%)
Operational Classification					
Paucibacillary	45 (27.6%)	30 (14.6%)	36 (17.9%)	23 (16.3%)	134 (18.9%)
Multibacillary	118 (72.4%)	175 (85.4%)	165 (82.1%)	118 (83.7%)	576 (81.1%)
Nerves Affected					
0	129 (79.1%)	113 (55.1%)	49 (24.4%)	24 (17%)	341 (45.2%)
1	12 (7.4%)	14 (6.8%)	17 (8.5%)	14 (9.9%)	59 (7.8%)
2	12 (7.4%)	22 (10.7%)	28 (13.9%)	17 (12.1%)	82 (10.8%)
3	3 (1.8%)	12 (5.9%)	6 (3%)	11 (7.8%)	32 (4.2%)
More than 3	1 (0.6%)	14 (6.8%)	13 (6.5%)	15 (10.6%)	47 (6.2%)
Uninformed	6 (3.7%)	30 (14.6%)	88 (43.8%)	60 (42.6%)	195 (25.8%)
Degree of incapacity/disability					
0	108 (66.3%)	91 (44.4%)	38 (18.9%)	21 (14.9%)	258 (36.3%)
1	39 (23.9%)	78 (38%)	41 (20.4%)	47 (33.3%)	205 (28.9%)
2	11 (6.7%)	11 (5.4%)	6 (3%)	6 (4.3%)	34(4.8%)
Uninformed	5 (3.1%)	25 (12.2%)	116 (57.7%)	67 (47.5%)	213 (30%)
Input mode					
New Case	146 (89.6%)	172 (83.9%)	175 (87.1%)	114 (80.9%)	607 (85.4%)
Re-entry	6 (3.7%)	14 (6.8%)	11 (5.5%)	22 (15.6%)	53 (7.5%)
Another Municipality	4 (2.5%)	0	1 (0.5%)	0	5 (0.7%)
Same municipality	4 (2.5%)	8 (3.9%)	8 (4%)	3 (2.1%)	23 (3.3%)
Uninformed	3 (1.8%)	11 (5.4%)	6 (3%)	2 (1.4%)	22 (3.1%)
Smear					
Negative	114 (69.9%)	85 (41.5%)	51 (25.4%)	28 (19.8%)	278 (39.1%)
Positive	14 (8.6%)	30 (14.6%)	16 (8%)	12 (8.5%)	72 (10.1%)
Not performed	35 (21.5%)	90 (43.9%)	134 (66.6%)	101 (71.7%)	360 (50.8%)

Source: *Notification Forms SINAN – CES.*

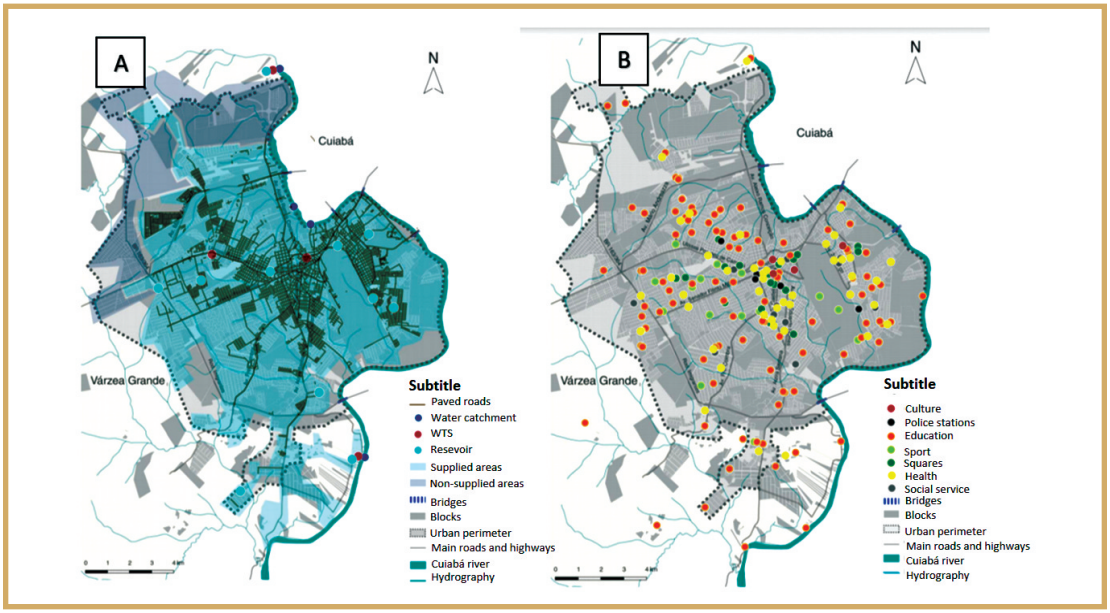

Fig. 1 : A : Sociocultural aspects – highlights in the urban area of the municipality of Várzea Grande. B : infrastructure – highlights: paving and water supply in the municipality.
Source: Várzea Grande Master Plan Review – Interim Report[20]

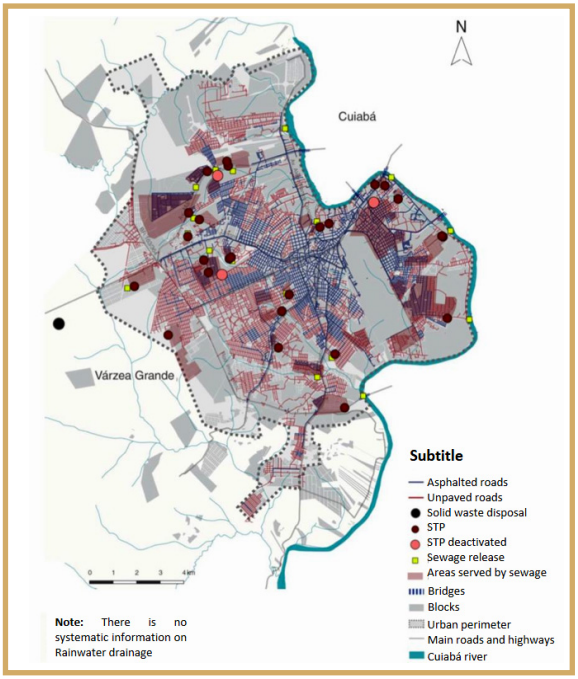

Fig. 2 : Infrastructure – highlights: paving and environmental sanitation.
Source: Várzea Grande Master Plan Review – Interim Report[21]

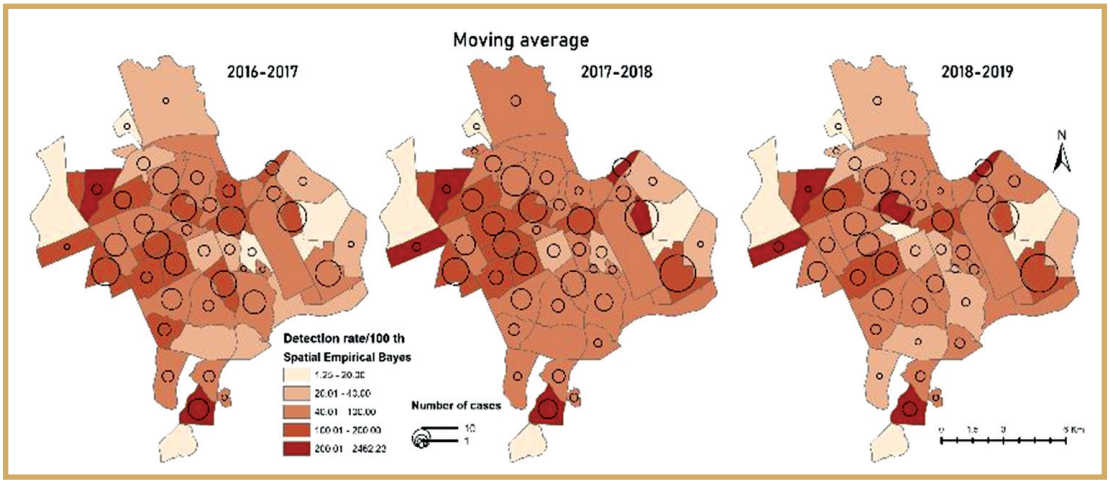

Fig. 3 : Spatial distribution of the moving average of detection rates of new leprosy cases by the Bayesian Empirical Local method, by district of the city of Várzea Grande, 2016 to 2019.

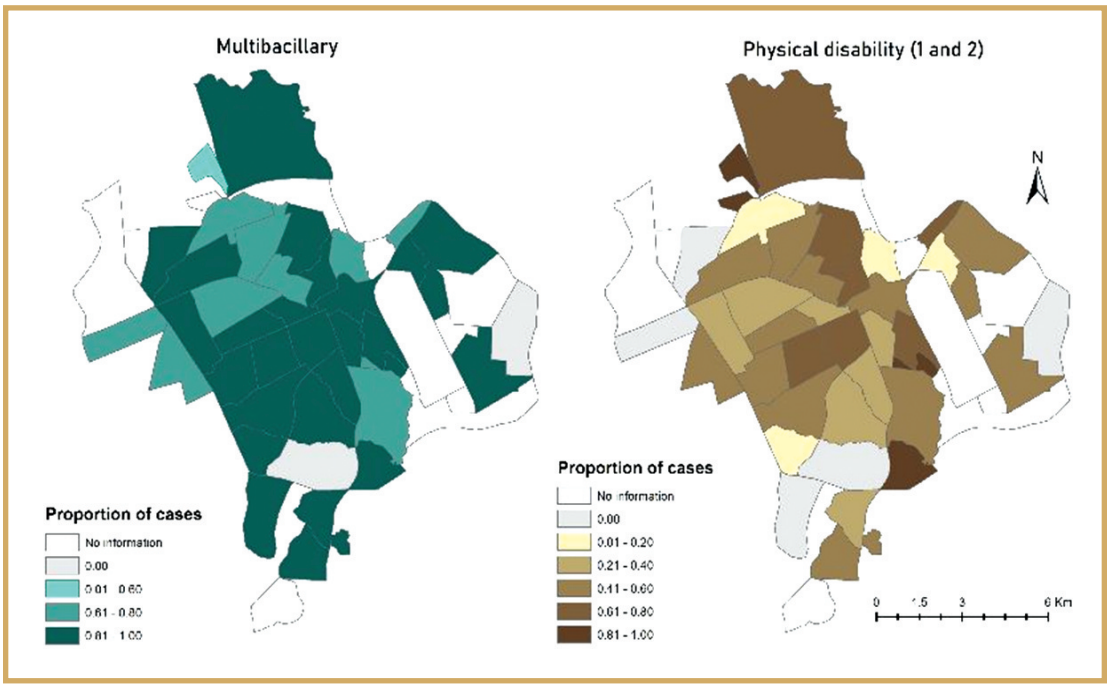

Fig. 4 : Spatial distribution of the proportion of MB cases and the proportion of cases diagnosed with some disability grade, by neighborhood of the city of Várzea Grande, 2016 to 2019.

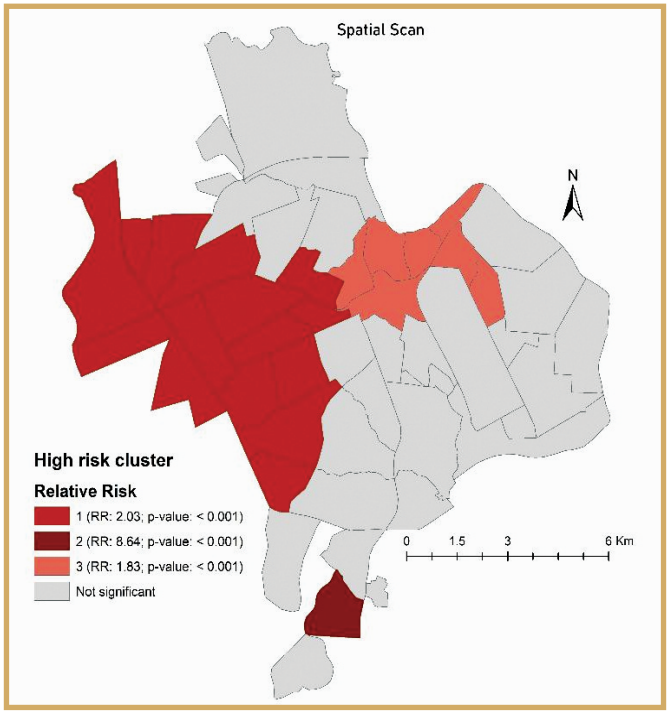

Fig. 5 : Spatial clusters of high risk for leprosy in Várzea Grande, 2016 to 2019.

including then 710 of the total cases notified in the CES. The Bayesian distribution of the moving average of detection rates in the city of Várzea Grande shows the evolution of the disease by neighborhood between 2016 and 2019. The highest rates are concentrated mainly in the neighborhoods that correspond to the eastern and central-western regions of the city. In the 3 periods analyzed (2016-2017; 2017-2018; 2018-2019) most neighborhoods were hyperendemic for the disease, with more than 40 cases/100,000 inhabitants (Fig. 3) (Ministry of Health Brazil Datasus 2016).

As for the characteristics of the new cases, among the neighborhoods that had a reported case, the majority had more than 50% of MB cases (39 neighborhoods), and 13 of these had their totality of MB cases (100%). Regarding the degree of physical disability at the time of diagnosis (DPD), 5 districts had no cases with any DPD, 15 districts had less than 50% of cases with some DPD, and 22 districts had 50% or more of the cases diagnosed with some DPD, and out of these 22, 5 neighborhoods had their totality of cases presenting some DPD (Fig. 4).

The spatial scan performed allowed the identification of 3 high-risk clusters for the occurrence of leprosy. Cluster 1, the largest of them, includes 15 neighborhoods (RR:2.03; p-value < 0.001), and is located in the central-west portion of the city. Cluster 2, with the highest risk (RR: 8.64, p-value <0.001) includes only one neighborhood and is located in the southern region. The third cluster includes 7 neighborhoods (RR: 1.83; p-value: < 0.001) and is located in the eastern region of Várzea Grande (Fig. 5).

Discussion

The present study shows that in Várzea Grande, the second largest city in Mato Grosso, the transmission of *M. leprae* is intense, a fact observed by the situation of very high detection rate. In addition, we can see that the number of leprosy cases is concentrated in certain locations in the city, coinciding with regions with more access to basic health care and a smaller sewage system.

In this study, it was observed that most of the diagnosed patients had the borderline clinical form (70.8%). On the other hand, 45.2% of the patients had no affected nerves and 36.3% were classified as having a degree of disability of zero. This fact leads us to believe that the patients were diagnosed early.

As for the degree of disability, according to our research, most of the patients were evaluated with zero degree of disability (36.3%), followed by non-evaluated cases (30%). The percentage of cases not evaluated in terms of the degree of disability in the diagnosis draws attention, similarly to the study by Marques et al (2017), as they obtained a high proportion of ignored (not evaluated) information, totaling 29.36% of the cases. It is believed that the omission of information is often evidenced by the neglect of the management body to train professionals and make them aware of the importance of correctly collecting all information pertaining to the notification form, thus contributing to future evaluation processes and diagnosis of this public health problem, it is possible to infer that the diagnosis has been made early and the strategies for prevention and control of the disease more effective (Sarmento et al 2015).

Regarding bacilloscopy, the study indicates that the exam was performed in only 49.2% of the patients. The unfavorable number in relation to the examination shows that the diagnosis remains predominantly in the clinical form of the disease (Simpson et al 2010).

Focal and heterogeneous distribution is a characteristic of leprosy in many locations in Brazil and in the world (Penna et al 2009, Magalhães & Rojas 2005). Situation remains similar even 15-20 years later as seen in the present study. In Várzea Grande, areas with the highest concentration of cases were found, located in the central-west region of the city, totaling 15 affected neighborhoods. Historically, leprosy has been related to poverty and in these neighborhoods, despite being within the urban perimeter, there is still low coverage of basic sanitation, as shown in the Municipal Master Plan (State of Mato Grosso 2021).

Arraes et al (2017) researched the presence of viable *M. leprae* in water samples in five municipalities in the state of Ceará with high detection rates of leprosy, these municipalities have a semi-arid and hot climate. All water samples were obtained from natural sources such as reservoirs, rivers, streams, springs and wells. Of the 30 sources analyzed, the presence of viable *M. leprae* was found in 23 (76.7%), demonstrating that the environment is an important factor to be considered in the spread of the disease. Analyzing the municipality of Várzea Grande, we observed that the climate is similar to the study by Arraes and collaborators (2017), as it is a tropical and hot municipality.

In addition, almost all cases occur in regions of the city where there is no sewage system. This is relevant data, as it demonstrates that unfavorable sanitary conditions can be an important risk factor for the spread of the disease. The water system serves 93% almost entire population of the municipality. The source of production is mixed. The surface source being the Cuiabá River and 82 deep tubular wells (PTP), which leads us

to question the water purification system (State of Mato Grosso. Varzea Grande City Council. Law No. 4,286. Municipal Basic Sanitation Plan).

Environmental conditions including water have also been emphasized to be important for understanding the transmission of leprosy. Presence of *Mycobacterium leprae* by molecular/microbiological approaches has been demonstrated in the environment/ water in studies from Indonesia (Matsuoka et al 1999) and India (Lavania et al 2008, Turankar et al 2022). There is justification to investigate this aspect further and take public health measures accordingly.

Overlaying the data on the number of leprosy cases with the municipal services, we found that a greater number of leprosy cases occur in the vicinity of health posts. This may indicate that active search may be an important factor in identifying and fighting leprosy. This needs to be investigated by active surveys away from health facilities to determine if there are missed cases/ delayed diagnosis in such areas which are difficult to access by affected people either due to distance or other conditions.

Conclusion

The increase in the detection of new cases has been happening throughout the urban area of the municipality of Várzea Grande, with concentrations in certain areas. The geographic distribution of leprosy has been associated with a low quality of life for the population, which includes basic sanitation, access to basic health units, among others. The recurrence of cases in certain districts of the city of Várzea Grande is a worrying factor, as it may indicate the presence of untreated Virchowian cases and requires a more careful monitoring of the contacts. In-depth investigations into the cause effect relationship of these possible determinants and analysis based on national as well as international experiences should be the future course of research into these aspects.

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