PUBLICAÇÃO OFICIAL DO NÚCLEO HOSPITALAR DE EPIDEMIOLOGIA DO HOSPITAL SANTA CRUZ E PROGRAMA DE PÓS GRADUAÇÃO EM PROMOÇÃO DA SAÚDE - DEPARTAMENTO DE BIOLOGIA E FARMÁCIA DA UNISC

ISSN 2238-3360

Revista de Epidemiologia e Controle de Infecção

Original Article

Dengue mortality and social vulnerability in Brazilian macro-regions: an ecological study from 2019 to 2023

Mortalidade por dengue e vulnerabilidade social nas macrorregiões brasileiras: estudo ecológico no período de 2019 a 2023
Mortalidad por dengue y vulnerabilidad social en las macrorregiones brasileñas: estudio ecológico del período de 2019 a 2023

Site doi: https://doi.org/10.17058/reci.v16i.20656

Submitted: 09/15/2025
Accepted: 05/13/2026
Available online: 08/14/2026

Corresponding author:
E-mail: marinahamaral@gmail.com
Address:

Marina Henriques Amaral[1]
Giovanna Xavier Toledo[1]
Edna Lúcia Campos Wingester[1]
Anna Carolina Vieira Felício[2]
Henrique Amaral Brasil[3]

[1]Faculdade de Ciências Médicas de Minas Gerais, Belo Horizonte, Minas Gerais, Brasil.
[2]Hospital Municipal de Contagem, Contagem, Minas Gerais, Brasil.
[3]Hospital Felício Rocho, Belo Horizonte, Minas Gerais, Brasil.

ABSTRACT

Background and Objectives: Arboviruses represent a significant threat to global public health, affecting billions of people. Among them, dengue stands out as an acute and debilitating infection, with a significant impact in Brazil. This study aims to analyze dengue mortality and its association with the Social Vulnerability Index (SVI) across Brazilian macro-regions between 2019 and 2023. **Methods:** An ecological, observational, and descriptive study was conducted using data from the Mortality Information System (SIM/DATASUS) and the Social Vulnerability Atlas, aggregated by macro-region and year. Deaths due to dengue (ICD-10 codes A90 and A91) were analyzed, and incidence rates, mortality rates, and proportional mortality were calculated. The Shapiro-Wilk normality test, Kruskal-Wallis test, and Spearman correlation were used to assess the association with the SVI. **Results:** Between 2019 and 2023, dengue-related deaths were analyzed across Brazilian macro-regions, with the highest absolute concentration observed in the Southeast region (median of 417 deaths; IQR 200–506). The Central-west showed the highest proportional mortality (0.0021; IQR 0.0017–0.0024). Statistically significant differences were observed between macro-regions ($p < 0.05$). No statistically significant correlation was found between SVI and proportional dengue mortality (r = -0.21; $p = 0.32$). **Conclusion:** Dengue mortality showed a heterogeneous distribution in Brazil between 2019 and 2023. The association with the SVI was not statistically significant, suggesting the influence of other structural and healthcare-related factors at the macro-regional level.

Keywords: *Dengue. Social Vulnerability. Mortality. Observational Studies. Ecological Studies.*

RESUMO

Justificativa e Objetivos: As arboviroses representam uma ameaça relevante à saúde pública global, afetando bilhões de pessoas. Entre elas, a dengue se destaca por ser uma infecção aguda e debilitante, com impacto significativo no Brasil. Este estudo tem como objetivo analisar a mortalidade por dengue e sua correlação com o Índice de Vulnerabilidade Social (IVS) nas macrorregiões brasileiras entre 2019 e 2023. **Métodos:** Estudo ecológico, observacional e descritivo, com dados do Sistema de Informação sobre Mortalidade (SIM/DATASUS) e do Atlas da Vulnerabilidade Social, agregados por macrorregião e ano. Foram analisados óbitos por dengue (CID-10 A90 e A91), e foram calculadas as taxas de incidência, as taxas de mortalidade e a mortalidade proporcional. Utilizou-se teste de normalidade (Shapiro-Wilk), teste de Kruskal-Wallis e correlação de Spearman para avaliar a associação com o IVS. **Resultados:** Entre 2019 e 2023, foram analisados óbitos por dengue nas macrorregiões brasileiras, com maior concentração absoluta na região Sudeste (mediana de 417 óbitos; IQR 200–506). O Centro-Oeste apresentou maior mortalidade proporcional (0,0021; IQR 0,0017–0,0024). Houve diferenças estatisticamente significativas entre as macrorregiões ($p < 0,05$). Não foi observada correlação estatisticamente significativa entre IVS e mortalidade proporcional por dengue (r = -0,21; $p = 0,32$). **Conclusão:** A mortalidade por dengue apresentou distribuição heterogênea no Brasil entre 2019 e 2023. A associação com o IVS não foi estatisticamente significativa, sugerindo a influência de outros fatores estruturais e assistenciais em nível macrorregional.

Descritores: *Dengue. Vulnerabilidade Social. Mortalidade. Estudos Observacionais. Estudos Ecológicos.*

RESUMEN

Justificación y Objetivos: Las arbovirosis representan una amenaza relevante para la salud pública global, afectando a miles de millones de personas. Entre ellas, el dengue se destaca como una infección aguda y debilitante, con un impacto significativo en Brasil. Este estudio tiene como objetivo analizar la mortalidad por dengue y su asociación con el Índice de Vulnerabilidad Social (IVS) en las macrorregiones brasileñas durante el período de 2019 a 2023. **Métodos:** Se realizó un estudio ecológico, observacional y descriptivo con datos del Sistema de Información sobre Mortalidad (SIM/DATASUS) y del Atlas de Vulnerabilidad Social, agregados por macrorregión y año. Se analizaron las muertes por dengue (CIE-10 A90 y A91), calculándose los indicadores de incidencia, mortalidad y mortalidad proporcional. Se aplicaron las pruebas de normalidad de Shapiro-Wilk, Kruskal-Wallis y la correlación de Spearman para evaluar la asociación con el IVS. **Resultados:** Entre 2019 y 2023, se analizaron las muertes por dengue en las macrorregiones brasileñas, con la mayor concentración absoluta de casos en la región Sudeste (mediana de 417 muertes; IQR 200–506). La región Centro-Oeste presentó la mayor mortalidad proporcional (0,0021; IQR 0,0017–0,0024). Se observaron diferencias estadísticamente significativas entre las macrorregiones ($p < 0,05$). No se observó una correlación estadísticamente significativa entre el IVS y la mortalidad proporcional por dengue (r = -0,21; $p = 0,32$). **Conclusión:** La mortalidad por dengue presentó una distribución heterogénea en Brasil entre 2019 y 2023. La asociación con el IVS no fue estadísticamente significativa, lo que sugiere que otros factores estructurales y asistenciales podrían influir en este desenlace a nivel macrorregional.

Palabras Clave: *Dengue. Vulnerabilidad Social. Mortalidad. Estudios Observacionales. Estudios Ecológicos.*

INTRODUCTION

Arboviral diseases, which are transmitted primarily by arthropod vectors, pose a significant challenge to global public health. Among these diseases, dengue stands out as the most important in humans. It is an acute, systemic, and debilitating infection that can range from asymptomatic to severe, with the potential to result in death.[1] Approximately 3.9 billion people across more than 120 countries are at risk of infection with arboviruses such as dengue virus (DENV), zika virus (ZIKV), and chikungunya virus (CHIKV).[2-3] Furthermore, dengue imposes a substantial burden on healthcare systems, increasing demand for healthcare services, hospitalizations, and pressure on healthcare delivery.[4]

In Brazil, dengue has become an increasingly important public health problem. During the first 48 epidemiological weeks of 2023, more than 1.6 million suspected cases were reported, representing a 15.8% increase compared with the same period in the previous year. [5-6] Dengue epidemics in Brazil exhibit a cyclical and seasonal pattern, with peaks in reported cases and an increased risk of outbreaks during specific periods of the year, accompanied by shifts in the predominant serotypes. [7]

Mortality from tropical diseases, including dengue, is directly associated with settings characterized by low human development and high social vulnerability, including inadequate sanitation, unplanned urbanization, and poor housing conditions.[8]

In this context, the Social Vulnerability Index (SVI) emerges as a relevant tool for investigating the impact of these inequalities on dengue mortality. The SVI is a composite index that integrates 16 indicators across three dimensions — Urban Infrastructure, Human Capital, and Income and Labor — and allows the identification of areas with conditions indicative of social exclusion and vulnerability. It ranges from 0 to 1, with values closer to 1 indicating greater social vulnerability. [9]

Despite the relevance of social determinants, studies evaluating the relationship between social vulnerability and dengue mortality at the macroregional level in Brazil remain limited, particularly considering the context of the Covid-19 pandemic.

Beyond social factors, the Covid-19 pandemic substantially changed the epidemiological scenario of dengue, influencing its distribution patterns and mortality. Social distancing measures, changes in healthcare provision, and population behavioral changes may have influenced infection and mortality rates in recent years.[10-11] In this context, the analysis of dengue mortality over this period may contribute to a better understanding of these changes and their relationship with social vulnerability.[12-13]

In this scenario, understanding the influence of social determinants on dengue mortality may contribute to the improvement of more effective public health strategies targeted at vulnerable populations.

Therefore, the present study aims to assess dengue mortality and its correlation with the Social Vulnerability Index (SVI) across Brazilian macro-regions from 2019 to 2023, encompassing the pre-pandemic, pandemic, and post-pandemic periods.

METHODS

This is an ecological study based on secondary data from public domain sources. Data collection was conducted between February and October 2025.

The unit of analysis consisted of aggregated data by macro-region and year, totaling 25 observations (five macro-regions over five years), with no possibility of individual-level inferences. All five Brazilian macro-regions were included, with no sampling procedure performed. The analyzed period comprised the years 2019 to 2023, corresponding to the pre-pandemic (2019), pandemic (2020–2021), and post-pandemic (2022–2023) periods.

The choice of proportional mortality as an analytical indicator was based on its ability to highlight the relative importance of dengue deaths among all defined causes of death, emphasizing the burden of the disease on the mortality profile of each region, although it does not reflect the absolute risk of dying from dengue. This indicator allows the analysis of geographical and temporal variations, supporting the identification of trends and inequalities.[14] Proportional mortality was defined as the ratio between the number of dengue deaths and the total number of deaths from defined causes in the same period and location, multiplied by 100.

The study included all dengue deaths recorded in the five Brazilian macro-regions during the defined study period. The sample size corresponded to the number of ecological units available (macro-regions). No prior sample size calculation was performed, as this was a study based on secondary data with national coverage. Deaths for which the underlying cause was classified as classic dengue (ICD-10: A90) or dengue hemorrhagic fever (ICD-10: A91) were included, while deaths due to ill-defined causes were excluded to reduce distortions in the records.

Mortality data were obtained from the Mortality Information System (SIM), made available by the Ministry of Health through DATASUS. Dengue notifications used to calculate incidence rates were obtained from morbidity databases available through DATASUS, and population estimates were extracted from intercensal projections provided by the Brazilian Institute of Geography and Statistics (IBGE). The Social

Vulnerability Index (SVI) and its subindices — Income and Labor, Urban Infrastructure, and Human Capital — were obtained from the Atlas of Social Vulnerability in Brazilian Municipalities, developed by the Institute for Applied Economic Research (IPEA).[9]

The outcome variables included the absolute number of dengue deaths, dengue proportional mortality, and dengue incidence rate per 100,000 population. Geographic location (macro-region) was used as a stratification variable. The SVI was treated as a contextual indicator of social vulnerability rather than as an independent variable subjected to inferential correlation testing.

Dengue proportional mortality was defined as the ratio between the number of dengue deaths and the total number of deaths from defined causes in the same period and location, expressed as a proportion. This indicator was used to contextualize the relative burden of dengue deaths among all deaths from defined causes, without representing the absolute risk of dying from the disease.[14]

Dengue incidence was calculated as the number of new/reported dengue cases divided by the estimated resident population in the corresponding macro-region and year, multiplied by 100,000 population. This procedure allowed for the standardization of results for temporal description and comparison between regions with different population sizes.

In SIM/DATASUS, dengue mortality data were extracted using region as the row variable, ICD-10 categories A90 and A91 as the column variables, with the content defined as deaths by place of residence and the period from 2019 to 2023. For the denominator of proportional mortality, data extraction was performed in an analogous manner, selecting all ICD-10 categories and excluding ill-defined causes, in accordance with recommendations for basic health indicators.

The data were organized into a dedicated database and subjected to statistical analysis using RStudio, version 1.3.1073 (Boston, USA). Descriptive analyses were performed, including the calculation of absolute frequencies, proportions, means, standard deviations, medians, and interquartile ranges (Q1–Q3). Given the asymmetric distribution of the data and the presence of outliers, results were primarily presented using medians and interquartile ranges.

The normality of the variables was assessed using the Shapiro-Wilk test. Since the data showed a non-normal distribution ($p < 0.05$), global comparisons among macro-regions were performed using the nonparametric Kruskal-Wallis test. This test was used exclusively to identify global differences among groups; no post hoc analyses were conducted, and thus no pairwise comparisons or inferences among macro-regions were performed.

The relationship between SVI and dengue proportional mortality was analyzed descriptively. Spearman's correlation was not applied because the available SVI data correspond to the year 2010 and would have been repeated for the years 2019 to 2023 in each macro-region, which could result in pseudo-replication, violation of the assumption of independence between observations, low variability in the SVI values, and tied ranks. Furthermore, dengue time series data present temporal dependence and epidemic dynamics, which are not adequately accounted for by simple correlation analyses based on aggregated data.

The significance level adopted for the global comparisons was 5% ($p < 0.05$), and confidence intervals were calculated at a 95% confidence level when applicable. No relevant missing data were identified in the databases used; however, the possibility of underreporting and inconsistencies in secondary information systems is acknowledged.

The study was exempt from submission to the Research Ethics Committee because it exclusively used secondary, publicly available, aggregated data without individual identification. This exemption is supported by Resolution No. 674, dated May 6, 2022, of the Brazilian National Health Council.

RESULTS

Between 2019 and 2023, dengue-related deaths were analyzed across Brazil's five macro-regions. The analysis began with a description of the absolute number of deaths, followed by an assessment of mortality rates and proportional indicators based on aggregated data by macro-region and year.

The absolute numbers of dengue-related deaths and all-cause deaths were described, with significant variation observed across the macro-regions, ranging from 96,552 (IQR 94,477–109,014) in the North to 695,469 (IQR 664,369–703,059) in the Southeast ($p < 0.001$) (Table 1).

Table 1. Regional distribution of deaths by place of residence due to dengue (ICD-10: A90 and A91) and all defined causes, according to Brazilian macro-regions, 2019–2023.

Variable	Total	Central-West	Northeast	North	Southwest	South	*p*-value
Dengue-related deaths (place of residence)	133 (66–215)	208 (179–215)	107 (91–133)	36 (21–41)	417 (200–506)	197 (49–267)	0.008
All defined cause deaths (place of residence)	225,570 (107,024–415,919)	103,892 (100,548–107,024)	403,132 (380,646–415,919)	96,552 (94,477–109,014)	695,469 (664,369–703,059)	225,570 (221,808–245,221)	<0.001
Proportional mortality due to dengue	0.0005 (0.0002–0.0011)	0.0021 (0.0017–0.0024)	0.0003 (0.0002–0.0004)	0.0003 (0.0002–0.0004)	0.0006 (0.0003–0.0008)	0.0009 (0.0002–0.0011)	0.034

Abbreviation: Values are expressed as median (interquartile range [IQR]: Q1–Q3). Data were aggregated by macro-region (n = 5 per group).

Dengue-related deaths had a median of 133 (IQR 66–215). The Southeast had the highest absolute median, at 417 (IQR 200–506), whereas the North had the lowest median, at 36 (IQR 21–41). The Central-West had a median of 133 (IQR 95–158), and the South had a median of 94 (IQR 64–119). The Northeast had a median of 47 (IQR 32–65). The overall comparison among macro-regions was statistically significant (p = 0.008), with no post-hoc pairwise analysis performed.

Proportional mortality due to dengue had an overall median of 0.0005 (IQR 0.0002–0.0011). The Central-West recorded the highest proportional median, 0.0021 (IQR 0.0017–0.0024), followed by the South, 0.0009 (IQR 0.0002–0.0011), Southeast, 0.0006 (IQR 0.0003–0.0008), Northeast, 0.0003 (IQR 0.0002–0.0004), and North, 0.0003 (IQR 0.0002–0.0004). The overall comparison was also statistically significant (p = 0.034), with no specific differences identified between pairs of regions.

Dengue incidence, expressed per 100,000 population, was analyzed to contextualize the temporal dynamics of reported cases across the macro-regions. The descriptive analysis showed higher values in the Central-West throughout the period, with annual variations also observed in the South and Southeast regions. The North and Northeast presented the lowest coefficients for most of the series (Figure 1).

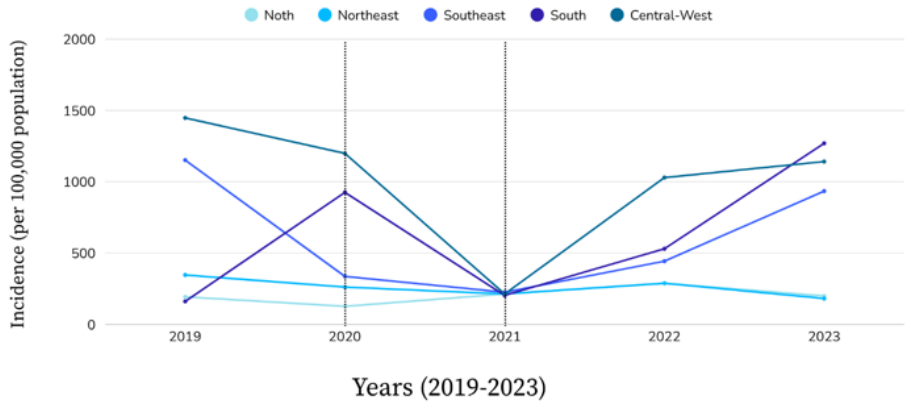

Figure 1. Dengue incidence rates adjusted per 100,000 population, by Brazilian macro-regions, 2019–2023. Line graph showing the annual variation in dengue incidence rates across the five Brazilian macro-regions from 2019 to 2023.

The joint temporal assessment of dengue incidence and deaths showed a reduction in reported cases during 2020–2021, followed by an increase in 2022 and 2023. Mortality peaked in 2022 in most Brazilian macro-regions, while the Southeast recorded the highest absolute number of deaths in 2019. These observations are descriptive and do not imply a causal relationship.

The boxplots of dengue-related deaths showed greater variability in the Southeast and South regions, as well as outlier values in some Brazilian macro-regions. The Kruskal–Wallis test indicated an overall difference in the distribution of dengue-related deaths among the Brazilian macro-regions (Figure 2).

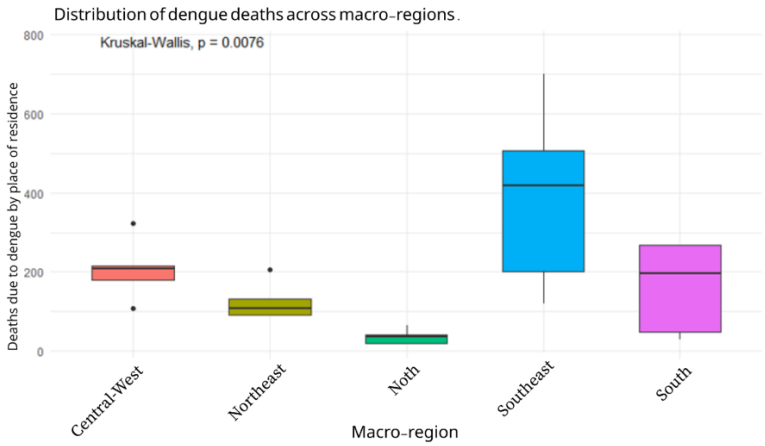

Figure 2. Distribution of dengue-related deaths across Brazilian macro-regions, 2019–2023. Boxplot showing the median, interquartile ranges (IQR), outlier values, and the result of the Kruskal–Wallis test ($p = 0.008$).

The descriptive comparison between the 2010 SVI and proportional dengue mortality did not reveal a consistent regional gradient. Considering the temporal lag of the social indicator, the small number of distinct SVI values, and the repeated use of the same index for each macro-region across the study years, no inferential correlation analysis was performed between the SVI and proportional dengue mortality.

In summary, heterogeneity was observed across the Brazilian macro-regions. The Southeast accounted for the highest absolute number of dengue-related deaths, whereas the Central-West exhibited the highest proportional mortality and the highest incidence rates. The North and Northeast recorded the lowest values throughout the study period.

DISCUSSION

The results of this study demonstrate significant regional disparities in dengue mortality and incidence in Brazil between 2019 and 2023. It was observed that the Southeast concentrated the highest absolute number of deaths, whereas the Central-West presented the highest incidence rates and the highest proportional mortality. These findings are consistent with previous studies that have identified the Central-West region as an area of high dengue endemicity, due to the combination of climatic conditions favorable for vector proliferation, accelerated urbanization, and structural vulnerabilities in regional healthcare services.[1,16]

The contrast between the high absolute burden of deaths in the Southeast and the lower proportional mortality highlights the importance of proportional indicators, especially in a country marked by profound regional inequalities. The North and Northeast regions showed consistently low incidence and mortality rates. Although part of this pattern may reflect local epidemiological characteristics, it is plausible that underreporting and limitations in surveillance systems and death registration contributed to an underestimation of the disease burden. Previous studies support this underestimation of the dengue burden in regions with limited access to healthcare services and reduced diagnostic capacity.[1,8]

The temporal analysis revealed that the peak of mortality and incidence occurred in 2022, coinciding with one of the largest dengue outbreaks recorded in the country, in agreement with epidemiological bulletins from the Ministry of Health and reports from recent literature.[13,17] Notably, the Southeast region reached its mortality peak in 2019, before the Covid-19 pandemic, possibly related to localized outbreaks or variations in viral transmission dynamics.

The period of reduced healthcare flexibility during the pandemic appears to have indirectly influenced dengue surveillance and case reporting in Brazil. An apparent reduction in incidence was observed during 2020–2021, a period coinciding with greater healthcare system overload and the prioritization of Covid-19 response efforts. A similar phenomenon was observed in other arbovirus-endemic countries, suggesting that the pandemic partially masked the true magnitude of dengue transmission.[18-19]

The regional heterogeneity and the outliers observed in 2022 indicate that the impact of the pandemic on dengue reporting was not uniform, reflecting differences in the coverage and response capacity of local surveillance systems. These findings reinforce that epidemiological, healthcare-related, and contextual factors may influence disease expression, highlighting the need for strategies adapted to regional contexts.

The statistical analyses confirmed regional heterogeneity, with greater dispersion of values in the Southeast and Central-West regions and the presence of extreme values in 2022. This pattern demonstrates that, although dengue is a disease with nationwide distribution, its expression in terms of mortality and incidence is influenced by local socio-environmental conditions and by the capacity of regional surveillance and response systems.

Additionally, no statistically significant correlation was observed between the Social Vulnerability Index

(SVI) and proportional dengue mortality (r = -0.21; p = 0.32). This finding indicates that, at the macro-regional level, social vulnerability, as measured by the SVI, did not show a direct relationship with the relative impact of dengue mortality during the analyzed period. This result should be interpreted with caution, considering the characteristics of the ecological study design, as well as the temporal aspects of the data, given that the SVI refers to the year 2010, whereas the analyzed outcomes correspond to subsequent periods.

As these are aggregated data, interpretations based on absolute values should be made cautiously, as they reflect population differences among the macro-regions and do not necessarily translate into the relative impact of dengue mortality. Thus, the absence of correlation may be explained by limitations inherent to the ecological study design, particularly the aggregation of data at the macro-regional level, which may reduce the sensitivity to detect more specific local inequalities. Additionally, the limited number of analytical units (n = 25) may have reduced the statistical power to identify significant correlations. Nevertheless, the adopted study design allows the analysis of temporal and geographical variations, without causal inference, providing context for the social and epidemiological impact of the disease before, during, and after the Covid-19 pandemic.

Another relevant factor concerns the possibility of underreporting and inconsistencies in information systems, particularly in regions with greater social vulnerability, which may introduce bias into mortality estimates and compromise the detection of associations.

Thus, although the SVI represents an important indicator of social inequality, the results suggest that its relationship with dengue mortality may be more complex, involving interactions with epidemiological, healthcare-related, and environmental factors not captured in the present analysis.

This study has limitations. The use of secondary data may be subject to recording errors and underreporting, especially in regions with lower healthcare service coverage. Additionally, the analysis did not consider the specific circulation of dengue virus serotypes, a variable that directly influences outbreak severity. Furthermore, as this is an ecological study, it is not possible to establish causal relationships or make individual-level inferences. Moreover, the use of aggregated data may mask intra-regional heterogeneities. It is also acknowledged that the quality of records may vary among regions, particularly in areas with lower coverage of vital statistics, such as municipalities in the North and Northeast regions, where there is under-enumeration of deaths. Additionally, the accuracy of the indicator may be compromised by errors in recording the underlying cause of death on death certificates, which may generate inconsistencies in proportional mortality estimates. The interpretation of percentage increases should consider that they may reflect both a true increase in mortality and a reduction in other competing causes of death. Nevertheless, the findings contribute to understanding the recent dynamics of dengue in Brazil and reinforce the importance of continuous monitoring, with special attention to the impact of the Covid-19 pandemic on arbovirus surveillance.

In summary, the findings of this study demonstrate regional inequalities in dengue mortality and incidence, with the Southeast presenting the highest absolute burden of deaths, the Central-West standing out for the highest proportional rates, and the North and Northeast regions showing consistently low values, possibly related to underreporting and limitations in epidemiological surveillance.

The temporal analysis showed a reduction in reported cases during the Covid-19 pandemic, followed by a substantial increase in 2022, coinciding with one of the largest recent outbreaks. These findings reinforce the influence of the pandemic context on arbovirus surveillance.

Although the SVI was considered an independent variable in the study, no statistically significant correlation with dengue mortality was observed, suggesting that other factors play a more relevant role in determining this outcome at the macro-regional level.

Thus, caution is recommended when interpreting the isolated influence of social vulnerability on dengue mortality, and future studies with greater territorial disaggregation and the inclusion of additional variables are needed.

The results of this study broaden the understanding of the recent dynamics of dengue in Brazil and reinforce the importance of policies adapted to regional realities, with the strengthening of epidemiological surveillance and response capacity in the face of outbreaks.

REFERENCES

1. Junior JBS, Massad E, Lobao-Neto A, et al. Epidemiology and costs of dengue in Brazil: a systematic literature review. Int J Infect Dis 2022; 122:521–8. https://doi.org/10.1016/j.ijid.2022.06.050

2. Bhatt S, Gething PW, Brady OJ, et al. The global distribution and burden of dengue. Nature 2013; 496:504–7. https://doi.org/10.1038/nature12060

3. World Health Organization (WHO). Global strategy for dengue prevention and control, 2012–2020. Geneva: WHO; 2012. https://www.who.int/publications/i/item/9789241504034

4. Zhang HT, Wang LM, Zhang M, et al. Assessing the global dengue burden: incidence, mortality, and disability-adjusted life years from 1990 to 2021. PLoS Negl Trop Dis 2025; 19(3):e0012932. https://doi.org/10.1371/journal.pntd.0012932

5. Andrioli DC, Busato MA, Lutinski JA. Spatial and temporal distribution of dengue in Brazil, 1990–2017. PLoS One 2020; 15(2):e0228346. https://doi.org/10.1371/journal.pone.0228346

6. Ministério da Saúde (MS). Nota Informativa nº 38/2023 - CGARB/DEDT/SVSA/MS. Brasília: Ministério da Saúde; 2023. https://www.gov.br/saude/pt-br/centrais-de-

conteudo/publicacoes/estudos-e-notas-informativas/2023/nota-informativa-no-38-2023-cgarb-dedt-svsa-ms/view

7. Ministério da Saúde (MS). Diretrizes Nacionais para Prevenção e Controle das Arboviroses Urbanas: Vigilância Entomológica e Controle Vetorial. Brasília: Ministério da Saúde; 2025. https://www.gov.br/saude/pt-br/centrais-de-conteudo/publicacoes/svsa/dengue/diretrizes-nacionais-para-prevencao-e-controle-das-arboviroses-urbanas-vigilancia-entomologica-e-controle-vetorial.pdf/view

8. Rocha MIF, Maranhão TA, Frota MMC, et al. Mortalidade por doenças tropicais negligenciadas no Brasil no século XXI: análise de tendências espaciais e temporais e fatores associados. Rev Panam Salud Publica 2023; 47:e146. https://doi.org/10.26633/RPSP.2023.146

9. Instituto de Pesquisa Econômica Aplicada (IPEA). Atlas da Vulnerabilidade Social nos Municípios Brasileiros. Brasília: IPEA; 2015. https://repositorio.ipea.gov.br/entities/book/7c139f01-9ac7-48fa-8159-ec16018fa98c

10. Malavige GN, Jeewandara C, Ogg GS. Dengue and Covid-19: two sides of the same coin. J Biomed Sci 2022; 29(1). https://doi.org/10.1186/s12929-022-00833-y

11. To KKW, Sridhar S, Chiu KHY, et al. Lessons learned one year after SARS-CoV-2 emergence leading to Covid-19 pandemic. Emerg Microbes Infect 2021; 10(1):507–35. https://doi.org/10.1080/22221751.2021.1898291

12. Veljković M, Pavlović DR, Stojanović NM, et al. Behavioral and dietary habits that could influence both Covid-19 and non-communicable disease prevention. Medicina (Kaunas) 2022; 58(11):1686. https://doi.org/10.3390/medicina58111686

13. Sheng ZY, Li M, Yang R, et al. Covid-19 prevention measures reduce dengue spread in Yunnan Province, China. Emerg Microbes Infect 2021; 11(1):240–9. https://doi.org/10.1080/22221751.2021.2022438

14. Ministério da Saúde (MS). Indicadores Básicos para a Saúde no Brasil: Conceitos e Aplicações [Internet]. Brasília: DATASUS; 2012. Disponível em: http://tabnet.datasus.gov.br/tabdata/livroidb/2ed/indicadores.pdf

15. Brasil. Conselho Nacional de Saúde (CNS). Resolução nº 674, de 06 de maio de 2022: dispensa de apreciação ética para pesquisas com dados públicos, secundários e sem identificação individual. Brasília: CNS; 2022. https://www.gov.br/conselho-nacional-de-saude/pt-br/atos-normativos/resolucoes/2022/resolucao-no-674.pdf/view

16. Teixeira MG, Siqueira JB, Ferreira GLC, et al. Epidemiological trends of dengue disease in Brazil (2000–2010): a systematic literature review and analysis. PLoS Negl Trop Dis 2013; 7(12):e2520. https://doi.org/10.1371/journal.pntd.0002520

17. Ministério da Saúde (MS). Boletim Epidemiológico Vol. 54 nº 1. Brasília: Ministério da Saúde; 2023. https://www.gov.br/saude/pt-br/centrais-de-conteudo/publicacoes/boletins/epidemiologicos/edicoes/2023/boletim-epidemiologico-volume-54-no-01/@@download/file/Boletim_epidemiologico_SVS_1_v2.pdf

18. Pinto MS, Ponte CHF, Toledo LFES, et al. Subnotificação de doenças sazonais na pandemia. Braz J Health Rev 2023; 6(5):20971–8. https://doi.org/10.34119/bjhrv6n5-127

19. Leandro CS, Barros FB, Cândido EL, Azevedo FR. Redução da incidência de dengue no Brasil em 2020: controle ou subnotificação de casos por Covid-19? Res Soc Dev 2020; 9(11):e76891110442. https://doi.org/10.33448/rsd-v9i11.10442

AUTHORS' CONTRIBUTIONS

Marina Henriques Amaral contributed to project administration, literature review, abstract writing, introduction, methodology, discussion, data collection, interpretation and description of results, table preparation, conclusions, manuscript review, and statistical analyses. **Giovanna Xavier Toledo** contributed to project administration, literature review, abstract writing, introduction, methodology, discussion, data collection, interpretation and description of results, table preparation, conclusions, manuscript review, and statistical analyses. **Edna Campos Wingester** contributed to project administration, interpretation and description of results, table preparation, conclusions, manuscript review, and statistical analyses. **Anna Carolina Vieira Felício** contributed to the interpretation and description of results, table preparation, conclusions, manuscript review, and statistical analyses.

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

Please cite this article as: Amaral MH, Toledo GX, Wingester ELC, Felício ACV, Brasil HA. Dengue mortality and social vulnerability in Brazilian macro-regions: an ecological study from 2019 to 2023. Rev Epidemiol Control Infect [Internet]. 2026 Aug. 14; 16. Available from: https://seer.unisc.br/index.php/epidemiologia/article/view/20656