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ORIGINAL ARTICLE

EPIDEMIOLOGICAL PROFILE AND SPATIAL ANALYSIS OF PROBABLE CASES OF DENGUE REGISTERED FROM 2010 TO 2021 IN THE STATE OF MARANHÃO

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ABSTRACT

Dengue is a disease of viral etiology transmitted by mosquitoes, with a high incidence in tropical countries. Dengue has great epidemiological importance in the Americas and in Brazil. The goal of this study was to analyze the spatial distribution and to describe the epidemiological profile of probable cases of dengue in the State of Maranhão from 2010 to 2021. Statistical analysis through non-parametric tests and spatial analysis were performed using the Moran's Global Index and Local Indicators of Spatial Association (LISA) and Space-time Scan statistic. Data were collected from the Department of Informatics of the Unified Health System in Brazil (DATASUS) between 2010 and 2021. The highest number of probable cases occurred in 2016 (23,938) and they were concentrated in the first half of each year. The female gender had the highest proportion of cases (54.9%). The cases predominated in the group of people aged between 20 and 39 years old (35.5%). People with incomplete elementary school degree were the most affected (43.0%). The brown race had more registered cases (80.7%). The municipality that had the highest incidence was Barra do Corda (7,418.5 per 100.000 inhabitants in 2016). In the local spatial analysis, 55.8% of the clusters of municipalities High-High occurred in the South region from the State of Maranhão. The municipality of Barra do Corda presented the highest relative risk (55.91) in the Space-time Scan statistic. People of the brown race, with incomplete schooling and young adults were the most affected by the dengue disease. The South region of the State showed greater epidemiological importance because it has representative clusters High-High.

KEY WORDS: Dengue; incidence; spatial analysis; State of Maranhao.

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INTRODUCTION

Dengue is a disease of viral etiology transmitted by mosquitoes, with a high incidence in tropical countries. Dengue virus (DENV) belongs to the Flaviviridae family and the *Flavivirus* genus, with four antigenically distinct circulating serotypes in humans denominated DENV-1, DENV-2, DENV-3 and DENV-4 (Zeng et al., 2021). Transmission is caused by the bite of female mosquitoes of the species *Aedes aegypti* (Linnaeus, 1786), which is considered the main vector of dengue (Câmara et al., 2020). The occurrence of dengue in urban spaces is influenced by vector and socio-environmental factors, such as climatic conditions favorable to the mosquito, demographic differences, urbanization, public health infrastructure, imported cases and low epidemiological surveillance (Jing & Wang, 2019).

Dengue epidemics impose high costs on health services, families, and the economic systems in the affected countries. Dengue has a high global burden, it is estimated that in 2017 there were about 100 million infections and about 40,000 deaths (Zeng et al., 2021). In 2022, approximately 1.37 million confirmed cases of dengue have been reported in the Americas, of which 1.21 million were registered in Brazil (PAHO, 2023). In the State of Maranhão, 7,369 probable cases of dengue were reported in 2022, an increase of 434% compared to the previous year (SESMA, 2023).

Because dengue is a disease of great public health concern, different control strategies must be used to battle against it. The main measures focus on prevention, clinical treatment, and vector control. Population data obtained from surveillance are important for accurately understanding the epidemiology of dengue and assessing the disease burden (Jing & Wang, 2019). A better understanding of the dynamics and epidemiological patterns of dengue can help in formulating policies and allocating resources to combat the disease (Skalinski et al., 2018; Zeng et al., 2021). Understanding the epidemiological profile of dengue is crucial, as sociodemographic factors have been linked to its incidence.

Furthermore, a comprehensive understanding of dengue epidemiology requires a consideration of its geographic distribution. In this regard, spatial analysis is a valuable tool in the field of public health as it enables the identification of spatial and temporal patterns of diseases (Silva et al., 2020). Statistical models that account for spatial dependence can also help to pinpoint areas with a higher risk of disease clustering (Skalinski et al., 2018; Silva et al., 2020). In this context, this study aimed to analyze the spatial distribution and to describe the epidemiological profile of probable cases of dengue in the State of Maranhão from 2010 to 2021.

MATERIAL AND METHODS

Study area

The State of Maranhão is in the Northeast region of Brazil, it is the second largest State in territorial extension in the region, with a total area of 329,642 km². The estimated population of the State in 2021 was 7,153,262 inhabitants and a population density of 19.81 inhabitants/km² in 2010 (IBGE, 2022). The State has 217 municipalities, divided into five mesoregions: North, West, Central, East, and South. It has the fourth-largest Gross Domestic Product (GDP) in the Northeast Region and 17th in Brazil. It has a per capita income of R$ 635.00 and one of the lowest Human Development Indexes (HDI) in the country, with 0.639 points (IBGE, 2022).

Study design and analyzed variables

The study is characterized as observational, ecological, and retrospective, in which the epidemiological profile and spatial distribution of dengue in the State of Maranhão from 2010 to 2021 was analyzed. The following variables were included: probable cases of dengue per month and per year, deaths, gender, age group, race and education, confirmation criteria and final classification.

Data source

The study was conducted by collecting secondary data from the Notifiable Diseases Information System (SINAN), available on the Tabnet platform on the website of the Department of Informatics of the Unified Health System (DATASUS), of the Ministry of Health of Brazil (Ministério da Saúde, 2022). Data collection from the platform was carried out on August 23 and 24, 2022, and the last update of the data contained in DATASUS was carried out in March 2022. The cartographic files used in the preparation of choropleth maps were obtained from the Brazilian Institute of Geography and Statistics – IBGE (IBGE, 2022). The population data necessary to calculate incidence and mortality were obtained from the 2010 demographic census and from population estimates for the years 2011 to 2021 carried out by the Brazilian Institute of Geography and Statistics (IBGE, 2022).

Descriptive and statistical analysis

Total data distributed annually were described in probable cases, deaths, annual incidence, annual mortality, and monthly probable cases between 2010 and 2021. Incidence was calculated in cases per 100,000 inhabitants and mortality in deaths per 100,000 inhabitants. The spatial distribution of the incidence was performed using the territorial division by municipality in the State of Maranhão. The epidemiological profile variables were evaluated using descriptive statistics (absolute and relative frequencies) and analytical statistics.

After confirming that the data did not follow a normal distribution through the Shapiro-Wilk test, non-parametric analyses were conducted. The Kruskal-Wallis statistical test was utilized to assess the difference between the medians of probable dengue cases among age, education, and race variables. Subsequently, Dunn's test was employed to compare each category of variables. Moreover, the Mann-Whitney test was applied to examine differences in mediated probable cases based on gender, confirmation criteria, and final classification. The parameter considered for the analysis was the number of probable cases per variable in each municipality, and the significance level adopted for all tests was 5% ($p < 0.05$).

Ignored, blank, inconclusive, or investigational data were excluded from statistical analysis. Statistical tests were performed using GraphPad Prism 8.0.1 software (San Diego, United States of America). Tables, charts, and calculations were managed in the Microsoft Excel 2016 package (Washington, United States of America). The preparation of annual maps referring to the incidence rate was performed using the QGIS 3.22 software (Norden, Germany).

Spatial analysis

To characterize the spatial dependence and verify how the values of dengue incidence are correlated between neighboring areas, the Moran Global Index was used. The Moran index expresses a general value to indicate correlation between all polygons in the study area. The value of Moran's index ranges from -1 to 1. Value equal to zero indicates spatial independence (null hypothesis). Positive values indicate a direct correlation (neighbors have similar incidence rates), and negative values indicate an inverse correlation (Cavalcante et al., 2020).

The specific spatial dependence for each location was verified using the Local Spatial Association Indicators (LISA). LISA identifies the existence of clusters, which are not shown by the Moran Global Index (Anselin, 1995). The map generated by LISA shows only areas with statistical significance, separating them into four classes: High-High are areas with high incidence rates surrounded by neighboring locations with similar values; Low-Low are areas with a low incidence rate surrounded by neighboring sites with similar values;

High-Low are areas with a high incidence rate surrounded by neighboring sites with divergent values; Low-High are areas with a low incidence rate surrounded by neighboring sites with divergent values (Cavalcante et al., 2020).

Space-time Kulldorff Scan statistic was employed to identify high-risk clusters in time and space, with annual reported cases as the analysis variable. The analysis utilized a discrete Poisson probability model and adhered to the following criteria: circular clusters with a maximum size of 50% of the population at risk, maximum temporal cluster size of 50%, and minimum aggregation time of two years. The statistical significance was assessed using a Monte Carlo simulation with 999 replications. Clusters were considered high-risk if the relative risk (RR) was greater than 1 (Tango et al., 2011).

The spatial methods were performed using the softwares GeoDa version 1.10 (Chicago, United States of America) and SaTScan version 10.1.3 (Bethesda, United States of America). A first order neighborhood matrix (Queen contiguity) was created, using the municipalities of the State of Maranhão as the unit of analysis. To determine the significance of the Global Moran Index, a randomized simulation procedure based on 999 permutations was used. LISA maps were created using QGIS 3.22 software (Norden, Germany).

Ethical aspects

The data described in this study that were made available by the DATASUS platform does not include information that allows the identification of patients or that may affect their confidentiality. The study includes only secondary data in the public domain, and the approval of the Research Ethics Committee is unnecessary, according to Resolution No. 466/2012, of the National Health Council (CNS), which regulates research involving human beings (CNS, 2012).

RESULTS

Through the period from 2010 to 2021, a total of 78,692 probable cases of dengue were recorded in the State of Maranhão, with an average of 6,558 cases per year. A total of 110 deaths were recorded in the period, with an average of 9.2 deaths per year. The year with the highest number of records was 2016, with 23,938 probable cases (30.4% of the total) and an incidence of 344.2 cases per 100,000 inhabitants (Figure 1A). The highest number of deaths was recorded in 2011, with 19 deaths (17.3% of the total) and mortality of 0.29 deaths per 100,000 inhabitants (Figure 1B). Analysis of the monthly distribution of probable cases revealed that the highest number of notifications between 2010 and 2021 occurred from January to July, accounting for 80.1% (63,053) of the 78,692 probable cases notified during this period (Figure 1C and D).

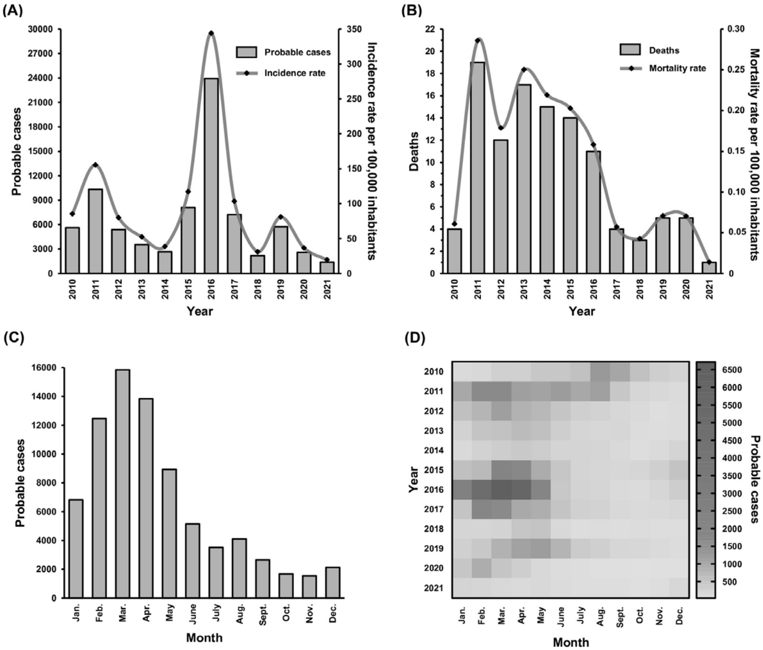

Figure 1. Epidemiological data of dengue in the State of Maranhão, from 2010 to 2021. (A) Probable cases and incidence per 100,000 inhabitants. (B) Deaths and mortality per 100,000 population. (C) Distribution of cases by month. (D) Heatmap of cases by month and year. Source: DATASUS (Ministério da Saúde, 2022).

The female gender had 42,429 cases (54.9%), with no significant difference between the medians ($p = 0.14$). For the age group variable, cases predominated in the 20 to 29 age categories, with 27,420 cases, with a significant difference compared to most categories [35.5%; ($p < 0.0001$)]. People with incomplete elementary school degree were the most affected, with 21,069 cases [43.0%; ($p < 0.0001$)]. In the race variable, the one that concentrated the largest number of cases was brown race, with 58,657 cases [80.7%; ($p < 0.0001$)]. Regarding the confirmation criterion, 42,894 cases (81.2%; $p < 0.0001$) were confirmed clinically and epidemiologically. Considering the disease classification, 54,523 cases (98.5%; $p < 0.0001$) were classified as dengue fever (Table 1).

Table 1. Epidemiological profile of probable cases of dengue reported in the State of Maranhão, from 2010 to 2021.

Variable[a]	N	%	p-value[b]
Gender			
Males	35,512	45.1	0.14
Females	43,162	54.9	
Age range (years)			
Under 1	2,347	3.0	< 0.0001
1 to 4	4,237	5.4	
5 to 9	7,594	9.7	
9 to 14	7,720	9.8	
15 to 19	8,209	10.4	
20 to 39**	27,838	35.4	
40 to 59	14,417	18.3	
60 to 64	1,972	2.5	
65 to 69	1,583	2.0	
70 to 79	1,964	2.5	
80 or more	784	1.0	
Schooling			
No schooling	1,513	3.1	< 0.0001
Incomplete elementary school**	21,069	43.0	
Complete elementary school	4,368	8.9	
Incomplete high school	6,242	12.7	
Complete high school	12,847	26.2	
Incomplete higher education	1,070	2.2	
Complete higher education	1,896	3.9	
Race			
White	8,902	12.3	< 0.0001
Black	4,092	5.63	
Asian	727	1.0	
Brown**	58,657	80.7	
Indigenous	282	0.4	
Diagnostic criteria			
Laboratory	9,912	18.8	<0.0001
Clinical-epidemiological	42,894	81.2	
Classification			
Dengue fever	54,523	98.5	< 0.0001
Severe dengue	835	1.5	

Source: DATASUS (Ministério da Saúde, 2022). N = Probable cases. % = Percentage. a) Missing data (Gender = 22; Age range = 28; Scholarity = 29,691; Race = 6,036; Diagnostic = 9,912; Classification = 23,338). b) p-value of statistical test (Mann-Whitney to variables gender, diagnostic criteria, and classification; Kruskal-Wallis to variables age range, schooling, and race). **Category with a significant median greater than other categories ($p < 0.05$ in Dunn's test). No significant difference between the 20 to 39 years old and 40 to 59 years old categories ($p = 0.39$).

Regarding the spatial distribution of incidence, the municipality that had the highest incidence was Barra do Corda (7,418.5 cases per 100,000 inhabitants in 2016), followed by the city São Pedro dos Crentes (7,112.3 cases per 100,000 inhabitants in 2019). Only the municipalities with highest incidence each year are presented as follow: 2010 – São Pedro dos Crentes [2,056.5 (South region)]; 2011 – Junco do Maranhão [1,588.1 (West region)]; 2012 – Pedreiras [756.5 (Central region)]; 2013 – São Pedro dos Crentes [929.2 (South region)]; 2014 – Turilândia [252.5 (West region)]; 2015 – Campestre do Maranhão [2,345.3 (South region)]; 2016 – Barra do Corda [7,418.5 (Central region)]; 2017 – Barra do Corda [2,383.7 (Central region)]; 2018 – Barra do Corda [455.6 (Central region)]; 2019 – São Pedro dos Crentes [7,112.3 (South region)]; 2020 – São Pedro dos Crentes [2,455.2 (South region)]; and 2021 – Benedito Leite (South region) with 1,258.2 cases per 100,000 inhabitants (Figure 2).

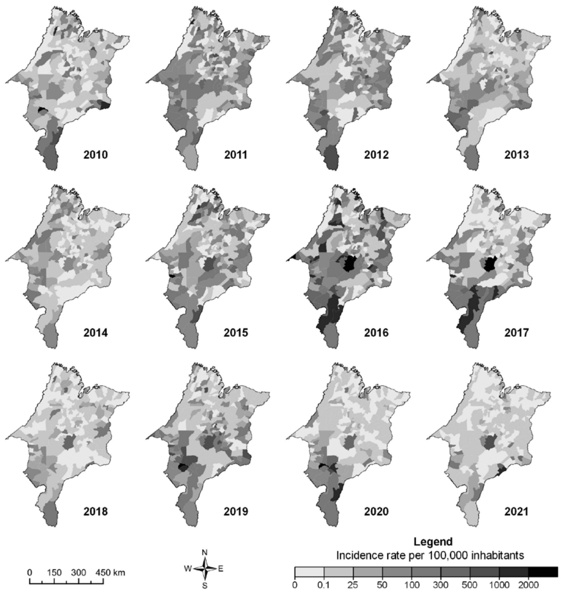

Figure 2. Spatial distribution of the incidence per 100,000 inhabitants of probable cases of dengue in the State of Maranhão, from 2010 to 2021. Source: DATASUS (Ministério da Saúde, 2022).

After applying the Global Moran Index, it was found that the years 2010, 2011, 2012, 2015 and 2018 had random distribution, given that the p-value was not significant for rejecting the null hypothesis ($p > 0.05$). For the years 2013, 2014, 2016, 2017, 2019 and 2020, a direct correlation was found (values > 0 and with $p < 0.05$), indicating the existence of places surrounded by neighbors with similar incidence values (Table 2).

Table 2. Annual values of the Global Moran Index in the State of Maranhão, from 2010 to 2021.

Year	Moran Index	p-value
2010	0.027	0.141
2011	-0.005	0.467
2012	0.053	0.103
2013	0.191	0.002
2014	0.075	0.048
2015	0.044	0.088
2016	0.115	0.009
2017	0.146	0.005
2018	-0.023	0.389
2019	0.136	0.004
2020	0.257	0.002
2021	0.081	0.027

Regarding Local Indicators of Spatial Association, there were a total of 77 occurrences of municipalities classified as High-High between 2010 and 2021 (Figure 3A). Of the 77 High-High occurrences, 55.8% (43) were concentrated in the South region of the State, 26.0% (20) in the Central region and 18.2% (14) distributed in the other regions (Figure 3B and C). The years 2017 and 2020 had the largest number of High-High municipalities (13 municipalities each year), and they are concentrated in the South region, in addition to sharing the occurrence of eight municipalities. The third year in terms of the number of High-High municipalities was 2013 (10 municipalities), where half belong to the South region (Figure 3A).

The municipality with the most frequent High-High pattern in LISA was Feira Nova do Maranhão (South region), with five occurrences. Three municipalities appeared four times each, all of them in the South region (Alto Parnaíba, Carolina and São João do Paraíso). Seven municipalities had three occurrences each, five in the South region (Fortaleza dos Nogueiras, Nova Colinas, Riachão, São Pedro dos Crentes and Tasso Fragoso) and two in the Central region (Formosa da Serra Negra and Sítio Novo). Among the municipalities assessed, nine had two instances of dengue, with four located in the South region (Balsas, Benedito Leite, Estreito, and São Raimundo das Mangabeiras), two in the Central region (Jenipapo dos Vieiras and São Domingos do Azeitão), one in the East (Barão de Grajaú), one in the West (Lajeado Novo), and one in the North (Santa Helena). Additionally, 21 municipalities experienced a single occurrence of dengue (Figure 3A).

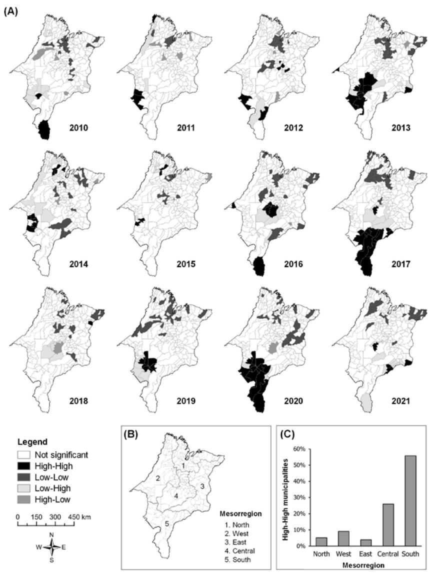

Figure 3. Spatial analysis of dengue incidence in the State of Maranhão, from 2010 to 2021. (A) Clusters found in Local Spatial Association Indicators (LISA). (B) Mesoregions of the State of Maranhão. (C) Distribution of High-High municipalities by mesoregion. Source: DATASUS (Ministério da Saúde, 2022).

Spatial-temporal scan analysis identified four high-risk clusters for dengue cases. The first cluster was detected from 2016 to 2017 in the Central region of the State, with only the municipality of Barra do Corda (8,506 cases; RR = 55.91; $p < 0.0001$). The second cluster was detected from 2011 to 2016 in the North, including the municipalities of São José de Ribamar and São Luís (17,145 cases; RR = 2.74; $p < 0.0001$). A third cluster was identified from 2015 to 2016 in the East, with nine municipalities (1,961 cases; RR = 2.48; $p < 0.0001$). The fourth cluster was detected from 2015 to 2016 in the West, including eight municipalities (1,246 cases; RR = 3.14; $p < 0.0001$) (Figure 4).

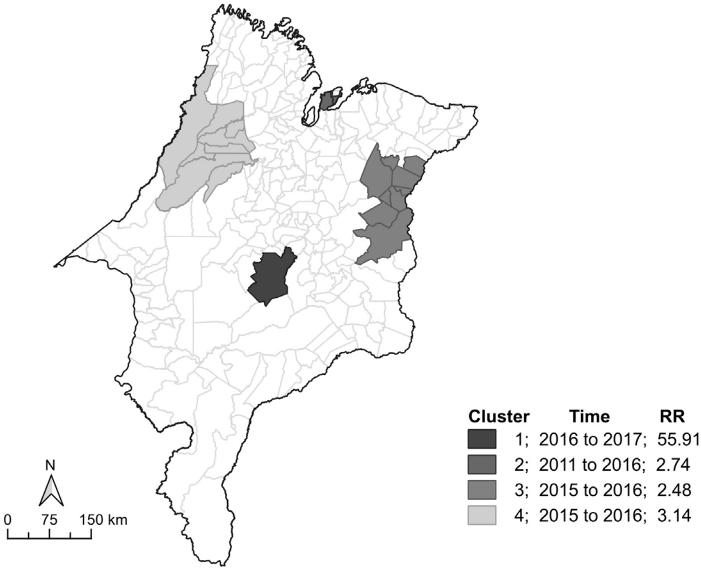

Figure 4. Space-time clusters of dengue cases in the State of Maranhão, from 2010 to 2021. RR = relative risk.

DISCUSSION

The total number of probable cases reported in the State of Maranhão between 2010 and 2021 corresponds to 3.7% of the 2,108,034 cases in the Northeast region, and 0.7% of the 11,066,056 reported cases of dengue in Brazil during the same period (Ministério da Saúde, 2022). The highest number of cases in the State occurred in 2016, this year was marked by large outbreaks worldwide. More than 2.38 million cases were recorded in the Americas, of which at least 1.5 million cases occurred in Brazil (Ministério da Saúde, 2022; PAHO, 2023). The increase in dengue cases during this year requires careful analysis, considering the possibility of underreporting of other arboviruses, such as chikungunya and zika (Perez et al., 2019). In 2016, approximately 280,000 cases of zika were registered in the country, and in Maranhão, 5,031 cases were registered, with the diagnosis being performed mainly by clinical-epidemiological criteria (Ministério da Saúde, 2022). A considerable number of zika cases may have been misclassified as dengue, mainly due to symptoms shared by this arbovirus (Borchering et al., 2019).

A study conducted between 2010 and 2020 using data provided by the Maranhão State government described 12,185 confirmed cases in 2016 (Aguiar et al., 2022). In addition to misclassification based on clinical signs, the discrepancy between confirmed and probable cases may be due to the low availability of laboratory diagnostics (Borchering et al., 2019). During the study period, Maranhão had three epidemic waves, with peaks occurring at intervals of two to four years (2011, 2016 and 2019). This information is consistent with the cyclical pattern of epidemic and inter-epidemic transmission existing in Brazil, which had peaks occurring every three or five years until 2010, when it changed to every two years (Salles et al., 2018).

After the 2016 epidemic, there was a decrease in cases in the following two years and a resumption in 2019 in the State of Maranhão and in Brazil. Similar patterns were seen in other countries in America. The decrease in cases in 2017 and 2018 was followed by a synchronized resurgence in 2019 on the American continent (Brito et al., 2021; PAHO, 2023). In Brazil, the causes for the declines may relate to the role of prior dengue virus immunity in previous outbreaks and perhaps public health interventions in response to the dengue and zika epidemics (Brito et al., 2021). The predominance of cases in the first half of the year indicates a seasonal pattern of dengue in Maranhão. In Brazil, most dengue cases occur between December and June, with peaks usually observed during the hottest months with the highest precipitation, generating favorable conditions for the proliferation of the vector (Churakov et al., 2019).

In the epidemiological profile, the female gender had the highest proportion of cases (54.9%). A similar result to that obtained in a study carried out in Maranhão between 2008 and 2012, where 53.0% of confirmed cases were female (Oliveira et al., 2020), and 54.4% from 2014 to 2021 (Pereira et al., 2022). In a study with data from the State of Bahia, Northeast region of Brazil, the female gender represented 57.5% of the total number of cases (Menezes et al., 2021a). There was also a predominance of females (56.3%) in a study carried out with data from the State of Minas Gerais, Southeast region (Moreira et al., 2022), and in the State of Alagoas (56.4%), Northeast region (Nascimento Junior et al., 2022). It is assumed that this scenario occurs because men seek health services less, which consequently generates fewer notifications for the male gender (Stefani et al., 2020). Another contributing factor is that women tend to spend more time in their homes, making them more susceptible to dengue infection, as the domestic environment harbors numerous breeding sites for the dengue vector (Nascimento Junior et al., 2022), as confirmed by study conducted with *Ae. aegypti* in the State of Maranhão (Bezerra et al., 2017).

Considering the age group, most cases were found in the 20 to 39 age group, with a proportion of 35.5% of the cases analyzed, in agreement with 33.8% reported in Maranhão (Oliveira et al., 2020). The same predominance was also found in the State of Minas Gerais (Moreira et al., 2022; Moura et al.,

2022) and in the State of Alagoas (Nascimento Junior et al., 2022). Similar to national-level trends reported in the literature (Correia et al., 2019; Menezes et al., 2021b), the highest proportion of dengue cases in this study was observed in the 20 to 39 age group. Nevertheless, statistical analysis revealed no significant difference between the 29 to 39 age category and the 40 to 59 age group. Individuals with incomplete elementary education degree represented 43.0% of the cases evaluated, which is consistent with findings from a study conducted in 12 municipalities in the North region of Pará, where this category accounted for 26.3% of cases (Nunes et al., 2021). It should be noted that 29,691 cases from the category “ignored or blank data” were excluded from the analysis, which corresponds to 37.7% of the total cases. This irregularity affects the reliability of the analysis.

The race variable showed a significant difference, with the largest number of cases concentrated in individuals of the brown race (80.7%), which is consistent with previous studies conducted in the State of Maranhão where this category represented 65.7% (Oliveira et al., 2020) and 79.5% of all cases (Pereira et al., 2022). Similar trends were also observed in other States such as Pará (Leite et al., 2021), Bahia (Menezes et al., 2021a) and Minas Gerais (Moura et al., 2022). Although a study aggregating data from Brazil did not find a significant difference in dengue occurrence between patients who self-reported as brown (29.9%) and white (28.4%), the proportion of missing data was high (37.0%), which hinders the analysis of the situation (Menezes et al., 2021b).

Regarding clinical and laboratory aspects, 81.6% of dengue cases were confirmed clinically and epidemiologically. Clinical-epidemiological confirmation was also higher in studies with data from Maranhão (Pereira et al., 2022), from Bahia (Menezes et al., 2021a), from Alagoas (Santos et al., 2019) and with data from Brazil (Menezes et al., 2021b). Regarding the classification of the disease, 98.5% of the cases were dengue fever and 1.5% were classified as severe dengue. This proportion is consistent with the result of a study on the epidemiological profile of dengue in Alagoas (Santos et al., 2019).

A study evaluating the dynamics of dengue in the Northeast region of the country showed that the municipalities with the highest incidence were the most populous, with a population of over 50,000 inhabitants (Carmo et al., 2020). However, unlike other regions, this pattern is not observed in the State of Maranhão, where many of the municipalities with high incidence rates have a population below 50,000 inhabitants, and some even have less than 10,000 inhabitants (such as São Pedro dos Crentes, Junco do Maranhão, Presidente Médici, São Raimundo do Doca Bezerra, Tasso Fragoso, São Félix de Balsas, São Pedro dos Crentes, and Feira Nova do Maranhão).

Positive spatial autocorrelation was found in the years 2013, 2014, 2016, 2017, 2019 and 2020. Positive autocorrelation was also found for dengue in a study on arboviruses between 2015 and 2016 in the State of Maranhão (Costa et al., 2018). In the studied period, 55.8% of the municipalities with the High-High standard were concentrated in the South region of the State. The higher proportion of clusters in the south of Maranhão is consistent with the clusters of dengue risk found in the study carried out in the Northeastern States (Carmo et al., 2020). The spatial clusters were also concentrated in the south of the State in the period from 2015 to 2016 in the study carried out in Maranhão (Costa et al., 2018). Considering this, the municipalities belonging to the South region are likely to be areas that need greater attention in terms of epidemiological surveillance.

Four high-risk spatial-temporal clusters for dengue cases were identified. The cluster identified in Barra do Corda (2015-2016) had a very high risk (55.91), representing more than 50 times the expected number of cases (169.6 cases). The municipality of Barra do Corda was also highlighted by the LISA method, indicating positive spatial correlation with neighboring municipalities in 2016. This municipality had a high incidence of cases in 2016 and 2017. The relative risk of the others ranged from 2.48 to 3.14. No spatial autocorrelation clusters were found using the LISA method in the spatial-temporal cluster regions. Spatial analysis is a very useful tool for the study of spatial and temporal distribution dynamics, which makes it possible to observe areas of greater epidemiological risk (Skalinski et al., 2018).

Recent studies conducted in Maranhão using secondary data have only evaluated descriptive data on the epidemiological profile of dengue (Oliveira et al., 2020; Pereira et al., 2022), and the annual and spatial distribution of raw dengue cases (Aguiar et al., 2022). This study addressed descriptive data on the epidemiological profile of dengue cases, monthly distribution of cases, annual distribution of cases and deaths, incidence, mortality, and spatial distribution of incidence. In addition, it performed spatial analysis that verified the existence of clusters with spatial autocorrelation and space-time analysis that identified high relative risk clusters. This study has limitations inherent to studies that used secondary data. The data comes from the SINAN system whose records of some variables may be compromised due to the lack of filling in the information, in addition to the possible underreporting of cases. This study differs from the previous ones, as it is the first one to combine the description of the epidemiological profile with the distribution and analysis of dengue in the State of Maranhão.

This study revealed that the occurrence of dengue in the State of Maranhão exhibited seasonal patterns and interannual variations, affecting mainly young adults and individuals with incomplete primary education degree, with a higher percentage among those self-reported as brown. Incidence rates were found to be highest in municipalities located in the Central and South regions of the State. Notably, the identification of high-incidence clusters in the South region was the main finding of the study, highlighting the need for further analysis to understand the underlying socio-environmental factors contributing to the spatial autocorrelation of dengue incidence in this region.

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CONFLICT OF INTEREST

The authors declare they have no conflicts of interest to disclose.

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