

DETERMINING FACTORS OF LEPROSY: A CASE-CONTROL STUDY IN A HYPERENDEMIC AREA OF THE BRAZILIAN LEGAL AMAZON

FATORES DETERMINANTES DA HANSENÍASE: UM ESTUDO CASO-CONTROLE EM ÁREA HIPERENDÊMICA DA AMAZÔNIA LEGAL BRASILEIRA

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ABSTRACT

Leprosy is a chronic infectious disease caused by *Mycobacterium leprae*. It can result in permanent physical disabilities if not diagnosed early. A case-control study was conducted to identify the factors associated with the occurrence of leprosy in individuals living in a region of high incidence of the disease in the Tocantins state in northern Brazil. Sixty cases were diagnosed between 2016 and 2018, and 120 controls were included in the study. The control group consisted of residents from the same area as the cases, the same sex, and with an age variation of up to 5 years. Data were collected through interviews with each participant. Associations were assessed by univariate analysis, followed by logistic regression analysis. The following factors were associated with leprosy in the logistic regression model: households with no more than four rooms (OR = 4.01), absence of a BCG vaccination scar (OR = 2.16), and a previous case of leprosy in the family (OR = 4.32). The data indicated that a close relationship between individuals of the same family in small households, without any immunological protection, and with a history of leprosy cases, significantly increased the risk of *M. leprae* infection and development of leprosy.

Keywords: *Mycobacterium leprae*. Risk factors. Social determinants of health. Social vulnerability.

RESUMO

A hanseníase é uma doença infecciosa crônica causada pelo *Mycobacterium leprae*. Pode resultar em incapacidades físicas permanentes se não for diagnosticado precocemente. Um estudo do tipo caso-controle foi conduzido para identificar os fatores associados à ocorrência de hanseníase em indivíduos residentes em uma região de alta incidência da doença no estado do Tocantins, no Norte do Brasil. Sessenta casos diagnosticados entre 2016 e 2018 e 120 controles foram incluídos no estudo. O grupo controle foi constituído por moradores da mesma área dos casos, do mesmo sexo e com variação de idade de até 5 anos. Os dados foram coletados por meio de entrevistas com cada participante. As associações foram avaliadas por análise univariada, seguida de análise de regressão logística. Os seguintes fatores foram associados à hanseníase no modelo de regressão logística: domicílios com até quatro cômodos (OR = 4,01), ausência de cicatriz de vacina BCG (OR = 2,16) e caso anterior de hanseníase na família (OR = 4,32). Os dados apontam que o convívio íntimo entre indivíduos em famílias mais numerosas e domicílios pequenos, sem qualquer proteção

imunológica e com histórico de casos de hanseníase, aumentou significativamente o risco de infecção por *M. leprae* e desenvolvimento de hanseníase.

Palavras-chave: *Mycobacterium leprae*. Fatores de risco. Determinantes sociais da saúde. Vulnerabilidade social.

INTRODUCTION

Leprosy is a chronic infectious disease whose etiological agent is *Mycobacterium leprae*. The disease has a progressive evolution and presents with dermato-neurological involvement (skin and peripheral nerves), which can evolve into permanent physical disability if not diagnosed early (BRASIL, 2019a). Transmission occurs by inhaling droplet aerosols when a susceptible individual is in close and prolonged contact with someone with untreated leprosy (MARTINEZ et al, 2017).

According to the World Health Organization, in 2021, 140,594 new cases of leprosy were reported in the world, of which 18,318 occurred in Brazil, corresponding to 13.02% of the cases occurring in the world and 92.4% of the total cases occurring in the American continent. The percentage of cases occurring in children under 15 years of age corresponded to 6.4% of the cases diagnosed that year, and the presence of Grade 2 disability (G2D) at diagnosis was observed in 6% of the total number of new cases assessed. In Brazil, cases in children under 15 years old represented 4.1%, and the presence of GD2 was 9.5% (WHO, 2022).

In 2018, Tocantins had the second-highest detection rate in the general population (109.32 cases/100,000 inhabitants) and the highest detection rate in the population under 15 years of age (30.13 cases/100,000 inhabitants) among the Brazilian states. This characterizes this region as a hyperendemic area for leprosy, according to the parameters of the Ministry of Health. Despite the reduction in the number of cases reported from 2020 onwards, this classification remains until the present day (BRASIL, 2023; BRASIL, 2019b).

Bico do Papagaio, one of the five health macro-regions in the state of Tocantins, is made up of 24 cities and is recognized as a hyperendemic area for leprosy, with a general detection rate of 63.31 new cases per 100,000 inhabitants in 2018 (BRASIL, 2019b). This scenario indicates a high risk of exposure of the population to the bacillus and reflects the presence of an active transmission chain and late diagnosis (MONTEIRO et al., 2017; MONTEIRO et al., 2019).

The disease remains a health problem of global importance, despite the leprosy prevention and control policies developed by health agencies in recent decades (WHO, 2022). It typically affects populations in developing countries, tending to occur in poorer and more marginalized areas, which suggests that socioeconomic and environmental factors favor the onset of the disease and its complications (MAKHAKHE, 2021).

Social inequality is 1 of the main obstacles to the control and prevention of leprosy in these countries, as the disease is generally associated with unhealthy living conditions, low levels of education and income, and a deficient healthcare system (CHAPTINI; MARSHMAN, 2015). Furthermore, the lack of basic sanitation, water, and waste treatment—all of which are associated with urban agglomerations—are environmental conditions that favor disease transmission and onset in these populations (LOPES et al., 2021). Other factors that have already been associated with the occurrence of leprosy are poor nutritional status, poverty, and lack of hygiene of the individual (CUNHA et al., 2017), the number of family members, and lack of access to social programs ((SALES et al., 2011; LOPES; RANGEL, 2014) and armadillo hunting or eating (KERR et al., 2016; DA SILVA et al., 2018).

Against this background, studies have sought to investigate the individual and collective factors that predispose to the onset of leprosy and its complications (BHATIA; SINGH; CHOPRA, 2018; NERY et al., 2019), as understanding these factors is imperative for improving disease prevention and control strategies. Although some epidemiological studies have been carried out on Tocantins (MURTO et al., 2014, MONTEIRO et al., 2017; MONTEIRO et al., 2019), few have investigated factors that may influence the occurrence of leprosy, therefore, the present study aimed to identify factors associated with the occurrence of leprosy in individuals residing in a hyperendemic region of the state of Tocantins, northern Brazil.

METHODS

Study location

The study was conducted in the health region of Bico do Papagaio, North of the State of Tocantins, Brazil, in the cities of Augustinópolis (Latitude: 5° 28' 7" South, Longitude: 47° 53' 22" West), Araguatins (Latitude: 5° 39' 22" South, Longitude: 48° 7' 8" West), and Buriti do Tocantins (5° 19' 5" South, Longitude: 48° 13' 44" West), the cities with the greater number of cases of leprosy in the region from 2016 to 2018, according to data from the Ministry of Health (BRASIL, 2020; BRASIL, 2019b). The municipalities studied have a Municipal Human Development Index (MHDI) between 0.631 and 0.670, which is considered medium according to the United Nations Development Program (PNUD, 2022).

Study design

This was an unpaired case-control study covering 60 cases and 120 controls. Cases were defined as subjects living in the urban area, diagnosed with leprosy, treated, or undergoing treatment, registered in the Notifiable Diseases Information System (SINAN), from January 1, 2016, to December 31, 2018. Two controls were selected for each case to provide a more accurate estimate of the frequency of exposure in the control group, thereby increasing the power of the study (OLIVEIRA; PARENTE, 2010). The control group was composed of individuals without leprosy, of the same sex, and with a maximum of 5 years of difference from the individual case and who lived in the same street block, starting recruitment by adjacent neighbors to the case. Age less than 18 years old was the exclusion criterion for both groups.

Data collection

The subjects were approached and invited to participate in the study in Basic Health Units (BHUs) or during home visits by health professionals designated by the Health Department of each participating city, after previous instruction from the responsible researcher. Only individuals living in the study cities and those who agreed to participate in the research by signing the informed consent form were included in the study.

Data were collected through an interview using a structured questionnaire addressing individual and sociodemographic characteristics of the subject (gender, ethnicity, age group, level of education, occupation, family income, and social benefit received), housing conditions (number of rooms in residence, type of housing, number of people living in home, availability of water supply, garbage and sewerage system and asphalt coverage on the street), and characteristics and health-related habits (monitoring of the family by a health agent and endemic agent, frequency of consultations carried out in the last year, presence of vaccine scar, a previous case of leprosy in the family, consumption of armadillo meat and other wild animals, spotted wild animals in the peridomicile, and living with a wild animal).

The interview was conducted individually at the respondent's home or at the BHU where the subject was registered, as previously scheduled between the researcher and the BHU in the most private place possible and respecting the confidentiality of the information provided. Sixty questionnaires were administered in each of the three participating cities (20 to cases and 40 to controls). To minimize biases, the interviewers were previously trained to apply the questionnaire, aiming to standardize the approach and stimuli related to remembering past events.

Data analysis

The data obtained in the interviews were tabulated and analyzed using the EpiInfo7.0@ (<https://www.cdc.gov/epiinfo/support/downloads.html>) and SPSS version 28.0.1 (IBM SPSS Inc., Armonk, NY, USA) statistical packages were used for logistic regression. The variables were grouped into sociodemographic factors and housing conditions, health-related factors, and contact with wild animals. The measure of association used was the *odds ratio* (OR). Associations were initially assessed by univariate analysis using the Mantel–Haenszel chi-square test or Fisher's exact test, when indicated, with a significance level of 5%. The variables with a p-value < 0.10 in the univariate analysis were included in a logistic regression model using the backward stepwise method, and variables were analyzed in blocks based on the likelihood ratio. Variables that remained statistically significant ($P < 0.05$) in each block were integrated into a final model.

Ethical aspects

The present study was approved by the Research Ethics Committee (*Comitê de Ética em Pesquisa - CEP*) of the Hospital for Tropical Diseases of the Federal University of Tocantins (*Hospital de Doenças Tropicais da Universidade Federal do Tocantins - HDT/UFT*), under protocol number 3,532,723.

RESULTS AND DISCUSSION

The 180 study participants tended to be male (58.33%) older than 39 years (58.33%), and identify as a person of color (76.7%). Participants who self-identified as black represented 15.5% of the interviewed population, while white participants accounted for 7.8%. Most of the individuals worked in farming or domestic activities (57.2%), and 37.8% declared a family income of minimum wage or less, while only 4.44% had a family income equal to twice the minimum wage.

The result of the univariate analysis of individual and socioeconomic characteristics is shown in Table 1. The factors associated with leprosy were identifying as “black” (OR = 2.30), low education level (OR = 3.23), and primarily working as a farmer, housekeeper, bricklayer, or fisherman (OR = 2.00). Only education level remained significant following the blocked logistic regression analysis; however, it did not show significance in the final adjusted model (Table 4).

Table 1 – Distribution of sociodemographic variables between case and control groups, in cities in the health region of Bico do Papagaio, Brazil, 2016 to 2018

	Cases N = 60		Controls N = 120		OR (95%CI*)	p-value*
	No	%	No	%		
Sex						
Male	35	58.33	70	58.33	1.00 (0.53–1.89)	>0.999
Female	25	41.67	50	41.67	1	
Age						
19 to 39 years	24	40.00	51	42.50	1.13 (0.56-2.24)	0.727
40 to 59 years	11	18.33	22	18.33	1.06 (0.44–2.54)	0.900
≥60 years	25	41.67	47	39.17	1	
Ethnicity						
Black	14	23.33	14	11.67	2.30 (1.01-5.22)	0.042
Brown/White	46	76.67	106	88.33	1	
Level of education						
Up to 8 years	53	88.32	84	70	3.23 (1.38-8.35)	0.006
Over 8 years	7	11.68	36	30	1	
Occupation						
Farmer / Houseworker / Bricklayer / Fisherman	43	71.7	67	55.83	2.00 (1.03–3.90)	0.040
Other occupation	17	28.3	53	44.17	1	
Family income						
Up to 1 minimum wage	25	41.67	43	35.83	1.28 (0.68–2.41)	0.448
Above 1 minimum wage	35	58.33	77	64.17	1	
Receives any social benefit						
No	39	65.00	87	72.50	0.70 (0.36–1.37)	0.30
Yes	21	35.00	33	27.50	1	

OR: Odds ratio; 95%CI: 95% confidence interval.

Source: Own elaboration.

The higher risk of leprosy development in blacks versus whites exposed to the same determining factors was also described by a study that analyzed the social determinants of leprosy in the Brazilian population between 2007 and 2014 (NERY et al., 2019). The greater risk attributed to black individuals may be associated with the spatial occupation and migratory movements of the Brazilian population and the historical process of social exclusion, which disproportionately exposed blacks to sociodemographic and environmental conditions favorable to the spread of the disease (RODRIGUES, 2018; RIBEIRO JÚNIOR; VIEIRA; CALDEIRA, 2012). In this study, 75% of individuals who identified as black resided in households with no more than four rooms, 60.71% were illiterate, 53.57% had a family income of up to 1 minimum wage, and 60.71% were not receiving social benefits.

The association of low or no education and the risk of developing leprosy is widely discussed in the literature (BASSO, 2018; COSTA et al., 2019). In an epidemiological study conducted by the Brazilian Ministry of Health between 2014 and 2018, 43.3% of individuals affected by leprosy had not completed elementary school, and 9.2% were illiterate (BRASIL, 2020). The higher proportion of individuals with leprosy and low education was also identified in a study conducted in the states of Bahia, Piauí, and Rondônia (BOIGNY et al., 2019). A low education level is an important vulnerability factor for leprosy, considering that it limits knowledge about the disease; impairs identification of signs, symptoms, prevention measures, and treatment; and limits access to health services. These factors may contribute to an increased risk of treatment abandonment and the development of physical disabilities and relapses (LEANO et al., 2019; SANTOS et al., 2019).

The occupations we identified as being associated with leprosy are characteristic of inland regions and require few qualifications. This finding is expected given the low average education level of our study population. These results were similar to those found in other studies, which also observed a higher frequency of patients in low-paid occupations that did not require high technical knowledge or formal education (BASSO, 2018; SILVA et al., 2018; MARTINS et al., 2019; MOURA et al., 2016; BASSO; SILVA, 2017).

When asked about receiving social benefits, most participants (65% of cases and 72.5% of controls) answered that they did not receive any benefits, with *Bolsa Família*, a government income transfer program, being the main benefit received by those who did. Only a small portion of individuals who called themselves retired (20.56%) received social security benefits. Because most of our participants were farmers and houseworkers, who are not registered in the social security system, they would not receive the benefit. Similar results were observed in other studies in Brazil, with 66.7% (LOPES; RANGEL, 2014) and 73.08% (BASSO; SILVA, 2017) of individuals with leprosy not being included in any governmental assistance programs.

The univariate analysis of factors related to housing conditions in the case and control groups showed that the risk of leprosy development was 4.02 times greater in individuals who lived in houses with no more than four rooms. No significant difference was observed between cases and controls in terms of the number of people in the household, type of housing, number of bathrooms, presence of a septic tank, availability of garbage collection, a sewage network, and street paving (Table 2). Living in a household with no more than four rooms remained a risk factor in the final logistic regression model (Table 4).

Table 2 – Distribution of variables related to housing conditions between case and control groups, in cities in the health region of Bico do Papagaio, Brazil, 2016 to 2018

	Cases		Control		OR (95%CI*)	p-value*
	N = 60		N = 120			
	No	%	No	%		
Number of residents						
4 or more people	24	40	63	52.5	0,604 (0.32–1.13)	0.115
up to 3 people	36	60	57	47.5	1	
Number of rooms						
Up to 4	35	58.33	31	22.83	4.02 (2.09–7.75)	<0.001
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5 or more	25	41.67	89	74.17	1	
Type of housing						
Other material	7	11.67	7	5.83	2.13 (0.71–6.39)	0.170
Masonry	53	88.33	113	94.17	1	
Number of bathrooms						
1 bathroom	50	83.33	99	82.50	1.06 (0.46–2.42)	0.889
2 bathrooms	10	16.67	21	17.50	1	
Septic tank						
No	28	46.67	56	46.67	1 (0.54–1.860)	0.999
Yes	32	53.33	64	53.33	1	
Piped water						
No	25	41.70	42	35.00	0.75 (0.40–1.42)	0.384
Yes	35	58.33	78	75.00	1	
Garbage collection						
Yes	45	75.00	87	72.50	1.14 (0.52–2.36)	0.721
No	15	25.00	33	27.50	1	
Sewerage system						
Yes	8	13.33	16	13.33	1 (0.40–2.49)	>0.999
No	52	86.67	104	86.67	1	
Asphalt/Paving						
Yes	32	53.33	66	45.00	0.94 (0.50–1.74)	0.833
No	28	46.67	54	55.00	1	

OR: Odds ratio; 95%CI: 95% confidence interval. Source: Own elaboration.

The presence of leprosy patients in small, crowded households is a frequent finding in Brazilian studies (BASSO; SILVA, 2017; REIS et al., 2019; RIBEIRO, 2012) and studies originating elsewhere (FEENSTRA, 2013; RUIZ-FUENTES et al., 2019). This setting favors disease transmission given the close and prolonged contact that occurs between the infected individual and susceptible contacts (BRASIL, 2016). Other studies that analyzed the socio-environmental determinants of leprosy showed that the highest proportion of leprosy individuals lived in households with no more than four rooms (RIBEIRO, 2012; BRASIL, 2016; CUNHA et al., 2017).

Although some studies have shown that subjects living in brick houses (compared to wood, mud, or adobe) are significantly less likely to be affected by leprosy (NERY et al., 2019; OLIVEIRA, 2014; MURTO et al., 2014); this may be related to the inhabitants' socioeconomic statuses. This would explain the lack of association between housing material and leprosy in this study; the study participants hailed from similar socioeconomic circumstances. All households had electricity (100%), and most had treated water (77.78%), weekly garbage collection (73.34%), a septic tank (53.34%), and paving asphalt or pavement on the street (54.44%).

Leprosy is commonly found in environments of social deprivation, and its occurrence is significantly influenced by socioeconomic and environmental conditions. Although many cases were previously associated with precarious housing conditions, difficulties in accessing basic public services, lack of hygiene in households, and unhealthy environments (NERY et al., 2019; BASEGGIO, 2016). Factors such as the presence of bacilliferous and immunological status may also facilitate agent and disease spread.

Table 3 presents the result of the univariate analysis of variables related to the interviewees' health and contact with wild animals. Only the absence of a BCG scar and a previous case of leprosy in the family were significantly associated with leprosy and remained risk factors for leprosy in the final logistic regression model (Table 4).

Table 3 – Distribution of variables related to health habits between case and control groups in cities in the health region of Bico do Papagaio, Brazil, 2016 to 2018

	Cases		Control		OR (95%CI)*	p-value*
	N = 60		N = 120			
	No	%	No	%		
Frequency of consultations						
Up to 2	32	53.33	73	60.83	1.36 (0.73–2.54)	0.337
3 or more	28	46.67	47	39.17	1	
BCG scar						
No	33	55.00	43	35.83	2.19 (1.16–4.11)	0.014
Yes	27	45.00	77	64.17	1	
Case of leprosy in the family						
Yes	17	28.33	10	8.33	4.35 (1.85–10.25)	<0.001
No	43	71.67	110	91.67	1	
Wild animal consumption (armadillo)						
Yes	29	48.33	55	45.83	1.11 (0.59–2.06)	0.750
No	31	51.67	65	54.17	1	
Spotted a wild animal						
Yes	4	6.67	11	9.17	0.71 (0.22–2.32)	0.570
No	56	93.33	109	90.83	1	
Lived with a wild Animal						
Yes	0	0.00	4	3.33	0.00 (0.00–3.02)	0.388
No	60	100.00	116	96.67	1	
Health agent						
Yes	53	88.33	102	85.00	1.33 (0.52–3.40)	0.543
No	7	11.67	18	15.00	1	
Endemic agent						
Yes	53	98.33	106	88.33	1.00 (0.38–2.62)	1.000
No	7	1.67	14	11.67	1	

OR: *Odds ratio*; 95%CI: 95% confidence interval.
 Source: Own elaboration.

Table 4 – Factors associated with the occurrence of leprosy in Bico do Papagaio adjusted in a multivariate logistic regression model

Variable	B	SE	Wald	P-value	Exp(B) (Odds Ratio)	95% CI for OR	
Low level of education	0.476	0.527	0.816	0.366	1.610	0.573	4.523
4 or more people in the household	-0.555	0.393	1.996	0.158	0.574	0.266	1.240
Up to 4 rooms in the household	1.390	0.384	13.114	<0.001	4.017	1.893	8.525
BCG scar absent	0.771	0.373	4.269	0.039	2.162	1.040	4.493
Leprosy case in the family	1.464	0.485	9.123	0.003	4.325	1.672	11.186
Constant	-1.992	0.539	13.657	<0.001	0.136	-	-

B = Constant; SE = Standard error; OR = Odds Ratio.
 Source: Own elaboration.

A higher percentage of individuals in the control group had a BCG vaccination scar (64.17%), which suggests that immunization for BCG is protective against leprosy. Corroborating the present study, other studies that analyzed the vaccination status of (non-ill) household contacts of patients with leprosy have reported that 60–67.85% of the non-ill respondents had a BCG vaccination scar (MENDONÇA et al., 2019; GARCIA et al., 2020), while the absence of a BCG vaccination scar is reported as a risk factor (SCHNEIDER; FREITAS, 2018).

Moreover, 51.5% (17/33) of individuals without a scar reported previous leprosy in either their father or mother. This finding indicated a possible failure in the process of identification and protection of contacts by the healthcare system of the study region, considering that the administration of a dose of BCG in contacts of leprosy patients is part of the disease management protocol of the Brazilian Ministry of Health (BRASIL, 2022). According to the Ministry of Health, the BCG vaccine is indicated for the treatment of severe forms of tuberculosis and is not a specific vaccine for leprosy (BRASIL, 2019a). However, BCG vaccination is associated with a high reduction in the incidence of multibacillary forms of the disease, reducing the incidence from 20% to 90%, depending on individual immunological factors (SCHREUDER; NOTO; RICHARDUS, 2016).

Most of the participants immunized with BCG had only one vaccination scar (96.15%). The presence of a single scar is the most frequent finding in studies conducted in Brazil, with a low frequency of leprosy in individuals with two scars (LAGES, 2017; LOZANO et al., 2019; GARCIA et al., 2020).

The high percentage of individuals with no vaccination scar (55%) may indicate possible inadequate vaccination coverage in the health region of Bico do Papagaio, as the BCG vaccine is administered from birth until the child reaches 5 years of age (BRASIL, 2019a). Consequently, this finding suggested possible operational failures in local health services.

The occurrence of a previous case of leprosy in the family was another risk factor for the disease, with individuals with a history of leprosy in the family being 4.34 times more likely to develop the disease. This result corroborates other studies that demonstrated the relevance of intradomiciliary contact in the active transmission of leprosy (MENDONÇA et al., 2019; OFUSU; BONSU, 2010; MONTEIRO et al., 2018). All those who reported a case of leprosy at home had a degree of consanguineous kinship with the index case, which was also observed in several previous studies, with more than 70% of patients showing some degree of consanguineous kinship with the index case (OLIVEIRA, 2014; MENDONÇA et al., 2019; LOZANO et al., 2019; LOZANO et al., 2020). This can be explained by inter-human transmission of the disease, through intimate and prolonged exposure of a susceptible person to an untreated, multibacillary case (BRASIL, 2020).

In this study, the provision of care by healthcare workers at patients' homes was reported by 86.11% of the research participants, with no significant difference between cases and controls. The work of

community health agents in home visits is an important way that patients with leprosy access health services. They are the main agents for active searches for suspected cases in communities and for providing different guidelines to leprosy patients (BRASIL, 2019c; LIMA, 2018). The community health agent is part of a multidisciplinary family health team that makes up the Family Health Strategy Brazil program. The teams are linked to a Basic Health Unit and are generally composed of a doctor, a nurse, a nursing assistant or technician, and community health agents. Each team is responsible for individual, family, and collective health actions that involve promoting, preventing, and protecting the health of a defined number of families located in a delimited geographical area (BRASIL, 2017). In a study conducted by Ribeiro (2012), 78.9% of the study population reported that the community health agent was the first health professional that they sought to obtain information about disease symptoms. This highlights the importance of primary care within the National Program of Leprosy Control (*Programa Nacional de Controle da Hanseníase - PNCH*).

The present study also investigated the association of consumption, exposure, or cohabitation with wild animals—particularly armadillos—and leprosy. Despite nearly half of the participants (46.7%) reported consuming armadillos, there was no risk of illness related to consumption, being exposed, or living with a wild animal near the household.

Our findings were similar to those reported in a study conducted in Curitiba-PR (SCHMITT et al., 2010), but differed from a study conducted with 146 individuals living in a hyperendemic area of the state of Pará, which found an association of armadillo meat consumption with a higher risk of developing leprosy and higher anti-PGL-I (phenolic glycolipid antigen-1) titers in individuals who ate armadillo meat regularly, as compared to subjects who did not consume armadillo meat (DA SILVA et al., 2018). Although *M. leprae* has already been observed in armadillos and monkeys in hyperendemic areas of Brazil, there is insufficient evidence that bacillus can be transmitted from these animals to humans (BRITTON; LOCKWOOD, 2004; KEER et al., 2015). Therefore, further studies should be conducted to understand this variable better.

The fact that education, ethnicity, and occupation did not remain significant variables in the regression analysis can be explained by the study cohort's relatively low level of education and income and the fact that our participants came from similar socioeconomic conditions. The most frequent monthly income of the leprosy population varied from 1 to 2 minimum wages (BASSO; SILVA, 2017; REIS et al., 2019).

Low-income individuals with leprosy are at increased risk for physical disabilities and relapses, which influence their quality of life and social interaction (BOIGNY et al., 2019; LEANO et al., 2019; MOURA et al., 2016). Social factors perpetuate the chain of transmission, thereby allowing the disease inroads into the poorest populations. Over the years, we have accumulated strong evidence of the association between poverty and leprosy (NERY et al., 2014).

As a case-control study, our work is prone to selection and recall biases. The sample size is small and may limit the generalizability of the findings.

CONCLUSION

Our results indicated that variables that expose contacts, such as small residences with a larger number of people, previous cases of leprosy in the family, and individuals not immunized with BCG, may be the main risk factors for leprosy in places of low socioeconomic status, such as in the North of Tocantins. Thus, the intensification of new case tracking processes, combined with education and health actions for the population regarding the disease and the training of health professionals in the region regarding the adoption of prevention and control measures aimed at patients and contacts are strategies that can effectively contribute to reducing the number of leprosy cases in the region.

ACKNOWLEDGEMENTS

The present work was carried out with the support of the National Program for Academic Cooperation in the Amazon – PROCAD/Amazônia of the Coordination for the Improvement of Higher Education Personnel – CAPES/Brazil” and the Postgraduate Program in Animal Health and Public Health in the Tropics of the University Federal North of Tocantins.

AUTHORS' CONTRIBUTION

All authors contributed to the article and approved the submitted version.

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