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Analysis of the spatial distribution of dengue in the state of Piauí from 2015 to 2019

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Abstract

Dengue is an arboviral disease considered global public health challenge, as it provides lasting damage, thus representing a threat to human health. Therefore, this study aimed to analyze the spatial distribution of dengue cases in Piauí between 2015 and 2019. This was a spatial ecological study of dengue, with data from the Disease Notification Information System (SINAN) from 2015 to 2019. The X^2 association test was applied for the bivariate analysis and the Qgis software (version 3.16.7. Hannover) was used for spatial analysis. During this period, 27,289 cases and 21,944 confirmed cases of dengue were reported. The city of Teresina (62.9%) and the health region Entre Rios (65.84%) had the highest records. Females (58.4%), between 20 and 34 years old (33.52%) and mixed race (44%) were the most affected. As for education, 58.5% did not respond. Dengue cases are concentrated in poles with large population flows. The identification of the epidemiological profile, as well as its main risk factors, is a way to help the health system of the entire state to elaborate specific control policies for the population most vulnerable to the disease.

Keywords: Arbovirus Infections. Aedes aegypti. Disease Notification. Epidemiology.

INTRODUCTION

Dengue is an arbovirus disease that is considered a public health problem with a high number of reported cases. It affects a large portion of the population annually and the number of infections and also the number of deaths increases, which end up having major consequences within the health system and important repercussions on morbidity and mortality rates[1,2].

Dengue virus (DENV) is transmitted to humans by mosquitoes of the genus Aedes sp. and it has four different serotypes (DENV-1, DENV-2, DENV-3, and DENV-4), which manifest themselves in different ways and intensities[3]. The genus Aedes has two species that stand out among the transmission of arboviruses, Aedes aegypti and Aedes albopictus. The transmission of the dengue virus (DENV) occurs through the bite of female mosquitoes of the Aedes genus, with A. aegypti being the primary vector[4].

Dengue is a disease with an infectious and febrile condition, usually of a high and abrupt nature, in addition to other symptoms such as: headache, adynamia, myalgias and arthralgias, retro orbital pain, with or without maculopapular exanthema, and with or without the

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presence of pruritus. They can be classified as classic, dengue hemorrhagic fever, and dengue with complications. The initial stage is characterized by the clinical manifestations that were previously mentioned, the second stage presents hemorrhagic processes as well as hepatic alterations (hepatomegaly), and circulation and blood disorders (circulatory failure, hemoconcentration, and thrombocytopenia), and the third stage consists of some cases that do not fit this classification[5].

The propagation of this arbovirus has occurred, mainly in tropical and subtropical countries, where the environment favors the development and proliferation of Aedes aegypti, such as Brazil, where environmental conditions are favorable for the permanence and dissemination of the transmitter of the disease. Its reproduction is favored by puddles of water in urban areas, environments with standing water (which are common in places with garbage accumulated in the streets and in vacant lots), and areas with an ineffective water supply and without basic sanitation[6,7].

Knowledge of the characteristics about transmission, seasonal profile, prevalence and incidence in certain social groups and regions, the causes as well as aggravators of the disease are essential in order to establish a direction of strategies and educational measures for prevention and health promotion. The knowledge of the real infestation of this arbovirus favors the development of actions in public health policies, encompassing points such as vector control, effectiveness of the notification system, and training of professionals, in order to provide greater effectiveness of control strategies and population orientation[8].

Therefore, since dengue is a serious threat to human health and the world economy, especially in developing countries where access to basic health services is limited, and due to the relevance of the disease in the state of Piauí, which has the highest number of cases of diseases transmitted by Aedes aegypt, the tracking and epidemiological analysis of this arbovirus is extremely important for the establishment of important strategies to reduce the risk and vulnerability of individuals and communities, as well as adapt current public policies in the local epidemiological context. Thus, this study aimed to analyze the spatial distribution, temporal variation, and sociodemographic characteristics of dengue cases in the state of Piauí, from 2015 to 2019. The results obtained by the research in question may serve as subsidies for the elaboration of public policies aimved at to combat dengue in the state of Piauí.

METHODOLOGY

This is an ecological, quantitative, analytical, descriptive, and retrospective epidemiological study on dengue in the state of Piauí, conducted between December 2020 and September 2021.

The state of Piauí is located in the Northeast region of Brazil, with a total area of 251,611.93 km^2, which corresponds to 16.19% and 2.95% of the total areas of the Northeast and Brazil, respectively. It is the third largest state in the Northeast in terms of land area. According to the last demographic census of 2010, Piauí has 3,118,360 inhabitants. As for its political-administrative division, Piauí has 224 municipalities divided into four developing mesoregions, namely: North Piauí, North-Central Piauí, Southeast Piauí, and Southwest Piauí[9].

The state has 11 health regions: I – Littoral Plain (11 municipalities), II – Cocais (22 municipalities), III – Entre Rios (31 municipalities), IV- Carnaubais (16 municipalities), V - Vale do Guaribas (42 municipalities), VI – Vale do Ca-

nindé (14 municipalities), VII – Vale do Sambito (14 municipalities), VIII – Vale do Rios Piauí and Itaueiras (28 municipalities), IX – Serra da Capivara (18 municipalities), X – Chapada das Mangabeiras (23 municipalities), and XI – Tabuleiros do Alto Parnaíba (5 municipalities)[10].

The study population consisted of the registered cases of dengue in the Disease Notification Information System (SINAN) during the period from 2015 to 2019, obtained through the State Department of Health of Piauí (SDHPI), located in the capital Teresina. Reported and confirmed cases of dengue between 2015 and 2019 in all municipalities in the state were included. Data that showed incompleteness regarding the variables used, as well as data recorded outside the established period, were excluded.

Secondary data were collected using a data collection instrument developed and adapted by the researchers, containing the variables gender, age group, race/color, schooling, month of notification, reported cases, confirmed cases, dengue cases with warning signs, and severe dengue. Data were collected between April and May 2021, extracted at the State Health Department from SINAN.

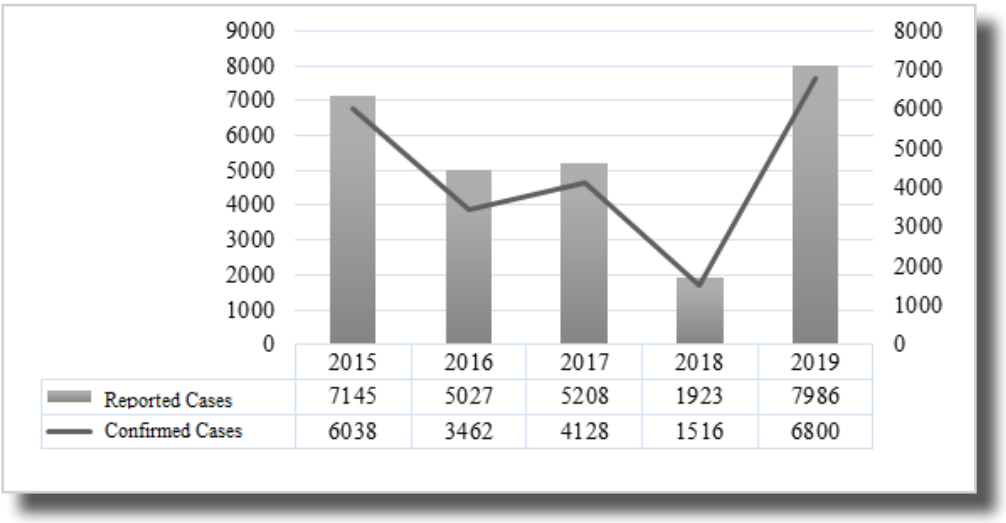
Spatial analysis was performed from data processing to combine with the cartographic base in the free software Qgis (version 3.16.7 Hannover), which is a Geographic Information System (GIS) widely used in handling tabular and vector data for production of maps. The spatial distribution of cases by municipalities was used by combining the secondary data obtained with SDHPI and then converting them into the ".csv" extension that is accepted by the SIG Environment. Furthermore, the names of the municipalities were used to make the connection between the cartographic base and the tabular data for the table of attributes, this same process was carried out for the 11 health regions. However, for the delimitation of these data, it was necessary to use the geoprocessing command "dissolve", because only then would we have the distinctions of the 11 regions. Finally, the confirmed cases of dengue in the municipalities of each region were added to obtain the total number of cases per region[11].

An exploratory, descriptive analysis was applied to verify data consistency and absolute and relative frequencies were used to characterize them. For the bivariate analysis, the X^2 association test was used to calculate the evidence of statistical association of the qualitative data. For all analyses, a significance level of $p < 0.05$ was considered. Data were entered into a spreadsheet in the Microsoft Excel® editor and analyzed using the Statistical Package for the Social Sciences, version 26.

The study was carried out in accordance with Resolution 466/12 of the National Health Council (CNS), which deals with research involving human beings. The study was also carried out after the project was approved by the Research Ethics Committee (CEP) of the Federal University of Piauí (UFPI), with approval No. 4.518.995 and the Certificate of Presentation for Ethical Assessment (CAAE) No. 41610720.2.0000.5214.

RESULTS

With regards to dengue in the state of Piauí, 27,289 cases were reported and 21,944 cases were confirmed between 2015 and 2019. The year 2019 had the highest record, with 7,986 reported cases (29.26%) and 6,800 confirmed cases (31%), followed by the year 2015 with 7,145 reports (26.18%) and 6,038 confirmed cases (27.5%) (Figure 1).



Source: SINAN/SDHPI, 2015-2019.

Figure 1 – Distribution of reported and confirmed cases of dengue in the state of Piauí, 2015 to 2019.

Regarding the spatial distribution of reported cases of dengue in the state of Piauí, 213 municipalities reported cases, with Teresina having the highest number of records, corresponding to 17,169 cases (62.9%), followed by Picos with 914 reports (3.4 %), Parnaíba with 589 reports (2.2%), Oeiras with 307 reports (1.1%), São Raimundo Nonato with 304 reports (1.1%), Pedro II with 301 reports (1.1%), Uruçuí with 255 reports (0.9%), and Cocal with 244 reports (0.9%) (Figure 1). Regarding confirmed cases of dengue, 188 municipalities reported cases, of which 16,016 (73%) were registered in Teresina, 914 (4.2%) in Picos, 589 (2.7%) in Parnaíba, 269 (1.2%) in Pedro II, 213 (1.0%) in Oeiras, 186 (0.9%) in Bom Jesus do Piauí, 174 (0.8%) in São Raimundo Nonato, 172 (0.8%) in Uruçuí, and 164 cases (0.8%) in Floriano (figure 2).

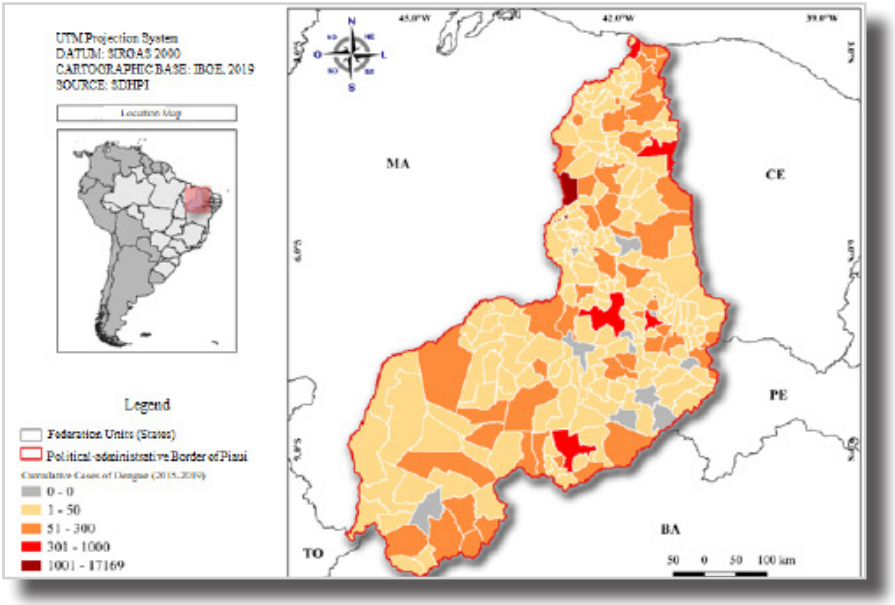
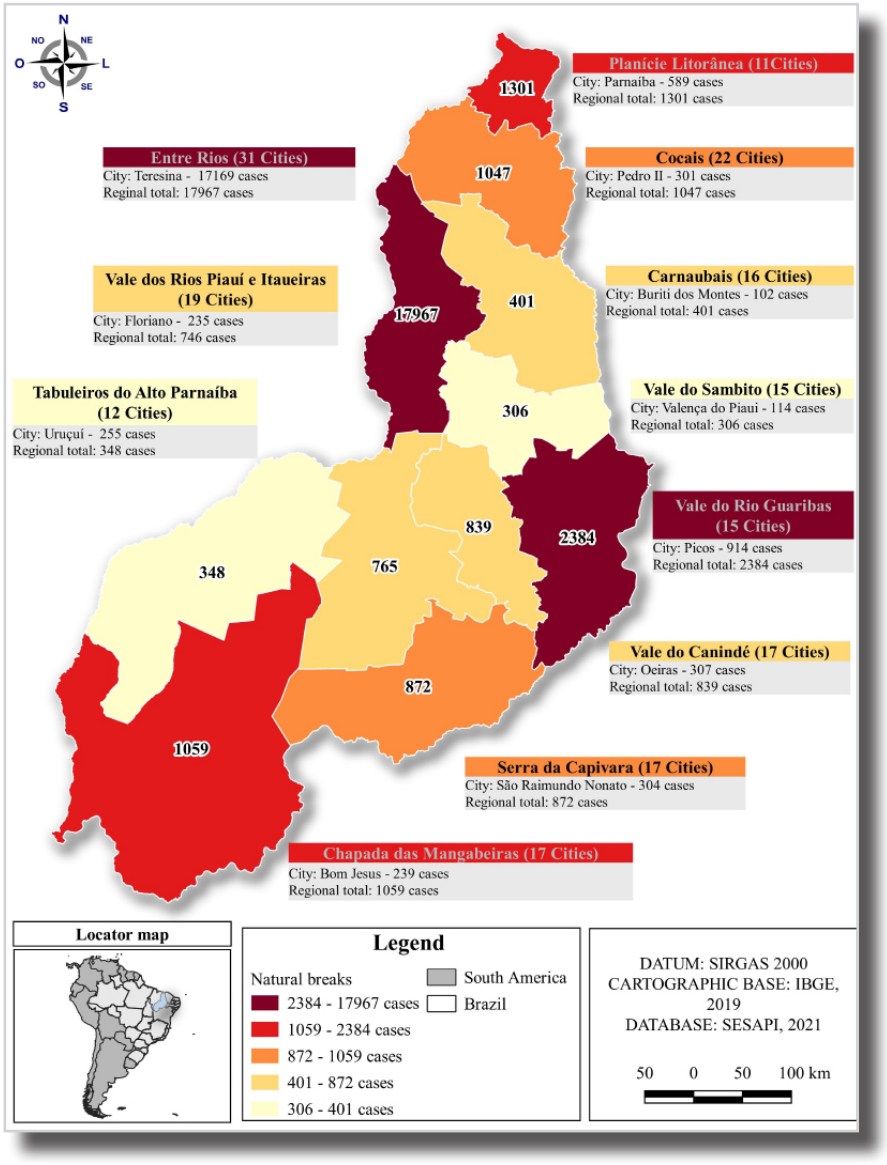


Figure 2 – Distribution of reported cases of Dengue by municipality in the state of Piauí, 2015 to 2019.

With regards to reported cases of dengue by health region in the state of Piauí, the region Entre Rios had the highest number (n=17,967), followed by the regions Vale do Rio Guaribas (n=2,384), the Littoral Plain (n= 1,301), Chapada das Mangabeiras (n=1,059), Cocais (n=1,047), Serra da Capivara (n=872), Vale do Canindé (n=839), Vale do Rio Piauí and Itaueiras (n=765), Carnaubais (n=401), Tabuleiros do Alto Parnaíba (n=348), and Vale do Sambito (n=306) (Figure 3).

The characterization of the reported cases was performed according to sex, age group, race and education (Table 1). When considering the gender variable in the reported cases of dengue, the majority were female, with a percentage of 58.4% (n=15,930), 41.4% (n=11,300) were male, and 0.2% (n=59) did not respond/blank. The year 2019 had the highest number, with 3,451 cases (43.2%) in males, 4,513 cases (56.5%) in females, and 22 cases (0.3%) did not respond/blank.



Source: SINAN/SDHPI, 2015-2019.

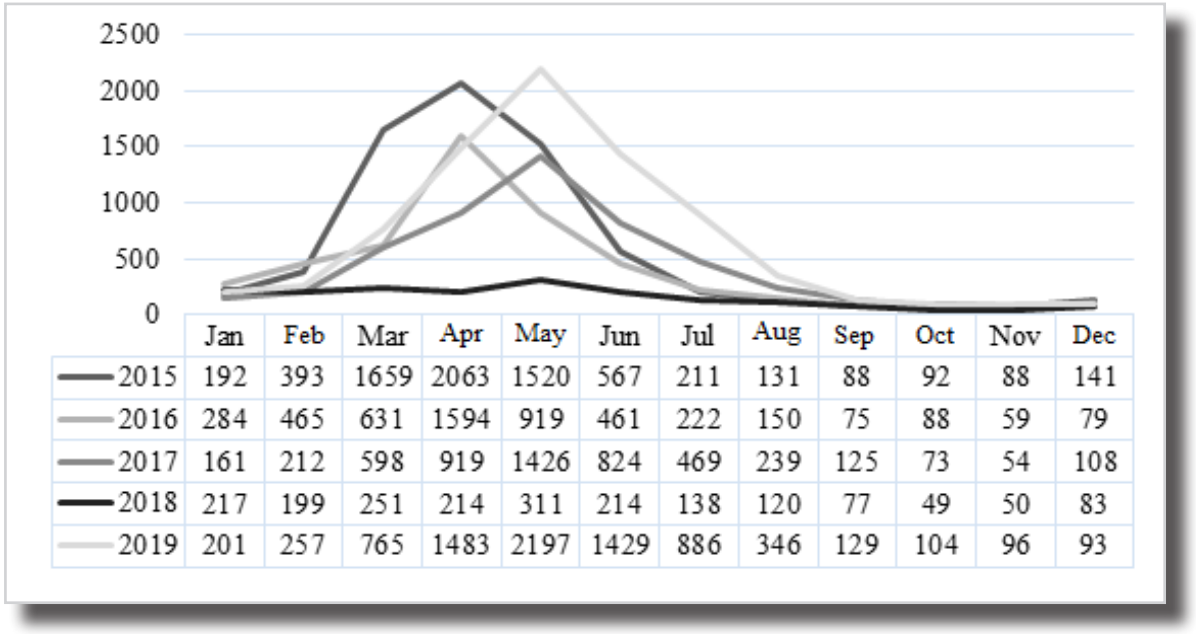
Figure 3 – Distribution of reported cases of Dengue by health region in the state of Piauí, 2015 to 2019.

Regarding the age group, the highest number of reported cases of dengue occurred among 20 and 34 years old, with a total of 9,146 notifications (33.52%), followed by the age group between 35 and 49 years old with 5,788 reports (21.21 %), 50- and 64-year olds with 3,278 reports (12.01%), 15- and 19-year olds with 2,910 reports (10.66%), 10- and 14-year olds with 1,989 reports (7.29%), 5- and 9-year olds with 1,474 reports (5 .40%), 65- and 79-year olds with 1,306 reports (4.79%), 01- and 04-year olds with 721 reports (2.64%), < 1 year old with 416 reports (1.52%), and 80 years old and over with 261 reports (0.96%). Regarding the ethnicity variable, 44.0% (n=12,007) were brown, 43.9% (n=11,974) unknown/blank, 8.3% (n=2,265) white, 3.1% (n=855) black, 0.5% (n=140) yellow, and 0.2% indigenous (n=48).

Regarding the education of the notified cases, 58.5% did not respond (n=15,973), 8.7% had completed high school (n=2,385), 7.2% were not applicable (n=1,969), 4.8% did not complete the 5th to 8th grades of primary school (PS) (n=1,559), 5.7% did not complete 1st to 4th grades of PS (n=1,315), 4.6% did not complete high school (n=1,250), 2.8% completed PS (n=761), 2.8% had completed higher education (n=760), 1.9% had completed the 4th grade of PS (n=511), 1.8% had an incomplete higher education (n=491), and 1.2% were illiterate (n=315). All independent variables had a statistically significant association.

As for the monthly distribution of dengue cases, the month of May had the highest number of notifications, with 6,373 cases in all the years studied (23.4%), followed by the month of April with 6,273 cases (23.0%) (Figure 4).

Regarding the classification of reported cases of dengue, between 2015 and 2019, in the state of Piauí, 173 cases were confirmed as dengue with warning signs and 54 cases as severe dengue.



	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2015	192	393	1659	2063	1520	567	211	131	88	92	88	141
2016	284	465	631	1594	919	461	222	150	75	88	59	79
2017	161	212	598	919	1426	824	469	239	125	73	54	108
2018	217	199	251	214	311	214	138	120	77	49	50	83
2019	201	257	765	1483	2197	1429	886	346	129	104	96	93

Source: SINAN/SDHPI, 2015-2019.

Figure 4 – Monthly distribution of reported cases of dengue in the state of Piauí, 2015 to 2019.

Table 1 – Characterization of reported cases of dengue according to sex and age group, race, and education, in the state of Piauí, 2015 to 2019. Teresina-PI, 2021.

	2015		2016		2017		2018		2019		P-value
	N	%	N	%	N	%	N	%	N	%	<0.001
Sex											
Did not respond	5	0.1	13	0,3	15	0.3	4	0.2	22	0.3	
Male	2867	40.1	2081	41.4	2112	40.6	789	41.0	3451	43.2	
Female	4273	59.8	2933	58.3	3081	59.2	1130	58.8	4513	56.5	
Age											<0.001
<1 Year	89	1.2	93	1.9	44	0.8	32	1.7	158	2.0	
1-4	225	3.1	138	2.7	96	1.8	47	2.4	215	2.7	
5-9	331	4.6	227	4.5	221	4.2	81	4.2	614	7.7	
10-14	416	5.8	328	6.5	325	6.2	96	5.0	824	10.3	
15-19	710	9.9	530	10.5	544	10.4	212	11.0	914	11.4	
20-34	2522	35.3	1724	34.3	1723	33.1	709	36.9	2468	30.9	
35-49	1696	23.7	1046	20.8	1119	21.5	419	21.8	1508	18.9	
50-64	853	11.9	593	11.8	726	13.9	222	11.5	884	11.1	
65-79	265	3.7	287	5.7	322	6.2	92	4.8	340	4.3	
80 and up	38	0.5	61	1.2	88	1.7	13	0.7	61	0.8	
Race											<0.001
Did not respond	2732	38.2	2684	53.4	2317	44.5	1064	55.3	3177	39.8	
White	610	8.5	356	7.1	457	8.8	133	6.9	709	8.9	
Black	276	3.9	154	3.1	147	2.8	38	2.0	240	3.0	
Yellow	22	0.3	19	0.4	33	0.6	11	0.6	55	0.7	
Brown	3497	48.9	1807	35.9	2244	43.1	673	35.0	3786	47.4	
Indigenous	8	0.1	7	0.1	10	0.2	4	0.2	19	0.2	
Education											<0.001
Did not respond	3778	52.9	3253	64.7	3275	62.9	1290	67.1	4377	54.8	
Illiterate	77	1.1	68	1.4	70	1.3	14	0.7	86	1.1	
Incomplete 1st to 4th grade	296	4.1	252	5.0	279	5.4	73	3.8	415	5.2	
Complete 4th grade	141	2.0	111	2.2	88	1.7	34	1.8	137	1.7	
Incomplete 5th to 8th grade	478	6.7	227	4.5	245	4.7	80	4.2	529	6.6	
Complete primary school	271	3.8	103	2.0	122	2.3	44	2.3	221	2.8	
Incomplete high school	399	5.6	177	3.5	229	4.4	56	2.9	389	4.9	
Complete high school	797	11.2	292	5.8	409	7.9	132	6.9	755	9.5	
Incomplete higher Education	174	2.4	73	1.5	77	1.5	23	1.2	144	1.8	
Complete higher Education	214	3.0	111	2.2	163	3.1	49	2.5	223	2.8	
Not applicable	520	7.3	360	7.2	251	4.8	128	6.7	710	8.9	

Source: SINAN/SDHPI, 2015-2019.

DISCUSSION

Dengue is considered a challenging disease for public health, as it causes lasting damage, thus representing a threat to human health and world economic development[12]. Thus, this study aimed to analyze the spatial distribution, temporal variation and sociodemographic characteristics of dengue cases in the state of Piauí, from 2015 to 2019.

This study was possible due to the evolution of disease mapping that has been carried out since the 19th century, contributing to the increase of understanding and the fight against contagious diseases. Along this line, the English physician John Snow stood out when he conducted a pioneering study on disease mapping, in 1854, making it possible to detect the focal point of the disease, the regions, and the most affected people[13].

Mapping became possible due to the computational and technological advances that allowed for the development of maps with varied applications in a GIS environment, which permit the integration of several numerical and textual databases with cartographic bases, modeling scenarios and performing temporal analyses of the advancement of diseases in a particular region[14], as is the case with Dengue.

This system consists of a framework of computational tools that can be used to obtain, store, analyze, and represent spatial data[15]. In this sense, the use of GIS in epidemiological surveillance is promising and effective in the health area, since spatial monitoring and data georeferencing provide the analysis of the distribution of risk situations and health-related problems[16].

The spatial analysis showed that Teresina was the municipality in the state that had the highest number of reported cases in the period from 2015 to 2019. This information can be justified because it is an urban center in the state, with a large contingency and population flow, together with social and political problems that favor the spread of the virus[17].

The reported and confirmed cases of dengue in the state of Piauí were higher in females, which corroborates studies carried out in Recife-PE, Belo Horizonte-MG and Piracicaba-SP[18,19,20]. This fact can be explained by the fact that women stay longer in the home and the peridomiciliary environment, especially during the day, and are more exposed to the vector[21].

In this study, all age groups had suspected and confirmed cases of dengue; however, most were observed in individuals between 20 and 34 years of age. Moreover, a similar result was found in a study carried out in the cities of Picos-PI, Araraquara-SP, and Recife-PE[22,23,24].

In Piauí, regarding the race/skin color variable, 44% of the reported cases were in people self-reported as brown and 43.9% had an unknown/blank result. This finding is in line with a survey carried out in the city of Aracaju-SE, where it was observed that the highest frequency of notification was also in the brown and black population, although 51.7% of the notifications also did not report their race[25]. Thus, authors recommend continuous monitoring of filling in the variables, making it possible to carry out an adequate assessment of health information systems for the ethnic-racial variables[26].

As for the notifications of dengue cases, more than half ignored or left blank the question regarding the level of education. In view of this, some authors claim that this variable is poorly recorded in the required dengue notification forms[8,25], which in a way ends up making conclusions about the disease/educational relationship impossible. However, it is known that the lower the level of education, the lower the knowledge regarding the aspects related to

the disease, thus increasing the risk of infection in the population[8,27].

The absence or error in filling out the notification forms is worrying, since underreported cases and divergences may be generated when tracing the epidemiological profile of dengue in a municipality. The authors also state that the information collected through the notification forms are of paramount importance for the formulation of strategies to combat the disease, Aedes aegypti control policies, as well as prevention and health promotion of the population/community[28].

Therefore, the notification of suspected cases must always be carried out, since epidemiological surveillance obtains a reliable estimate of the number of confirmed and suspected cases due to the disease, in order to establish effective control policies. Thus, it is important to sensitize health professionals to completely fill out the notification forms, as it is through them that the surveillance system monitors the behavior of the disease in a municipality, state, and region[29].

As for the monthly distribution of dengue cases, the month of May had the highest number of notifications. A study carried out in the capital Teresina showed a high rate of dengue cases throughout the first half of the year, with an emphasis on the months from March to May[30].

Some cases of dengue can progress to the critical phase, which involves dengue with warning signs, severe dengue, shock, severe bleeding, and also severe organ dysfunction. Dengue with warning signs is usually due to increased vascular permeability and its possible evolution to shock due to plasma leakage, starting with the decline of fever, between the third and seventh day of the onset of the disease, followed by the appearance of warning signs[31].

Severe dengue can present with plasma leakage, characterized by hemoconcentration, leading to shock or fluid accumulation with respiratory distress, severe bleeding, or signs of organ dysfunction such as in the heart, lungs, kidneys, liver, and central nervous system (CNS). The involvement of these organs promotes a clinical picture similar to that observed in other diseases. Pleural effusion and ascites may be clinically detectable, depending on the extravasation and excessive volume of administered fluids[31].

The literature highlights that it is a disease that is easy to diagnose and treat. Reported deaths are a public health concern, since deaths from dengue are considered preventable, which reinforces the need to promote adequate care and improvements in health care and the flow of health information, in order to generate effective actions in the fight and prevention of the disease[32].

Dengue is a serious health problem in the state of Piauí. Therefore, identifying the epidemiological profile, as well as its main risk factors, is a way of helping the health system of the entire state to elaborate specific control policies for the population most vulnerable to the disease. Authors believe that epidemiological surveillance is the greatest strategy to control dengue-transmitting mosquitoes and, therefore, it is necessary to work with an intersectoral perspective, with health education actions that inform people's actions in the fight against this epidemic and that would better train professionals to recognize the signs and symptoms of dengue and, thus, take the necessary precautions at an opportune time[22].

As a limitation of the study, it is worth mentioning the biases of ecological studies: 1) the findings may not be occurring at the individual level, and are only representative for the populations; 2) obtaining secondary data can generate incomplete information or errors inherent to the report and, consequently, bring possible biases in the investigation.

CONCLUSION

It can be concluded with the present study that dengue has a wide distribution and constitutes an important problem for all municipalities in the state of Piauí. It was observed that Teresina, the most populous and economically active city in the state, had most of the reported and confirmed cases, affecting mainly the female population, young people, those of a mixed race, and those with a lower level of education. Thus, this spatial analysis identified the groups and municipalities with the highest concentration, allowing for strategies to control this arbovirus to be implemented.

It is believed that epidemiological surveillance is the greatest strategy for controlling the vector that transmits dengue. Thus, it is necessary to work with an intersectoral perspective, with health education actions that inform people's actions in the fight against this arbovirus and that would better train professionals to fill out the notification forms completely, so that there would be an accurate monitoring of cases throughout the state.

CRediT author statement

Conceptualization: Lemos, MHS; Lopes Filho, LLL; Costa, MAO; Cavalcante, MAS. Methodology: Lemos, MHS; Lopes Filho, LLL; Costa, MAO; Cavalcante, MAS; Campelo, V. Validation: Lemos, MHS; Lopes Filho, LLL; Costa, MAO. Statistical analysis: Sousa Júnior, VPS; Lemos, MHS; Lopes Filho, LLL. Formal analysis: Lemos, MHS; Lopes Filho, LLL; Costa, MAO; Cavalcante, MAS; Campelo, V; Sousa Júnior, VPS. Investigation: Lemos, MHS; Lopes Filho, LLL; Costa, MAO; Cavalcante, MAS; Campelo, V; Sousa Júnior, VPS. Resources: Lemos, MHS; Lopes Filho, LLL; Costa, MAO; Cavalcante, MAS. Writing-original draft preparation: Lemos, MHS; Lopes Filho, LLL; Costa, MAO. Writing-review and editing: Lemos, MHS; Lopes Filho, LLL; Costa, MAO. Visualization: Cavalcante, MAS; Campelo, V; Sousa Júnior, VPS. Supervision: Cavalcante, MAS; Campelo, V; Sousa Júnior, VPS. Project administration: Lemos, MHS; Lopes Filho, LLL; Costa, MAO; Cavalcante, MAS.

All authors have read and agreed to the published version of the manuscript.

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