Spatial distribution of Zika virus cases in a Northeast Brazilian state

RESUMO | Objetivo: Analisar a distribuição espacial dos casos de Zika vírus no Piauí entre 2015 e 2019. Método: Tratou-se de um estudo ecológico espacial da Zika vírus, com dados do Sistema de Informação de Agravos de Notificação (SINAN)de 2015 a 2019. Foi aplicado o teste de associação X^2 para a análise bivariada e para análise espacial foi utilizado o software Qgis (versão 3.16.7). Resultados: Foram notificados 1354 casos e 207 casos confirmados da doença. O município de Teresina (51,33%) e a região de saúde Entre Rios (42%) apresentaram os maiores registros. O sexo feminino (72,30%), a faixa entre 20 e 34 anos (40,03%), etnia parda (65,88%) e escolaridade ignorada (43,21%) foram os mais afetados. Conclusão: A identificação do perfil epidemiológico da Zika é uma forma de auxiliar o sistema de saúde de todo o estado na elaboração de políticas de controle específicas para as populações mais vulneráveis.
Descritores: Infecções por Arbovírus; Notificação de Doenças; Epidemiologia; Sistema de Informação em Saúde.

ABSTRACT | Objective:To Analyze The spatial distribution of Zika virus cases in Piauí between 2015 and 2019. Method: Thiswas a spatialecologicalstudyoftheZikavirus, with data fromtheNotifiableDiseasesInformation System (SINAN) from 2015 to 2019. The X^2 association test was applied for thebivariateanalysisandtheQgis software (version 3.16.7) was used for spatial analysis. Results:1354 cases and 207 confirmed cases of the disease were reported. The municipality of Teresina (51.33%) and the health region Entre Rios (42%) had the highest records. Females (72.30%), aged between 20 and 34 years (40.03%), mixed race (65.88%) andunknowneducation (43.21%) were the most affected.Conclusion: The epidemiological profile ofZikais a way to help the health system of the entire state in the elaboration of specific control policies for the most vulnerable populations.
Keywords: ArbovirusInfections; DiseaseNotification; Epidemiology; Health Information Systems.

RESUMEN | Objetivo:Analizar La Distribución espacial de los casos de virus Zika Piauí entre 2015 y 2019. Método:Este fue un estudio ecológico espacial del virus Zika, con datos del Sistema de Información de Enfermedades de Declaración Obligatoria (SINAN) de 2015 a 2019.Para el análisis bivariado se aplicó la prueba de asociación X^2 y para el análisis espacial se utilizó el software Qgis (versión 3.16.7). Resultados:Se reportaron 1354 casos y 207 casos confirmados de la enfermedad. La ciudad de Teresina (51,33%) y laregiónsanitaria Entre Ríos (42%) tuvieronlos registros más altos.El sexo femenino (72,30%), conedad entre 20 y 34 años (40,03%), mestizo (65,88%) y sinescolaridad (43,21%) fueronlos más afectados.Conclusíon: La identificacióndel perfil epidemiológico delZika es una forma de ayudar al sistema de salud de todo el estado enlaelaboración de políticas de control específicas para laspoblaciones más vulnerables.
Palabras claves: Infecciones por Arbovirus; Notificación de Enfermedades; Epidemiología; Sistemas de Información en Salud.

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INTRODUCTION

Zica virus (ZIKV) is a flavivirus related to dengue virus, yellow fever virus and West Nile virus. Its discovery took place in 1947 in the Zika forest in Uganda, isolated from a rhesus

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monkey. The first human case occurred in Nigeria in 1954, and epidemics have been continuously described in Micronesia and other islands in the Pacific Ocean and, more recently, in Brazil. [1].

Zika virus (ZIKV) infection is the one with the greatest potential risk for the development of neurological complications, such as encephalitis, Guillain Barré syndrome and other neurological diseases. [2] In cases of pregnancy, if the mother is infected, she can easily transmit it to the child, through the fetal circulation, which leads to long-term congenital repercussions, such as microcephaly. [3]

ZIKV is an emerging arbovirus transmitted by mosquitoes of the Culicidae of the Aedes genus. The genus Aedes has as one of its main representatives the Aedes aegypti, in addition to other species of mosquitoes in the world capable of transmitting the virus, such as the Aedes africanus, Aedes albopictus, Aedes polynesiensis and Aedes hensilli. In addition to the vector form, there are reports of sexual, perinatal, post-transfusional transmission and occupational exposure. [4,5]

In Brazil, it is believed that ZIKV entered through the Football World Cup, held in the country between June and July 2014. Another hypothesis about the arrival of the virus in Brazil suggests that ZIKV entered during the canoeing championship held in the city of Rio de Janeiro in August 2014, with the participation of athletes from French Polynesia, New Caledonia, Cook Islands and Easter Island. Subsequently, it was found that the introduction of the Zika virus in Brazil may have occurred a year earlier, between May and December 2013, a period coinciding with the Confederations Cup – July and August 2013. [6,7,8]

In addition, ZIKV infection, in most cases, is characterized as mild and self-limiting, with an average duration of symptoms of ten days. When symptomatic, it manifests with low-grade or afebrile fever, maculopapular rash, arthralgia, myalgia, headache, conjunctival hyperemia and, less frequently, odynophagia, dry cough and gastrointestinal disorders, especially vomiting. Severe forms are rare, and when they occur, they can exceptionally lead to death. [9]

Thus, as the Zika virus is a serious threat to human health and the world economy, especially in developing countries, where access to basic health services is limited, and the relevance of the disease in the state of Piauí, Brazilian state that has the highest number of cases of diseases transmitted by Aedes aegypt, the tracking and epidemiological analysis of this arbovirus is extremely relevant for the establishment of important strategies for the reduction of risk and vulnerability of individuals and communities, in addition to the adaptation of public policies in force in the local epidemiological context. Thus, the study aimed to analyze the spatial distribution, temporal variation and sociodemographic characteristics of Zika virus cases in the state of Piauí, between the period from 2015 to 2019.

METHOD

This is an ecological, quantitative, analytical, descriptive and retrospective epidemiological study on the Zika Virus in the state of Piauí, where data collection was 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 km², 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 development mesoregions, they are: North Piauí, Center-North Piauí, Southeast Piauí and Southwest Piauí. [10]

The state has 11 health regions: I – Coastal 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 Canindé (14 municipalities), VII – Vale do Sambito (14 municipalities), VIII – Vale do Rio 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 Zika in the Notifiable Diseases Information System (SINAN) during the period from 2015 to 2019, obtained through the State Department of Health of Piauí (SESAPI), located in the capital Teresina. Reported and confirmed cases of Zika that occurred 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, education, month of notification, reported cases, confirmed cases and confirmation criteria. Data were collected in April and May 2021, extracted at the State Health Department, at 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 the handling of tabular and vector data for the production of maps. The spatial distribution of cases by municipalities was used by combining secondary data obtained with SESAPI and a transformation to the ".csv" extension, which is accepted by the SIG Environment, below, the names of the municipalities were used to link the cartographic base with 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

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would we have the delimitation of the 11 regional health of the state and, finally, confirmed cases of dengue in the municipalities of each region were added to obtain the total number of cases per region.

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 from 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 Software, version 26.

The study was carried out in accordance with Resolution 466/12 of the National Health Council (CNS - Conselho Nacional de Saúde), which deals with research involving human beings. The research was carried out after the project was approved by the Research Ethics Committee (CEP - Comitê de Ética de Pesquisa) of the Federal University of Piauí (UFPI), with opinion No. 4,518,995 and Certificate of Presentation for Ethical Assessment (CAAE) No. 41610720.2.0000.5214.

RESULTS

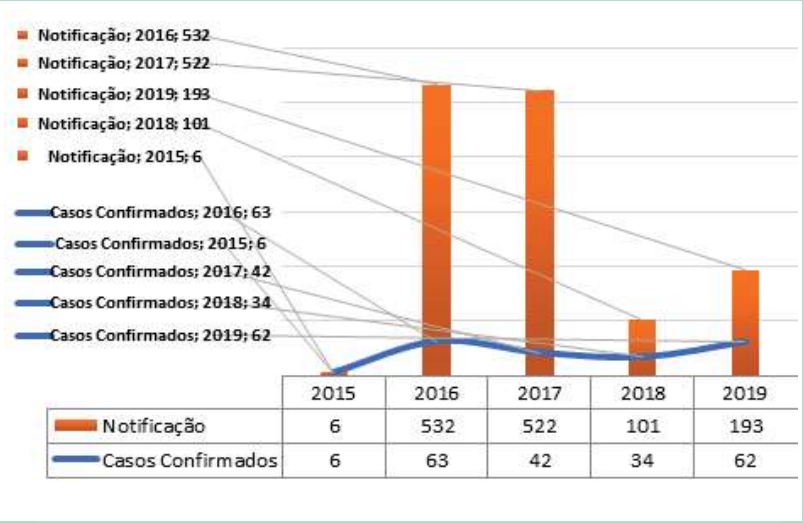
Regarding cases of Zika virus, in the period from 2015 to 2019, respectively, 1,354 reported cases and 207 confirmed cases were recorded in the state of Piauí.

Regarding the year, 6 cases (0.04%) and 6 confirmed cases (2.90%) were reported in 2015, 532 (39.29%) and 63 confirmed (30.43%) in 2016, 522 (38.55%) and 42 confirmed (20.29%) in 2017, 101 notified (7.46%) and 34 confirmed (16.43%) in 2018 and 193 notified (14.25%) and 62 confirmed (29.95%) in 2019 (Graph 1).

Regarding the spatial distribution of reported cases in the state of Piauí, 132 municipalities registered notifications, with Teresina having the highest number of records, a total of 695 cases (51.33%), followed by Oeiras with 153 notifications (11.30%), Parnaíba with 140 (10.34%), Piripiri with 110 (8.12%), Bom Jesus with 23 (1.70%) and Batalha with 16 notifications (1.18%) (Map 1).

In the state of Piauí, between 2015 and 2019, 82 municipalities presented records of confirmed cases. However, the municipalities with the highest number of cases were Teresina, with 57

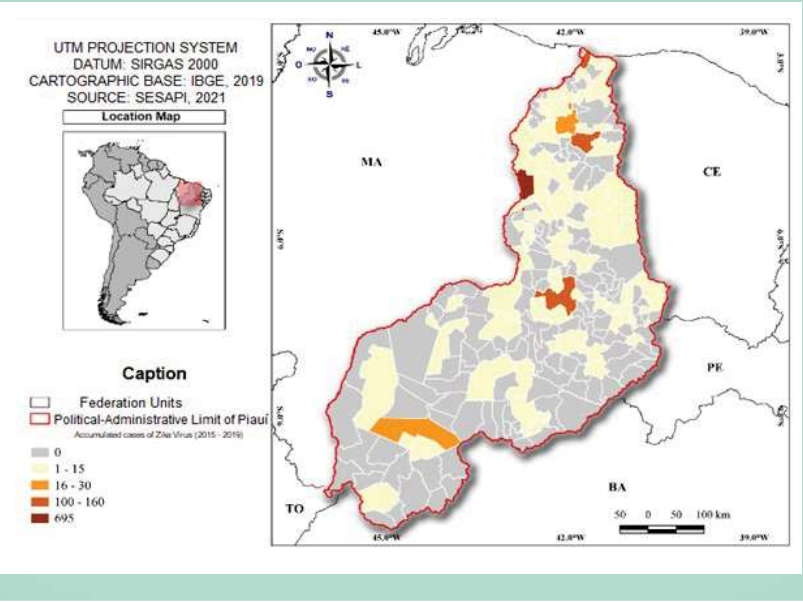
Graph 1 - Distribution of reported and confirmed cases of Zika virus. Teresina/PI, Brazil, 2021.



	2015	2016	2017	2018	2019
Notificação	6	532	522	101	193
Casos Confirmados	6	63	42	34	62

Source: SINAN/SESAPI, 2021.

Map 1 - Spatial distribution of reported cases of Zika virus. Teresina/PI, Brazil, 2021.



Source: SINAN/SESAPI, 2021.

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cases (27.54%), 31 (14.98%) in Piripiri, 17 (8.21%) in Oeiras and Parnaíba, 9 (4.35%) in Campinas do Piauí, and 7 cases (3.38%) in Bom Jesus.

With regard to the prevalence of confirmed cases, Teresina presented a rate of 0.07/1000 inhab., 0.50/1000 inhab. in Piripiri, 0.47/1000 inhab. in Oeiras, 0.11/1000 inhab. in Parnaíba, 1.66/1000 inhab. in Campinas do Piauí and 0.31/1000 inhab. in Bom Jesus do Piauí.

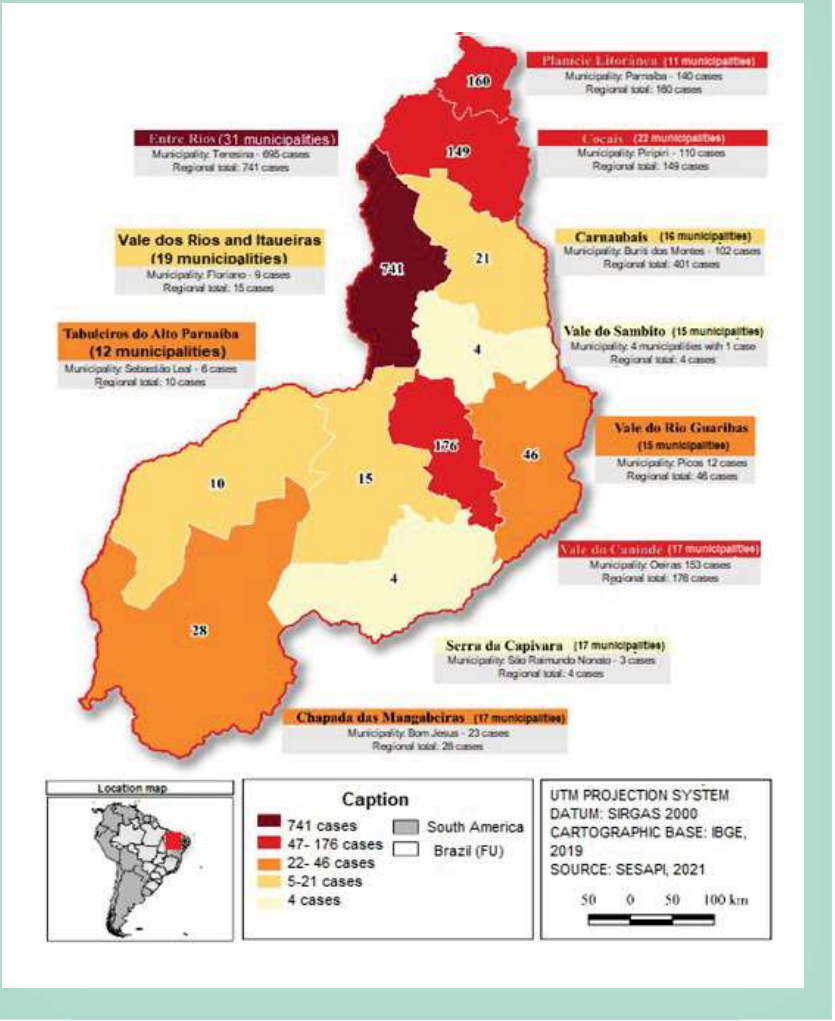
As for the reported cases of Zika virus, according to the regional health variable, the regional Entre Rios had the highest number of cases (n=741), followed by Carnaubais (n=401), Canindé Valley (n=176), Coastal Plain (n=160), Cocais (n=149), Guaribas River Valley (n=46), Chapada das Mangabeiras (n=28), Piauí and Itaueiras River Valley (n=15), Tabuleiros do Alto Parnaíba (n=10), Vale do Sambito (n=4) and Serra da Capivara (n=4) (Map 2).

Regarding the sex of reported cases of Zika virus in the state of Piauí, 72.30% (n=979) were female and 27.70% (n=375) were male. With regard to age, the highest number of Zika cases was between 20 and 34 years old, with 542 cases (40.03%), 266 (19.65%) between 35 and 49 years old, 118 (8.72%) between 15 and 19 years old, 116 (8.57%) between 50 and 64 years old, 70 (5.17%) between 10 and 14 years, 62 (4.58%) between 5 and 9 years, 59 (4.36%) between < 1 year, 52 between 65 and 79 years (3.84%) , 49 (3.62%) between 1 and 4 years and 20 cases (1.48%) in 80 years and older.

Regarding the ethnicity of the reported cases of Zika virus in the state of Piauí, of the total number of cases registered between the period 2015 to 2019, 65.88% (n=892) were brown, 14.77% (n=200) were white, 14.70% (n=199) ignored/white, 0.66% (n=9) yellow and 0.22% (n=3) indigenous.

Regarding the education variable, 43.21% (n=585) were ignored/white, 13.59% (n=184) had completed high school, 9.68% (n=131) did not apply, 9.68% (n=104) with complete higher education, 7.53% (n=102) with incomplete secondary education, 4.43% (n=60) with incomplete 5th to 8th grades of Elementary School, 3, 84% (n=52) with incomplete higher education, 3.77% (n=51) with complete elementary school, 3.25% (n=44) with incomplete 1st to 4th grade of elementary school 1.92% (n =26) with complete 4th grade of Elementary School and 1.11% (n=15) illiterate (Table 1). All the variables mentioned had a statistically significant association.

Map 2 – Spatial distribution of reported cases of Zika virus by health region. Teresina/PI, Brazil, 2021.



Source: SINAN/SESAPI, 2021.

Chi-square test of proportions at the 5% level.

Regarding the distribution of Zika virus cases per month, between 2015 and 2019, the month of May had the highest number of notifications, with 386 cases (28.51%), followed by the month of June with 248 cases (18.32%) that belong to the wettest period in the state (Graph 2).

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Table 1 - Characterization of reported cases of Zika virus according to sex, age group, race and education. Teresina/PI, Brazil, 2021.

Variáveis	2015		2016		2017		2018		2019		P-value
Sex	N	%	N	%	N	%	N	%	N	%	0,022
Male	1	16,7	159	29,9	12	23,0	36	35,6	59	30,6	
Female	5	83,3	373	70,1	42	77,0	65	64,4	134	69,4	
Age											0,006
<1 Year	0	0,0	12	2,3	21	4,0	8	7,9	18	9,3	
1-4.	0	0,0	26	4,9	8	1,5	5	5,0	10	5,2	
5-9.	0	0,0	32	6,0	16	3,1	5	5,0	9	4,7	
10-14.	1	16,7	27	5,1	26	5,0	6	5,9	10	5,2	
15-19	0	0,0	41	7,7	52	10,0	6	5,9	19	9,8	
20-34	0	0,0	22	41,3	213	40,8	38	37,6	71	36,8	
35-49	4	66,7	13	19,4	111	21,3	19	18,8	29	15,0	
50-64	1	16,7	48	9,0	43	8,2	8	7,9	16	8,3	
65-79	0	0,0	18	3,4	2	3,8	4	4,0	10	5,2	
80 and +	0	0,0	5	0,9	12	2,3	2	2,0	1	0,5	
Race											<0,001
Ign/Blank	0	0,0	151	28,4	44	8,4	1	1,0	3	1,6	
White	1	16,7	91	17,1	59	11,3	21	2,8	28	14,5	
Black	0	0,0	16	3,0	23	4,4	4	4,0	8	4,1	
Yellow	0	0,0	6	1,1	3	0,6	0	0,0	0	0,0	
Brown	5	83,3	267	50,2	391	74,9	75	74,3	154	79,8	
Indigenous	0	0,0	1	0,2	2	0,4	0	0,0	0	0,0	
Education											
Ign/Blank	2	33,3	242	45,4	243	46,5	35	34,7	63	32,6	
Illiterate	1	16,7	8	1,5	3	0,6	1	1,0	2	1,0	
Incomplete 1st to 4th grade of ES	0	0,0	19	3,6	14	2,7	3	3,0	8	4,1	
4th complete series of ES	0	0,0	9	1,7	4	0,8	8	7,9	5	2,6	
5th to 8th grade incomplete of ES	0	0,0	28	5,3	16	3,1	6	5,9	10	5,2	
Complete ES	1	16,7	18	3,4	25	4,8	0	0,0	7	3,6	
Incomplete High School	0	0,0	29	5,5	5	9,6	7	6,9	16	8,3	
Complete High School	1	16,7	63	11,8	78	14,9	13	12,9	29	15,0	
Incomplete Higher Education	0	0,0	19	3,6	2	3,8	6	5,9	7	3,6	
Complete Higher Education	1	16,7	48	9,0	35	6,7	6	5,9	14	7,3	
Doesn't apply	0	0,0	49	9,2	34	6,5	16	15,8	32	16,6	

Caption: ES: Elementary School
Source: SINAN/SESAPI, 2021.

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DISCUSSION

Between 2015 and 2019, suspected and confirmed cases of Zika in the state of Piauí were concentrated in the age group between 20 and 34 years and in females. A similar result was found in the city of Maceió, in the state of Tocantins, as well as in a study carried out in Paraguay. [11,12,13] However, authors claim that Zika virus (ZKV) infection is likely to affect the entire population, in their different age groups. [11]

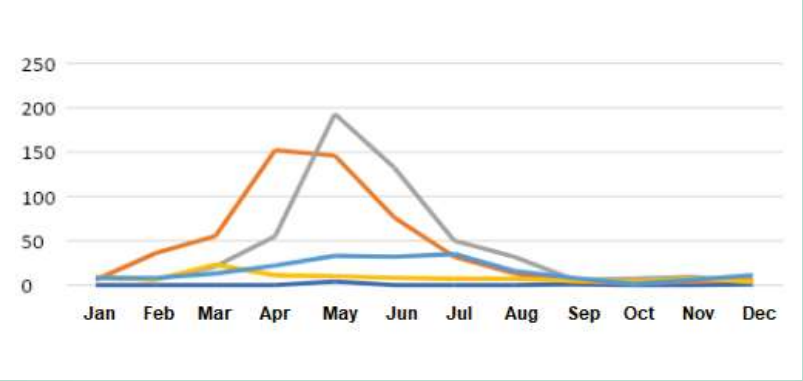
The results found regarding the race variable indicate that the majority declared themselves to be brown, in relation to education, most notifications were not registered (ignored/blank) and those that were completed indicated that the majority had completed high school. These findings are in line with research carried out in municipalities in the state of Rondônia, Alagoas and Minas Gerais. [11-14,15]

Lower levels of education are related to a higher proportion of arbovirus cases, since the level of education may be related to the inability to eliminate vector foci, in the same way as the low demand for hospital services after symptoms appear. This would create difficulties in understanding preventive measures against these arboviruses, thus favoring an increase in the number of suspected cases. [16]

As for the criteria for confirming Zika cases in the state of Piauí, clinical, epidemiological and laboratory criteria predominated. Regarding symptoms, the initial symptoms of Zika can be similar to dengue and chikungunya, which include: fever, myalgia, arthralgia, headache, maculopapular rash, lymphadenopathy and retro orbital pain. [17]

With regard to laboratory criteria, the protocols recommend collecting samples for laboratory confirmation of the first cases and from 100% of pregnant women who meet the case definition, 100% of neurological manifestations with previous viral infection, as well as deaths. Samples should be collected preferably until the 5th day of illness. [18]

Graph 2 - Monthly distribution of reported Zika virus cases. Teresina/PI, Brazil, 2021.



Source: SINAN/SESAPI, 2021.

Studies carried out in the states of Goiás, Tocantins, São Paulo and Rio Grande do Sul showed that the majority of reported and confirmed cases of Zika virus (ZIKV) infection occur respectively in the first semester. [12-19,20,21] These findings are similar to the results of this study, where notified and confirmed cases of Zika virus in the state of Piauí were concentrated in the months of May and June.

In the present study, it was not possible to verify the number of newborns with microcephaly or Congenital syndrome of Zika virus (CSZV). However, a study carried out in the state of Piauí showed that between 2015 and 2016, there was an outbreak of microcephaly caused by the introduction of the Zika virus (ZIKV) upon confirmation of a case detected in a neonate. [22]

The cases of microcephaly associated with Zika virus infection, initially detected in the Brazilian Northeast, generated intense social commotion due to the severity of the events related to women's reproductive health and neurological development, cognitive and motor skills of newborns, the lack of knowledge about the cause and risk factors, in addition to the national and international expansion of this epidemic. [23]

In the Northeast region, from 2015 to 2020, a total of 126,276 cases of Zika virus were reported in the epidemiological bulletins of the Ministry of Health. [24] The reasons why the Northeast region presented such high numbers of cases are: ecological context, climatic and environmental conditions favorable to the reproduction of the vector, population with unplanned growth (characteristic of middle-income countries and regions), favorable locations for the proliferation of vector-borne diseases and the high population flow. [25]

In this sense, it is necessary that in the state of Piauí there are multiple capacity building services for the registration of suspected and confirmed cases in these health information systems, the investigation of Zika virus infection in pregnant women with exanthema and in live births with microcephaly and, mainly, the inclusion of the investigation of Zika virus infection in prenatal care. [22]

CONCLUSION

It can be concluded with the present study that the Zika virus has a wide distribution and constitutes an important problem for all municipalities in the state of Piauí. It was observed that Teresina, the

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most populous and economically active city in the state, had most of the reported and confirmed cases, affecting mainly the female population, young people, of mixed race and those with a lower level of education. Thus, the spatial analysis identified the groups and municipalities with the highest concentration, allowing strategies to control this arbovirus to be implemented.

Epidemiological surveillance is believed to be the greatest strategy for controlling the vector that transmits the Zika virus. Thus, it is necessary to work from an interstate perspective, with health education actions that sensitize people's actions in the fight against this arbovirus and that there is better training of professionals to complete the notification forms completely, in order to have the correct monitoring of cases throughout the state.

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