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Spatio-temporal dynamics of visceral leishmaniasis transmission in a highly endemic region of Brazil

Dinâmica espaço-temporal da transmissão de leishmaniose visceral em uma região altamente endêmica do Brasil

Dinámica espaciotemporal de la transmisión de la leishmaniasis visceral en una región altamente endémica de Brasil

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ABSTRACT

Introduction: Brazil concentrates 96% of visceral leishmaniasis cases occurred in Americas, and Maranhão is the Brazilian state with the highest number of registered cases. **Aim:** to analyze the spatio-temporal dynamics of visceral leishmaniasis transmission in a Brazilian region with high endemicity between 2009 to 2017. **Outlining:** We carried out an ecological and time series study using spatio-temporal analysis techniques. A time-trend analysis was performed by the segmented linear regression. High-risk clusters were identified through spatial autocorrelation (Moran's global and local indexes) and space-time scan statistics. **Results**: There were 5,128 visceral leishmaniasis cases, and it was observed increasing trends of new cases in the general population, among men, adults ≥20 years old, especially ≥60 years old. VL-HIV coinfection, mortality and lethality were crescent. Spatial analysis revealed intense visceral leishmaniasis transmission in almost the entire state and high-risk priority areas. **Implications**: Visceral leishmaniasis is in a substantial geographical expansion, demonstrating that the surveillance policies need to be reformulated.

DESCRIPTORS
Geographic information system; Spatial analysis; Time series studies; Visceral leishmaniasis.

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INTRODUCTION

Visceral Leishmaniasis (VL) is one of the most lethal neglected tropical diseases (NTDs), affecting the poorest and the most vulnerable people.[1-2] In both Americas, VL is caused by Leishmania infantum protozoan, whose urban reservoir is the domestic dog.[3] The transmission happens when the female sandfly (Lutzomiya longipalpis) bites the host. This vector is very well adapted to urban sites with high populational density.[4]

It is estimated that 1 billion people live in VL endemic regions worldwide and that 50,000 to 90,000 news cases happen per year. In the Americas, the disease is endemic in 12 countries, including Brazil,[5] which is responsible for 97% of the registered cases in 2018.[6] In Brazil, VL has a wide territorial distribution, with diversified geographic and social characteristics, including expansion to urban areas.[4,7-8] The vector is disseminated throughout the country and has become adapted to inhabit the modified environment by anthropic actions.[9] In the 90s, about 90% of notified cases were from the Northeast of Brazil, but with the VL dissemination to other regions, in 2012, the Northeast represented only 43.1% of national cases.[10] However, 56% of VL deaths, between 2000 to 2011, occurred in this region.

Maranhão, located in the Northeast region, is the state with the highest number of VL cases. The endemic scenario stems from the conducive environment to disease transmission, due to unplanned environmental destruction, industrialization, and urbanization, lack of sanitation and poor housing conditions. Moreover, the Amazonian ecosystem in which the state is located, characterized by high luminosity and temperature, provides the proper situation for the proliferation and dissemination of the vector.[11-13]

It is notable that these socio-environmental conditions make Maranhão conducive to the development of several tropical diseases, whose vectors are mosquitoes, such as VL,[13] which has been associated to poverty and poor living conditions.[14] Thus, the aim of this study is to analyze the spatio-temporal dynamics of VL transmission in Maranhão, a Brazilian region with high endemicity.

We hypothesize that the spatial distribution of VL in the state of Maranhão is not random (principle of spatial independence) but presents a pattern of clustering due to proximity to municipalities with high rates of the disease.

METHOD

Study Design

An ecological and time series study that used Spatio-temporal analysis techniques, including all VL confirmed cases from Maranhão, Northeast of Brazil, during 2009-2017. The units of analysis were the 217 municipalities of the state.

Study area

The state of Maranhão is located in the Northeast region of Brazil (4°57'39.4"S 45°16'27.9"W), which possesses a territorial extension of 329,642.170 km^2 and estimated population of 6,574,789 inhabitants, its municipalities are grouped in 5 mesoregions (North, South, East, West, and Center).[15] Poverty is a concerning indicator in this state, since it has low Human Development Index (HDI), with about one-third of its population living without piped water, garbage collection and appropriate sewage.[16-17]

Data Sources

Morbidity data, clinical and demographic characteristics of registered cases were obtained from Information System for Notifiable Diseases (Sistema de Informação de Agravos de Notificação – SINAN) database of the Secretariat of Health Surveillance of the Brazilian Ministry of Health (Secretaria de Vigilância em Saúde do Ministério da Saúde - SVS/MS). Population estimations and the digital cartographic mesh (shapefile extension) of the Universal Transverse Mercator (UTM) system - Terra Datum horizontal model (SIRGAS 2000), segmented by municipalities and mesoregions were obtained from databases of the Brazilian Institute of Geography and Statistics (Instituto Brasileiro de Geografia e Estatística - IBGE).

Variables and Measures

Incidence rates (per 100,000 inhabitants) were considered main variables of the study. These rates were calculated in state and municipality levels, annually, triennially, by sex and age group (≤ 4 years old, 5-19 years old, 20-39 years old, 40-59 years old and ≥ 60 years old). Triennial crude rates were obtained calculating the mean of cases triennially (2009-2011, 2012-2014, 2015-2017) divided by central population (2010, 2013 and 2016, respectively), multiplied by 100,000. The transmission risk stratification followed the most recent guideline of Health Surveillance Guide of the Brazilian Health Ministry (Guia de Vigilância em Saúde do Ministério da Saúde do Brasil),[18] according to the following classification: sporadic transmission (< 2.4 cases/100,000 inhabitants), moderate transmission (≥ 2.4 and < 4.4 cases/100,000 inhabitants), and intense transmission (≥ 4.4 cases/100,000 inhabitants). The secondary measures considered were prevalence, mortality, lethality, percentage of cases with VL-HIV co-infection and proportion of infected municipalities. Sex, age group, race/skin color, residence zone, level of education, case type and clinical outcome were used to epidemiological characterization and represented through absolute and relative frequencies.

Time trends analysis

Time trends of VL incidence were analyzed by segmented linear regression (joinpoint) and classified into decreasing, stable and increasing. Monte Carlo's permutation test was applied to choose the best segment of each model. The annual percent change (APC) was calculated for each period and the average annual percent change (AAPC) from the entire period was calculated to simplify the comparison among trends with more than one significative inflexion. Trends were considered statistically significant when APC and AAPC showed p-value < 0.05 and theirs CI95% did not include zero.[19]

Spatial Analysis

Initially, crude incidence rates were smoothed by the empirical Bayes method to correct the random fluctuation of rates, mainly in small population municipalities. The area analysis by Global Moran's was used to verify spatial autocorrelation, using a first-order contiguity matrix. Once the existence of spatial dependence was identified, the occurrence of local spatial autocorrelation was evaluated by Local Moran's (Local Indicators of Spatial Association - LISA). Which indicates the clustering of municipalities with high VL transmission and generates a diagram with four quadrants: Q1 (municipalities with high VL incidence and high neighborhood incidence rates); Q2 (municipalities with low VL incidence and low neighborhood incidence rates); Q3 (municipalities with high VL incidence and low neighborhood incidence rates); Q4 (municipalities with low VL incidence and high neighborhood incidence rates). The diagram was represented through Moran maps, in which only statistically significant results (p-value < 0.05) were considered.[20]

Spatio-temporal cluster analysis

Retrospective space-time scan statistics were used to identify spatio-temporal clusters with high-risk to new VL cases, using the Poisson distribution model according to the following parameters: time aggregation of 1-year, circular clusters, no geographical or temporal overlapping, maximum size of spatial and temporal clusters equal to 50% of area and period of study, respectively. The primary and secondary clusters were detected using the likelihood-ratio test (LRT) and represented by table and map. Relative risks (RR) to VL occurrence in each cluster were calculated. The results were statistically significant when p-value < 0.05, using 999 Monte Carlo simulations.[21]

Softwares

Microsoft Office Excel 2016 (Microsoft Corporation; Redmond, WA, EUA), TerraView 4.2.2 (Nacional Institute for Spacial Research, INPE, SP, BR), QGIS 2.18.10 (Open Source Geospatial Foundation), JointPoint Regression 4.3.1.0 (US National Cancer Institute, Bethesda, MD, EUA) and SaTScan 9.1.1 (Harvard Medical School, Boston and Information Management Service Inc., SiVLer Spring, MD, EUA) were used to analysis and data processing.Microsoft Office Excel 2016 (Microsoft Corporation; Redmond, WA, EUA), TerraView 4.2.2 (Nacional Institute for Spacial Research, INPE, SP, BR), QGIS 2.18.10 (Open Source Geospatial Foundation), JointPoint Regression 4.3.1.0 (US National Cancer Institute, Bethesda, MD, EUA) and SaTScan 9.1.1 (Harvard Medical School, Boston and Information Management Service Inc., SiVLer Spring, MD, EUA) were used to analysis and data processing.

Ethical Considerations

The present study used aggregated secondary data available in public domain and followed the Brazilian National Health Council's (Conselho Nacional de Saúde do Brasil) and Declaration of Helsinki's recommendations. All analyzed and presented data were anonymous, dispensing the necessity of the Free and Informed Consent Form. This research project was approved by the local Ethics Committee (Comitê de Ética em Pesquisa da Universidade Federal de Sergipe), registered under the number: 2.537.671.

RESULTS

According to the research, 5,128 VL cases were confirmed in the state of Maranhão during 2009-2017, with an average annual prevalence rate of 8.4 cases/100,000 inhabitants in the general population. Most cases were new (4,735/92.3%) with average annual incidence corresponding to 7.76 cases/100,000 inhabitants. Table 1 shows the baseline characteristics of the study population. VL affected predominantly males (63.8%), < 5 years (47.5%), nonwhite people (89%), urban residents (68.5%), low education people (26.3%) and that were later cured (56.7%). Lethality was 8.1% and the percentage of VL-HIV co-infection was 8.6%. It is important to highlight that there was no outcome register in almost 20% of the cases.

The assessment of annual percentage change of VL epidemiologic indicators was estimated by segmented linear regression, as shown in Table 2. There were no inflexion points in all trends, considering the entire period (2009-2017). VL prevalence ranged from 7.1, in 2009, to 11.3/100,000 inhabitants, in 2017, with an annual increment of 6.8 (CI95%: 1.5 to 12.4). There was a rising trend of new cases in the general population (APC: 6.1; CI95%: 0.6 to 12.0), as well as among males and age groups ≥ 20 years old, especially elderly (APC: 24.2; CI95%: 13.5 to 35.9). In addition, VL-HIV coinfection (APC: 8.9; CI 95%: 1.9 to 16.4), mortality rate (APC: 17.1; CI95%: 9.1 to 25.6) and lethality (APC: 5.5; CI95%: 3.2 to 7.8) in general population evidenced significant increasing trends.

VL is in expansion and widely spread throughout the state, since there was a significant increment in the proportion of municipalities with VL transmission (APC: 5.5; CI95%: 3.2 to 7.8). The spatial analysis presented in Figure 1 corroborates with this finding. The maps with spatial distribution of triennial crude incidence rates (Figure 1A) and smoothed (Figure 1B) point intense transmission in all mesoregions of the state. Among 2009-2011, VL new cases concentrated in the East, Center, and South of Maranhão. From 2012 to 2014, an increase in transmission intensity was observed in areas that had sporadic transmission previously. In the last triennium (2015-2017), the VL transmission in all mesoregions and the rise of the transmission intensity is remarkable, mainly in the Midwest of the state.

Table 1. Baseline characteristics, Maranhão, Brazil, 2009-2017. (n=5,128)

Variables	n	%
Type of case		
New	4,735	92.3
Relapse	221	4.3
Transference	111	2.2
Miss data	61	1.2
Sex		
Male	3,270	63.8
Female	1,858	36.2
Age group		
0-4 years	2,437	47.5
5-19 years	902	17.6
20-39 years	1,022	19.9
40-59 years	562	11
≥ 60 years	201	3.9
Miss data	4	0.1
Race/skin color		
White	468	9.1
Nonwhite	4,551	88.7
Miss data	109	2.1
Zone		
Urban	3,513	68.5
Rural	1,375	26.8
Periurban	75	1.5
Miss data	165	3.2
Level of education		
< 8 years	1,348	26.3
≥ 8 years	580	11.3
Miss data	3,200	62.4
VL-HIV coinfection	439	8.6
Outcome		
Cure	2,908	56.7
Abandonment	41	1.0
Death	416	8.1
Transference	782	15.2
Miss data	981	19.1

Source: authors (2024).

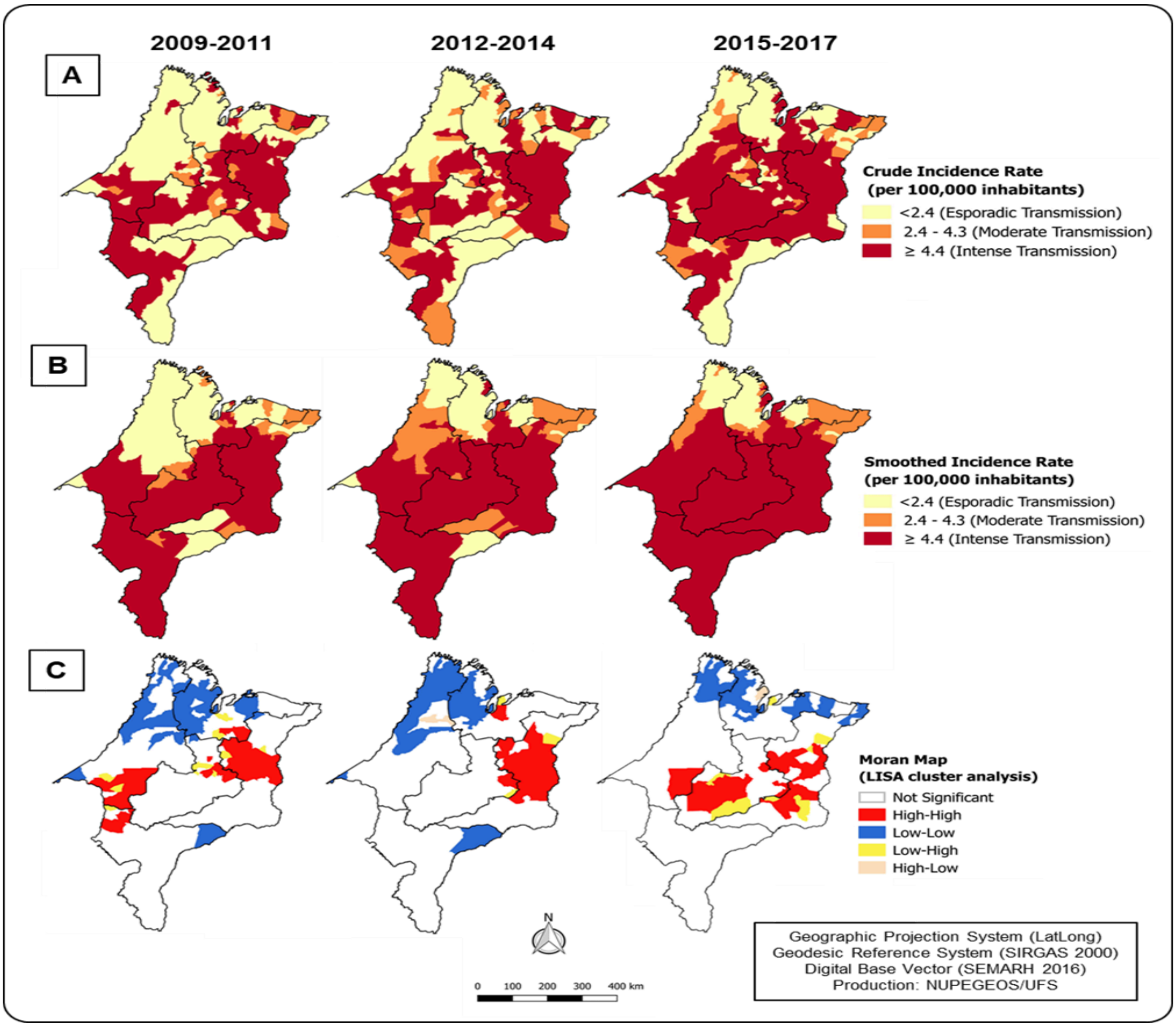
Table 2. Time trends of VL epidemiologic indicators, Maranhão, Brazil, 2009-2017

Indicator/variable	APC (CI95%)	Trend
Crude incidence rate (per 100,000 inhabitants)		
General population	6.8* (1.5 - 12.4)	Increasing
Crude prevalence rate (per 100,000 inhabitants)		
General population	6.1* (0.6 - 12.0)	Increasing
Sex		
Male	6.8* (0.6 - 13.3)	Increasing
Female	4.9 (-0.4 - 10.5)	Stable
Age group		
≤ 4 years	4.4 (-2.3 - 11.6)	Stable
5-19 years	4.6 (-0.5 - 9.9)	Stable
20-39 years	8.0* (1.4 - 15.1)	Increasing

40-59 years	11.6* (6.0 – 17.4)	Increasing
≥ 60 years	24.2* (13.5 – 35.9)	Increasing
Zone		
Urban	0.1 (-0.8 – 1.0)	Stable
Rural	1.5 (-1.3 – 4.5)	Stable
Percentage of VL-HIV coinfection		
General population	8.9* (1.9 – 16.4)	Increasing
Crude mortality rate (per 100,000 inhabitants)		
General population	17.1* (9.1 – 25.6)	Increasing
Lethality		
General population	9.4* (4.4 – 14.7)	Increasing
Proportion of municipalities with VL transmission		
	5.5* (3.2 – 7.8)	Increasing

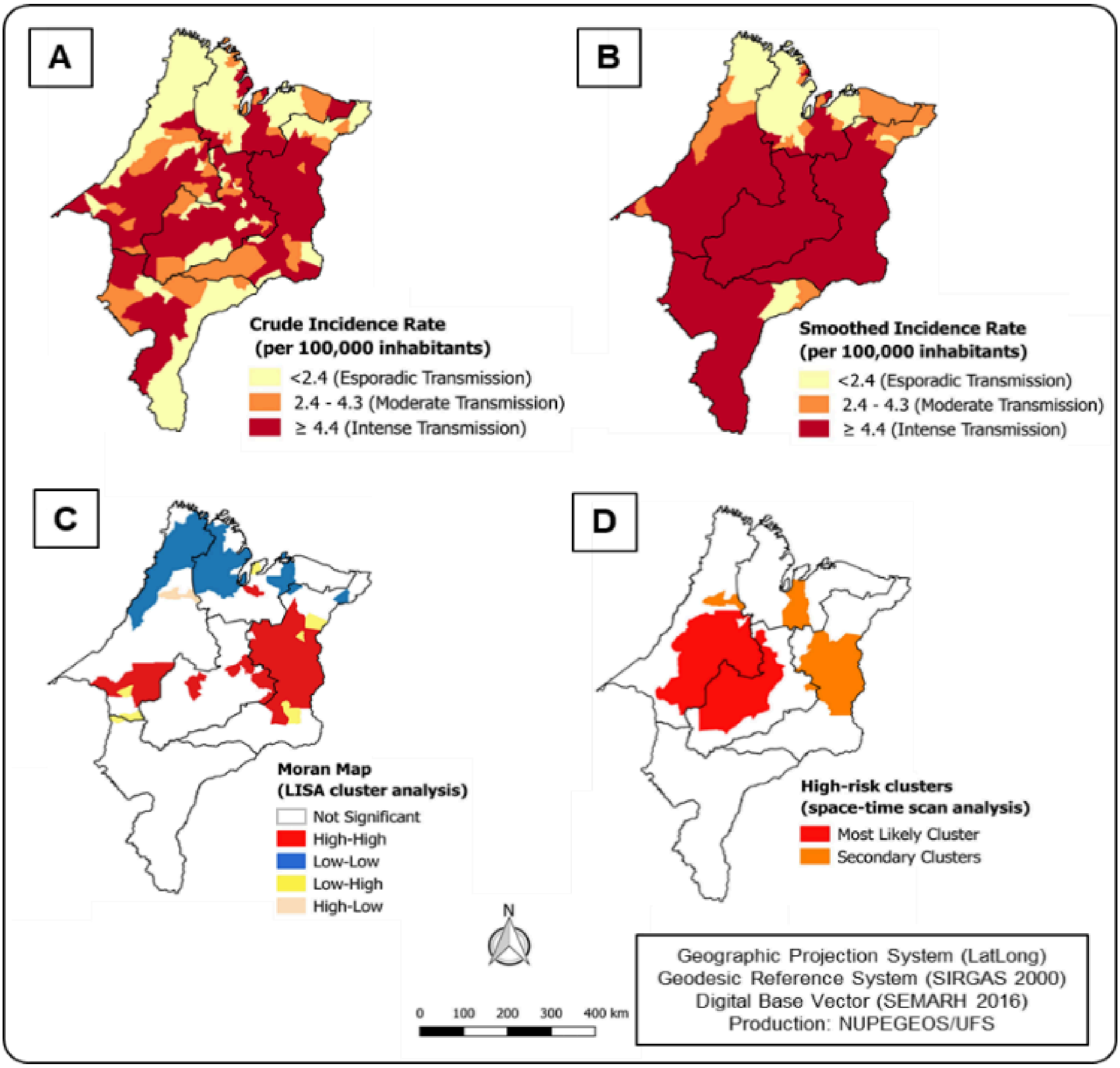
Legend: VL - visceral leishmaniasis, VL-HIV – visceral leishmaniasis-HIV co-infection.
Source: authors (2024).

Figure 1. Spatial dynamics of VL transmission in municipalities of Maranhão, Brazil, grouped into mesoregions and represented by triennial incidence rates (per 100,000 inhabitants)



Legend: (A) Spatial distribution of VL crude incidence rates. (B) Spatial distribution of VL smoothed incidence rates. (C) Moran maps highlighting high-risk spatial clusters for VL.
Source: authors (2024).

Figure 2. Spatial and spatiotemporal analysis for VL transmission in municipalities of Maranhão, grouped into mesoregions and represented by average incidence rates (per 100,000 inhabitants) of entire period (2009-2017)



Legend: (A) Spatial distribution of crude incidence rates. (B) Spatial distribution of smoothed incidence rates. (C) Moran map highlighting spatial high-risk clusters for VL. (D) Map representing space-time scan analysis.
Source: authors (2024).

The spatial cluster analysis was performed by calculating Global Moran's I for each triennium. Spatial dependence of VL occurrence in Maranhão was evidenced, once there was spatial autocorrelation in all periods (2009-2011: I=0.713; p-value=0.001. 2012-2014: I=0.667; p-value=0.001. 2015-2017: I=0.715; p-value=0.001. Therefore, LISA analysis was executed and represented through Moran maps, which enabled to identify the classified municipalities according to the level of significance of their local indexes (Figure 1C).

During 2009-2011, high-risk clusters were identified in all mesoregions, highlighting the West and East mesoregions of the state. From 2012 to 2014, the high-risk area to VL has been limited almost exclusively to the East, expanding again to Midwest in the last triennium. The municipalities grouped into Q4 indicate disease's transition areas, but they deserve attention because they are close to municipalities with a high incidence of VL. The clusters classified as Q3 present an elevated VL incidence and can interfere with the neighbors with low VL incidence.

According to analysis of the average incidence rate of the entire period (2009-2017), intense transmission prevailed in all mesoregions (Figures 2A and 2B), with high-risk spatial clustering formation (I=0.783; p-value=0.001) in the East and, to a lesser extent, in Center, West and North mesoregions (Figure 2C).

Five spatio-temporal high-risk clusters were identified through space-time scan statistics (Table 3), which can be visualized in Figure 2D. The cluster no. 1 represents the primary cluster, and the others are secondary clusters. The primary cluster occurred during 2011-2014, with the highest number of VL cases in the state and was limited to the Center and West of Maranhão. The cluster no. 2 (2016-2017) comprised the highest number of municipalities. Nevertheless, the cluster no. 3 (2013-2015) had the highest relative risk (RR: 3.64). It shows that, despite the decrease of risk of the exposed population in developing VL between 2015 to 2017, the number of municipalities with VL transmission increased.

Table 3. Spatiotemporal clusters of VL new cases (per 100,000 inhabitants), Maranhão, Brazil, 2009-2017

Cluster	Period	Number of cities	Mesoregions	New cases	Expected cases	Annual incidence	RR	LLR	p-value
1	2011 to 2014	12	Center and West	573	203	22.0	3.08	240.7	<0.001
2	2016 to 2017	32	East	315	143	17.2	2.3	80.63	<0.001
3	2009 to 2011	5	North	101	31	25.2	3.29	49.39	<0.001
4	2013 to 2015	3	West	78	22	28.0	3.64	43.83	<0.001
5	2014 to 2016	1	West	42	12	27.7	3.58	23.22	<0.001

Source: authors (2024).

DISCUSSION

The results revealed that VL is a serious public health issue in expansion in the state of Maranhão, once the state remains leading the number of VL registered cases in regional and national levels. The spatio-temporal analysis evidenced increasing trends in VL incidence and intense transmission in all mesoregions, with incidence rates higher than the national rate registered in 2017 (1.98 cases/100,000 inhabitants).[22]

The highest VL prevalence occurred among males, < 5 years old, nonwhite skin color, urban residents and low education. This epidemiologic profile was also observed in São Luís, state's capital, during 2014-2017,[23] and other sites from Northeast and Midwest regions of Brazil.[24-28]

Despite the occurrence of most cases being among children and adolescents, there were rising trends among adults, especially among elderlies. Young children are more susceptible to VL infection due to immaturity of an immune response, which can be aggravated by malnutrition, a common phenomenon of endemic areas.[3,29] However, in a study performed in Rio Grande do Norte, Brazil, similar findings were observed, since it was noticed a progressive increase of VL among adults,[30] possibly associated with the aging population and decrease of fecundity in the country.[15] VL can have more severe consequences at the extremes of age, particularly in the elderly, due to the burden of comorbidities and immunosenescence.[31]

Mortality, lethality, and VL-HIV co-infection increased significantly in the study period. Among the main contributive factors to the rise of lethality is the age < 5 years old,[32] late diagnosis, mainly in elderly people,[33] and the expansion of the epidemic in individuals with comorbidities,[34] such as VL-HIV coinfection.1 HIV-positive patients are more susceptible to develop VL, which is considered an opportunistic infection that accelerates the HIV replication and the progression to AIDS.[35]

The spatial dynamics of VL demonstrated expansion of the disease in all mesoregions of Maranhão, with the intense transmission in almost the whole state and a higher number of cases in the urban zone. Additionally, VL distribution proved to be heterogeneous with the formation of spatial and spatio-temporal clusters. In addition to the possible factors associated with VL dynamics that will be discussed below, it is necessary to highlight the different capacities of local systems for epidemiological surveillance of infectious diseases. Although there is a national policy of VL control, municipalities have important disparities in the resources available to prevent, diagnose, notify and timely treat VL.

The disoriented urbanization leads to environmental and climate changes, interruption of control actions and vector adaptation to the humanly modified environment.[36-37] Furthermore, the VL occurrence in municipalities with no previous registered cases was observed, as well as an increase of transmission intensity in municipalities with sporadic transmission.

Several factors may have contributed to VL dissemination, started in the 2000s, among them, the intense migratory flow between municipalities and states, especially next to Teresina, Piauí, and in neighboring of Vale do Rio Doce railroad, as well as in cities with intense deforestation.[38] The phenomenon of migration enables both the introduction of the etiologic agent and the insertion of susceptible individuals in endemic areas with poor living conditions and no proper infrastructure and sewage. Additionally, it is important to mention the adaptation ability of vector, L. longipalpis, to indoor environment, which can be found practically throughout the state.[24,38]

The Moran maps pointed out to the West, Center and East mesoregions, that showed higher concentration of cases and significant spatial dependence. On the other hand, the primary high-risk spatio-temporal cluster comprised municipalities from West and Center mesoregions, which had the worst HDI of the state[39] and are located into the Brazilian Legal Amazon. Similarly, spatio-temporal clustering of leprosy cases at the same region was observed.[40] This finding is concerning because the overlapping of several infectious diseases could overwhelm the health surveillance system.

The Brazilian Legal Amazon is a strategic region for great development projects, the agribusiness, and extensive livestock. Granting the advances in the regional economy, nonetheless there were serious changes in the ecosystem, caused by deforestation, as well as due to the implementation of industrial projects that favored populational growth, as in the cities of Açailândia and Imperatriz,[13] making the scenario of social vulnerability more critical.[41]

Environmental modifications, massive human migrations, unplanned urbanization, deforestation, and irregular occupation of forest areas, combined with low quality sewage and low host immunity are related to the occurrence of VL new cases.[3] Excepting some forest protection and indigenous areas, part of the coast and far South of the state of Maranhão has already undergone important anthropic modification.[42] Consequently, these preserved areas were those that exhibited a lower risk for VL transmission. Accordingly, one of the priorities of the development policies should be the promotion of the socio-environmental sustainability of Maranhão.[42]

It is fundamental to know the spatial, temporal, and spatio-temporal patterns of the diseases to effective surveillance, mainly in those vector-borne diseases like VL. Spatio-temporal analysis techniques have been showing to be useful for the comprehension of the occurrence of health events in the territory.[43] However, their applicability in nationwide surveillance and disease control services are still incipient.

This study has some limitations, particularly related to underreporting and the quality of records in northeastern municipalities. This may be due to the operational difficulties of surveillance services and the fragility of the primary care network in the most underserved and hard-to-reach municipalities. Furthermore, it is not possible to establish casual link between individual variables and the occurrence of VL.

Despite these limitations, our results represent the epidemiological scenario of LV in the Maranhão state over a 9-year period and demonstrate the usefulness of spatiotemporal analyses for the surveillance and control of public health diseases. These analyses allow for the identification of high-risk priority areas for transmission and provide an understanding of the association between disease dynamics and social phenomena occurring in the region. These interventions need to be improved through a more coherent health policy with local reality, whose implementation is supported by a focused research agenda.[29,35,44]

On the other hand, ecological research offers a myriad of possibilities and hypotheses for the development of new studies as one of its primary benefits. Throughout the course of this research, several insights and operational questions have emerged that warrant further investigation. The first is the lack of open access to local, regional, and national data concerning vector control actions and canine surveillance data. Integrating these data with those available in SINAN would be useful not only for prioritizing high-risk areas but also for conducting cost-effectiveness studies of the national program of VL control.

Investigating the epidemiological characteristics associated with illness, increased severity, and mortality from VL in specific populations, such as children, the elderly, and patients with HIV infection, is essential for planning actions to combat VL lethality. Another significant aspect is the lack of communication between the Mortality Information System (SIM) and SINAN. A study that properly linked these systems could provide more accurate data on mortality and lethality, as well as more accurate incidence data, given that some patients reported in SIM are not recorded in SINAN.

Additionally, it is recommended to conduct more focused analyses in West and East mesoregions of the Maranhão state. Finally, few studies were found addressing the role of primary care and the operationalization of the local surveillance system. Research is needed to evaluate how primary health care units and their teams provide care to VL patients; the level of knowledge that professionals have about the disease; the structure (rapid tests, therapeutic-diagnostic support, matrix support, and notification procedures); and the points of care to which patients are referred, especially in cases of VL-HIV coinfection. Late diagnosis has been identified as one of the main factors contributing to increased lethality, so evaluating the journey of these patients through the health system would be useful.

CONCLUSION

The results of this study demonstrate that VL eradication and control programs have not been successful in Maranhão, since the territorial expansion of the disease, spatial and spatio-temporal high-risk clustering, and increasing trends of new cases in general population, especially among adults, simultaneously to an increase of percentage of VL-HIV coinfection, mortality, and lethality was evidenced. Thus, VL control strategies should include an integrated approach of actions through the strengthening of epidemiological surveillance of several NTDs and local decision-making, use of spatio-temporal analysis tools, continuing education of health teams, and last, but not least, the reduction of social inequities through intersectoral public policies.

RESUMO

Introdução: O Brasil concentra 96% dos casos de leishmaniose visceral ocorridos nas Américas, sendo o Maranhão o estado brasileiro com maior número de casos registrados. **Objetivo:** analisar a dinâmica espaço-temporal da transmissão da leishmaniose visceral em uma região brasileira com alta endemicidade entre 2009 e 2017. **Delineamento:** Realizamos um estudo ecológico e de séries temporais utilizando técnicas de análise espaço-temporal. Uma análise de tendência temporal foi realizada por meio de regressão linear segmentada. Clusters de alto risco foram identificados através de autocorrelação espacial (índices globais e locais de Moran) e estatísticas de varredura espaço-temporal. **Resultados:** Houve 5.128 casos de leishmaniose visceral, e observou-se tendência crescente de novos casos na população geral, entre homens, adultos ≥20 anos, especialmente ≥60 anos. A coinfecção LV-HIV, a mortalidade e a letalidade foram crescentes. A análise espacial revelou intensa transmissão de leishmaniose visceral em quase todo o estado e áreas prioritárias de alto risco. **Implicações:** A leishmaniose visceral está em expansão geográfica substancial, demonstrando que as políticas de vigilância precisam ser reformuladas.

DESCRITORES

Sistemas de Informação Geográfica; Análise Espacial; Estudos de Séries Temporais; Leishmaniose Visceral.

RESUMEN

Introducción: Brasil concentra el 96% de los casos de leishmaniasis visceral ocurridos en las Américas, y Maranhão es el estado brasileño con mayor número de casos registrados. **Objetivo:** analizar la dinámica espacio-temporal de la transmisión de la leishmaniasis visceral en una región brasileña con alta endemicidad entre 2009 y 2017. **Delineación:** Realizamos un estudio ecológico y de series temporales utilizando técnicas de análisis espacio-temporal. Se realizó un análisis de tendencia temporal mediante regresión lineal segmentada. Los grupos de alto riesgo se identificaron mediante autocorrelación espacial (índices globales y locales de Moran) y estadísticas de escaneo espacio-temporal. **Resultados:** Se registraron 5.128 casos de leishmaniasis visceral y se observó una tendencia creciente de nuevos casos en la población general, entre hombres, adultos ≥20 años, especialmente ≥60 años. La coinfección VL-VIH, la mortalidad y la letalidad fueron crecientes. El análisis espacial reveló una intensa transmisión de leishmaniasis visceral en casi todo el estado y áreas prioritarias de alto riesgo. **Implicaciones:** La leishmaniasis visceral se encuentra en una expansión geográfica sustancial, lo que demuestra que es necesario reformular las políticas de vigilancia.

DESCRIPTORES

Sistemas de Información Geográfica; Análisis Espacial; Estudios de Series Temporales; Leishmaniasis Visceral.

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COLLABORATIONS

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CONFLICTS OF INTEREST

The authors report no conflict of interest.