

ORIGINAL ARTICLE

**Spatial and temporal dynamics of neglected tropical diseases in the Marajó Archipelago, Amazon-PA**

*Dinâmica espacial e temporal das doenças tropicais negligenciadas no Arquipélago do Marajó, Amazônia-PA*

*Dinámica espacial y temporal de enfermedades tropicales desatenidas en el Archipiélago de Marajó, Amazonia-PA*

Alcione Pinheiro de Oliveira<sup>1</sup> ORCID 0000-0002-0587-4204

Enilde Santos de Aguiar<sup>1</sup> ORCID 0000-0001-8820-5403

Marcelo Coelho Simões<sup>1</sup> ORCID 0000-0001-6764-1126

Altem Nascimento Pontes<sup>1</sup> ORCID 0000-0002-9001-4603

<sup>1</sup>Universidade do Estado do Pará, Belém, PA, Brazil.

Email: enildeaguiar@gmail.com

Address: Tv. Dr. Enéas Pinheiro, 2626, Marco, Belém - PA, Belém, PA, Brazil.

Submitted: 08/29/2022

Accepted: 12/26/2022

**ABSTRACT**

**Background and objective:** the self-styled population of Marajoara is vulnerable due to the neglect of basic services governed by the constitution, such as basic sanitation, health and education. Therefore, the search and mapping of epidemiological data are necessary in order to have a real dimension of how certain diseases behave in the region. Therefore, this study aimed to analyze the space-time distribution of neglected tropical diseases and their relationship with socio-environmental indicators in the Marajó Archipelago, Pará, Amazon. **Methods:** this is a descriptive and ecological study, with a time series, with a quantitative approach, which assessed the incidence rate of neglected tropical diseases in the 16 municipalities that make up Marajó from 2007 to 2016. Analyzes of socioeconomic and population data were carried out, extracted from the Federation of the Industries of the State of Rio de Janeiro (FIRJAN System) and the Brazilian Institute of Geography and Statistics. **Results:** according to the survey, American cutaneous leishmaniasis, dengue and tuberculosis were the most reported diseases in total. All municipalities had at least one disease in the period. The spatial distribution of the numbers of cases of tropical diseases in all the municipalities that make up the Archipelago between 2007 and 2016 was carried out. **Conclusion:** the anthropization of the environment has favored the

proliferation of vector agents and, consequently, the incidence of diseases related to inadequate basic sanitation, whose configuration is the result of a disorganized urbanization process and historically exclusive development, with a lack of investment, making this damage even more dramatic for the population.

**Keywords:** *Neglected Diseases. Basic Sanitation. Dengue.*

## RESUMO

**Justificativa e objetivo:** a população autodenominada de marajoara encontra-se em vulnerabilidade devido às negligências de serviços básicos regidos na constituição, como saneamento básico, saúde e educação. Logo, a busca e o mapeamento de dados epidemiológicos são necessários para que se tenha uma dimensão real de como se comportam determinados agravos na região. Diante disso, o estudo objetivou analisar a distribuição espaço-temporal das doenças tropicais negligenciadas e sua relação com indicadores socioambientais no Arquipélago do Marajó, Pará, Amazônia. **Métodos:** este estudo é do tipo descritivo e ecológico, de série temporal, com abordagem quantitativa, que avaliou a taxa de incidência das doenças tropicais negligenciadas nos 16 municípios que compõem o Marajó no período de 2007 a 2016. Foram realizadas análises de dados socioeconômicos e populacionais extraídos da Federação das Indústrias do Estado do Rio de Janeiro (Sistema FIRJAN) e do Instituto Brasileiro de Geografia e Estatística. **Resultados:** de acordo com o levantamento, a leishmaniose tegumentar americana, a dengue e a tuberculose foram os agravos de maior notificação no total. Todos os municípios apresentaram, ao menos, uma doença no período. Realizou-se a distribuição espacial dos números de casos de doenças tropicais em todos os municípios que compõem o Arquipélago entre 2007 e 2016. **Conclusão:** a antropização do ambiente vem favorecendo a proliferação de agentes vetoriais e, conseqüentemente, a incidência de doenças relacionadas ao saneamento básico inadequado, cuja configuração é fruto de um processo de urbanização desordenado e desenvolvimento historicamente excludente, com ausência de investimentos, tornando esse prejuízo ainda mais dramático para a população. **Descritores:** *Doenças Negligenciadas. Saneamento Básico. Dengue.*

## RESUMEN

**Justificación y objetivo:** la población autodenominada marajoara es vulnerable debido a la desatención de los servicios básicos regulados en la constitución, como saneamiento básico, salud y educación. Por lo tanto, la búsqueda y el mapeo de datos epidemiológicos son necesarios para tener una dimensión real de cómo se comportan ciertas enfermedades en la región. Por lo tanto, el estudio tuvo como objetivo analizar la distribución espacio-temporal de las enfermedades tropicales desatendidas y su relación con los indicadores socioambientales en el Archipiélago de Marajó, en el estado de Pará, Amazonas. **Métodos:** se trata de un estudio descriptivo y ecológico, con serie temporal, con enfoque cuantitativo, que evaluó la tasa de incidencia de las enfermedades tropicales desatendidas en los 16 municipios que componen el Marajó de 2007 a 2016. Se realizaron análisis de datos socioeconómicos y poblacionales extraídos de la Federación de Industrias del Estado de Rio de Janeiro (Sistema FIRJAN) y del Instituto Brasileño de Geografía y Estadística. **Resultados:** según la encuesta, la leishmaniasis cutánea americana, el dengue y la tuberculosis fueron las enfermedades más notificadas en total. Todos los municipios presentaron al menos una enfermedad en el período. La distribución espacial de las cifras de casos de enfermedades tropicales en todos los municipios que conforman el Archipiélago se realizó entre 2007 y 2016. **Conclusión:** la antropización del medio ambiente viene favoreciendo la proliferación de agentes vectores y, consecuentemente, la

incidencia de enfermedades relacionadas con saneamiento básico inadecuado, cuya configuración es fruto de un proceso de urbanización desordenado y desarrollo históricamente excluyente, con ausencia de inversiones, lo que hace aún más dramática esta pérdida para la población.

**Palabras clave:** *Enfermedades Desatendidas. Saneamiento Básico. Dengue.*

## INTRODUCTION

Neglected tropical diseases (NTDs) are morbidities that affect an economically poor population, lacking basic health services and living in precarious sanitation conditions.<sup>1</sup> In Latin America, Brazil represents the highest rates of occurrence of NTDs, with the Amazon being the Brazilian epicenter of important epidemiological findings for a variety of pathogenic agents.<sup>2</sup>

The health and disease situation in the Amazon is conditioned both to changes in the socioeconomic scenario and to the geographic reality, since the difficult access in some municipalities becomes a justification for the lack of investments and the absence of public management policies in the region.<sup>3</sup> Interest in the Amazon territory comes from a historical context, and from the 1960s onwards, it became more intense, under the argument of providing technological advancement for the place, accelerated population growth, the result of the intense migratory process related to favorable economic prospects in the Amazon.<sup>4</sup>

This in turn presents populous urban centers at the same time that there are small isolated cities with unfavorable living conditions and socioeconomic and health indicators, such as the Marajó Archipelago.<sup>3</sup> Due to geopolitical aspects, Marajó is not included in the state's large enterprises because it is far from the road axes that cross the Amazon, making even more economic and infrastructure investments unfeasible.<sup>5</sup> For this, space-time analysis in the peri-urban study in the Amazon is essential to understand the spatial dynamics, as the region brings together unequal and differentiated spatial times.<sup>5</sup>

Formerly called the "Geographical Mesoregion of Marajó", the Archipelago is a region formed by sixteen municipalities, with a rate equivalent to about 6% of the population of Pará, with growth similar to the rest of the state, although it has one of the lowest demographic densities in the country.<sup>6</sup>

These municipalities are characteristic for presenting precarious socioeconomic conditions, with Municipal Human Development Indexes (MHDI) lower than the national

average, since in the ranking of the 100 municipalities with the highest degree of social exclusion, 19 are in the state of Pará, eight of which are in Marajó.<sup>7</sup>

With regard to public policies, the self-styled population of Marajoara are vulnerable due to the neglect of basic services governed by the constitution, such as basic sanitation, health and education.<sup>7</sup> In the context, the search and mapping of epidemiological data are necessary in order to have a real dimension of how certain diseases behave. That said, this study aimed to analyze the space-time distribution of NTDs and their relationship with socio-environmental indicators in the Marajó Archipelago, in the state of Pará, Amazon.

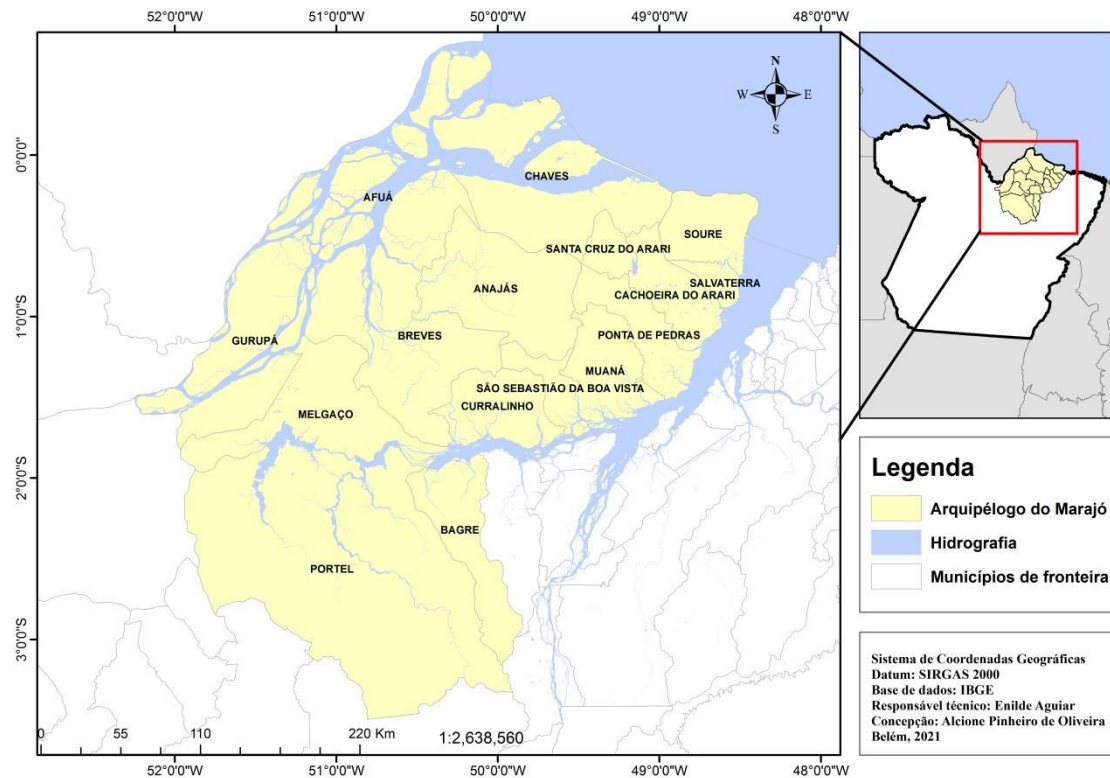
## **METHODS**

### ***Study design***

This is a descriptive and ecological study, with a time series with a quantitative approach, which assessed the incidence rate of NTDs in the 16 municipalities that make up the Marajó Archipelago, Pará, from 2007 to 2016. Evolution analyzes were carried out on socioeconomic and population data, extracted from the Federation of Industries of the State of Rio de Janeiro (FIRJAN System - *Federação das Indústrias do Estado do Rio de Janeiro*) and the Brazilian Institute of Geography and Statistics (IBGE - *Instituto Brasileiro de Geografia e Estatística*).

### ***Study area***

Marajó is made up of 16 municipalities, such as Afuá, Anajás, Bagre, Breves, Cachoeira do Arari (C. Arari), Chaves, Curralinho, Gurupá, Melgaço, Muaná, Ponta de Pedras (P. Pedras), Portel, Salvaterra, Santa Cruz do Arari (S.C.Arari), São Sebastião da Boa Vista (S.S.B.V.) and Soure, the capital, as shown in Figure 1.



**Figure 1.** Geographic location of the municipalities in the Marajó Archipelago, Pará  
 Source: authors.

Breves is the most populous municipality in the region, with more than 100,000 inhabitants, followed by Portel, which had a population growth of 30% between 2007 and 2016, and Muaná, with a population of over 40,000 inhabitants. Santa Cruz do Arari, in turn, is the municipality with the smallest population (approximately 10,000 inhabitants).<sup>8</sup>

### **Study characterization**

The NTD mapping data are of a secondary nature and were obtained by consulting the Reporting Disease Information System (SINAN - *Sistema de Informações de Agravos de Notificação*) database, made available by the Unified Health System Department of Informatics (DATASUS - *Departamento de Informática do Sistema Único de Saúde*) at the electronic address: <http://www.datasus.gov.br>. The diseases raised for this study were visceral leishmaniasis (VL), American cutaneous leishmaniasis (ACL), dengue, tuberculosis (TB) and Chagas disease (CD).

The FIRJAN Municipal Development Index (IFDM - *Índice FIRJAN de Desenvolvimento Municipal*) was used to analyze the municipalities' socioeconomic evolution in the study area. The IFDM assimilates data on employment, income, health and education as a metric for municipal development. Its index ranges from 0 to 1, divided

into four development categories: low (from 0 to 0.4); fair (from 0.4 to 0.6); moderate (from 0.6 to 0.8); and high (from 0.8 to 1).<sup>9</sup>

All extracted data were used in Excel to create tables and graphs, and to carry out the mapping, free software QGIS 2.18 was used. From the intensity of the colors presented, it was possible to analyze the spatial distribution of the reported disease with the number of cases in each municipality. The darker the color, the greater the number of cases reported in this location.

## RESULTS

### *FIRJAN Municipal Development Index*

In Table 1, it is possible to observe that 9 municipalities, such as Afuá, Bagre, Breves, Cachoeira do Arari, Melgaço, Muaná, Ponta de Pedras, Santa Cruz do Arari and São Sebastião da Boa Vista, showed low development until around 2008/2009. From 2009 onwards, they moved to regular development IFDM, just as Chaves, Curralinho, Gurupá, Portel, Anajás and Salvaterra underwent this transition from 2011. Soure has, since 2008, presented growth in the IFDM from 0.4 to 0.5, being classified as regular development.

**Table 1.** IFDM of Marajó Archipelago municipalities, Pará, between 2007 and 2016

Municipalities	Period (years)									
	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
Afuá	0.35	0.38	0.39	0.41	0.44	0.47	0.49	0.48	0.46	0.45
Anajás	*	*	*	0.39	0.46	0.46	0.45	0.44	0.44	*
Bagre	0.39	0.37	0.43	0.34	0.36	0.38	0.39	0.4	0.42	0.49
Breves	0.43	0.42	0.44	0.47	0.5	0.51	0.5	0.46	0.47	0.46
C. Arari	0.38	0.36	0.39	0.44	0.44	0.47	0.47	0.46	0.43	0.47
Chaves	0.41	0.36	0.42	0.39	0.43	0.44	0.47	0.52	0.48	0.56
Curralinho	0.39	*	0.4	0.42	0.41	0.44	*	0.42	0.41	0.46
Gurupá	0.29	0.39	0.4	0.39	0.42	0.43	0.4	0.39	0.44	0.49
Melgaço	0.28	0.36	0.35	0.42	0.42	0.44	0.43	0.49	0.44	0.49
Muaná	0.33	0.36	0.39	0.4	0.4	0.4	0.42	0.37	0.47	0.48
P. Pedras	0.34	0.38	0.43	0.42	0.43	0.47	0.46	0.47	0.47	0.5
Portel	0.41	0.41	0.43	0.41	0.4	0.41	0.37	0.5	0.49	0.52
Salvaterra	0.4	0.36	0.37	0.38	0.4	0.43	0.47	0.47	0.5	0.51
S. C. Arari	0.34	*	*	0.36	0.39	0.41	0.45	0.43	0.45	0.54
S. S. B. V.	0.35	0.35	0.39	0.4	*	0.42	0.46	0.47	0.51	0.53
Soure	0.38	0.41	0.44	0.48	0.49	0.52	0.54	0.51	0.5	0.54

\*data not available.

### ***Basic sanitation***

As for the water supply system, there is great disparity between the study sample, with emphasis on the capital Soure, which has the greatest hydrographic network coverage (Table 2). It is also possible to observe that only Afuá, Anajás, Breves, Cachoeira do Arari, Ponta de Pedras, Salvaterra and Soure present complete data for the period, leaving gaps in the information provided by the competent bodies.

**Table 2.** Percentage of water supply service provision in the Marajó Archipelago, Pará, between 2007 and 2016

Municipalities	Period (years)									
	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
Afuá	15.8%	15.7%	15.7%	14.9%	13.1%	12.9%	12.0%	12.6%	12.4%	12.4%
Anajás	5.3%	5.1%	5.9%	6.6%	6.3%	6.6%	6.4%	7.3%	7.2%	6.5%
Breves	32.6%	31.7%	30.6%	33.5%	26.8%	27.2%	26.7%	26.5%	26.2%	26.0%
C. Arari	18.5%	18.7%	19.4%	18.7%	15.0%	14.2%	12.1%	11.8%	11.6%	11.9%
P. Pedras	35.0%	35.3%	35.6%	36.1%	29.1%	29.8%	31.6%	32.3%	31.7%	31.2%
Portel	7.3%	7.2%	7.5%	3.4%	2.6%	3.0%	3.0%	3.2%	3.1%	2.9%
Salvaterra	26.8%	27.2%	29.1%	27.2%	21.0%	21.5%	19.5%	23.5%	24.3%	14.4%
Soure	65.4%	72.0%	80.8%	82.4%	71.0%	74.7%	75.2%	75.0%	76.3%	77.8%
S. C. Arari	44.70%	45.4%	49.2%	39.5%	73.9%	76.8%	*	45.7%	44.6%	64.5%
Bagre	36.3%	37.9%	48.3%	45.2%	50.0%	30.8%	*	*	*	*
Curralinho	*	*	*	*	*	33.5%	38.2%	41.1%	49.1%	*
Melgaço	*	*	*	*	*	*	13.8%	13.8%	15.4%	18.7%
Muaná	*	58.3%	63.1%	51.0%	*	*	*	*	*	*
Gurupá	*	*	*	36.9%	*	31.6%	30.8%	*	*	*
S. S. B. V.	*	*	*	23.7%	*	*	*	*	*	5.9%
Chaves	*	*	*	*	*	*	*	11.3%	*	*

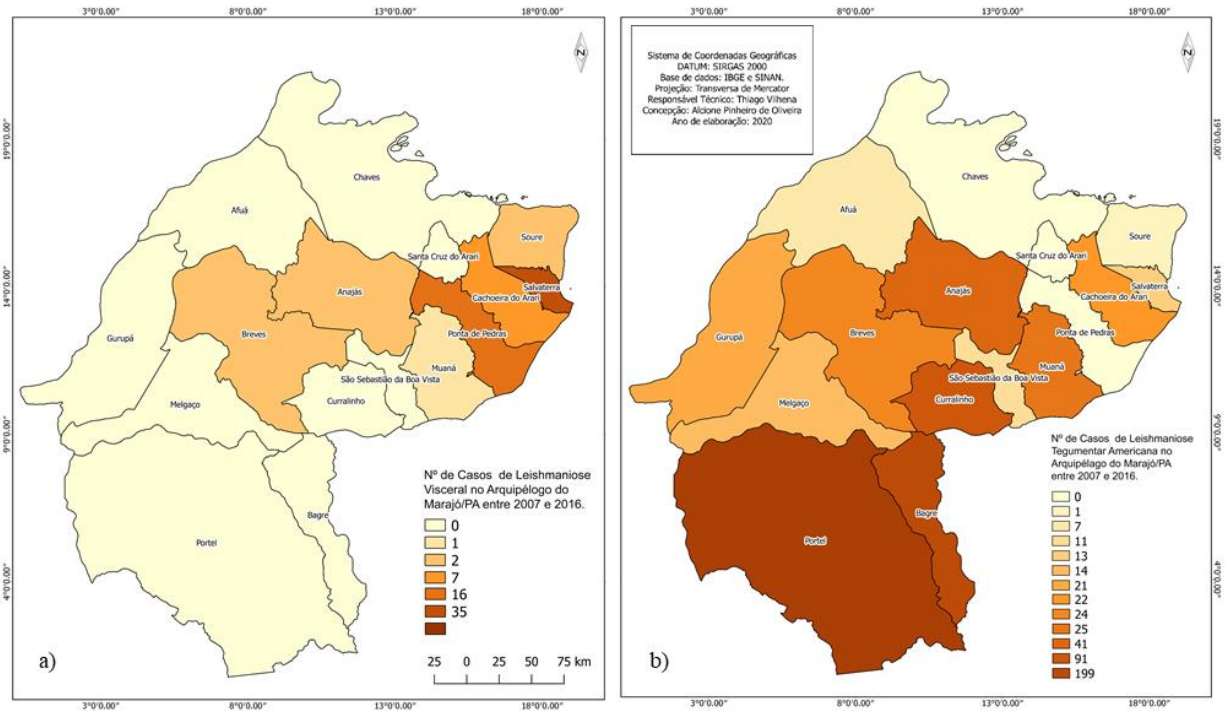
\*data not available.

Regarding Marajó's sewage services, this presents an even more aggravating situation when compared to the deficient water supply, since only Santa Cruz do Arari and Chaves have data available for this service, referring to 2014 and 2015.

### ***Spatial distribution of neglected tropical diseases in the Marajó Archipelago***

According to the survey, ACL, dengue and TB were the most reported diseases in total. All municipalities had at least one NTD in the period. Figure 2 shows the spatial

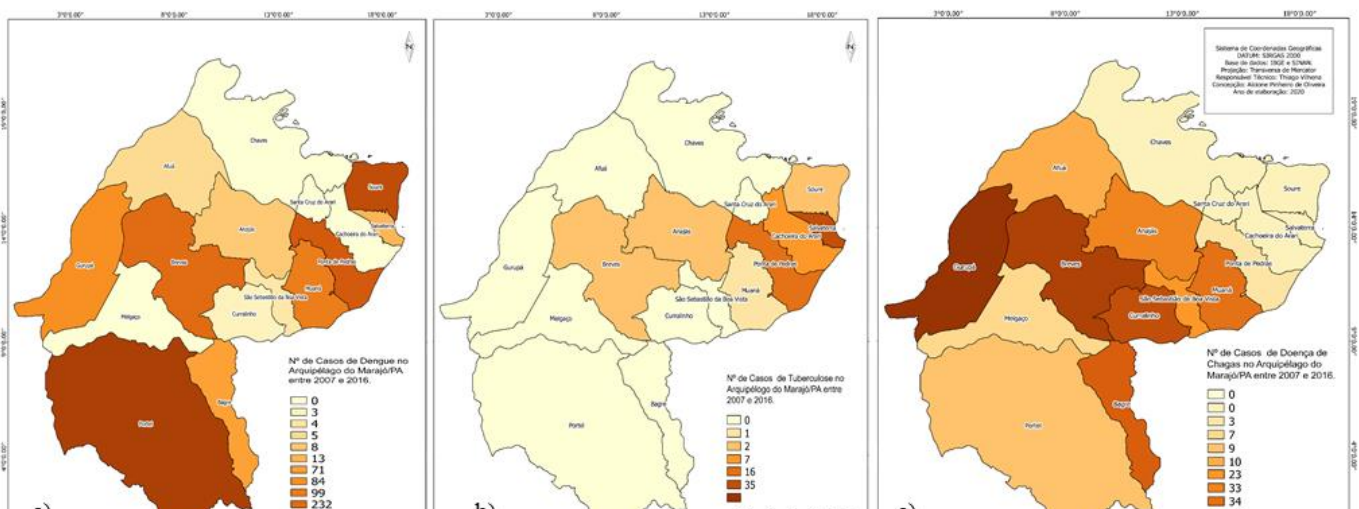
distribution of the numbers of cases of tropical diseases in all the municipalities that make up the Marajó Archipelago, between 2007 and 2016.



**Figure 2.** Spatial distribution of the number of cases of: a) visceral leishmaniasis; and b) American cutaneous leishmaniasis in Marajó Archipelago municipalities, Pará, between 2007 and 2016

It is noted that, although Salvaterra was the municipality with the highest record for VL, neighboring municipalities also have a discreet record, with this endemic having a lower incidence. ACL was the second most reported disease throughout the Marajoara territory, with records in 13 of the 16 municipalities, with emphasis on Portel and Bagre. Only Chaves, Ponta de Pedras and Santa Cruz do Arari did not present any cases.

With regard to dengue, TB and CD, illustrated in Figure 3, it is possible to observe that the municipalities with the highest number of reported dengue cases (Figure 3a) are not neighboring municipalities, namely Breves, Ponta de Pedras, Portel and Soure. In total, it was the most reported disease with records in 12 municipalities.





**Figure 3.** Spatial distribution of the number of cases: a) dengue; b) tuberculosis; and c) Chagas disease in Marajó Archipelago municipalities, Pará, between 2007 and 2016

In Figure 3b, it is possible to observe that TB was present in all locations, in addition to being third in number of cases, with emphasis on Breves, Portel and Soure. Chaves and Santa Cruz do Arari were the only municipalities that presented data only for TB. Despite many confirmed cases of CD, the highest numbers were in Breves and Gurupá (Figure 3c).

## DISCUSSION

It was possible to verify that, throughout the Marajoara territory, ACL was the second most reported disease, present in 13 of the 16 municipalities, with emphasis on Portel and Bagre. In total, dengue was the most reported with records in 12 municipalities, with a high rate in Breves, Ponta de Pedras, Portel and Soure.

Breves is considered an important Marajoara city, whose economic base for a long time was focused on the extraction of natural resources, such as wood, *açaí* (fruit) and heart of palm exploitation.<sup>10</sup> Currently, the municipality concentrates a consolidated trade and with service offer in the most diverse areas, in addition to hosting various public bodies.<sup>11</sup> The municipality has low population growth due, in part, to the evasion of many families to other locations, due to the search for alternatives for better living conditions, a consequence of the closure of many logging companies that impacted the local dynamics and economy.<sup>11</sup>

In Table 1, Anajás is presented as the municipality with the worst socioeconomic indices, considering that in some years (2007, 2008, 2009 and 2016) data were not available, making a deeper analysis impossible. Breves and Soure are the municipalities with the highest IFDM in this region, however, far from ideal. The IFDM was created with the aim of understanding and monitoring the level of human development of municipalities in socioeconomic aspects over the years.<sup>12</sup> In general, Marajó

Archipelago's IDHM has shown a slight evolution in terms of its classification in most municipalities.

The low IFDM in Breves is related to the decay of logging activities, although the activity may be linked to social segregation in the municipality.<sup>13</sup> However, the low index both in Breves and the other municipalities may be associated with the absence of public policies and investments in infrastructure.<sup>14</sup>

Despite not presenting data for the entire analyzed period, in Table 2, it is possible to observe that Santa Cruz do Arari, Bagre, Curralinho and Muanáhave hydrographic network coverage in more than 40% of households; despite having deficit, it is still one of the largest in the region. Cachoeira do Arari, Melgaço and Chaves do not reach 20% of homes.

In municipalities such as Anajás, Cachoeira do Arari, Salvaterra and Portel, the access network is less than 40%, which highlights worrying rates.<sup>15</sup> Of these, only the capital Soure exceeds the coverage of the service by 60%, however below 85%, foreseen by the country's basic sanitation companies.

As for the sewage service, it was found that only the municipality of Santa Cruz do Arari, between 2014 and 2015, and the municipality of Chaves, in 2014, provided data on coverage. The North region has the worst sanitary percentages in Brazil, as only 14.36% of sewage is treated, with a total service rate of only 7.88%.<sup>16</sup>

These data affect the IFDM calculation in the Marajoara region, since not even 50% of the population is contemplated with the provision of these services, and priority must be given to the universalization of sanitation so that IFDM evolution actually occurs. Basic sanitation services are essential to ensure a better quality of life for the population, being essential for health care and maintenance<sup>14</sup>

Non-availability of data warns about a worrying reality for the Marajoaras, inferring that the population's basic rights are being neglected not only due to low supply, but also due to the lack of information or the service itself, an act that violates human dignity. Investments in health in the Amazon region were deficient, resulting in a neglected population, especially rural/riverside populations, a situation that has not improved significantly over time and remains similar in 2019.<sup>3</sup>

As can be seen in Figures 2 and 3, the spatial distribution of NTDs in the municipalities of Marajó reveals that, from 2007 to 2016, the number of cases of VL, ACL, dengue, TB and CD is not consistent with the region's socioeconomic data. It was expected that these diseases would present more alarming data, since the region in

question does not have adequate sanitary conditions or IFDM, which opens the door to a discussion about underreporting or the lack of medical assistance to the resident population.

Figure 2 a and b shows the distribution of leishmaniasis caused by protozoa of the genus *Leishmania*. These are endemic diseases in the Amazon, where anthropic actions directly compromise environmental spaces.<sup>17</sup> Researching ATL in Marajó, studies identified that Portel, Anajás and São Sebastião da Boa Vista have high rates of the disease, compatible with those found in the present study.<sup>18</sup>

All highlighted diseases are considered serious public health problems compatible with precarious sanitation conditions and difficult access to health services.<sup>1</sup> With the exception of TB, the others are of a vector nature, with a direct correlation to environmental impacts, especially deforestation and fires, with loss of habitat for species that until then lived isolated from urban and peri-urban areas.<sup>18</sup>

Figure 3a shows the distribution of dengue in Marajoara municipalities. Dengue is a viral infectious disease transmitted by the *Aedes aegypti* mosquito that spreads rapidly worldwide, with morbidity and mortality.<sup>19</sup> The dengue index is higher in municipalities with low socioeconomic indicators, whose lack of registration in Afuá, Cachoeira do Arari, Currealinho, Gurupá, Melgaço and Santa Cruz do Arari culminated in divergences with exposed data.<sup>20</sup>

TB in Figure 3b was the only disease reported in all Marajoara municipalities. TB is an infectious and contagious disease of important epidemiology in Amazonian capitals such as Belém and Manaus, with high coefficients associated with socioeconomic vulnerability issues, among other factors.<sup>21</sup>

Despite several municipalities reporting the disease, CD (Figure 3c) had a relatively low number of cases. CD is an anthrozoosis caused by the parasite *Trypanosoma cruzi* and transmitted by the vector *Triatoma brasiliensis*, popularly known as kissing bug. Its contamination can be acquired through blood transfusion, organ transplantation and orally and vertically.<sup>22</sup>

The consumption of *açaí* (*Euterpa oleracea*) *in natura* is a cultural factor in the region that is related as a means of contamination for CD, considering that most of the so-called “*açaí* beaters” do not use the bleaching technique, a practice that prevents contamination, for pulp production.<sup>23</sup> Another preponderant factor would be the material with which many houses are still built in the region, with the use of clay and wood, which facilitates vector installation in these constructions.<sup>24</sup>

Breves, Portel and Soure were the municipalities that had the most reports regarding at least two of the five identified tropical diseases. Breve stood out for dengue, TB and CD; Portel stood out for ACL, dengue and TB; and Soure stood out for dengue and TB. Breves and Portel are municipalities that have similar socioeconomic aspects, since both had logging as their main economic activity, which, for a long time, was the economic base that led to changes in environmental, socioeconomic and territorial aspects.<sup>13</sup>

This epidemiological reality in the Marajó Archipelago is due, mainly when talking about the rates of ACL, TB and dengue, to the fact that, historically, the diseases considered endemic for the Amazon region are linked to conditions and life behavior of this region.<sup>18,20,21</sup> The anthropization of the environment resulted in these changes, favoring the proliferation of vector agents and, consequently, the incidence of diseases related to inadequate basic sanitation, whose configuration is the result of a disorganized urbanization process and historically exclusive development.<sup>25</sup>

The Marajó Archipelago is geographically positioned in an area where difficult access to some of its municipalities is used as a justification for the lack of investment, making this damage even more dramatic for the population.<sup>3</sup> The socioeconomic dynamics in the cities of Marajó has peculiar characteristics. Studying the cities and the way this dynamic take place is essential for understanding the spatial distribution of diseases in the Amazonian context.<sup>25</sup>

## **ACKNOWLEDGMENTS**

The authors would like to thank the *Universidade do Estado do Pará*, the coordination of the Graduate Program in Environmental Sciences, the advising professor and everyone who made this work possible.

## **REFERENCES**

1. World Health Organization. Accelerating work to overcome the global impact of neglected tropical diseases: a roadmap for implementatio. Suíça: World Health Organization; 2012. 42 p.

<https://apps.who.int/iris/bitstream/handle/10665/338712/WHO-HTM-NTD-2012.5-eng.pdf>

2. Menezes ALR, Oliveira GF de, Ribeiro MAL, et al. Panorama epidemiológico da doença de chagas no estado do Amazonas, de 2004 a 2014. *Rev Epidemiol e Control Infecção*. 2019; 9(2):1–6. <http://dx.doi.org/10.17058/reci.v9i2.12127>
3. Garnelo L. Especificidades e desafios das políticas públicas de saúde na Amazônia. *Cad Saúde Pública*. 2019;35(12). <https://doi.org/10.1590/0102-311X00220519>
4. Silva JMC, Prasad S, Diniz-Filho JAF. The impact of deforestation, urbanization, public investments, and agriculture on human welfare in the Brazilian Amazonia. *Land Use Policy*. 2017; 65(1):135-142 <https://doi.org/10.1016/j.landusepol.2017.04.003>.
5. Leão Carvalho JP, Valente da Cruz BE, Freitas Calvi M. Agrarian policy and territorial ordination in Marajó – Pará. *Mercator* [Internet]. 2019;18(5):e18013. Disponível em: <https://www.redalyc.org/articulo.oa?id=273659779002>
6. Ministério da Mulher, da Família e dos Direitos Humanos. *Abrace o Marajó: Plano de Ação 2020-2023*. Brasil: Ministério da Mulher, da Família e dos Direitos Humanos; 2020.
7. Guerra A, Pochmann M, Silva RA (editores). *Atlas da exclusão social no Brasil: dez anos depois*, 1nd ed. São Paulo: Cortez; 2014. p. 352.
8. Instituto Brasileiro de Geografia e Estatística. *Cidades*. <https://cidades.ibge.gov.br/brasil/pa/breves/panorama>
9. Índice FIRJAN de Desenvolvimento Municipal: Consulta. [www.firjan.com.br](http://www.firjan.com.br).
10. Alves OJA, Silva CN, Palheta da Silva JM. Socioeconomic and territorial dynamics in Breves-Marajó (Pa), post-decline of madeira activity. *CONJ*. 2021 ;21(7):140-62 <https://doi.org/10.53660/CONJ-427-301>
11. Silva JPP da, Silva Júnior FLC da, Ferreira BJ dos S, et al. Socioeconomic profile of agroextractivists in associativism, Marajó archipelago, Pará, Brazil. *RSD*. 2020; 9(9):e835997988 <https://doi.org/10.33448/rsd-v9i9.7988>
12. Lobão MSP, de Lima, JF, Raiher, AP. Região Norte do Brasil: uma análise do desenvolvimento humano municipal entre 2000 e 2010. *Acta Geográfica*. 2019; 13 (31): 1-18. doi: <https://doi.org/10.5654/acta.v13i31.3653>
13. Andrade, SS. Políticas Públicas Na Amazônia Marajoara: Os Índices De Desenvolvimento Socioeconômico Na Região. *Nova Revista Amazônica*. 2019; 7 (1):159-179. <http://dx.doi.org/10.18542/nra.v7i1.6981>
14. Crispim DL, Rodrigues RSS, Vieira AS de A, et al. Espacialização da cobertura do serviço de saneamento básico e do índice de desenvolvimento humano dos municípios do Marajó, Pará. *Revista Verde*. 2016; 11 (4):112. <http://dx.doi.org/10.18378/rvads.v11i4.4507>

15. Instituto Brasileiro de Geografia e Estatística. Pesquisa nacional de saneamento básico 2017: abastecimento de água e esgotamento sanitário. Rio de Janeiro: Coordenação de População e Indicadores Sociais; 2020.
16. Carcará MSM, Silva EA, Moita Neto JM. Basic sanitation as human dignity: between the minimum existential and the reserve of the possible. *Eng Sanit Ambient.* 2019; 24 (3): 493-500. <https://doi.org/10.1590/S1413-41522019183095>
17. Veasey JV, Zampieri RA, Lellis RF, et al. Identification of Leishmania species by high-resolution DNA dissociation in cases of American cutaneous leishmaniasis. *An Bras Dermatol.* 2020; 95(4):459–468. <https://doi.org/10.1016/j.abd.2020.02.003>
18. Rosário ING, Andrade AJ, Ligeiro R, et al. Evaluating the Adaptation Process of Sandfly Fauna to Anthropized Environments in a Leishmaniasis Transmission Area in the Brazilian Amazon. *J Med Entomol.* 2016; 54(2): 450-459. <https://doi.org/10.1093/jme/tjw182>
19. Jing Q, Wang M. Dengue epidemiology. *Global Health Journal.* 2019; 3(2): 37–45. <https://doi.org/10.1016/j.glohj.2019.06.002>
20. Chaves EC, Costa SV, Flores RL dos R, et al. Condições de vida populacional e incidência de dengue no estado do Pará, Brasil. *Pará Res Med J.* 2018; 2(1):1-4. <http://dx.doi.org/10.4322/prmj.2018.002>
21. Ceccon RF, Maffaccioli R, Burille A, et al. Mortalidade por tuberculose nas capitais brasileiras, 2008-2010. *Epidemiol Serv Saude.* 2017; 26(2):349–58. <https://doi.org/10.5123/S1679-49742017000200012>
22. Lidani KCF, Andrade FA, Bavia L, et al. Chagas Disease: From Discovery to a Worldwide Health Problem. *Front. Public Health.* 2019; 7:166. <https://doi.org/10.3389/fpubh.2019.00166>
23. Barbosa RL, Dias VL, Lorosa ES, et al. Virulence of Trypanosoma cruzi from vector and reservoir in in natura açai pulp resulting in foodborne acute Chagas disease at Pará State, Brazil. *Exp Parasitol.* 2019; 197: 68–75. <https://doi.org/10.1016/j.exppara.2018.10.012>
24. Lima VM, Costa SMF da, Rangel JA, et al. Do local para a compreensão do global: saúde e ambiente em uma pequena cidade da Amazônia. *Revista Univap.* 2019; 25(48): 118–134. <https://doi.org/10.18066/revistaunivap.v25i48.2271>
25. Aguiar ES de, Ribeiro MM, Viana JH, et al. Doenças relacionadas ao saneamento ambiental inadequado e indicadores socioeconômicos na Amazônia brasileira. *RSD.* 2020; 9(9). <https://doi.org/10.33448/rsd-v9i9.7302>

**Authors' contributions:**

**Alcione Pinheiro de Oliveira** and **Altem Nascimento Pontes** – study conception and article design; **Alcione Pinheiro de Oliveira** and **Enilde Santos de Aguiar** – data collection and analysis and article writing; **Alcione Pinheiro de Oliveira** and **Marcelo Coelho Simões** - article design and article writing; **Enilde Santos de Aguiar**, **Marcelo Coelho Simões** and **Altem Nascimento Pontes** – article review; **Altem Nascimento Pontes** – article review and final approval.

All authors approved the final version to be published and are responsible for all aspects of this work, including ensuring its accuracy and integrity.

Layout Version