Original Article

Leprosy in central Amazon: an epidemiological approach

Hanseníase na Amazônia central: um olhar epidemiológico

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ABSTRACT: OBJECTIVE: To describe the epidemiology and clinical profile of leprosy in the western region of the state of Pará, Brazil, in the period from 2014 to 2020. METHODS: This is a cross-sectional, descriptive study. Data collection was performed from the Sistema de Informação de Agravos de Notificação (SINAN) of the Secretaria de Vigilância em Saúde (SVS) of the Brazilian Ministry of Health in the period from june 2021 to august 2021, and a literature review in the PUBMED database. RESULTS: 1764 cases were registered, with a prevalence of 17.5 per 10.000 inhabitants, 942 (53.5%) in the region of Tapajós and 822 (47.9%) in the region of Baixo Amazonas. There was a predominance in the age group of 40 to 49 years (20.6%); colour "Parda" (73.6%); Incomplete Primary Education (55.7%); male sex (66.3%); clinical form Dimorphic (54.5%); Multibacillary operational classification (82.3%); zero degree of functional disability (41.6%); type I reaction episodes (11.6%). In the literature review, 9 articles were included after applying the inclusion and exclusion criteria and reading the articles in full. CONCLUSION: There was a reduction in the number of leprosy cases in the Mesoregion in the studied period. However, there are still deficits in the strategies of screening, treatment and monitoring of cases of leprosy, with prevalence of highly transmissible and clinically severe cases, especially among men in economically active age. Thus, it is essential to adopt regional public policies to combat, control and prevent leprosy in the western region of the state of Pará.

Keywords: Epidemiology; Leprosy; Amazonian Ecosystem; Public Health; Amazon.

RESUMO: OBJETIVO: Descrever a epidemiologia e o perfil clínico da hanseníase na região oeste do estado do Pará, Brasil, no período de 2014 a 2020. MÉTODO: Trata-se de um estudo de corte transversal, descritivo. A coleta de dados foi realizada a partir do Sistema de Informação de Agravos de Notificação (SINAN) da Secretaria de Vigilância em Saúde (SVS) do Ministério da Saúde do Brasil no período de junho de 2021 a agosto de 2021, e uma revisão da literatura na base dados PUBMED. RESULTADOS: Foram registrados 1764 casos, com uma prevalência de 17,5 por 10.000 habitantes, sendo 942 (53,5%) na região do Tapajós e 822 (47,9%) na região do Baixo Amazonas. Houve predomínio na faixa etária de 40 a 49 anos (20,6%); cor "parda" (73,6%); escolaridade com Ensino Fundamental Incompleto (55,7%); sexo masculino (66,3%); forma clínica Dimorfa (54,5%); classificação operacional Multibacilar (82,3%); grau zero de incapacidade funcional (41,6%); episódios reacionais tipo I (11,6%). Na revisão de literatura, foram incluídos 9 artigos após aplicação dos critérios de inclusão e exclusão e leitura dos artigos na íntegra. CONCLUSÃO: Houve redução no número de casos de hanseníase na Mesorregião no período estudado. Todavia, ainda existem déficits nas estratégias de rastreio, tratamento e acompanhamento dos casos de hanseníase, com prevalência de casos altamente transmissíveis e clinicamente graves, especialmente entre homens em idade economicamente ativa. Dessa forma, faz-se essencial a adoção de políticas públicas regionais para combate, controle e prevenção da hanseníase na região Oeste do estado do Pará.

Palavras-chave: Epidemiologia; Ecossistema amazônico; Hanseníase; Saúde coletiva; Amazônia.

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INTRODUCTION

Leprosy is an infectious disease that mainly affects skin and peripheral nerves, due to impairment of Schwann cells. This leads to its main feature: the manifestation of skin lesions with loss of thermal, touch and pain sensitivity. Depending on the time of evolution, it can also cause physical disability. The etiological agent is the microorganism *Mycobacterium leprae*, an acid and alcohol-fast, rod-shaped bacillus and an obligatory cellular parasite with a long incubation period of 2 to 7 years[1]. It is transmitted via droplets from the nose or saliva, and it is characterized by high infectivity and low pathogenicity, meaning it is easily transmitted, but only a small proportion of infected people develop symptoms, as the person must be highly immunocompromised for the disease to manifest[2].

In 1982, the World Health Organization (WHO) established a functional classification based on the bacterial index: paucibacillary leprosy has an index of <2+ and multibacillary leprosy has an index of ≥ 2+[3]. In 1988, seeking not to restrict classification to laboratory factors, the WHO established clinical criteria, classifying cases with up to five skin lesions and/or only one affected nerve trunk as paucibacillary leprosy, and cases with more than five skin lesions and/or more than one affected nerve trunk as multibacillary leprosy[4].

Brazil has the highest number of cases in the entire American continent and ranks first in the prevalence coefficient, with more than 1 case per 10,000 inhabitants, failing to reach the goal of reducing the prevalence of leprosy to less than 1 case per 10,000 inhabitants by the end of 2015. Brazil has the second largest number of reported cases, behind only India. The distribution of cases in the Brazilian territory is heterogeneous, with a higher prevalence of cases in the Center-West, North and Northeast regions. In 2018, the prevalence of leprosy was 4.54 cases per 10,000 inhabitants in the Center-West region, 3.34 cases in the North region and 2.15 cases in the Northeast region. On the other hand, in the Southeast and South regions, prevalence was below 0.5 cases per 10,000 inhabitants[5]. Thus, there is a significant discrepancy in the distribution of cases of leprosy in the country[6].

The Brazilian regions with the highest rates of cases are historically disadvantaged in terms of socioeconomic status and access to health services when compared to the South and Southeast regions[7]. This confirms that leprosy, Chagas disease and Leishmaniasis are neglected conditions, included in a set of diseases that are common in the country but receive little investment[8].

The North region, specifically the state of Pará, has a relatively high rate of new cases of leprosy (10.5 cases per 100,000 inhabitants) in adolescents younger than 15 years, behind only the states of Maranhão (15.3), Mato Grosso (22.6) and Tocantins (24.3). It is worth noting that, in the state of Pará, the predominance of leprosy in the age group of 60 years or more was also high (72.2), while the mean rate in the county is 25.1[9]. Thus, considering that Pará has a high number of cases, especially when compared to other Brazilian states, it is necessary to intensify health surveillance actions[10].

Thus, the present study aims to identify the clinical and epidemiological characteristics of leprosy cases registered in the western region of Pará from 2014 to 2020.

METHOD

This is a descriptive cross-sectional study conducted to determine the prevalence of leprosy in the western region of the State of Pará. Data was collected using the Notifiable Diseases Information System (SINAN) of the Health Surveillance Department of the Brazilian Ministry of Health. Geographic mapping was used to define the study area, based on the health regions that corresponded to the Regional Intermanagement Commissions (CIR), according to the Department of Informatics of the Unified Health System (DATASUS). According to the Health Plan of the State of Pará, the state is composed of 13 health regions, as shown in Figure 1. The health regions selected were: *Baixo Amazonas* and *Tapajós*, due to their proximity and common characteristics, as well as the scarcity of research in these two regions.

Data was collected from June to August 2021 and the information obtained referred to the period from 2014 to 2020. The following categorical variables were collected: gender, age group, race/color, education, proportion of new multibacillary cases, level of disability (zero, I and II), diagnostic class (paucibacillary/multibacillary), clinical form (indeterminate, tuberculoid, borderline, Virchowian) and reactional episodes (types 1 and 2).

Data were collected and stored in Microsoft Office Excel spreadsheets and secondary data analysis was performed. The Shapiro-Wilk test and the Chi-Squared test were used for the statistical analysis of categorical variables. ODDS Ratio was also calculated. The significance level was set at $p < 0.05$. The Biostat 5.3 software was used.

As the data used is public and unrestricted, appreciation by the Research Ethics Committee (CEP) was not necessary, as provided by Resolution No. 466/2012 of the National Health Council (CNS). The study met all ethical standards of research conduct.

The following guiding question was used for the literature review: "What is the epidemiology and clinical profile of Leprosy in the western region of the state of Pará?". The search for studies was carried out using the PubMed platform. The descriptors used were (epidemiologia OR epidemiology) AND (hanseníase OR leprosy OR lepra) AND (Amazônia OR Amazon).

The following inclusion criteria were used for the

selection of articles: articles in English, Portuguese and Spanish, available in full, and published from 2014 to 2021. The exclusion criteria were: any scientific material extracted from thesis, dissertations, simple and expanded abstracts, case reports and any articles that did not assess the reality of the state of Pará. The literature review procedure can be seen in the flowchart in Figure 2.
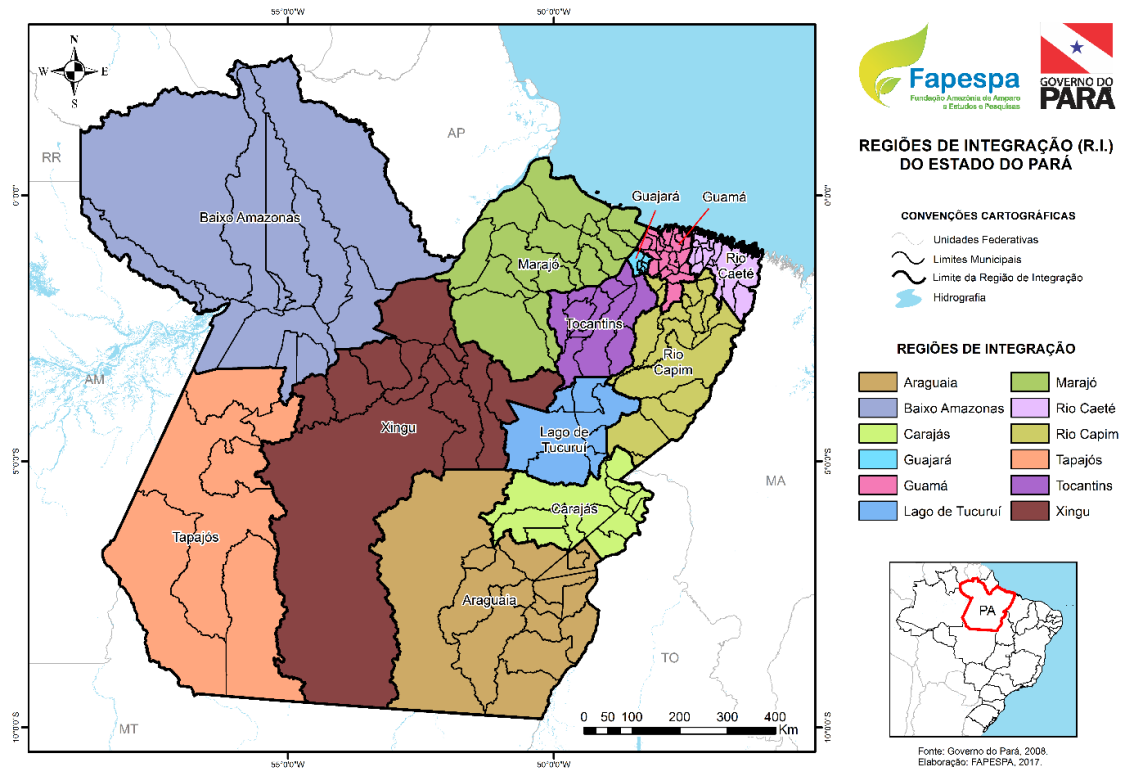
Source: 2016-2019 Health Plan of the state of Pará.

Figure 1. Map of the Health Regions of the state of Pará
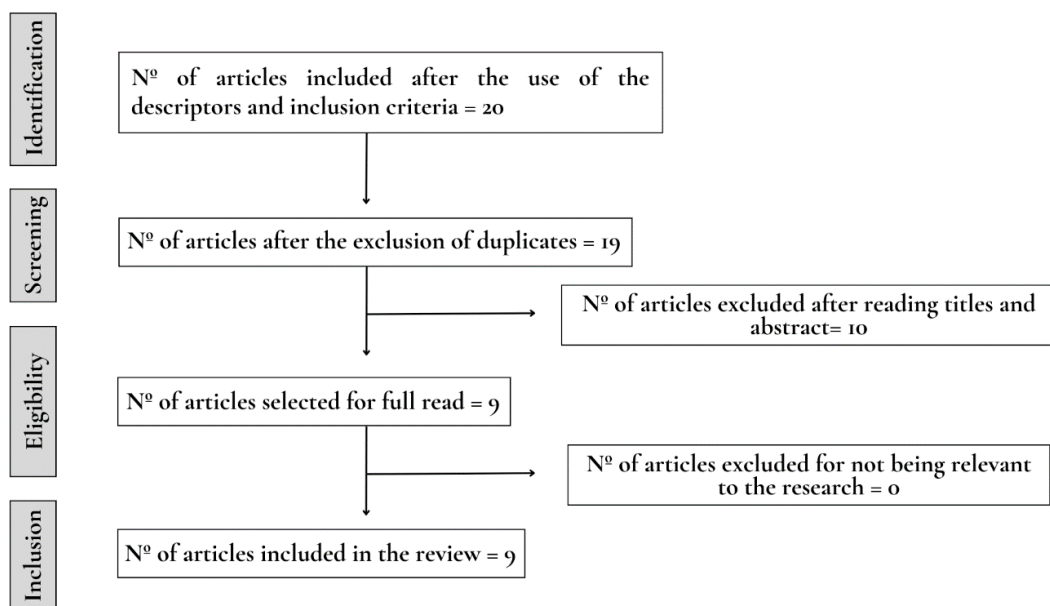
Source: Elaborated by the authors, 2021.

Figure 2. Flowchart of the methodology adopted for the selection of articles

RESULTS

A total of 1764 leprosy cases registered in the SINAN files from 2014 to 2020 were evaluated. The cases occurred in the *Baixo Amazonas* and *Tapajós* regions, with a prevalence ratio of approximately 17.5 per 10,000 inhabitants. The cities with the highest number of diagnosed cases were *Santarém* (21.2%), *Itaituba* (19.9%) and *Novo Progresso* (16.2%). The city with the lowest prevalence of the disease was *Terra Santa*, with only 8 cases (0.4%).

The analysis of the distribution of diagnoses per year showed a normal distribution (*p*=0.9188 according to the Shapiro-Wilk method), with a mean of 254 cases per year and a standard deviation of 74.6, demonstrating the heterogeneity of the sample.

The highest frequency of cases was in 2014 (n=323, 19.1%), followed by 2015 (n=333, 18.3%), and the lowest occurrence was in 2020 (n=125, 6.5%). A significant part of the cases occurred in the *Tapajós* region (n=942, 52%), as shown in Table 1.

Table 1. Distribution of leprosy cases per year in each mesoregion of West Pará from 2014 to 2020, Brazil.

	Integration regions of Western Pará			
Year	Baixo Amazonas	Tapajós	Total	*P-value*
2014	149	174	323	
2015	165	168	333	
2016	125	148	273	
2017	106	133	239	*p*=0.9188
2018	98	125	223	
2019	118	127	245	
2020	60	65	125	
Total	822	942	1764	

Source: SINAN/SVS-MS.

The epidemiological profile is described in Table 2. The data showed a higher prevalence of leprosy among males, with more than half of the cases (66.3%). The data followed a normal distribution for age, according to the Shapiro-Wilk method (*p*=0.7879) and based on the following categories: <19 years, 20 to 29, 30 to 39, 40 to 49, 50 to 59, > 60 years. Most of the cases occurred in the 40-49 age group (20.6%), followed by the 30-39 age group (18.6%) and the 50-59 age group (18.6%). Furthermore, 1239 cases (70.7%) occurred in the working age group - from 20 to 59 years old.

Information regarding race/skin color was not known and/or not recorded in 0.8% of cases. According to the available data, 73.6% of the cases occurred in the group of people who self-identified as "*pardos*", followed by "white" with 12.7%, "black" with 11.8%, "indigenous" with 0.6% and "yellow" with 0.4%.

Regarding the level of education, more than half of the people diagnosed (55.7%) had not completed elementary school, only 10% had completed high school, and 10.8% were registered as illiterate. About 198 (11.2%) cases had their level of education registered as "ignored" in the health notification system. It is worth noting that the data did not follow a normal distribution for this variable (*p*=0.008).

Table 2. Socio-economic characterization of patients diagnosed with leprosy between 2014 and 2020 in Western Pará, Brazil.

Variables	No	%	P-Value (Shapiro-Wilk)
Gender			not applicable
Female	595	33.7	
Masculine	1169	66.3	
Age Group			*p* = 0.7879
<19	191	10.8	
20-29	228	12.9	
30-39	329	18.6	
40-49	363	20.6	
50-59	329	18.6	
>60	324	18.4	
Race			not applicable
White	224	12.7	
Black	209	11.8	
Yellow	8	0.4	
Pardo	1299	73.6	
Indigenous	10	0.6	
Ignored/Blank	14	0.8	
Level of education			*p* = 0.008
Illiterate	190	10.8	
Incomplete Elementary Education	983	55.7	
Complete Elementary Education	79	4.5	
Incomplete Secondary Education	86	4.9	
Complete Secondary Education	176	10.0	
Incomplete Higher Education	13	0.7	
Complete Higher Education	33	1.9	
Not applicable	6	0.3	
Ignored/Blank	198	11.2	

Source: SINAN/SVS-MS

Table 3 shows the analysis of the association between gender and the clinical forms of leprosy, in

addition to the ODDS Ratio of males in relation to females. The chi-square tests showed a statistically significant association ($p<0.001$) between gender and the clinical forms of leprosy. Being male was a protective factor for the indeterminate and tuberculoid forms and a risk factor for the borderline and Virchowian forms.

Table 3. Analysis of the association between the clinical forms of Leprosy and gender and ODDS Ratio of males in relation to females.

Clinical Forms	Male		Female		- value	ODDS Ratio CI 95%
	No.	%	No.	%		
Undetermined	107	6.0%	127	7.2%		0.34 [0.28-0.43]
Tuberculoid	84	4.8%	60	3.4%		0.69 [0.48-0.97]
Borderline	658	37.3%	303	17.2%	$p <0.0001$	1.24 [1.01-1.51]
Virchowian	250	14.2%	61	3.4%		2.31 [1.76-3.21]
Unclassified	37	2.1%	23	1.3%		Not applicable
Ign/Blank	33	1.9%	21	1.2%		Not applicable
Total	1169	66.3%	595	33.7%		

Table 4 describes the analysis of the association between the clinical forms of Leprosy and the Level of Disability, in addition to the ODDS Ratio of Level I and II in relation to Level 0. The Chi-squared test showed $p <0.0001$, revealing a statistically significant association between the Clinical Form and the Level of Disability. The ODDS Ratio revealed that Level I has an increased risk for the Virchowian form and that Level II has an increased risk for the Borderline and Virchowian forms.

Table 4. Analysis of the association between the clinical forms of Leprosy and the Levels of Disability and ODDS Ratio of Level I and II in relation to Level 0.

Clinical Form	LEVEL OF DISABILITY							
	Zero		Level I			Level II		
	No	%	No	%	ODDS Ratio CI 95%	No	%	ODDS Ratio CI 95%
Undetermined	157	8.9%	50	2.8%	0.34 [0.28-0.43]	5	0.3%	0.09 [0.03-0.22]
Tuberculoid	92	5.2%	30	1.7%	0.69 [0.48-0.97]	6	0.3%	0.22 [0.09-0.51]
Borderline	338	19.2%	423	24.0%	1.24 [1.01-1.51]	118	71.9%	1.77 [1.29-2.47]
Virchowian	100	5.7%	104	5.9%	2.31 [1.76-3.21]	56	3.2%	2.55 [1.75-3.71]
Unclassified	23	1.3%	13	0.7%	Not applicable	8	0.4%	Not applicable
Ign/Blank	24	1.4%	8	0.4%	Not applicable	two	0.1%	Not applicable
Total	734	41.6%	628	35.6%		195	11.0%	

Source: SINAN/SVS.

The detailed clinical characterization is described in Table 5. According to the operational classification, 82.3% of cases were characterized as multibacillary, which is the form with greater severity and higher susceptibility to systemic repercussions and transmission.

The predominant clinical forms were "Borderline", with 54.5%, and "Indeterminate", with 17.3%, followed by "Virchowian" (13.2%) and "Tuberculoid" (8.2%). The clinical form was recorded as "Unclassified" in 3.1% of the cases and as unknown in 3.4%.

All notifications were also analyzed for the level of disability resulting from leprosy. In 41.6% of the sample, level zero of disability was observed at the time of diagnosis, while 35.6% had level I disability and 11.0% had level II. This evaluation was not performed in 125 individuals (6.8%) and 4.9% of the data were left blank.

Reactional episodes occurred in 17.5% of registered cases; 11.8% were type 1 reactions; 4.7% were type 2 reactions; and 1.0% were type 1 and type 2 reactions. In about 17.8% of cases, no data on reactional episodes were recorded.

In the literature review, 9 articles were selected and are shown in Chart 1, along with their main findings.

Table 5. Clinical characterization of leprosy cases between 2014 and 2020 in Western Pará, Brazil.

VARIABLES	No	%
Operational Classification		
Paucibacillary	312	17.9
Multibacillary	1452	82.3
Clinical Form		
Not Classified	60	3.4
Virchowian	234	13.2
Borderline	961	54.5
Tuberculoid	144	8.2
Undetermined	311	17.6
Ignored	54	3.1
Level of Disability		
Level Zero	734	41.6
Level I	628	35.6
Level II	195	11.0
Not Evaluated	120	6.8
Ignored/Blank	87	4.9
Reactional Episode		
Type 1 reaction	209	11.8
Type 2 reaction	83	4.7
Type 1 and 2 reaction	17	1.0
No reaction	1140	64.6
Ignored/Blank	315	17.8

Source: SINAN/SVS-MS.

Chart 1. Distribution of articles according to title, authors, years of publication, type of study and main findings

TITLE	AUTHORS/YEAR	TYPE OF STUDY	MAIN FINDINGS
Nerve Damage in Young Patients with Leprosy Diagnosed in an Endemic Area of the Brazilian Amazon: A Cross-Sectional Study	Bandeira et al., 2017	Analytical, descriptive and cross-sectional study	The lack of coverage by Community Health Agents and the difficulty in diagnosing leprosy in children contribute to late treatment initiation and peripheral nerve damage. The study reinforces the importance of health surveillance in PHC to reduce the damages caused by leprosy.

Chart 1. Distribution of articles according to title, authors, years of publication, type of study and main findings   *continuation*

TITLE	AUTHORS/YEAR	TYPE OF STUDY	MAIN FINDINGS
Emergence and Transmission of Drug-/Multidrug-resistant Mycobacterium leprae in a Former Leprosy Colony in the Brazilian Amazon	Rosa et al., 2020	Systematic population-based study	Underdetection of *M. leprae* resistant strains was observed in the context of a unique community. The study raises awareness to the need for surveillance regarding the emergence of primary and secondary *M.leprae* resistance in Brazil and worldwide.
BCG Vaccination Status, Age, and Gender as Risk Factors for Leprosy in Endemic Areas in the Brazilian Amazon	Lima et al., 2020	Descriptive, cross-sectional and quantitative study	A relationship between the multibacillary form and older age groups was observed. In addition, males were more frequently infected with *M. leprae* and were less vaccinated against BCG. The BCG vaccine had a protective effect against leprosy.
Spatial Analysis Spotlighting Early Childhood Leprosy Transmission in a Hyperendemic Municipality of the Brazilian Amazon Region	Barreto et al., 2014	Geographic and spatial analysis combined with epidemiological survey	The study revealed a high rate of undiagnosed and underreported leprosy cases in Pará and indicated the need for geographic tracking of cases in order to understand the spatial distribution of leprosy and break the chain of transmission.
Evidence of zoonotic leprosy in Pará, Brazilian Amazon, and risks associated with human contact or consumption of armadillos	Silva et al., 2018	Cross-sectional, descriptive and quantitative study	The consumption of wild animals, especially armadillos, is a potential source of leprosy infection – mainly in rural areas of the Amazon. It is essential to develop strategies to prevent animal-to-human transmission.
Leprosy in elderly people and the profile of a retrospective cohort in an endemic region of the Brazilian Amazon	Oliveira et al., 2019	Retrospective cohort study	There is a trend for an increase in cases of leprosy in Pará – especially among older adults – in the next 10 years. In the state, there is a predominance of the condition in males in the 60- to 69-year-old age group; also, there is a predominance of the multibacillary form. Reactions to treatment are common, especially in the first 6 months after starting the treatment. The most used medication is Prednisone. Most older adults with leprosy have some type of physical disability.
High-risk areas of leprosy in Brazil between 2001-2015.	Rodrigues et al., 2020	Ecological Study	Pará is home to areas of high incidence and high-risk for leprosy, with 44% of the population residing high-risk areas of leprosy in Brazil.
Spatial epidemiology and serologic cohorts increase the early detection of leprosy.	Barreto et al., 2015	Prospective cohort study	Geographic screening of leprosy cases involving school settings and contact tracing strongly contribute to early detection and harm reduction.
Prevalence of autoantibodies against cellular antigens in patients with HIV and leprosy coinfection in the Amazon region.	Bichara et al., 2017	Descriptive, cross-sectional and quantitative research	HIV-infected leprosy patients are more likely to develop autoimmune diseases. More studies are necessary to evaluate the factors that modulate this process.

DISCUSSION

The analysis of the results on the cases of leprosy in the Mesoregion of Western Pará showed a reduction in the number of diagnoses from 2014 to 2020. This reduction is observed not only in the Brazilian region studied, but also in the world[11]. It is worth noting that, as of 2020, with the COVID-19 pandemic, several sectors were impacted by the need to change their workflows, including the compulsory diagnosis and notification of diseases such as leprosy, which caused late diagnosis, spread of the disease and increase of disabilities[12].

On the other hand, a study carried out in the state of Pará showed that, despite the trend towards a reduction

in the number of cases, the prevalence of leprosy among older adults remains high, with possible increase in the coming years[13]. It should be noted, however, that the state is in one of the high-risk areas of leprosy in the country, which include the Center-West, North and Northeast Regions. The higher prevalence in these areas is a result of a combination of factors, including low socioeconomic status, immunologic and genetic determinants, and insufficient coverage of health services aimed at the early diagnosis of this disease, among others[14].

In addition, there was a difference in the number of cases between the cities in the regions of *Baixo Amazonas* and *Tapajós*. This is mainly due to a spatial association between the occurrence of leprosy and the social deprivation index of the cities, since disease transmission is enhanced when the population has worse living conditions, lower level of education and lower income, leading to the heterogeneous distribution of leprosy cases[15]. These disparities are also found at regional and municipal levels throughout Brazil, with the poorest regions being the most endemic areas[11].

The epidemiological profile revealed a prevalence of the disease in the age groups of 30-39 years and 40-49 years, which indicates that the economically active population is the most affected by leprosy. This tends to affect the labor market, considering that this population can develop disabilities, injuries and reactions, sometimes needing to take time off from their work activities, which generates personal and local economic losses[16].

As for gender, more than 60% of the people diagnosed were male. Some studies show that the disease is more common in men, and it can be inferred that men are responsible for the majority of the transmission of leprosy[17]. This occurs because men are more exposed to *Mycobacterium leprae* and, consequently, more prone to infection, and because they are less likely to seek health care, which increases the time of evolution of the disease, putting them at higher risk for disability and making them a more probable source of transmission. Moreover, there may be a biological relationship between the male gender and the predominance of the multibacillary form of leprosy[11].

As for older adults, Oliveira et al.[13] found that, among those evaluated, most were in the age group of 60-69 years, with a predominance of males (64.3%), a result similar to that of the present study (65.7%).

A study in endemic areas in the Amazon found that the multibacillary form was associated with the oldest age group of the research (> 46 years), as well as with the male gender. In addition, there was a significant association between the male gender and the absence of BCG vaccination (Bacillus de Calmette-Guérin) and between the female gender and the administration of two or more doses of the vaccine, suggesting greater vaccination coverage of women when compared to contacts of cases of leprosy. The study also highlights that those who did

not get vaccinated were 8.2 times more likely to develop leprosy, with a greater chance of it being multibacillary[18].

Furthermore, as previously mentioned, men are less likely to seek health services. This may be related not only to a strong cultural pattern, but also to an incompatibility between working hours and availability of care, and to the health approach for men, which requires strategies targeted at men's health, especially in primary health care[11,18].

As for the level of education, more than 50% of the patients evaluated had not completed Elementary School, revealing a predominance of people with a low level of education. This shows that access to knowledge/information about health services and understanding of guidelines regarding treatment and prevention measures are associated with self-care agency and level of education[19].

Therefore, public health services have the important task of providing care, especially for those who depend exclusively on it, acting in the prevention of complications of leprosy. This was observed in a research conducted in the North Region of Brazil, which found more severe nerve damage during diagnosis in patients who received less visits of Community Health Agents (ACS) and those who had to see three or more doctors before receiving a diagnosis of their illness[20].

Finally, in relation to color/race, there was a predominance of people self-identified as "*pardas*", with more than 70% of cases. It is worth noting that this is the largest ethnic group in Brazil, added to those who self-identify as black, according to the IBGE census (2010). These results are in agreement with studies carried out in different Brazilian regions, which also demonstrated that "*pardo*" was the predominant ethnic group[11,7,21].

The present study found that a considerable number of individuals with leprosy in the state of Pará had the multibacillary form of the disease. This result is not isolated, as several other studies found similar characteristics in different parts of the state[10,21,22].

Multibacillary leprosy is a concern because, among other reasons, individuals with that form of the disease are the main transmitters of the disease, due to their high bacterial load. This is a determinant for intra-household transmission and exposure of children and young people to *M. leprae,* in the absence of contact tracing[23]. The literature points out that factors such as precarious living conditions and low level of education influence the incidence of intra-household transmission, and the population of the present study fits this profile[24].

Furthermore, the prevalence of multibacillary cases is an indication that there are flaws in early detection and effective treatment of the disease, pointing to structural problems and to the need for better organization of control actions involving Primary Health Care (PHC)[25], Family Health Strategy (FHS), Community Health Agents (ACS), home visits, active search and contact tracing, as well as BCG vaccination. An example of this reality was described

in a study carried out in the city of *Canaã* dos *Carajás*, *Pará*, which identified flaws in health prevention and promotion in PHC in the context of leprosy due to the lack of supplies and trained personnel[24].

Moreover, in *Belém*, *Pará*, the existence of highly endemic locations was correlated with the low coverage of health services and the poor distribution of Basic Health Units (UBS), which is also related to a higher incidence of physical disabilities due to delays in diagnosis[22].

The clinical form of the disease depends on the body's immune response to the pathogen. In this sense, at the beginning of leprosy, when the immune response is still developing, the "indeterminate" clinical form is more common[1]. However, in the present study, the most prevalent form was "Borderline", considered an intermediate form of the disease. This indicates that, in most cases of leprosy in the state of Pará, the disease was not detected in its initial stages, corroborating the data previously mentioned.

The levels of disability are divided into three: zero (absence of nerve involvement), level I (decrease or loss of sensitivity in the hands, eyes or feet) and level II (severe injuries to the hands, eyes or feet). Among the analyzed population, most had some level of disability, with predominance of level I (35.0%). However, 41.6% had level zero disability. In comparison, data from 2007 to 2013 on leprosy in *Belém*, Pará, showed a higher number of level zero disability (53.8%), whereas in a study carried out in *Marabá*, Pará, analyzing data from 2005 to 2014, this variable was even more significant, with a rate of 75.1%, demonstrating that there is a variety of scenarios in the state of *Pará*[10,26].

The consequences of this high incidence of physical disability include, in addition to psychological damage, withdrawal from the labor market due to the limitation caused by high-grade injuries. This problem gets worse when taking into account that the age groups that are most affected are part of the economically active population[21]. Furthermore, physical disabilities can occur even in younger populations, as seen in a study on nerve injuries in a population in the age group of 10-14 years old, which found that 17.1% already had some level of disability[20].

Early detection of leprosy cases by serological tests can help control the spread of the disease. Serological data from the anti-PGL-I Test against the phenolic glycolipid 1 antigen on the surface of *M. leprae* are used for this purpose. The test can be applied to household contacts and in regions with a high risk of transmission, where the disease is more common. It is observed that those who test positive have a high chance of developing leprosy within two years, demonstrating the importance of analyzing the spatial distribution of cases[27,28].

Another problem that leads to the continuity of the transmission of leprosy is antimicrobial resistance. A study by Rosa et al. found that 43.2% of cases displayed drug-resistance variants, more common in cases of relapse. The mechanism is still not well understood, but the association of individual and environmental aspects can lead to drug-resistance, making the condition more worrying due to its underdiagnosis[29]. Another issue with an unclear cause is the co-infection with Human Immunodeficiency Virus (HIV) and leprosy, which leads to higher levels of autoantibodies that, when in circulation, can be deposited in the organs, activating the Complement System and leading to inflammatory processes[30].

Social and individual vulnerability is still a major factor affecting the continuity of the transmission of leprosy in the studied population. Several factors are involved in this situation, such as the difficulty in accessing health services due to the low socioeconomic status, material hardship, leading to lack of access to basic sanitation and isolated rooms in the household, lack of access to a healthy and balanced diet, which can lead to the consumption of wild meat that can contain pathogens, such as armadillo meat, which can be infected with *M. leprae.* Lack of guidance and understanding regarding the forms of transmission of leprosy is another factor that can contribute to the infection of people sharing the same environment. Failure to wear masks or wearing them incorrectly can contribute to the spread of the disease[28,31].

Therefore, regional public policies that promote greater epidemiological surveillance, health promotion regarding leprosy, and monitoring and supervision of active cases and patients in treatment are of paramount importance for the control and prevention of the disease in the western region of the state of Pará. For. In addition, guaranteed employment and income can contribute to better living conditions, helping people to avoid attitudes that favor transmission and, consequently, reflecting in the reduction of cases.

CONCLUSION

There was a reduction in the number of leprosy cases between the years 2014 and 2020, not only in the Mesoregion studied, but also in the whole country and in the world. It is worth noting that this decrease is more evident after the repercussions of the COVID-19 pandemic, due to the urgent need to change/adapt the flow of diagnosis and notification of diseases.

However, the research conducted in the state of Pará revealed a continuity of transmission among older adults, with a possible growth in the coming years. This is associated with the vulnerabilities of the fight against Leprosy in the western region of the state of Pará, which contributes to the prevalence of highly transmissible diseases and severe cases. These vulnerabilities are related to deficits in screening, treatment and follow-up of leprosy cases. In addition, the regions studied have a vast territory and significant socioeconomic inequalities, making it difficult for the population to have full access to health

services.

Therefore, it is essential to have regional public policies for the management and prevention of leprosy in the western region of the state of *Pará*. In addition, guaranteed employment and income should be an essential government strategy, as it promotes better living and housing conditions for the population and, consequently, reduces exposure to risk and incidence and prevalence of leprosy in the *Amazon* region.

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