Revista ARACÊ
ISSN: 2358-2472

EVOLUTION OF DENGUE IN RIO GRANDE DO SUL: EPIDEMIOLOGICAL PROFILE, SPATIALITY AND HEALTH INDICATORS

https://doi.org/10.56238/arev6n4-189

Submitted on: 12/11/2024 **Publication date:** 12/12/2024

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ABSTRACT

Dengue is a viral disease transmitted by the *Aedes aegypti mosquito*, with a relevant impact on global public health. This study aimed to analyze the spatio-temporal evolution of dengue, the epidemiological profile of those affected, and health indicators in the state of Rio Grande do Sul, Brazil, between 2014 and 2023. The research used data from the Notifiable Diseases Information System (SINAN) and evaluated confirmed cases of dengue according to the variables of sex, age group, color/race and education. A total of 127,904 cases were recorded in the period analyzed, with a predominance of women, aged 20 to 59 years, white and with elementary or secondary education. The Metropolitan, Missioneira and North macro-regions concentrated the highest incidence rates. The study showed that factors such as accelerated urbanization, climate change, and population dynamics have contributed to the expansion of dengue in previously non-endemic areas. It is concluded that the effective control of the disease in Rio Grande do Sul requires a multidimensional, interdisciplinary and regional approach, with the strengthening of epidemiological surveillance and a more equitable distribution of health resources.

Keywords: Arbovirus. *Aedes aegypti*. Spatio-temporal evolution.

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INTRODUCTION

Dengue is a Neglected Tropical Disease (NTD), characterized by its rapid spread and propensity for a pandemic profile, standing out as one of the main challenges in terms of public health on a global scale. The transmission of the dengue virus occurs by female mosquitoes of the *Aedes aegypti* species, which is widely distributed in the American continent and is also a vector for the transmission of Chikungunya and Zika (Pan American Health Organization, 2023).

Annually, in the world, the dengue virus infects up to 400 million individuals, resulting in about 100 million cases and approximately 40 thousand deaths due to the severe form of the disease (Centers For Disease Control and Prevention, 2023). The scenario is worrying because dengue and Chikungunya can occur simultaneously in the same individual. In this context, incorrect diagnoses lead to errors in disease outcomes (Melo *et al*., 2023; Souza *et al.,* 2023). In addition, with the COVID-19 pandemic, dengue cases in Brazil have shown an increase, since preventive measures have been relaxed. The decrease in vector control interventions has had a negative impact on dengue surveillance systems. The similarity in symptoms between dengue and COVID-19 has led to possible unidentified diagnoses, potentially due to co-infections. The predominant allocation of resources to confront the COVID-19 pandemic suggests that the severity of arboviruses in the country may be greater than the data indicate (Rabiu, 2021). In addition, there was a stationary trend in the Ministry of Health's investments between 2004 and 2020 (Melo *et al*., 2023).

In the state of Rio Grande do Sul (RS), dengue was historically rare, with the first autochthonous case recorded only in 2007. This epidemiological panorama has had a significant change (Gregianini *et al.,* 2018). Between 2014 and 2016, there was a significant increase in the number of cases, from 89 to 2,518, with DENV-1 as the predominant serotype (Gregianini *et al*., 2018). Between 2017 and 2021, there was an increase in the number of municipalities infested by *A. aegypti*, coinciding with an increase in the incidence of dengue cases (Oliveira *et al*., 2023). Accelerated urbanization, climate change, and the introduction of new serotypes are some of the factors that have directly contributed to the increase in cases of the disease (Rodrigues *et al*., 2016; Barcellos *et al*., 2024).

The disease has an impact on the socioeconomic and health spheres, has a high prevalence, resulting in the loss of years of healthy life due to disability and deaths (Araújo *et al*., 2017). In this context, a detailed understanding of the extent of the dengue problem is relevant for decision-making and proactive strategies. In-depth analysis of the

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ISSN: 2358-2472

epidemiological characteristics of the disease not only amplifies the capacity to respond to outbreaks and epidemics, but also promotes an efficient and optimized allocation of available resources. It is of paramount importance to recognize the role that the collection and use of information plays in the implementation of coordinated and shared prevention and control actions (Flisch, 2017).

In this context, the present study aims to analyze the spatio-temporal distribution of dengue and the epidemiological profile of people affected by dengue in Rio Grande do Sul, between 2014 and 2023. By addressing these aspects, the study aims to provide subsidies for the development of more effective strategies for the control and mitigation of dengue in the state.

METHODOLOGY

This is an epidemiological, descriptive, retrospective and quantitative study of dengue in the state of Rio Grande do Sul. Data collection was carried out using data made available by the Notifiable Diseases Information System (SINAN), accessed via the DATASUS database. All cases of dengue reported in the state between 2014 and 2023 were included. The epidemiological variables analyzed include gender, age group, color/race, and education level of individuals affected by dengue. In the schooling variable, incomplete and complete levels were grouped. The variables were chosen based on their relevance to identify potential disparities in the impact of dengue in different population groups, helping to define more targeted public policies.

Rio Grande do Sul is the southernmost state in Brazil, located in the South region (Figure 1), is the study area and covers a territorial extension of 281,748 km² and 11,088,065 inhabitants (IBGE, 2022). It is bordered by Uruguay to the south, Argentina to the west, and the Brazilian state of Santa Catarina to the north and the Atlantic Ocean to the east. It is composed of 497 municipalities and seven health macro-regions (North, South, Metropolitan, Valleys, Missioneira, Serra and Midwest), which are formed by groups of municipalities with similar geographical, population and health infrastructure characteristics.

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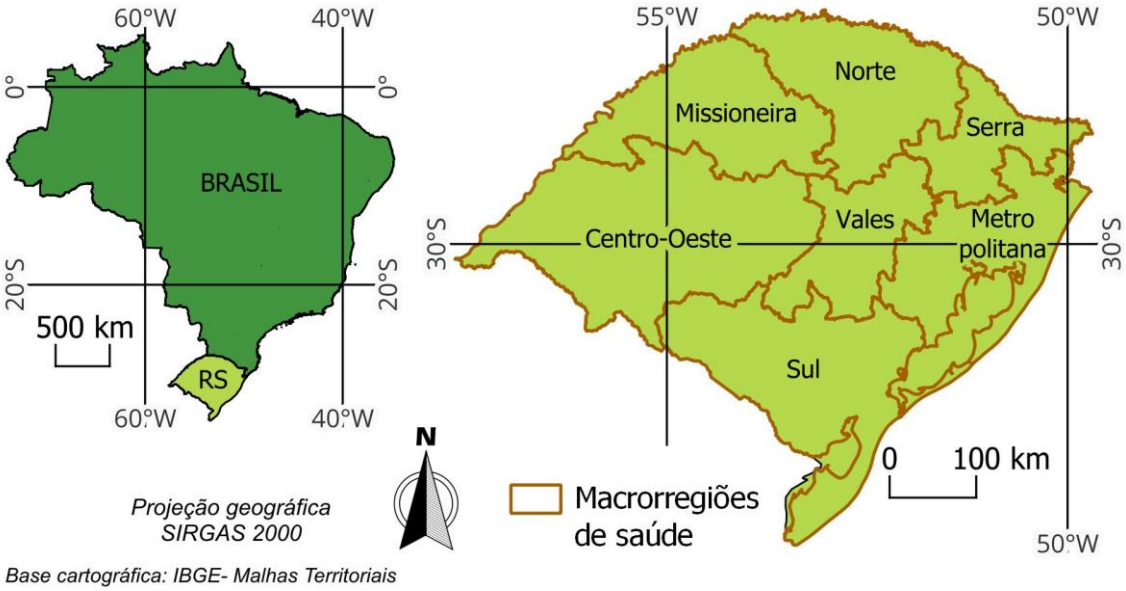
Figure 1 – Location of the study area



Source: authors (2024)

To assess dengue cases and their distribution in the state, which helps in monitoring the disease, risk groups and needs for interventions, the total incidence in the state and in each municipality during the study period was calculated. The calculation of the incidence rate took into account the number of reported cases of dengue divided by the total population of each municipality multiplied by 100,000 (BRASIL, 2005). To be precise about the number of inhabitants in each year analyzed, the population of each municipality from the years 2014 to 2021 was verified in DATASUS (BRASIL, 2024), and in the years 2022 and 2023 according to data reported by the IBGE (2022; 2023).

The prevalence rate was stratified based on the selected epidemiological variables, including gender, age group, color/race, and education. For each stratum, the prevalence rate was calculated independently, using the formula of the number of reported cases of dengue divided by the population of that stratum, multiplied by 100. This stratification allowed a more detailed analysis of the disparities in the distribution of dengue between different population groups and helped in the identification of possible risk populations.

The maps were prepared in QGIS, a free geoprocessing software. The table with the incidence rate data was associated with the spatial representation file (shapefile), made available by the IBGE - Cartographic Base - Territorial Meshes (IBGE, 2021). The divisions of the Health macro-regions of the state of Rio Grande do Sul for the elaboration of the map were removed from the https://portal.conasems.org.br/paineis-de-apoio/paineis/13_macrorregioes-e-regioes-de-saude.

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The collected data were organized and analyzed using Microsoft Excel software to calculate incidence and prevalence rates. The tables and graphs generated from these data helped in the visualization and interpretation of the results.

Due to the fact that the study was carried out with secondary data, available in the public domain and with free access, it was not necessary to submit it to the Research Ethics Committee, according to the principles of Resolution No. 510/2016 of the National Health Council.

RESULTS

The number of confirmed cases of dengue in the state of Rio Grande do Sul, in the period analyzed, was 127,904. Regarding the occurrence of this disease in the health macro-regions, in the historical series, the Metropolitan concentrated most of the cases, representing 42.54% of the total infections in the state, followed by the regions of Missioneira (15.67%), North (16.64%) and Vales (15.82%). The Central-West, Serra and South macro-regions had a lower participation, with 8.12%, 1.02% and 0.18%, respectively.

Based on the epidemiological profile of the health macro-regions (Table 1), it was observed that the female gender was predominant, but the male gender stood out in the South (50.21%) and Serra (52.02%). The predominant age group in all macro-regions was 20 to 59 years, as well as white color/race. As for education, higher education stood out in the South (31.20%), high school (31.70%) in the Serra and in the others elementary and high school.

Table 1 – Epidemiological profile of those affected by dengue, in the Health regions of RS, from 2014 to 2023.

	Vouchers (%)	South (%)	Sierra (%)	North (%)	Missioneira (%)	Metropolitana (%)	Midwest (%)
Sex							
Male	47,64	50,21	52,02	46,38	46,16	46,16	46,33
Female	52,35	49,79	47,90	53,60	53,81	53,66	53,64
Ig.	0,01	0,00	0,08	0,01	0,02	0,18	0,03
Age Group (years)							
<1	0,39	0,00	0,84	0,79	0,68	0,56	0,81
1-9	5,03	2,99	4,35	5,21	4,67	5,46	8,73
10-19	12,19	9,40	10,31	12,81	12,57	14,54	14,70
20-39	34,00	52,14	39,95	33,08	31,76	36,50	35,39
40-59	28,58	24,36	30,86	28,60	29,82	28,62	25,20
60-69	11,14	8,12	8,79	10,79	11,48	9,06	8,85
70-79	6,32	2,14	3,82	6,31	6,73	4,01	4,43
80 and +	2,34	0,85	1,07	2,40	2,25	1,24	1,87

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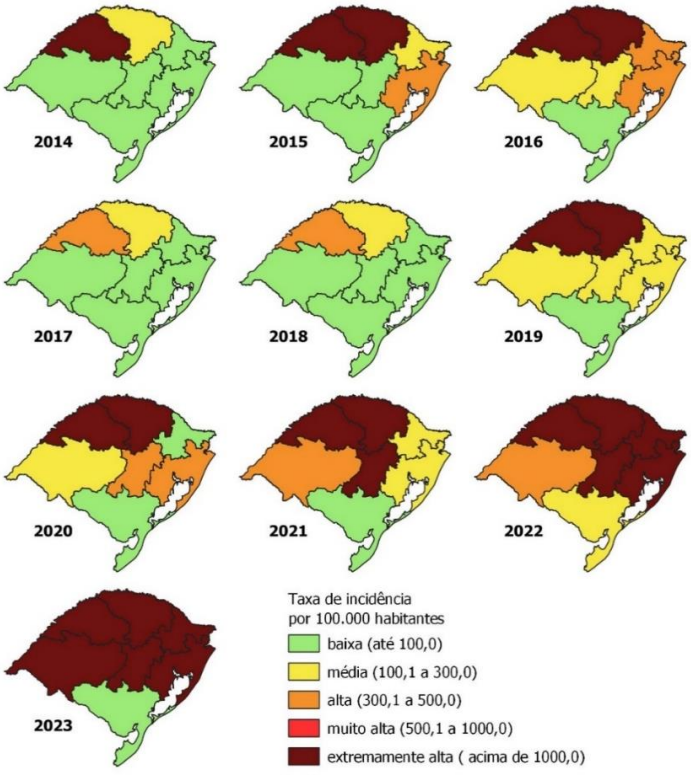
Ig./Br.	0,00	0,00	0,00	0,02	0,03	0,02	0,01
Schooling							
Illiterate	0,28	0,43	0,31	0,25	0,13	0,12	0,15
EF	22,36	13,25	19,79	15,96	17,32	8,28	17,89
IN	21,89	26,50	31,70	15,97	14,96	9,88	14,62
IS	7,45	31,20	13,52	6,84	5,78	3,04	5,96
Not applicable	3,59	2,56	3,67	4,47	3,60	3,97	7,07
Ig./Br.	44,43	26,07	31,02	56,50	58,21	74,70	54,31
Color/Race							
White	85,55	85,11	87,57	90,48	88,04	54,93	81,85
Black	3,31	3,40	1,60	1,04	0,44	4,61	4,51
Yellow	0,18	0,85	0,15	0,26	0,18	0,43	0,54
Brown	4,58	4,26	6,25	4,21	2,81	4,24	8,26
Indigenous	0,06	0,00	0,00	0,15	0,02	0,22	0,15
Ig./Br.	6,33	6,38	4,42	3,86	8,51	35,57	4,69

Source: DATASUS (2024); Legend: Ig – ignored; Br – blank; EF – elementary school; EM – high school; ES – higher education

The analysis of the incidences, by year, in each Health macro-region allowed us to identify that Missioneira and Norte were the most compromised regions in the historical series. Considering the evolution of dengue in the historical series, it was observed that the years 2022 and 2023 were the most compromised (Figure 2). Most macro-regions had an extremely high incidence rate.

Figure 2 – Spatialization of the dengue incidence rate, by health macro-region of RS, from 2014 to 2023.



Source: Authors (2024)

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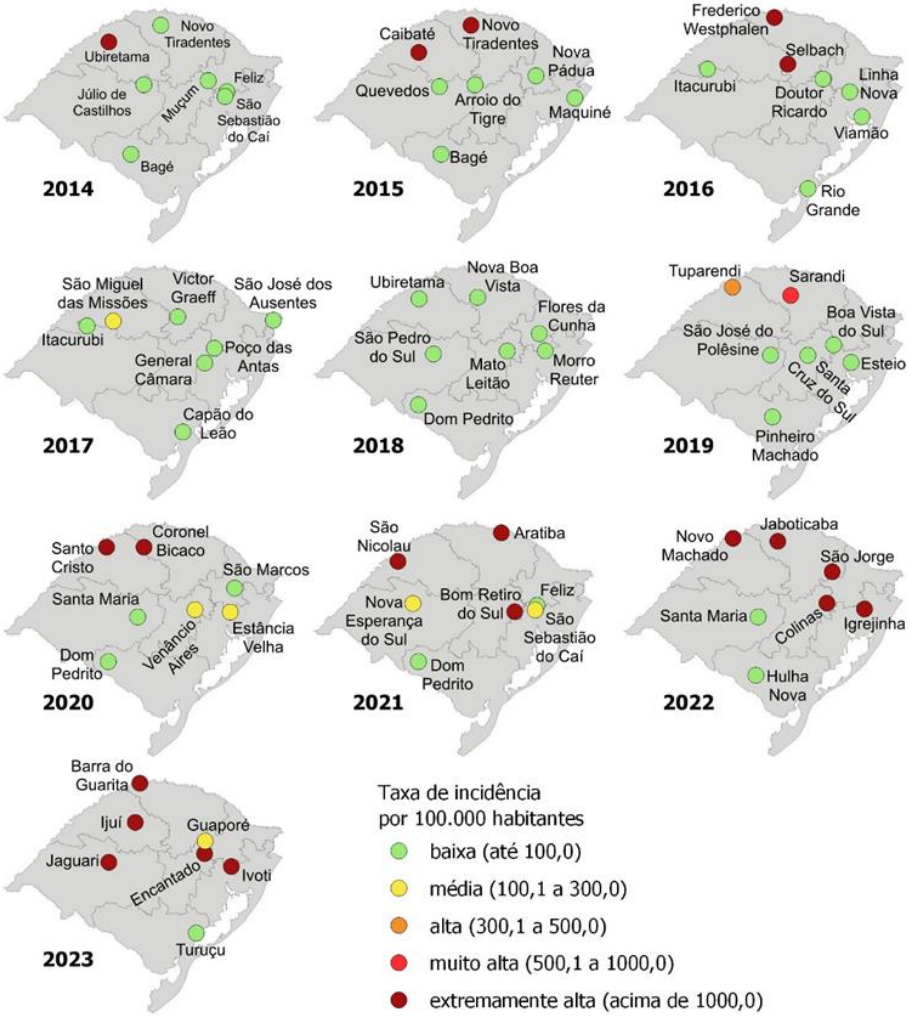
In the Missioneira macro-region, the municipality of Novo Machado had the highest incidence (8005/100 thousand inhabitants) and in the North it was the municipality of Jaboticaba (17491.40/100 thousand inhabitants). The only exception was for the South macro-region, which remained low. The Missioneira macro-region was the worst in the scenario of this disease in the period of 10 years. In this period, the incidence rate in this macro-region was extremely high, with the exception of 2017 and 2018, which was high.

When analyzing the incidence rate classified as extremely high in the state, it was found that in the Missioneira macro-region, which is the most epidemically compromised, the municipalities of Ubiretama, Caibaté, Selbach, Santo Cristo, São Nicolau, Novo Machado and Ijuí stood out. In the North macro-region, the relevance of dengue was present in the municipalities of Novo Tiradentes, Frederico Westphalen, Coronel Bicaco, Aratiba, Jaboticaba, and Barra do Guarita (Figure 3).

Figure 3 – Indication of the municipalities with the highest incidence of dengue, by health macro-region, in the period from 2014 to 2023.



Source: Authors (2024)

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In the Vales macro-region, this record was present in the municipalities of Bom Retiro do Sul, Colinas and Encantado; in the Metropolitan, the most compromised municipalities were Igrejinha and Ivoti. The Serra and Central-West macro-regions had only one municipality with an extremely high incidence rate, which were São Jorge and Jaguari, respectively, and the South was the exception with no municipality recorded an extremely high incidence.

DISCUSSION

Neglected Tropical Diseases (NTDs) are directly linked to vulnerable populations in regions with limited access to basic sanitation, drinking water and medical care (Silva; Machado, 2018; Engels; Zhou, 2020; Marshall; Coimbra, 2022). These diseases occur mainly in rural and urban areas of low- and middle-income countries, such as Brazil, reflecting global socioeconomic inequalities (Bavia *et al*., 2020; Engels, Zhou, 2020; Meurer, Coimbra, 2022; Carabali *et al*., 2022).

The profile of those affected by dengue in the state of Rio Grande do Sul revealed a predominance of cases in females, except in the South and Serra macro-regions. This may be related to women's specific behavioral or occupational factors in these regions, which favor vector exposure (Oneda *et al*., 2021). The national trend of the female population being higher may reflect the predominance of dengue in this sex, in addition to being possibly associated with greater exposure in home care activities where there may be a greater concentration of A. *aegypti mosquito foci* (Oneda *et al*., 2021; IBGE, 2022; Schröder *et al*., 2023; Sansone *et al*., 2024; Silva *et al*., 2024). The predominant age group for dengue occurrence was among young adults aged 20 to 59 years, who constitute the economically active population. This is in line with studies that indicate greater exposure to the mosquito in workplaces and daily traffic (Santana, Duarte, 2019; Silva *et al*., 2022; Silva *et al*., 2024), during the period of highest vector activity (PAHO, 2024). Regarding education, individuals with elementary education were the most affected by dengue and were predominant. The exception was in the South (high school) and Serra (higher education) macro-regions. These results may indicate that dengue affects people with intermediate levels of education, which may be associated with factors such as greater exposure to the vector due to the type of work or the location of residences, which may be in more vulnerable areas, with less access to basic sanitation and health services (Santana, Duarte, 2019; Sansone *et al*., 2024)**element.** However, the lower incidence of cases

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observed among individuals with higher education may suggest that this group with higher education is better able to adopt preventive measures or live in areas with better infrastructure conditions and vector control (Diaz-Quijano *et al.*, 2018; Joyce *et al.*, 2021). On the other hand, the South macro-region, by presenting the highest percentage of infected individuals in individuals with higher education, may suggest that in this region there is a greater concentration of individuals with this level of education. In this region there is the presence of several public and private universities, which may have contributed to this occurrence.

It is recognized that, in order to address the impact of NTDs, such as dengue, it is necessary to go beyond an exclusively biomedical approach, promoting public policies aimed at the education and socioeconomic development of the affected populations (Zicker *et al.*, 2019). Dengue has no direct correlation with the color/race variable (Silva *et al.*, 2019; Dias *et al.*, 2017); in this study, a higher prevalence of cases was observed in individuals of white color/race, corroborating Oneda *et al.* (2021). This data may be related to the predominant demographic composition in the state of Rio Grande do Sul, where the majority of the population declares itself white (Augustin *et al.*, 2021), according to data from the Demographic Census (IBGE, 2022). Records classified as "Unknown/Blank", especially in the schooling variable, may compromise a detailed analysis of this indicator. In addition, it may suggest failures in the completion of data or in the communication between the health units and the population served (Silva *et al.*, 2022). This fact highlights the importance of correct notification of the disease with completion of sociodemographic data for a better understanding of its epidemiological profile, in addition to reinforcing the need for more equitable health policies that reach all vulnerable populations.

The manifestation of dengue depends fundamentally on the simultaneous presence of the virus, vectors, and people (Flisch, 2017), which explains its presence in large and small urban centers. In this study, this dynamic was observed, with cases recorded from small municipalities to larger urban centers. The Metropolitan macro-region concentrated most of the cases, representing 42.54% of the total infections in the state, evidencing the wide distribution of the disease and the need for specific approaches for different urban and rural realities in the fight against dengue.

The analysis of the stratification of dengue among the municipalities studied reveals a heterogeneous distribution of incidence over the years, with emphasis on regional variations. In the first five years of the time series (2014 – 2018), only five municipalities had

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an extremely high incidence: Novo Tiradentes (4513.27 cases/100 thousand inhabitants) and Frederico Westphalen (1491.08 cases/100 thousand inhabitants) belong to the North health region. The municipalities of Ubiretama (1546.86 cases/100,000 inhabitants), Caibaté (5502.73 cases/100,000 inhabitants) and Selbach (1713.27 cases/100,000 inhabitants) are part of the Missioneira region. In the Northern health region, the high incidence can be explained, in part, by the climatic and environmental conditions favorable to mosquito proliferation, in addition to the geographic location of the municipalities, which may have limited access to vector control resources and health infrastructure (Gurgel-Gonçalves *et al*., 2024). In the Missioneira region, the continuous increase in cases in this region may be related to inadequate vector control and poor basic sanitation, in addition to reflecting the difficulty of monitoring and rapid response in more rural and remote areas (Gurgel-Gonçalves *et al*., 2024).

In the last five years of the analyzed period (2019-2023), there was a predominance of the extremely high incidence rate in most health regions, except only in the South. In Vales, the municipalities that stood out were Bom Retiro do Sul (4763.82 cases/100 thousand inhabitants), Colinas (8212.96 cases/100 thousand inhabitants) and Encantado (7895.65 cases/100 thousand inhabitants). The Serra health region with the municipality of São Jorge (1064.56 cases/100 thousand inhabitants) standing out with extremely high incidence. As of 2020, the North and Missioneira health regions maintained the occurrence of extremely high incidence continuously. The municipalities that recorded these peaks were: Coronel Bicaco (3591.08 cases/100 thousand inhabitants), Aratiba (13197.72 cases/100 thousand inhabitants), Jaboticaba (17491.40 cases/100 thousand inhabitants) and Barra do Guaratiba (7687.44 cases/100 thousand inhabitants) (all belonging to the North health region). Even though these high rates were recorded in different years, it should be noted that they are geographically close, which may suggest an expanded environmental distribution of the vector. The municipalities of Santo Cristo (1962.58 cases/100,000 inhabitants), São Nicolau (1571.90 cases/100,000 inhabitants), Novo Machado (8005.00 cases/100,000 inhabitants) and Ijuí (5589.76 cases/100,000 inhabitants). In the Metropolitan Health Region, the municipalities of Igrejinha and Ivoti with an incidence of 18013.90 cases/100 thousand inhabitants. and 3863.73 cases/100 thousand inhabitants, respectively.

And in the Central-West region, the municipality of Jaguari had an incidence of 3648.74 cases/100 thousand inhabitants. The presence of extremely high incidence

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suggests a possible lack of adequate public health infrastructure for dengue control, such as basic sanitation and preventive campaigns, in addition to combating the *A. aegypti mosquito* (Gurgel-Gonçalves *et al*., 2024). The high incidence may indicate weaknesses in the local health system, including the insufficiency of health units, such as UBSs (Basic Health Units) and UPAs (Emergency Care Units), to serve the affected population (Angelo *et al*., 2020). Lack of infrastructure in more remote areas, combined with inequalities in access to health services, contributes to the persistence of the disease (Lin, Wen, 2024). The increase in incidence in metropolitan areas may be related to high population density and the difficulty of maintaining effective vector control policies, even with a more developed health infrastructure than in rural areas (Lin; Wen, 2024). In Rio Grande do Sul, dengue outbreaks occur in regional clusters, requiring a comprehensive approach with rigorous sampling, detailed data collection, and the development of more sensitive and specific assays, and dengue should be addressed as a regional concern, and not just a municipal one (Gregianini *et al.,* 2017).

The COVID-19 pandemic, which occurred during part of the analyzed period, may also have had an impact on the increase in dengue cases, since vector control measures were relaxed and resources were redirected to combat the pandemic. This scenario also compromised the epidemiological surveillance system (Rabiu, 2021). In addition, the focus on combating COVID-19 resulted in the suspension or delay of several studies related to NTDs, which included dengue, delaying advances in the knowledge and control of these pathologies (WHO, 2022).

Global warming and climate change have impacted the increase in the incidence of dengue (Silva *et al*., 2024). The increase in global average temperatures is associated with a greater proliferation of the *A. aegypti mosquito*, which enhances outbreaks of the disease (Sansone *et al.,* 2024). The intensification of rainfall and flooding, due to the El Niño phenomenon, are also critical factors (Ortiz-Prado *et al*., 2024). Not only do these climate changes increase the risk of outbreaks in endemic areas, but they can also expand the reach of the disease to regions that were previously unaffected (Sansone *et al*., 2024). The impact of climate change on the increase in dengue incidence in 2022 and 2023 can be seen as a direct reflection of these unfavorable environmental conditions not only in Brazil, but in other parts of the world (López *et al*., 2023; Haider *et al*., 2024; Salim *et al*., 2024).

It is important to highlight that, as this is a study with secondary data, there are inherent limitations, such as underreporting, which may mean that the numbers presented

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do not reflect the real incidence of the disease (Oneda *et al*., 2021; Silva *et al.*, 2022). Dengue control, as a NTD, must have a permanent public agenda. In this context, it is a priority to reduce inequalities, improve the health of populations and meet the sustainable development goals established in the 2030 Agenda. In this way, it is tried to promote social justice and ensure adequate access to health care (Schröder *et al*., 2023).

CONCLUSION

The epidemiological analysis of dengue in Rio Grande do Sul between 2014 and 2023 revealed the complexity and scope of the problem, showing that the disease, originally associated with tropical regions, has become a growing concern in more temperate areas. From the epidemiological profile, a predominance of females was identified, aged between 20 and 59 years, white individuals with elementary and high school education.

The expansion of dengue to the state of Rio Grande do Sul indicates that urbanization, climatic conditions and changes in population dynamics are relevant and intrinsic factors. To address this challenge, it is essential that the government adopts a broader, multidimensional, and interdisciplinary approach, using epidemiological indicators to define regional priorities and thus allocate resources more efficiently. This will allow control campaigns to be targeted specifically to endemic areas and populations in at-risk areas.

Strengthening the surveillance system and improving the quality of epidemiological records are fundamental steps to ensure more assertive and inclusive interventions. Dengue control in Rio Grande do Sul will depend on coordinated action between different spheres of government, as well as greater equity in the distribution of resources and access to public health.

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