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TREND AND SPATIAL DISTRIBUTION OF DENGUE INCIDENCE IN THE SERIDÓ REGION (2001–2024)

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ABSTRACT

This study investigated the occurrence of dengue in the Seridó region (RN/PB), Brazil, between 2001 and 2024, analyzing temporal trends, spatial distribution, and serotype circulation. Using data from SINAN and SIH/SUS, incidence and hospitalization rates were calculated, with Prais–Winsten regression and spatial analyses (Moran's Index and LISA) applied. Most municipalities showed stable incidence trends, although some experienced significant increases. In contrast, hospitalization rates declined across much of the region, suggesting improvements in primary care. Regarding serotypes, circulation of DENV 1, DENV 2, and DENV 4 was identified between 2014 and 2024. These findings reinforce the importance of regional strategies for vector control and epidemiological surveillance, taking into account socio-spatial inequalities and the strengthening of primary health care.

KEYWORDS: Dengue, Epidemiology, Public Health Surveillance, Primary Health Care, Morbidity and Mortality Indicators.

TENDÊNCIA E DISTRIBUIÇÃO ESPACIAL DA INCIDÊNCIA DA DENGUE NA REGIÃO DO SERIDÓ (2001-2024)

RESUMO

Este estudo investigou a ocorrência da dengue na região do Seridó (RN/PB) entre 2001 e 2024, analisando a tendência temporal, a distribuição espacial e a circulação de sorotipos. Utilizando dados do SINAN e SIH/SUS, foram calculadas as taxas de incidência e hospitalização, com aplicação da regressão de Prais-Winsten e análises espaciais (Índice de Moran e LISA). A maioria dos municípios apresentou tendência estável na incidência, embora alguns tenham registrado crescimento significativo. Por outro lado, observou-se queda nas taxas de hospitalização em grande parte da região, sugerindo avanços na atenção primária. Quanto aos sorotipos, identificou-se a circulação de DENV-1, DENV-2 e DENV-4 entre 2014 e 2024. Os achados reforçam a importância de estratégias regionais de controle vetorial e vigilância epidemiológica, considerando desigualdades socioespaciais e o fortalecimento da atenção primária à saúde.

PALAVRAS-CHAVE: Dengue, Epidemiologia, Vigilância em Saúde Pública, Atenção Primária à Saúde, Indicadores de Morbimortalidade.

1. INTRODUCTION

The term *arbovirus*, used since the 1930s, refers to a group of viruses transmitted by hematophagous arthropods, primarily mosquitoes. These viruses follow a transmission cycle that typically involves a vertebrate host and an arthropod vector, and may include multiple vectors and hosts across different ecosystems (Huang *et al*., 2019). The World Health Organization officially defines arboviruses as viruses maintained through biological transmission between susceptible vertebrate hosts and hematophagous vectors (WHO, 1985).

According to the Brazilian Ministry of Health (2024), arboviral diseases comprise a group of viral illnesses transmitted mainly by arthropods, particularly mosquitoes of the genera *Aedes*, *Culex*, and *Anopheles*, which act as their principal vectors. Among them, *Aedes aegypti*—responsible for infectious diseases such as dengue, chikungunya, and Zika—shows greater reproduction in urban areas, especially within socioenvironmentally vulnerable populations (Almeida, Cota & Rodrigues, 2020).

Aedes aegypti, with a trajectory historically intertwined with human environments, is characterized as a synanthropic mosquito—inhabiting predominantly urban areas and adapting to human-modified conditions—and as anthropophilic, given its preference for human blood (Lima-Camara, 2016; Almeida; Cota & Rodrigues, 2020). These features make the vector closely linked to human activities and mobility, facilitating its dissemination and enhancing its role in disease transmission, particularly dengue. Due to socioenvironmental conditions such as high rainfall, elevated temperatures, and the widespread presence of artificial breeding sites, dengue is considered a difficult-to-control disease of major proportions in urban settings (Souza, Silva & Silva, 2010).

In 2021, the World Health Organization (WHO) estimated 100 to 400 million dengue cases annually worldwide, with approximately half of the global population at imminent risk of infection (WHO, 2023). Global dengue incidence has risen substantially in recent years, with most cases being asymptomatic or presenting mild symptoms.

In this context, dengue solidifies its position as an arbovirus of growing global importance, with ascending incidence and mortality, influenced by climate change, urbanization, and socioeconomic inequalities. In this scenario, Brazil stands out as one of the countries with the highest burden of the disease, frequently concentrating the majority of cases reported across the Americas (Ilic & Ilic, 2024).

In Brazil, dengue is a notifiable disease, requiring all suspected and confirmed cases to be reported to the Epidemiological Surveillance Service of the Municipal Health Secretariat, and subsequently registered in the National Notifiable Diseases Information System (SINAN) (Ministério da Saúde, 2017).

According to SINAN (2019), dengue transmission has occurred continuously in Brazil since 1986, interspersed with cyclical outbreaks every three to five years, usually associated with the introduction of new serotypes into previously unaffected areas or with shifts in the predominant serotype. Although the country already presents favorable environmental conditions for dengue transmission, projections indicate an increased risk in parts of the Midwest and inland Northeast, including the semi-arid region, due to rising temperatures and changes in rainfall patterns. Even in already affected areas, the risk is expected to intensify as the transmission season lengthens (Messina *et al*., 2019).

Furthermore, at the national level, despite studies pointing to a trend of stabilization or decline in severe cases in certain regions, the disease maintains a high incidence, characterized by heterogeneous spatial distribution and a greater prevalence among adults of economically active age. This profile highlights the complexity of the epidemic and the continuous need for effective control measures (Silva et al., 2022).

This study is justified by the need to generate local evidence that allows for the disaggregation of macro-data, identifying risk patterns, silent outbreaks, and the circulation of specific serotypes. Such information can precisely direct resources and subsidize decision-making by public health managers. Specifically, it seeks to analyze temporal trends in dengue incidence and hospitalization rates, as well as spatial associations in the Seridó region between 2001 and 2024, and to identify the dengue virus serotypes circulating in the area during this period.

2. METHODOLOGY

2.1. Study Introduction and Context

This study described the incidence rate of suspected dengue cases in the Seridó region, covering the states of Rio Grande do Norte and Paraíba, in Northeastern Brazil, from 2001 to 2024. The research focused on four microregions distributed across the two states, according to the regional division of Brazil into mesoregions and microregions established by the Brazilian Institute of Geography and Statistics (IBGE): Seridó Oriental, Seridó Ocidental, Seridó Ocidental Paraibano, and Seridó Oriental Paraibano. These microregions comprise a total of 32 municipalities, listed in Table 1 (Instituto Brasileiro de Geografia e Estatística, 1990). In addition to regional characterization, the study also compared indicators from the Seridó region with national data, enabling the analysis of local specificities in relation to Brazil's broader epidemiological context.

Table 1: Municipalities covered by the Seridó region and its micro-regions

Seridó Oriental (RN)	Seridó Ocidental (RN)	Seridó Ocidental Paraibano (PB)	Seridó Oriental Paraibano (PB)

Acari; Carnaúba dos Dantas; Cruzeta; Currais Novos; Equador; Jardim do Seridó; Ouro Branco; Parelhas; Santana do Seridó; São José do Seridó.	Caicó ; Ipueira; Jardim de Piranhas; São Fernando; São João do Sabugi; Serra Negra do Norte; Timbaúba dos Batistas.	Junco do Seridó; Salgadinho; Santa Luzia; São José do Sabugi; São Mamede; Várzea.	Baraúna; Cubati; Frei Martinho; Juazeirinho; Nova Palmeira; Pedra Lavrada; Picuí; São Vicente do Seridó; Tenório.

Source: Source: Adapted from the Brazilian Institute of Geography and Statistics, 1990.

2.2. Fonte de Dados e Definição dos Casos

To analyze the temporal and spatial distribution of dengue cases among residents of the Seridó region and Brazil, data from the Notifiable Diseases Information System (SINAN) were used. This system consolidates information on diseases and conditions subject to mandatory reporting based on records entered by health professionals, while the SIH/SUS system compiles data on hospitalizations funded by the Unified Health System (SUS).

For the analysis of incidence and spatial distribution, all suspected cases reported to SINAN between 2001 and 2024 in the 32 municipalities were included, as well as dengue-related hospitalizations recorded in SIH during the same period.

For the characterization of dengue serotype circulation, records with no information on the identified serotype (DENV-1, DENV-2, DENV-3, or DENV-4) were excluded from the SINAN data for the same period. These data were used descriptively, aiming to indicate, year by year, which serotypes circulated in the region, without performing quantitative analyses

2.3. Calculation of Incidence Rates

Annual incidence and hospitalization rates for dengue were calculated according to Equations (1) and (2), respectively. For incidence rate calculation, the numerator corresponded to the number of suspected dengue notifications recorded. For hospitalization rate calculation, the numerator represented the number of hospitalizations attributed to the disease. In both cases, the denominator was the estimated population average, based on census data from the Brazilian Institute of Geography and Statistics (IBGE) for the years 2000, 2010, and 2022. This calculation was performed for all municipalities in the Seridó region, subdivided by microregions, as well as for Brazil.

To reduce temporal variability and facilitate comparative analysis, the obtained values were transformed to a base-10 logarithmic scale, following the methodology proposed by Antunes e Cardoso (2015).

$$Incidence\ Rate\ = \frac{Number\ of\ reported\ dengue\ cases\ in\ theperiod}{Population\ at\ risk} 100.000 \quad (1)$$

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$$Hospitalization\ Rate\ = \frac{Number\ of\ dengue{-}related\ hospitalizations}{Population\ at\ risk} 100.000 \qquad (2)$$

2.4. Temporal Analysis

The temporal trend of dengue incidence and hospitalization rates was evaluated using the previously log-transformed rates (log10) and the Prais-Winsten linear regression model, implemented in STATA *software* , version 14.0 (College Station, Texas, USA). The incidence line graph comparing Seridó versus Brazil was constructed using *software* OriginPro 8.5®.

Based on this analysis, trends were classified as increasing, stable, or decreasing (Bottomley *et al.*, 2023). Trends were considered stable when the p-value was not significant ($p > 0.05$). For this analysis, the dependent variable was the logarithm of the rates, while the independent variable was the series of years. From the estimated coefficients, the Annual Percent Change (APC) was calculated, as shown in Equation (3), along with its 95% confidence interval (CI95%), presented in Equation (4). The β coefficient, representing the Prais-Winsten regression slope, expresses the direction and intensity of the temporal trend (Antunes & Cardoso, 2015; Bottomley *et al*., 2023;).

$$APC\ =\ [-1 + 10^{\beta}]100 \qquad (3)$$

$$IC_{95\%}\ =\ [-1 + 10^{\beta min}]100; [-1 + 10^{\beta max}]100 \qquad (4)$$

2.5. Spatial Analysis

To assess the spatial distribution of dengue incidence and hospitalization rates by municipality, choropleth maps were constructed, where color intensity proportionally represented the increase in these indicators. To complement the analysis and identify possible spatial patterns, Moran's Global Index and Moran's Scatterplot were applied. Moran's Global Index is a statistical measure that assesses spatial autocorrelation, determining whether disease distribution occurs randomly or follows significant spatial patterns (Zhang; Wei; Fang, 2024; Mendoza-Cano et al., 2025). Moran's Scatterplot, in turn, helps visualize the relationship between incidence values in a given area and those in neighboring areas, facilitating the interpretation of spatial patterns.

Analyses were performed using GeoDa software, an open-source tool for spatial data analysis, geovisualization, spatial autocorrelation, and geospatial modeling. Map construction was carried out using QGIS software, version 3.40.4.

Additionally, for the spatial analysis of dengue incidence and hospitalizations in the Seridó region (RN/PB) from 2001 to 2024, the Local Indicators of Spatial Association (LISA) map available in GeoDa was used, with a significance test at $p \leq 0.05$ and 99 permutations (Anselin, 1995). This statistical tool identifies spatial dependency patterns, highlighting areas with high or low incidence or hospitalization of the disease and revealing risk clusters, providing support for epidemiological surveillance and control measures.

2.6. Ethical Considerations

This study was not submitted for Research Ethics Committee review, as it was based exclusively on publicly available data sources, without involving identifiable individual information or direct interaction with participants. Generative artificial intelligence (ChatGPT, GPT-4.5 model, OpenAI) was used in the methodological process of data collection, including support in reading abstracts of scientific articles to optimize reference search and textual refinement of the manuscript. All interpretations, analyses, and decisions remained the full responsibility of the authors.

3. RESULTS AND DISCUSSION

3.1. Temporal Analysis

The analysis of the graph (Figure 1) highlights distinct patterns between the Seridó territory and the national scenario regarding dengue incidence over the years. While Seridó experienced more pronounced epidemic peaks in earlier periods—particularly between 2015 and 2016, when the rate exceeded 4,000 cases per 100,000 inhabitants—an inversion of the pattern was observed in 2024. In that year, Brazil registered an abrupt and marked increase in the incidence rate, representing one of the largest peaks in the national historical series.

However, unlike the national trend, Seridó did not follow this increase proportionally, maintaining lower levels compared to its own previous outbreak. This divergence reinforces the idea that dengue outbreaks display heterogeneous spatial dynamics, varying according to local contexts and specific vulnerabilities. Consequently, recent analyses indicate that the intensity and periodicity of epidemics also depend on the interaction between climatic factors, population mobility, and the effectiveness of local surveillance actions, which explains the distinct patterns observed between regions, as in Seridó compared to the national scenario (Wilder-Smith *et al*., 2019; Paz-Bailey *et al*., 2024).

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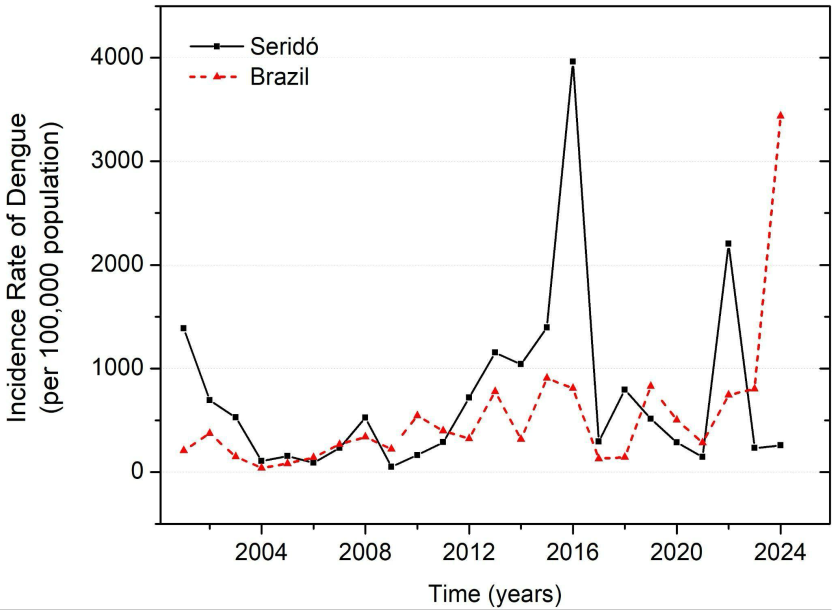

Figure 1 - Incidence rate of dengue fever in Brazil and Seridó from 2001 to 2024.
Source: Author's own elaboration based on data from the study.

Figure 2 compares the hospitalization rate (per 100,000 inhabitants) between Seridó and Brazil from 2001 to 2024, revealing significant differences. While Seridó recorded sharp peaks between 2002 and 2016, Brazil exhibited a more gradual increase until 2020, followed by an abrupt rise in 2024, approaching 200 cases. In the same year, Seridó maintained a low rate (below 50 hospitalizations), indicating a disconnection from the national trend. This pattern reinforces that dengue manifests in heterogeneous spatial patterns, influenced by local infrastructure and surveillance factors (Andrioli; Busato & Lutinski, 2020). Moreover, global analyses show that, even amid national increases, certain regions manage to sustain more effective responses, as demonstrated by Brady *et al*. (2012) and Messina *et al*. (2019), which helps explain the behavior observed in Seridó.

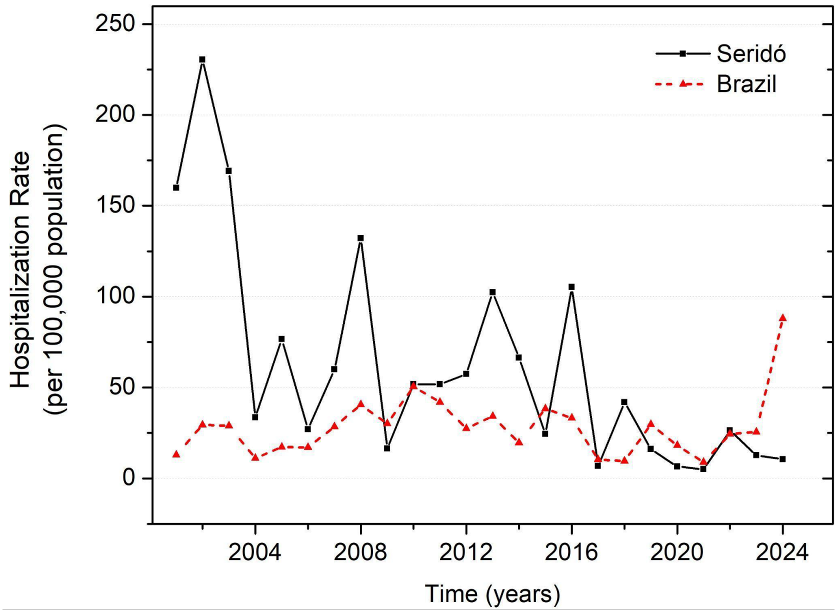

Figure 2 - Hospitalization rate for dengue fever in Brazil and Seridó from 2001 to 2024.
Source: Author's own elaboration based on data from the study.

Table 2 presents the Prais–Winsten regression estimates applied to dengue incidence rates from 2001 to 2024, showing temporal trends by municipality and for the Seridó territory as a whole, in comparison with the national average. While Brazil shows a statistically significant upward trend (p = 0.006), with an average annual variation rate of 9.0% (95%CI: 2.8; 15.5), Seridó as a region does not exhibit significant variation, being classified as stable. Some specific municipalities in Eastern Seridó Paraibano, such as Tenório, Baraúna, and Nova Palmeira, presented increasing trends, with variation rates above 10% per year. These results reveal that the evolution of dengue in the region does not uniformly follow the national trend.

Such uneven patterns have already been described in global studies, which show that dengue transmission tends to concentrate in specific areas shaped by local factors such as urbanization, vector density, and healthcare system capacity (Bhatt *et al.*, 2013).

Table 2 - Prais-Winsten regression estimates and the annual rate of change in dengue incidence rates in the Seridó region and in Brazil from 2001 to 2024.

Microregion	Municipality	β	p-value[1]	Rate of Change ($CI_{95\%}$)	Status
SERIDÓ PARAIBANO OCIDENTAL	Junco do Seridó	0,00903	0,756	2,1 (-11,0;17,1)	Stable
	Salgadinho	-0,02135	0,593	-4,8 (-21,1;14,9)	Stable
	Santa Luzia	0,00043	0,942	0,2 (-6,5;7,5)	Stable
	São José do Sabugi	0,00548	0,710	1,5 (-6,6;10,4)	Stable
	São Mamede	-0,01072	0,771	-2,6 (-19,1;17,3)	Stable
	Várzea	0,02679	0,538	6,4 (-13,4;30,7)	Stable
SERIDÓ PARAIBANO ORIENTAL	Baraúna	0,07640	0,030	19,2 (1,9;39,5)	Increasing
	Cubati	0,05599	0,089	13,8 (-2,1;32,2)	Stable
	Frei Martinho	0,00384	0,903	0,9 (-13,1;17,2)	Stable
	Juazeirinho	0,06553	0,047	16,3 (0,2;34,9)	Increasing
	Nova Palmeira	0,04170	0,141	10,1 (-3,4;25,4)	Stable
	Pedra Lavrada	0,03318	0,171	7,7 (-3,4;20,1)	Stable
	Picuí	0,04582	0,052	11,1 (-0,1;23,6)	Stable
	São Vicente do Seridó	0,05854	0,059	14,4 (-0,6;31,7)	Stable
	Tenório	0,08396	0,022	21,3 (3,2;42,7)	Increasing
SERIDÓ POTIGUAR OCIDENTAL	Caicó	0,00812	0.730	1,9 (–8,8; 13,9)	Stable
	Ipueira	0,01839	0.641	4,3 (–13,4; 25,6)	Stable
	Jardim de Piranhas	-0,05218	0.108	-11,3 (–23,6; 2,9)	Stable
	São Fernando	0,04861	0.184	11,8 (–5,6; 32,5)	Stable
	São João do Sabugi	0,01254	0.772	2,9 (–16,1; 26,2	Stable
	Serra Negra do Norte	-0,01690	0.603	-3,8 (–17,5; 12,1)	Stable
	Timbaúba dos Batistas	0,05282	0.083	12,9 (–1,7; 29,8)	Stable
SERIDÓ POTIGUAR ORIENTAL	Acari	-0,00876	0.740	-2,0 (–13,5; 11,0)	Stable
	Carnaúba dos Dantas	0,00356	0.855	0,8 (–8,1; 10,6)	Stable
	Cruzeta	-0,00832	0.802	-1,9 (–16,1; 14,7)	Stable
	Currais Novos	0,01658	0.528	3,9 (–8,2; 17,5)	Stable
	Equador	0,00982	0.821	2,3 (–16,7; 25,5)	Stable
	Jardim do Seridó	0,00524	0.797	1,2 (–8,1; 11,4)	Stable
	Ouro Branco	0,01513	0.687	3,5 (–13,2; 23,6)	Stable
	Parelhas	-0,01143	0.575	-2,6 (–11,5; 7,2)	Stable
	Santana do Seridó	0,01908	0.626	4,5 (–13,1; 25,6)	Stable

1 Regressão de Prais-Winsten (p<0,05)

	São José do Seridó	-0,00592	0.900	-1,4 (−21,1; 23,3)	Stable
Seridó		0,00692	0,698	1,6 (−6,6; 10,5)	Stable
Brazil		0,03761	0,006	9,0 (2,8; 15,6)	Increasing

Source: Author's own elaboration based on data from the study.

The Prais–Winsten regression analysis (Table 3) revealed a predominant downward trend in dengue hospitalization rates in the Seridó region between 2001 and 2024. Of the 28 municipalities analyzed, 18 (64.3%) showed a statistically significant decreasing trend. In contrast, Brazil as a whole did not show significant variation (1.4%; p = 0.522). These results reinforce the effectiveness of local primary healthcare actions in dengue control in Seridó, especially in municipalities that achieved significant reductions, such as Cruzeta and Acari. According to Tauil (2001), effective dengue control depends on the continuous strengthening of primary healthcare and vector surveillance, which explains the advances in these municipalities. Studies such as those by Gubler (1998) and Wilder-Smith et al. (2019) demonstrate that even in the absence of specific antiviral therapies, early detection and appropriate clinical management reduce case severity and hospitalizations.

Tabela 3 - Prais-Winsten regression estimates and the annual rate of change in dengue hospitalization rates in the Seridó region and in Brazil from 2001 to 2024.

Microregion	Municipality	β	p-value[2]	Rate of Change ($CI_{95\%}$)	Status
SERIDÓ PARAIBANO OCIDENTAL	Junco do Seridó	-0,01489	0,431	-3,3 (−11,5; 5,5)	Stable
	Salgadinho	0,02581	0,309	6,1 (−5,7; 19,4)	Stable
	Santa Luzia	-0,05568	0,000	-12,0 (−15,7; -8,1)	Decreasing
	São José do Sabugi	-0,07133	0,001	-15,1 (−22,2; -7,4)	Decreasing
	São Mamede	-0,04957	0,218	-10,7 (−25,9; 7,5)	Stable
	Várzea	-0,05784	0,014	-12,4 (−21,0; -2,9)	Decreasing
SERIDÓ PARAIBANO ORIENTAL	Baraúna	-0,02758	0,258	-6,1 (-16,2; 5,1)	Stable
	Cubati	-0,07346	0,016	-15,5 (−26,1; -3,4)	Decreasing
	Frei Martinho	-0,05310	0,048	-11,5 (−21,5; -0,1)	Decreasing
	Juazeirinho	-0,01879	0,314	-4,2 (−12,2; 4,4)	Stable
	Nova Palmeira	-0,06184	0,002	-13,2 (−20,1; -5,8)	Decreasing
	Pedra Lavrada	-0,07185	0,001	-15,2 (−22,7; -7,0)	Decreasing
	Picuí	-0,08769	0,000	-18,2 (−24,0; -12,0)	Decreasing
	São Vicente do Seridó	-0,00207	0,943	-0,4 (−13,3; 14,2)	Stable
	Tenório	0,01889	0,508	4,4 (-8,6; 19,4)	Stable

2 Regressão de Prais-Winsten (p<0,05)

SERIDÓ POTIGUAR OCIDENTAL	Caicó	-0,03648	0,063	-8,0 (–15,8; 0,4)	Stable
	Ipueira	-0,08543	0,018	-17,8 (–30,0; -3,5)	Decreasing
	Jardim de Piranhas	-0,06712	0,024	-14,3(-24,9;-2,2)	Decreasing
	São Fernando	-0,04941	0,014	-10,7 (-18,3; -2,4)	Decreasing
	São João do Sabugi	-0,03626	0,087	-8,0 (–16,4; -1,2)	Decreasing
	Serra Negra do Norte	-0,08235	0,002	--17,2 (-26,2; -7,1)	Decreasing
	Timbaúba dos Batistas	-0,04447	0,113	-9,7 (-20,6;-2,5)	Stable
SERIDÓ POTIGUAR ORIENTAL	Acari	-0,09372	0,000	--19,4 (-27,4; -10,4)	Decreasing
	Carnaúba dos Dantas	-0,05947	0,048	-12,8 (-23,8;-0,1)	Decreasing
	Cruzeta	-0,13258	0,000	-26,3 (-31,2;-21,1)	Decreasing
	Currais Novos	-0,00628	0,709	-1,4 (-9,0;6,7)	Stable
	Equador	-0,05353	0,199	-11,6 (-27,1;7,2))	Stable
	Jardim do Seridó	-0,04259	0,004	-9,3 (-15,0;3,5))	Decreasing
	Ouro Branco	-0,08067	0,048	-16,9 (-30,9;-0,1)	Decreasing
	Parelhas	-0,03089	0,138	-6,9 (-15,4;-2,4)	Stable
	Santana do Seridó	-0,02607	0,412	-5,8 (-18,8;9,3)	Stable
	São José do Seridó	0,02322	0,504	5,5 (-10,4;24,2)	Stable
Seridó		-0,04800	0,000	-10,5 (-14,1;-6,7))	Decreasing
Brazil		0,00636	0,522	1,4 (-3,1; 6,3)	Stable

Source: Author's own elaboration based on data from the study.

The analysis of SINAN records identified the circulation of different dengue serotypes in the Seridó region only from 2014 onwards, as no serotype records were found prior to that year. Between 2014 and 2024, DENV-4 was detected in 2014; DENV-1 in 2016, 2018, and 2020; and DENV-2 in 2021. In 2022, 2023, and 2024, the concomitant presence of DENV-1 and DENV-2 was observed. No serotype records were found for 2015, 2017, and 2019. The findings demonstrate that, during the study period, Seridó recorded circulation of at least three distinct dengue serotypes (DENV-1, DENV-2, and DENV-4). Even without case quantification by serotype, the identification of such viral diversity is epidemiologically relevant, since co-circulation and alternation among serotypes over time are associated with an increased probability of secondary infections and, consequently, a higher risk of severe clinical manifestations (Guzman & Harris, 2015; Shih *et al.*, 2024; Paz-Bailey *et al.*, 2024).

In available records, some studies mention co-circulation of DENV-1 and DENV-2 in Rio Grande do Norte in 1997, although they do not report the year of virus introduction (Cunha *et al.*, 1999; Bezerra *et al.*, 2021). For that state, the introduction of DENV-3 was recorded in 2002 and of DENV-2 in 2008 (Bessa Júnior *et al.*, 2013). In Paraíba, the same studies report the introduction of DENV-1 and DENV-2 in 2001, followed by DENV-3 in 2002 (Bezerra *et al.*, 2021). However, for the

Seridó region, no previous studies describing serotype circulation were identified, reinforcing the importance of the data presented in this study.

3.2. Spatial Analysis

The map in Figure 3 shows the spatial distribution of dengue incidence in the municipalities of Seridó, expressed as probable cases per 100,000 inhabitants. A higher concentration of the disease was observed in some municipalities of Rio Grande do Norte, particularly Cruzeta, São José do Seridó, Acari, and Currais Novos, which form the group with the highest incidence coefficients.

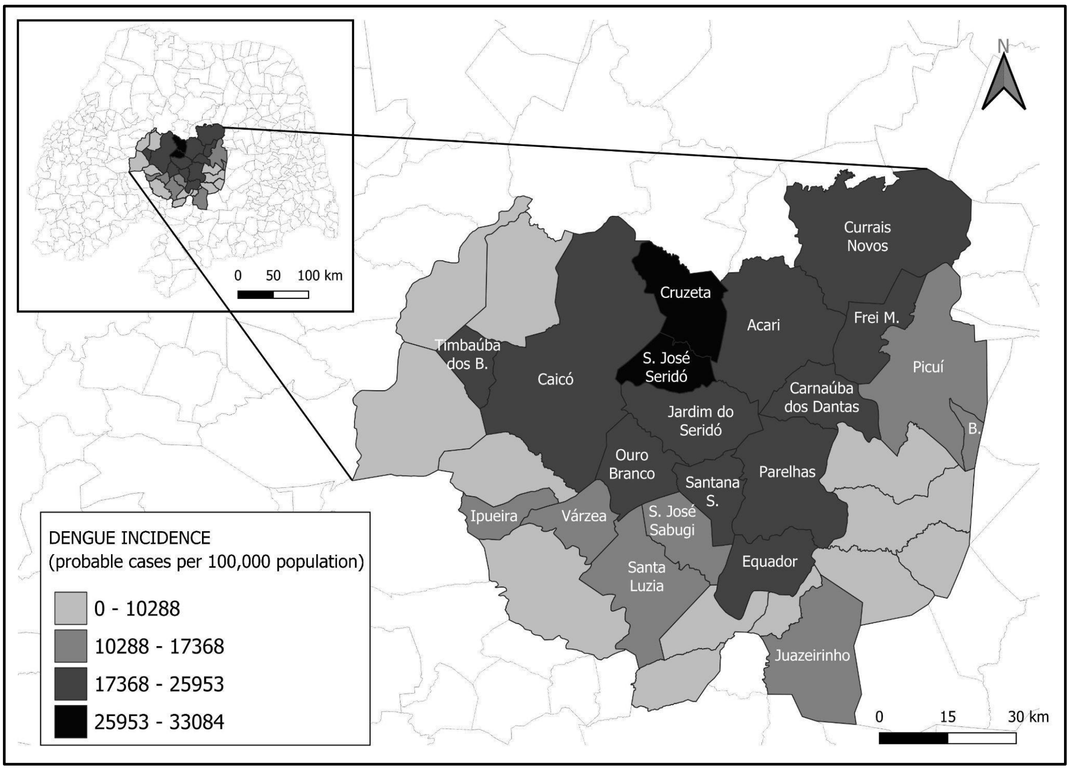

Figure 3 - Spatial Distribution of Dengue Incidence in the Municipalities of Seridó – RN/PB, from 2001 to 2024.
Source: Author's own elaboration based on data from the study.

Figure 4 shows the spatial distribution of dengue hospitalizations in Seridó (RN/PB) between 2001 and 2024, highlighting higher concentrations in municipalities such as Cruzeta, Jardim do Seridó, Acari, Ouro Branco, São Mamede, Ipueira, Serra Negra do Norte, and Jardim de Piranhas. This inequality may be related to local conditions such as healthcare infrastructure or environmental factors, indicating the need for targeted interventions in these areas to reduce case severity. The national epidemiological profile from 2010 to 2019 also points to a higher risk of hospitalization in urban contexts with structural vulnerabilities, reinforcing the need for specific, targeted strategies for the municipalities with higher concentrations of severe cases in Seridó (Menezes *et al.,* 2021).

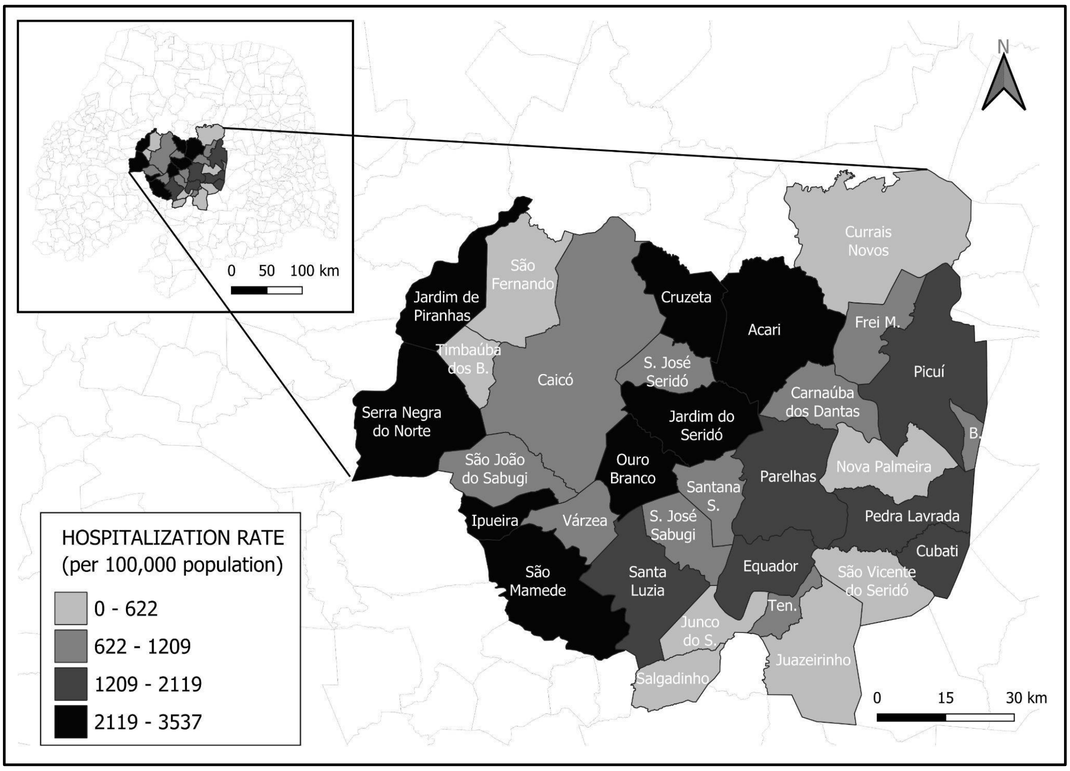

Figure 4 - Distribuição Espacial da Taxa de hospitalização por dengue nos Municípios do Seridó – RN/PB, acumulado do período de 2001 a 2024.

Source: Author's own elaboration based on data from the study.

The following graph (Figure 5a) revealed a moderate degree of spatial autocorrelation, evidenced by a Moran's I value of 0.389. This result indicates that some geographically close localities present similar patterns of disease occurrence, with high-incidence areas clustering near other high-incidence areas, and the same occurring in low-incidence regions (Anselin, 1995). Such a pattern reinforces the presence of spatial clustering of dengue, suggesting the influence of shared contextual factors among neighboring territories in disease spread. For the hospitalization rate (Figure 5b), no municipality showed statistically significant results.

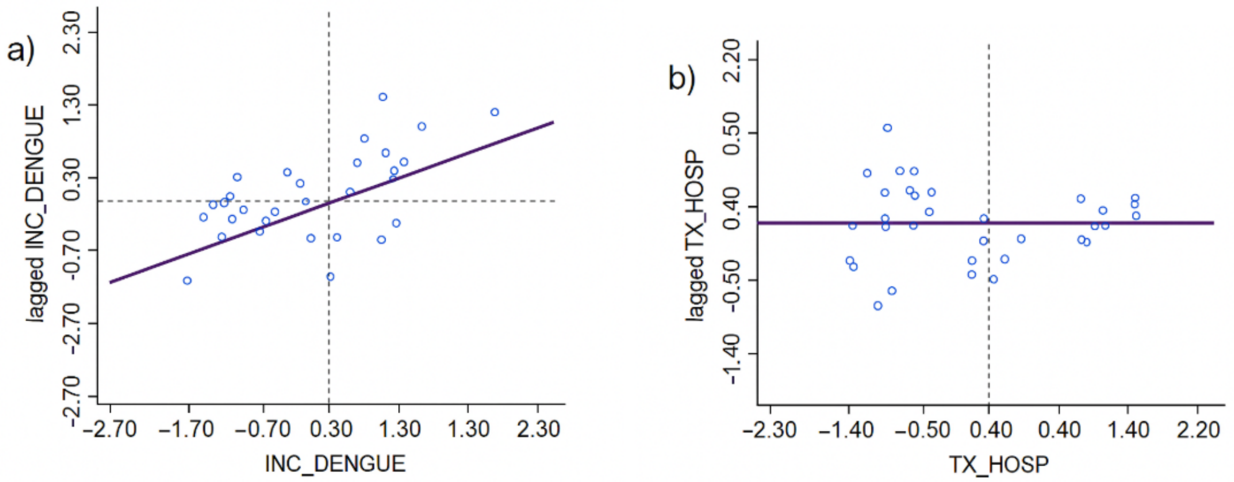

Figure 5 - Moran's scatter plot for dengue incidence (a) and hospitalization rates (b) in the cumulative period from 2001 to 2024.

Source: Author's own elaboration based on data from the study.

The LISA analysis map (Figure 6) highlights significant spatial clusters of dengue incidence in Seridó. Four municipalities in Rio Grande do Norte—Acari, Cruzeta, São José do Seridó, and Jardim do Seridó—were classified as High-High clusters, indicating areas with high incidence surrounded by municipalities with similar patterns. This configuration suggests shared contextual factors among neighboring municipalities, such as sanitation infrastructure, waste management, and community prevention practices (Kraemer *et al*., 2019; Almeida, Cota & Rodrigues, 2020). In this perspective, Tauil (2001) explains that dengue dynamics in Brazilian cities often organize into high-risk pockets, where high vector density associated with unfavorable socioeconomic conditions sustains persistent and difficult-to-interrupt transmission cycles. Conversely, the municipality of Cubati, in Paraíba, was the only one identified as Low-Low, reflecting low incidence amid areas also with low values. Most municipalities, however, did not show significant spatial autocorrelation.

It is important to emphasize that this ecological study has inherent methodological limitations, the main one being information bias arising from the possibility of underreporting, missing data, or temporal lag in the secondary data sources used. Nevertheless, the study maintains its relevance due to the robustness of the methodological and analytical rigor employed. Particular emphasis should be placed on the meticulous procedures adopted for the collection and validation of data sources, as well as on the application of spatial analysis and Prais–Winsten linear regression, which enabled the extraction of meaningful inferences from the available material, thereby providing a valuable contribution to the understanding of the phenomenon at the regional level.

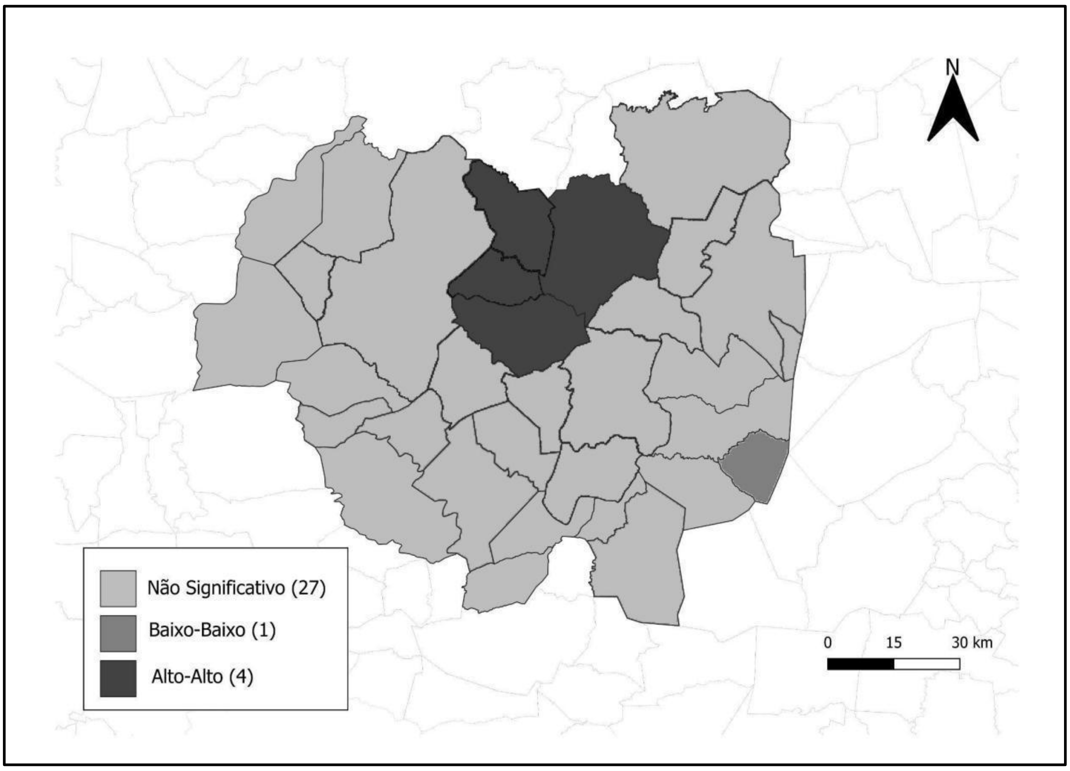

Figure 6 - Local Spatial Autocorrelation (LISA) map for dengue incidence in the Seridó region – RN/PB, from 2001 to 2024.

Source: Author's own elaboration based on data from the study.

4. CONCLUSION

The results highlight the complexity of the temporal and spatial dynamics of dengue in the Seridó territory, emphasizing the existence of patterns distinct from the national scenario. The temporal trend analyses reinforce this differentiation by indicating significant growth only in specific municipalities, while most localities remain stable.

From a spatial perspective, the choropleth and LISA maps reveal the concentration of the disease in certain clusters of Rio Grande do Norte, characterized by high-incidence groupings, suggesting the influence of local and contextual factors on viral spread. The moderate spatial autocorrelation demonstrated by Moran's I corroborates the presence of geographic clusters and underscores the importance of more targeted epidemiological surveillance and vector control strategies, taking into account the specificities of each territory.

At the same time, a downward trend in dengue hospitalization rates has been observed over recent decades, which may be interpreted as an indication of the progressive strengthening of Primary Health Care, particularly with regard to early detection, appropriate case management, and the reinforcement of preventive actions.

5. REFERÊNCIAS BIBLIOGRÁFICAS

Andrioli, D. C., Busato, M. A., & Lutinski, J. A. (2020). Spatial and temporal distribution of dengue in Brazil, 1990–2017. *PLOS ONE, 15*(2), e0228346. https://doi.org/10.1371/journal.pone.0228346

Almeida, L. S., Cota, A. L. S., & Rodrigues, D. F. (2020). Saneamento, arboviroses e determinantes ambientais: Impactos na saúde urbana. Ciência & Saúde Coletiva, 25(10), 3857–3868. https://doi.org/10.1590/1413-812320202510.30712018.

Anselin, L. (1995). Local indicators of spatial association—LISA. Geographical Analysis, 27(2), 93–115. https://doi.org/10.1111/j.1538-4632.1995.tb00338.x.

Antunes, J. L. F., & Cardoso, M. R. A. (2015). Uso da análise de séries temporais em estudos epidemiológicos. Epidemiologia e Serviços de Saúde, 24(3), 565–576. https://doi.org/10.5123/S1679-49742015000300024.

Bessa Júnior, F. N., Nunes, R. F. de F., Souza, M. A. de, Medeiros, A. C. de, Marinho, M. J. de M., & Pereira, W. O. (2013). Spatial distribution of dengue disease in municipality of Mossoró, Rio Grande do Norte, using the Geographic Information System. *Revista Brasileira de Epidemiologia, 16*(3), 603–610. https://doi.org/10.1590/S1415-790X2013000300005.

Bezerra, J. M. T., Sousa, S. C. de ., Tauil, P. L., Carneiro, M., & Barbosa, D. S.. (2021). Entry of dengue virus serotypes and their geographic distribution in Brazilian federative units: a systematic review. Revista Brasileira De Epidemiologia, 24, e210020. https://doi.org/10.1590/1980-549720210020.

Bhatt, S., Gething, P. W., Brady, O. J., Messina, J. P., Farlow, A. W., Moyes, C. L., Drake, J. M., Brownstein, J. S., Hoen, A. G., Sankoh, O., Myers, M. F., George, D. B., Jaenisch, T., Wint, G. R. W., Simmons, C. P., Scott, T. W., Farrar, J. J., & Hay, S. I. (2013). The global distribution and burden of dengue. *Nature, 496*(7446), 504–507. https://doi.org/10.1038/nature12060

Bottomley, C., Ooko, M., Gasparrini, A., & Keogh, R. H. (2023). In praise of Prais-Winsten: An evaluation of methods used to account for autocorrelation in interrupted time series. Statistics in medicine, 42(8), 1277–1288. https://doi.org/10.1002/sim.9669.

Brady, O. J., Gething, P. W., Bhatt, S., Messina, J. P., Brownstein, J. S., Hoen, A. G., Moyes, C. L., Farlow, A. W., Scott, T. W., & Hay, S. I. (2012). Refining the global spatial limits of dengue virus transmission by evidence-based consensus. PLoS Neglected Tropical Diseases, 6(8), e1760. https://doi.org/10.1371/journal.pntd.0001760.

Cunha, R. V., Schatzmayr, H. G., Miagostovich, M. P., Barbosa, A. M. A., Paiva, F. G., Miranda, R. M. O., Ramos, C. C. F., Coelho, J. C. O., dos Santos, F. B., & Nogueira, R. M. R. (1999). Dengue epidemic in the State of Rio Grande do Norte, Brazil, in 1997. *Transactions of the Royal Society of Tropical Medicine and Hygiene, 93*(3), 247–249. https://doi.org/10.1016/S0035-9203(99)90008-1.

DATASUS. (2024). Doenças e Agravos de Notificação – 2001 a 2006 (SINAN). Recuperado em 15 de julho de 2024, de https://datasus.saude.gov.br/acesso-a-informacao/doencas-e-agravos-de-notificacao-2001-a-2006-sinan.

DATASUS. (2024). Doenças e agravos de notificação – 2007 em diante (SINAN). Recuperado em 15 de julho de 2024, de https://datasus.saude.gov.br/acesso-a-informacao/doencas-e-agravos-de-notificacao-de-2007-em-diante-sinan.

DATASUS. (2024). Morbidade Hospitalar do SUS (SIH/SUS). Recuperado em 8 de Janeiro de 2025, de https://datasus.saude.gov.br/acesso-a-informacao/morbidade-hospitalar-do-sus-sih-sus.

Gubler, D. J. (1998). Resurgent vector-borne diseases as a global health problem. Emerging Infectious Diseases, 4(3), 442–450. https://doi.org/10.3201/eid0403.980326.

Guzman, M. G., & Harris, E. (2015). Dengue. The Lancet, *385*(9966), 453–465. https://doi.org/10.1016/S0140-6736(14)60572-9.

Huang, Y. S., Higgs, S., & Vanlandingham, D. L. (2019). Arbovirus-Mosquito Vector-Host Interactions and the Impact on Transmission and Disease Pathogenesis of Arboviruses. Frontiers in microbiology, 10, 22. https://doi.org/10.3389/fmicb.2019.00022.

Instituto Brasileiro de Geografia e Estatística. (1990). Divisão regional do Brasil em mesorregiões e microrregiões geográficas. Instituto Brasileiro de Geografia e Estatística. https://biblioteca.ibge.gov.br/index.php/biblioteca-catalogo?view=detalhes&id=22269.

Kraemer, M. U. G., Reiner, R. C., Brady, O. J., Messina, J. P., Gilbert, M., Pigott, D. M., Yi, D., Johnson, K., Earl, L., Marczak, L. B., Shirude, S., Davis Weaver, N., Bisanzio, D., Perkins, T. A., Lai, S., Lu, X., Jones, P., Coelho, G. E., Carvalho, R. G., Van Bortel, W., Marsboom, C., Hendrickx, G., Schaffner, F., Moore, C. G., Nax, H. H., Bengtsson, L., Wetter, E., Tatem, A. J., Brownstein, J. S., Smith, D. L., Lambrechts, L., Cauchemez, S., Linard, C., Faria, N. R., Pybus, O. G., Scott, T. W., Liu, Q., Yu, H., Wint, G. R. W., Hay, S. I., & Golding, N. (2019). Past and future spread of the arbovirus vectors Aedes aegypti and Aedes albopictus. Nature Microbiology, 4(5), 854–863. https://doi.org/10.1038/s41564-019-0376-y.

Lima-Camara, T. N. (2016). Emerging arboviruses and public health challenges in Brazil. Revista de Saúde Pública, 50, 36. https://doi.org/10.1590/S1518-8787.2016050006791.

Ilic, I., & Ilic, M. (2024). Global patterns of trends in incidence and mortality of dengue, 1990-2019: An analysis based on the Global Burden of Disease Study. Medicina, 60(3), 425. https://doi.org/10.3390/medicina60030425.

Mendoza-Cano, O., Danis-Lozano, R., Trujillo, X., Huerta, M., Ríos-Silva, M., Lugo-Radillo, A., Bricio-Barrios, J. A., Benites-Godínez, V., Cuevas-Arellano, H. B., Uribe-Ramos, J. M., Solano-Barajas, R., Cárdenas, Y., Venegas-Ramírez, J., Ríos-Bracamontes, E. F., García-Solórzano, L. A., Camacho-delaCruz, A. A., & Murillo-Zamora, E. (2025). Spatial patterns and clustering of dengue incidence in Mexico: Analysis of Moran's index across 2,471 municipalities from 2022 to 2024. PloS one, 20(5), e0324754. https://doi.org/10.1371/journal.pone.0324754.

Menezes, A. M. F., Almeida, K. T., de Amorim, A. dos S., & Lopes, C. M. R. (2021). Perfil epidemiológico da dengue no Brasil entre os anos de 2010 à 2019 / Epidemiological profile of dengue in Brazil between 2010 and 2019. Brazilian Journal of Health Review, 4(3), 13047–13058. https://doi.org/10.34119/bjhrv4n3-259.

Messina, J. P., Brady, O. J., Golding, N., Kraemer, M. U. G., Wint, G. R. W., Ray, S. E., Pigott, D. M., Shearer, F. M., Johnson, K., Earl, L., Marczak, L. B., Shirude, S., Davis Weaver, N., Gilbert, M., Velayudhan, R., Jones, P., Jaenisch, T., Scott, T. W., Reiner, R. C., & Hay, S. I. (2019). The current and future global distribution and population at risk of dengue. Nature Microbiology, 4(9), 1508–1515. https://doi.org/10.1038/s41564-019-0476-8.

Ministério da Saúde. (2017). Portaria de Consolidação nº 4, de 28 de setembro de 2017. Recuperado em 28 de abril de 2024, de https://www.gov.br/saude/pt-br/assuntos/saude-de-a-a-z/z/zika-virus/publicacoes/portaria-de-consolidacao-no-4-de-28-de-setembro-de-2017.pdf/view.

Ministério da Saúde. (2019). Sistema de Informação de Agravos de Notificação (SINAN): Dengue. Portal SINAN. http://www.portalsinan.saude.gov.br/dengue.

Ministério da Saúde. (2024). Arboviroses. Recuperado em 21 de abril de 2024, de https://www.gov.br/saude/pt-br/assuntos/saude-de-a-a-z/a/arboviroses.

Paz-Bailey, G., Adams, L. E., Deen, J., Anderson, K. B., & Katzelnick, L. C. (2024). Dengue. The Lancet, 403(10425), 667-682. https://doi.org/10.1016/S0140-6736(23)02576-X.

Shih, H.-I., Wang, Y.-C., Wang, Y.-P., Chi, C.-Y., & Chien, Y.-W. (2024). Risk of severe dengue during secondary infection: A population-based cohort study in Taiwan. *Journal of Microbiology, Immunology and Infection, 57*(5), 730–738. https://doi.org/10.1016/j.jmii.2024.07.004.

Silva, T. R. da., Costa, A. K. A. N., Alves, K. A. N., Santos, A. N., & Cota, M. de F.. (2022). Tendência temporal e distribuição espacial da dengue no Brasil. Cogitare Enfermagem, 27, e84000. https://doi.org/10.5380/ce.v27i0.84000.

Souza, S. S., Silva, I. G., & Silva, H. H. G. (2010). Associação entre incidência de dengue, pluviosidade e densidade larvária de Aedes aegypti no Estado de Goiás. Revista da Sociedade Brasileira de Medicina Tropical, 43(2), 152-155. https://doi.org/10.1590/S0037-86822010000200009.

Tauil, P. L.. (2001). Urbanização e ecologia do dengue. Cadernos de Saúde Pública, 17, S99–S102. https://doi.org/10.1590/S0102-311X2001000700018.

Wilder-Smith, A., Ooi, E. E., Horstick, O., & Wills, B. (2019). Dengue. The Lancet, 393(10169), 350–363. https://doi.org/10.1016/S0140-6736(18)32560-1.

World Health Organization - WHO (1985). Arthropod-Borne and Rodent-Borne Viral Diseases. Geneva: World Health Organization.

World Health Organization - WHO (2023). Epi-Win webinar: Managing dengue – A rapidly expanding epidemic. Recuperado em 25 de abril de 2024, de https://www.who.int/news-room/events/detail/2023/08/02/default-calendar/epi-win-webinar-managing-dengue-a-rapidly-expanding-epidemic.

Zhang, L., Wei, L., & Fang, Y. (2024). Spatial–temporal distribution patterns and influencing factors analysis of comorbidity prevalence of chronic diseases among middle-aged and elderly people in China: Focusing on exposure to ambient fine particulate matter (PM2.5). BMC Public Health, 24, 550. https://doi.org/10.1186/s12889-024-17986-0.

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