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COMBATING DENGUE IN BRAZIL: AN INTEGRATED ANALYSIS OF VACCINATION AND PUBLIC INVESTMENTS FOR DISEASE CONTROL

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Rafaele Fernanda Oliveira Caes
Department of Biomedicine – University Center of the Integrated Faculties of Ourinhos – Unifio/FEMM Ourinhos, SP, Brazil
ORCID: 0009-0008-1558-5415

Karina Neves
Department of Biomedicine – University Center of the Integrated Faculties of Ourinhos – Unifio/FEMM Ourinhos, SP, Brazil
ORCID: 0009-0003-2246-0630

Gabriel Teles Leite
Department of Biomedicine – University Center of the Integrated Faculties of Ourinhos – Unifio/FEMM Ourinhos, SP, Brazil
ORCID 0009-0006-9312-5495

Lorena Gabrielly Machado dos Santos
Department of Biomedicine – University Center of the Integrated Faculties of Ourinhos – Unifio/FEMM Ourinhos, SP, Brazil
ORCID: 0009-0000-9315-919X

Jéssica Cristina de Oliveira Corrêa
Department of Biomedicine – University Center of the Integrated Faculties of Ourinhos – Unifio/FEMM Ourinhos, SP, Brazil
ORCID: 0009-0003-0093-1710

Giovanna Albanez
Department of Biomedicine – University Center of the Integrated Faculties of Ourinhos – Unifio/FEMM Ourinhos, SP, Brazil
ORCID: 0009-0009-3990-9231

Roberto Venerando
Department of Biomedicine – University Center of the Integrated Faculties of Ourinhos – Unifio/FEMM Ourinhos, SP, Brazil
ORCID: 0000-0002-1937-0517

Luciano Lobo Gatti
Department of Biomedicine – University Center of the Integrated Faculties of Ourinhos – Unifio/FEMM Ourinhos, SP, Brazil
ORCID: 0000-0003-2723-3173

Douglas Fernandes da Silva
Department of Biomedicine – University Center of the Integrated Faculties of Ourinhos – Unifio/FEMM Ourinhos, SP, Brazil
ORCID: 0000-0002-0252-1112

Abstract: Vaccination against dengue is one of the most relevant strategies in combating infectious diseases in Brazil, especially given the high morbidity and mortality rates and the socioeconomic impact associated with the disease. Currently, two vaccines have been approved, representing a significant advance ( ) in controlling the disease in a context in which approximately 40% of the world's population remains at risk of infection. This study aimed to analyze the host's immune response to the dengue virus, with an emphasis on the role of adaptive immunity in preventing severe forms and deaths, as well as to discuss the potential of vaccination as a central tool for epidemiological control. To achieve these objectives, a literature review was conducted in databases such as PubMed, SciELO, and Google Scholar, in addition to the use of secondary data from DATASUS. Two generations of prophylactic measures were compared: vector control, based on the use of fogging, larvicides, and insecticides, and vaccination, represented by the incorporation of the Qdenga tetravalent attenuated vaccine into the National Immunization Program in 2023. The results indicate that, although vector control actions remain fundamental, their isolated effectiveness is limited, especially in the face of climatic conditions favorable to the proliferation of *Aedes aegypti*. In this scenario, vaccination is indispensable but faces challenges related to low population adherence, the need for continuous monitoring of efficacy against the four viral serotypes, and the implementation of public policies supported by scientific evidence. It is concluded that combating dengue requires an integrated approach, in which vaccination plays a strategic role and should be associated with environmental measures, epidemiological surveillance, and health education in order to consistently reduce the incidence, deaths, and costs resulting from the disease in Brazil.

Keywords: Dengue, Qdenga, Dengvaxia, Immunization, Mortality, Vaccine.

INTRODUCTION

Dengue is currently the most prevalent arbovirus disease in the world. According to the Pan American Health Organization (PAHO), about half of the world's population is at risk of contracting the disease. It is a disease caused by the dengue virus (DENV), belonging to the genus *Flavivirus* and the family *Flaviviridae,* and is a major cause of morbidity and mortality in Brazil and in various regions of the world, especially in tropical and subtropical areas. Factors such as periods of heavy rainfall, rapid urbanization, and poor housing conditions—including deficiencies in basic sanitation and adequate waste management—favor the proliferation of the vector. Insufficient environmental awareness among the population also plays a relevant role in this context, since the elimination of breeding sites and the containment of mosquito reproduction in the home environment depend, to a large extent, on individual action. In Brazil, the combination of climatic and social factors favors the spread of the virus, explaining the high frequency of outbreaks in the country (Khan et al., 2023; Lessa et al., 2023).

DENV transmission between humans can occur through four distinct serotypes (DENV-1, DENV-2, DENV-3, and DENV-4), mainly transmitted by the bite of female *Aedes aegypti* and, less commonly, *Aedes albopictus*. These serotypes can circulate simultaneously in the same region, and reinfection by a different type after previous exposure significantly increases the risk of clinical complications (Lessa et al., 2023; Ministry of Health, 2024).

The development and availability of dengue vaccines represent a milestone in combating the disease. However, the effectiveness of these interventions depends on factors such as population acceptance, vaccination coverage, regional epidemiological profile, and integration with public health policies. Therefore, it is essential to analyze vaccination and public investments in dengue control in an integrated manner in order to identify gaps and potentialities that can support more effective strategies. Understanding this relationship can contribute to improving immunization actions, strengthening health planning, and, consequently, reducing morbidity and mortality associated with the disease in Brazil (Ministry of Health/SVSA, 2024; World Health Organization, 2023).

In this context, integrating scientific evidence and official epidemiological data is essential to inform strategic decisions that strengthen prevention and control measures. Historical analysis of data from the Notifiable Diseases Information System (SINAN), combined with a review of scientific evidence on vaccination, allows us to understand the evolution of the epidemiological scenario and identify the potential impact of mass immunization in Brazil. In this context, this study sought to analyze, in an integrated manner, the scientific evidence and epidemiological data on dengue in Brazil, focusing on the effectiveness and feasibility of vaccination, associated with public investments, as a strategy for disease control and prevention.

MATERIALS AND METHODS

This study adopted a mixed design, consisting of an integrative review of the literature and a documentary analysis of secondary data on dengue cases in Brazil. The integrative review was conducted with the objective of gathering, critically evaluating, and synthesizing scientific evidence on the importance of vaccination in dengue control, considering aspects such as the efficacy, safety, and effectiveness of immunizers. Bibliographic searches were conducted in the PubMed, LILACS, SciELO, and Google Scholar databases. The central theme was "The importance of vaccination against dengue in the current critical scenario" and related descriptors: "immunization," "tetra-

valent vaccine," "dengue," "public health," and "biotechnology," in addition to specific terms such as "Dengvaxia," "Qdenga," and "vaccines and public health." The inclusion criteria covered articles that: (i) were aligned with the proposed theme; (ii) were published in journals indexed in the databases consulted; and (iii) were written in Portuguese, English, or Spanish. Primary studies, reviews, technical documents, and institutional reports were included.

At the same time, epidemiological data from the Notifiable Diseases Information System (SINAN), available at DATASUS, were analyzed for the period from 2002 to 2022, followed by a partial analysis from 2023 to 2025. Annual data on incidence, absolute number of cases, hospitalizations, and deaths from dengue in Brazil were extracted. The information obtained was systematized in spreadsheets and analyzed descriptively, allowing the identification of temporal trends and possible relationships with immunization policies. Additionally, data published by the Ministry of Health and the National Institute of Meteorology (INMET) were consulted.

DEVELOPMENT

Dengue is one of the most relevant arboviruses in the Brazilian epidemiological scenario, representing a serious public health problem due to its high incidence, potential to cause outbreaks, and significant socioeconomic impact (Ministry of Health, 2024; World Health Organization, 2023). In recent years, Brazil has seen a significant increase in the number of cases and the mortality rate associated with the disease, even with the adoption of traditional prevention strategies, such as vector control.

The first dengue epidemic associated with deaths in the Americas occurred in the 1980s, and since then, the number has accumulated over the years. Since 2007, there has been a progressive increase in the number of deaths associated with dengue in Brazil. The mortality rate rose from 0.01 per 100,000 people in 2000 to 0.4 per 100,000 people in 2010. The deaths are related to the severe form of the disease, which is dengue hemorrhagic fever, which still had a fatality rate of 12% that year, marking the highest rate recorded in this decade (Bavia et al., 2020; Paixão et al., 2015). Since 2011, there has been no decrease in the average number of cases in Brazil.

THE EPIDEMIOLOGY OF DENGUE IN BRAZIL

According to the World Health Organization (WHO), the number of dengue cases, both classic and hemorrhagic, has increased significantly in recent decades, with an average of 80 million annual notifications, 550,000 hospitalizations, and 20,000 deaths. The year 2019 stood out as the period with the highest global number of cases, affecting all regions of the world. The Americas had the highest number of notifications, with 3.1 million cases, of which more than 25,000 were classified as severe (Ministry of Health, 2009; World Health Organization, 2023).

In Brazil, the first clinical and laboratory confirmation of dengue cases occurred between 1981 and 1982, in the state of Roraima, totaling 11,000 records in which the DENV-1 and DENV-4 serotypes were identified. Since then, the country has faced successive epidemics, with a progressive increase in the number of cases. Since 1996, a seasonal pattern has been observed, with a higher risk of epidemics between October of one year and the middle of the following year, with annual incidences throughout the national territory (Ministry of Health, 2024).

In 2010, the country experienced the largest outbreak recorded to date, with 1,022,344 cases, according to data from the Notifiable Diseases Information System (SINAN) (Mi-

nistry of Health/SVSA, 2024). In subsequent years, notifications increased significantly, reaching almost 2 million cases in 2015 and maintaining an annual average of 919,836 records over the following seven years. In the absence of an effective vaccine, control strategies focused on vector elimination through awareness campaigns aimed at eradicating breeding sites and using insecticides and larvicides in endemic areas (Ministry of Health, 2024). However, the increase in numbers proved that these measures were not able to prevent new serious outbreaks of the disease. Mass immunization emerges as the best and most effective solution to break this cycle of epidemics in alarming numbers in the country.

VACCINES AGAINST VIRUSES

Until 2023, the only dengue vaccine available in the country was Dengvaxia, available only in private clinics. However, there is controversy because the efficacy and immunogenicity induced by Dengvaxia may not be sufficient in the first instance due to the variability in defense among the four serotypes, in addition to a considerable contraindicated audience (Barreto; Teixeira, 2008).

Qdenga, the second dengue vaccine to arrive in Brazil, was implemented in the public health system in 2023 and included in the National Immunization Plan (PNI) in 2024, according to the Ministry of Health, for children aged 10 to 14 years, with a vaccination schedule consisting of two doses three months apart. Brazil is the first country in the world to include the dengue vaccine in its public vaccination schedule. Currently, both dengue vaccines are available in Brazil, both in the public and private sectors, in addition to a national vaccine that is in the testing phase (Cidade de São Paulo Saúde, 2024; Da Silveira; Tura; Santos, 2019).

Dengue fever represents one of the greatest public health challenges in Brazil, with high incidence, wide geographical distribution, and significant social and economic impact. Despite government efforts focused on vector control and public awareness, the disease remains endemic, with recurring outbreaks of great magnitude, especially in tropical and subtropical regions. Technological advances in the field of immunization, with the development of vaccines such as Dengvaxia® and Qdenga®, open up new prospects for significantly reducing the burden of the disease. However, the effective incorporation of these strategies depends on adequate public policies, sustainable investments, and public awareness.

EPIDEMIOLOGICAL OVERVIEW OF DENGUE IN BRAZIL (2002–2022)

The increase in cases of arbovirus disease is directly related to the increased proliferation of the vector, the Aedes aegypti mosquito, which has a seasonal dynamic of highs related to increased temperatures, relative humidity, and rainfall, factors that contribute to an increase in the number of mosquito breeding sites – the first stages of mosquito development occur in an aquatic environment, egg, larva, and pupa. Although the highest vector density is generally observed during the rainy season, the distribution of rainfall and rainfall patterns vary in different geographical regions of the country and are not uniform throughout the national territory. In addition, the genetic complexity of the vector and the circulation of different serotypes also influence the occurrence of dengue, regardless of the climatic period—therefore, the survival of the vector does not depend exclusively on abiotic factors, and it is crucial to maintain surveillance and control of the vector throughout the year, given its ability to adapt to the human environment (Barreto; Teixeira, 2008; Viana; Ignotti, 2013).

According to data available in DATASUS's SINAN (Notifiable Diseases Information System), between 2002 and 2022, there were a total of 15,975,227 reported cases of dengue in Brazil (Ministry of Health/SVSA, 2024).

Graph 1 shows the evolution of the number of dengue cases in Brazil between 2002 and 2022, highlighting seasonal variations and significant fluctuations between regions. The analysis shows that the Southeast Region had a high number of notifications in several years, with significant peaks especially in 2010, 2013, 2016, and 2019. This pattern can be explained by high population density, intense urbanization, poor urban infrastructure in certain areas, and climatic conditions conducive to the proliferation of *Aedes aegypti*. However, the epidemiology of dengue in the country is not restricted to this region.

The graph shows alternating peaks between the other regions. The Midwest Region, for example, had significant peaks in 2013, surpassing the Southeast. This pattern suggests greater environmental and climatic vulnerability, which facilitates the maintenance and spread of the vector, even with a smaller population.

The North and Northeast regions also showed increases in the number of cases in specific years, as observed in the graph. This scenario is possibly associated with the introduction of new viral serotypes, which result in large-scale epidemics. Additionally, socioeconomic factors and limitations in basic sanitation infrastructure in these regions enhance the persistence and spread of the disease.

The South Region showed a notable increase in cases starting in 2019, reaching a significant peak in 2019 and rising again in 2022. This trend suggests an expansion of the vector's circulation area to previously less susceptible zones, a phenomenon possibly related to climate change and ecological adaptations of the mosquito.

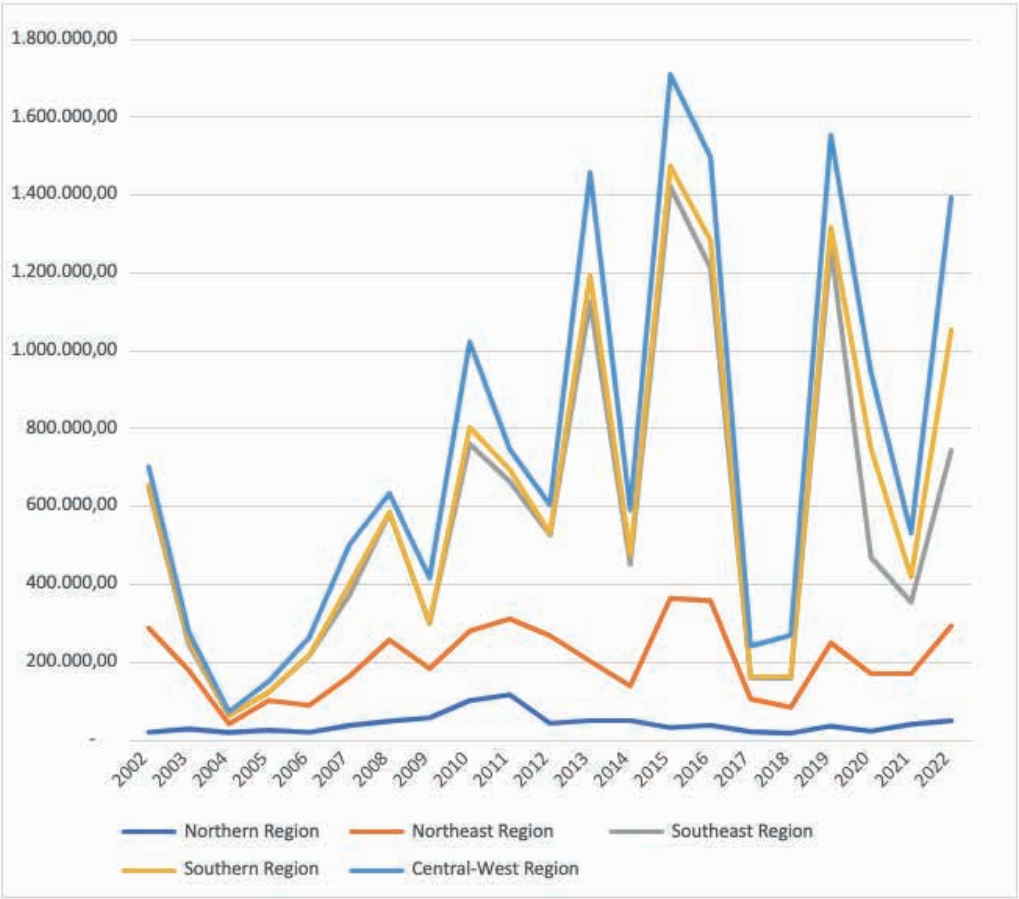
In short, the distribution of dengue in Brazil is dynamic and requires prevention and control approaches that take regional specificities into account. The development of effective strategies must integrate epidemiological surveillance, vector control, health education, and, when available, targeted population immunization, adapting to each local reality for a more effective response to the disease.

According to Paixão et al., 2015, the first dengue epidemic associated with deaths was reported in the Americas for the first time in the 1980s, and since then, the number of deaths from dengue fever has been increasing steadily. According to the same authors, half of the dengue deaths reported in the first decade of the 21st century in South America occurred in Brazil.

Graph 2 illustrates the variations in the number of probable deaths from dengue in Brazil between 2002 and 2022, highlighting distinct mortality patterns between geographic regions. The Southeast Region consistently had the highest mortality peaks throughout the period, particularly in 2015, 2019, and 2022. In 2015, the region recorded the highest peak in deaths for the entire period analyzed, suggesting that its high population density, rapid urbanization, and favorable climatic conditions contributed to a higher incidence of severe cases and deaths.

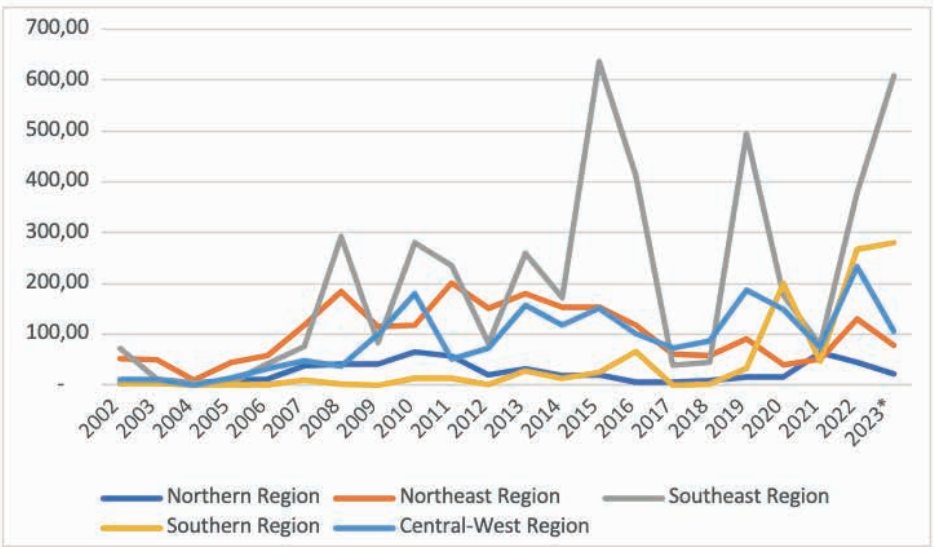
Although less populous, the Midwest region also stood out, with significant peaks in deaths in certain periods. In 2009, the region recorded a peak in deaths that exceeded that of the Southeast. This pattern may be related to the combination of a tropical climate favorable to vector reproduction and, possibly, limitations in the response capacity of health services during large-scale outbreaks.

The North and Northeast regions, in turn, recorded significant increases in the number of deaths in specific years. The pattern in the Northeast Region (orange) is particularly no-



1 Chart – NUMBER OF DENGUE CASES IN BRAZIL FROM 2002 TO 2022 BY REGION

Source: Prepared by the authors based on data provided by SINAN (Notifiable Diseases Information System), 2024.



2 Chart - NUMBER OF PROBABLE DENGUE DEATHS IN BRAZIL FROM 2002 TO 2022 BY REGION

Source: Prepared by the authors based on data provided by SINAN (Notifiable Diseases Information System) (Ministry of Health/SVSA, 2024).

table for its fluctuations, reflecting the occurrence of large-scale epidemics. This scenario may be associated with the introduction of new viral serotypes and, in general, the influence of socioeconomic factors and limitations in basic sanitation infrastructure, which increase the lethality of the disease.

The Southern Region, which historically has had low numbers of deaths, showed a notable increase starting in 2019, reaching significant peaks in 2022 and 2023. This increase suggests the expansion of the vector's circulation area to previously less affected zones, a phenomenon that is possibly related to climate and environmental changes.

Dengue mortality data in Brazil reinforce a heterogeneous pattern, influenced by a complex interaction of climatic, demographic, socioeconomic factors, and the response capacity of health services. Therefore, it is essential that control and prevention strategies be regionalized, integrating epidemiological surveillance, vector control, vaccination, and investments in health infrastructure to effectively reduce the lethality of the disease throughout the national territory.

Comparing Figures 1 and 2, peaks in deaths follow peaks in cases, as in 2015 and 2016, but not every outbreak results in a high proportion of deaths. After the peak in 2016, there was a reduction in 2017. However, in 2022, both cases and deaths began to rise again, showing that dengue remains a public health challenge.

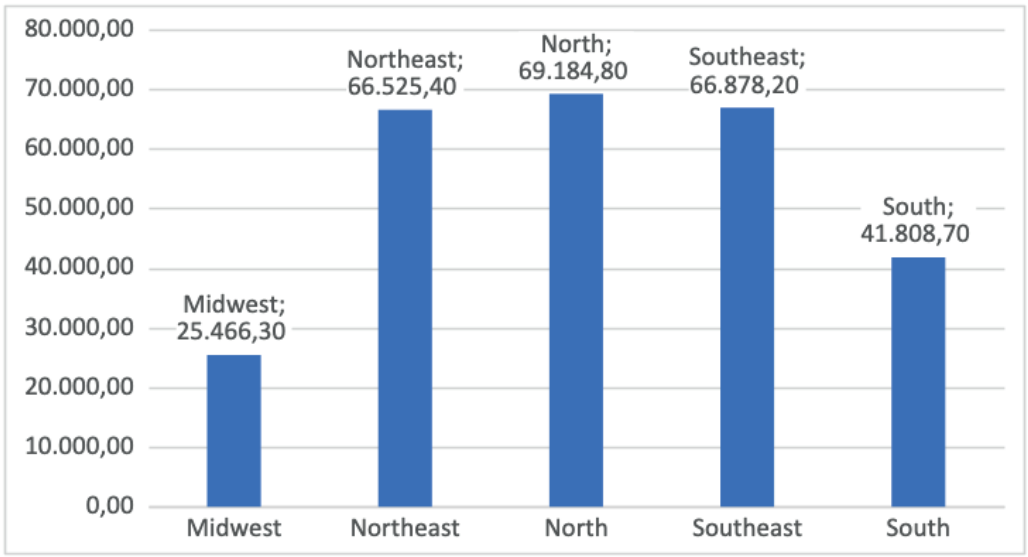
In addition, according to complementary data from the INMET report Normal Climatological Brazil 1991-2020 Monthly and Annual Accumulated Precipitation (mm) (Graph 3), during this period, the two regions were also among those with the highest accumulated precipitation, with the North reaching 69,184.80 mm and the Northeast in third place with 66,525.40, second only to the Southeast, which reached 66,878.20 mm, which is suggestively one of the main factors contributing to the development of the vector. This suggests that, even with more investment in larvicides and insecticides, other factors—such as climate, prevention campaigns, and control effectiveness—also influence outbreaks (INMET, 2022).

Graph 3 shows the total accumulated precipitation in different regions of Brazil from 1991 to 2020, allowing for a general analysis of rainfall volumes. It can be seen that the North, Southeast, and Northeast regions recorded the highest total rainfall volumes during the period. The Midwest and South regions, in turn, had the lowest accumulated rainfall volumes, with 25,466.30 mm and 41,808.70 mm, respectively.

Although the graph does not detail seasonality, the analysis of total rainfall volumes reinforces the complex relationship between climate and dengue dynamics. The high rainfall volumes in the North, Southeast, and Northeast regions, together with the particularities of their distribution throughout the year, create favorable conditions for the formation of *Aedes aegypti* breeding sites.

The Central-West Region, even with the lowest total rainfall volume, showed high incidence and mortality rates in other graphs. This suggests that the occurrence of dengue in the region is not directly related to the total volume of rainfall, but rather to its concentration in specific periods, which favor the explosion of breeding sites and the transmission of the disease.

The South Region, with the second lowest accumulated rainfall, has shown an increase in cases and deaths in recent years, as seen in the previous graphs. This trend, despite historically lower rainfall, may be associated with climate change, which has prolonged periods of high temperatures and concentrated rainfall, allowing the vector to spread to areas that were previously less susceptible. The correlation be-



3 Chart – MONTHLY AND ANNUAL ACCUMULATED PRECIPITATION IN mm IN THE REGIONS OF BRAZIL FROM 1991 TO 2020.

Source: Prepared by the authors based on data provided by INMET (National Institute of Meteorology), (INMET, 2022).

tween rainfall and the incidence of the disease reinforces the need to intensify surveillance and vector control actions, especially in areas with higher rainfall and during periods of greater epidemiological risk, adapting strategies to the climatic particularities of each region.

VACCINATION AGAINST DENGUE IN BRAZIL

According to the Ministry of Health, vaccination is one of the most important and relevant public health interventions for promoting health and controlling and eliminating vaccine-preventable diseases (Ministry of Health, 2024). There is no treatment for dengue, and since its control and prevention are based on epidemiological and laboratory surveillance and clinical management, the importance of a vaccine against the disease represents a major advance in immunization (it is a difficult vaccine to develop due to the need to encompass the four serotypes of the virus) and in controlling the spread of the disease as we have seen in recent years (City of São Paulo Health, 2024).

Brazil's National Immunization Schedule currently includes all vaccines recommended by the World Health Organization (WHO), and in March 2023, the dengue vaccine (attenuated) produced by IDT Biologika and distributed by Takeda Pharma LTDA was registered by the National Health Surveillance Agency (Anvisa), private services began to offer the vaccine while the manufacturer submitted the vaccine to the process of incorporating new technologies into the SUS. After evaluation by the National Commission for the Incorporation of Technologies (Conitec), it was approved on December 21, 2023, after all health, epidemiological, and economic criteria were met (Cidade de São Paulo Saúde, 2024). The product (VACCINE, DENGUE 1,2,3,4, ATTENUATED, INJECTABLE) according to contract No. 46/2024, was purchased for R$ 95.00 per unit in the quantity of 13,393,375 doses, which, according to the delivery schedule in the contract itself, provided for the delivery of 4,364,000 doses in 2024 and the remaining 9,029,375 in 2025. (R$ 1,272,370,625) (Ministry of Health, 2024).

According to Technical Note No. 11/2024-CGIRF/DPNI/SVSA/MS (Ministry of Health, 2024), the incorporation of the dengue vaccine was officially implemented in the National Immunization Program (PNI) on December 21, 2023 (Ministry of Health, 2024a). In this scenario, the recommendations of the World Health Organization (WHO), Pan American Health Organization (PAHO), and Technical Advisory Committee on Immunization (CTAI) were for children and adolescents aged 6 to 16 years living in environments with a high dengue burden and high level of transmission. In Brazil, it was decided in a tripartite discussion between the Ministry of Health, the National Council of State Health Secretaries (CONASS), and the National Council of Municipal Health Secretaries (CONASEMS) that the initial vaccination coverage would include people aged 10 to 14 years (initially with the first doses of for 10- and 11-year-olds due to the limited number of doses). according to the history of hospitalizations over the last 5 years, there would also be an analysis based on criteria for the distribution of doses by region, due to the limited number of doses and the production and delivery capacity of the responsible laboratory (Cidade de São Paulo Saúde, 2024). The first partial shipment of vaccines distributed as part of the dengue vaccination strategy consisted of 712,184 doses sent to the cities listed in the Technical Note. The recommended vaccination schedule consists of two doses, with a three-month interval between doses (Cidade de São Paulo Saúde, 2024).

Table 1 provides a detailed overview of the dengue immunization strategy in Brazil, showing the number of vaccine doses distributed per shipment until June 2024. The data highlight the Ministry of Health's efforts to operationalize vaccination in an epidemic scenario, with a total of 3,634,311 doses distributed in a period of a few months.

Analysis by shipment reveals the progressive nature of the vaccination campaign. The first shipments, such as the 1st and 2nd, had a more modest volume of doses distributed. However, the strategy intensified significantly with subsequent shipments. The 4th and 5th shipments, for example, recorded substantially higher volumes, with almost 1 million doses each. This increase in distribution suggests an acceleration of the campaign, possibly in response to the severity of the epidemiological situation and the growing availability of the vaccine. The mention of technical notes (No. 11/2024, No. 14/2024, etc.) reinforces that distribution was carried out in a controlled and coordinated manner, following technical guidelines and criteria to ensure the prioritization of groups and regions.

Although the total number of doses distributed is significant, its relevance for controlling the epidemic depends on its effective application. For vaccination to have a real impact on reducing mortality and severe cases, it is important that the doses reach the target population and that high vaccination coverage is achieved. The vaccine, which is administered in two doses, requires a logistical and communication effort to ensure that people return for the second dose.

Shipping	Technical note	Dosage
1	No. 11/2024-CGIRF/ DPNI/SVSA/MS	712,184
2	No. 14/2024-CGIRF/ DPNI/SVSA/MS	523,052
3	No. 39/2024-CGIRF/ DPNI/SVSA/MS	421,155
4	No. 47/2024-CGIRF/ DPNI/SVSA/MS	986,548
5	No. 81/2024-CGIRF/ DPNI/SVSA/MS	991,372

Table1 - Number of doses distributed per shipment according to the dengue vaccination operationalization strategy through June 2024.

Source: (Ministry of Health, 2024).

According to PAHO, QDENGA® (TAK-003) has been shown to be effective in endemic countries in preventing symptomatic dengue fever and hospitalization in children aged 4 to 16 who were previously infected with the four serotypes, as well as virologically confirmed dengue and hospitalization with serotypes 1 and 2 in seronegative children (PAHO, 2024). The vaccine has not been shown to be effective in children who have not been previously infected against symptomatic dengue, hospitalization, dengue hemorrhagic fever, or severe dengue when the infection was caused by serotypes 3 and 4, and it cannot be ruled out that the vaccine may have intensified the fever infection (Da Silveira et al., 2019).

Based on the information available to date, the dengue vaccine appears to be well tolerated, with most local and systemic reactions ranging from mild to moderate in intensity and resolving within one to three days after vaccination (Cidade de São Paulo Saúde, 2024). However, there remain significant gaps in knowledge regarding the safety and efficacy of this vaccine against dengue viruses types 3 and 4 in seronegative reference individuals (PAHO, 2024).

PUBLIC INVESTMENTS IN DENGUE CONTROL

Understanding the need to contain the reproduction and spread of dengue fever, the government continues to take action to combat dengue, focusing on measures against the mosquito vector through the use of insecticides (larvicides and adulticides) that prevent the *Aedes aegypti* life cycle from completing (Assis Mendonça; Souza; Dutra, 2009; City of São Paulo Health, 2024).

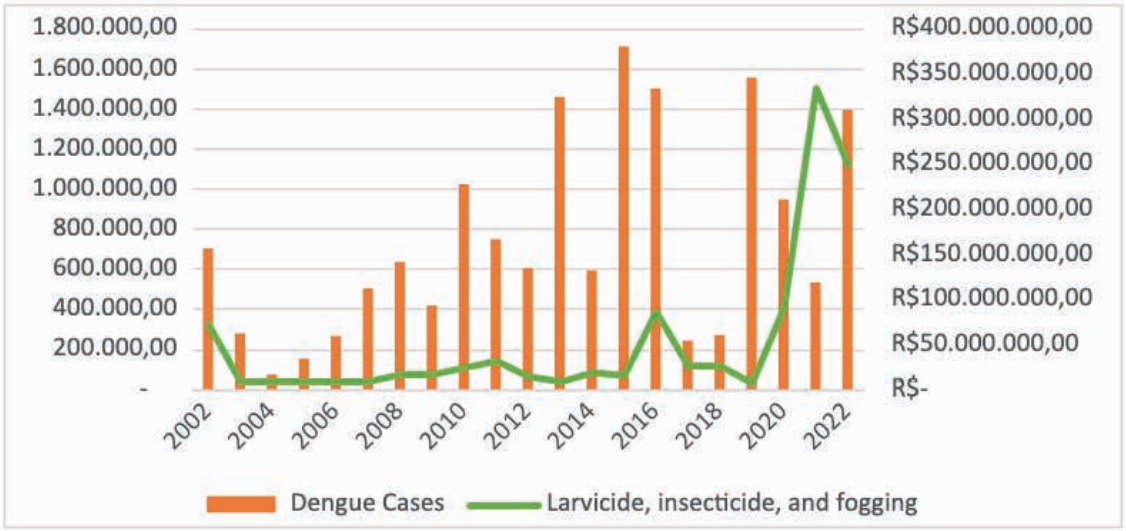
In terms of government spending, over 20 years (2002-2022), R$ 1,086,052,787.82 was invested in chemical and biological insecticides, excluding materials and accessories secondary to the application of these substances.

Graph 4 presents an overlap of data that correlates the number of dengue cases in Brazil and spending on insecticides, both chemical and biological, between 2002 and 2022. Visual analysis of the graph suggests that, for most of the period, the relationship between the two variables is not one of immediate cause and effect, but rather one of response and reaction.

Peaks in the number of dengue cases are clearly visible in years of major epidemics, such as 2010, 2013, 2015, and 2019. In contrast, spending on insecticides, represented by the green line, fluctuates over time. An observation is that the largest investments in insecticides often occur shortly after, or during, peaks in cases, suggesting that spending is a reactive measure to combat outbreaks that are already established. For example, after the record number of cases in 2015, spending on insecticides increased significantly in 2016. Similarly, after the peak in 2019, investment rose significantly in 2021, reaching the highest value for the period analyzed.

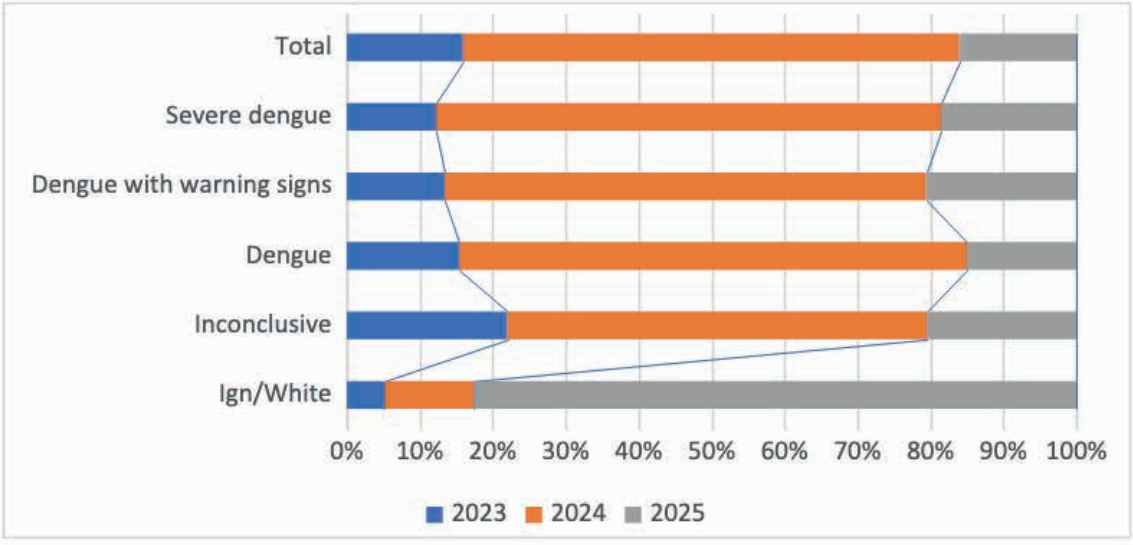
This time lag raises questions about the isolated effectiveness of chemical and biological control. The absence of an immediate and consistent inverse correlation can be attributed to several factors. The complexity of the disease goes far beyond vector control by insecticides, being influenced by variables such as population density, climatic conditions, viral circulation, and sanitation infrastructure. In addition, the intensive use of insecticides can lead to resistance of *the Aedes aegypti* mosquito to chemicals, making applications less effective over time.

Graph 4 indicates that there is no clear relationship between spending and the number of cases, as even with a significant increase in investments since 2020, cases have not decreased consistently. In 2022, it can be seen that, despite high spending, the number of cases has grown again. This suggests that dengue control requires more than just vector prophylaxis, demanding more effective prevention strategies.



Graph 4 - Dengue cases and spending on chemical and biological insecticides between 2002 and 2022

Source: Prepared by the authors based on data provided by SINAN (Ministry of Health/SVSA, 2024) and based on data provided by the Ministry of Health via Fala.Br (Protocol 25072.023878/2024-86) on May 20, 2024.



Graph 5 - NUMBER OF DENGUE CASES IN BRAZIL FROM 2023 TO 2025 BY CLASSIFICATION

Source: Prepared by the authors based on data provided by SINAN (Notifiable Diseases Information System), (Ministry of Health/SVSA, 2025). *Partial results for 2025.

The purchase of vaccines cost R$ 1,272,370,625 in stock planned for two years (2024 and 2025), indicating the government's large investment in this measure (Ministry of Health, 2024a, 2024).

Graph 5 illustrates the percentage distribution of dengue cases in Brazil from 2023 to 2025, according to their clinical classification. The analysis reveals the composition of the epidemic in terms of severity and the quality of surveillance data recording. The graph also highlights the presence of a portion of more severe cases. The categories "Dengue with warning signs" and "Severe dengue" represent a considerable portion of notifications, indicating that the lethality of the disease remains a central concern for the health system. The existence of these more severe cases reinforces the ongoing need for an efficient screening system and adequate clinical management to prevent disease progression and deaths.

In 2024, there was a significant increase in dengue cases compared to previous years, with 6,428,981 cases reported in Brazil according to SINAN, with 6,321 confirmed deaths from dengue, according to Graph 5. This year stood out in terms of cases compared to the previous year. However, according to the Ministry of Health, in the first two months of 2025, Brazil recorded a 69.25% reduction in dengue cases compared to 2024. The increased organization and coordinated movement of agencies, such as the creation of the Public Health Emergency Operations Center for Dengue and Other Arboviruses, may have played a key role in this context (Ministry of Health, 2025a).

On January 8, 2025, Ordinance GM/MS No. 6,531, dated January 8, 2025, established the Public Health Emergency Operations Center for Dengue and Other Arboviruses (COE Dengue), which was established "for the purpose of acting as a forum for articulation and coordination of the national response to public health emergencies related to arboviruses," with actions aimed at raising public awareness about dengue control and mobilizing schools, disseminating epidemiological data, strategic planning in partnership with the National Institute of Health ( ) and regulatory agencies, and supporting vaccination against dengue, including a partnership to provide 60 million doses annually starting in 2026 (Ministry of Health, 2025).

Table 2 shows the number of doses of dengue vaccine administered by the Unified Health System (SUS) in Brazil between 2024 and 2025. The data, even though partial for 2025, allow for an analysis of the pace of vaccination and the immunization effort of the population. An immediate analysis of the table reveals a total of 6,564,023 doses administered during the period, an important milestone for the dengue vaccination campaign in the country. The number of doses administered in 2024 was 4,020,626, reflecting the start and consolidation of the large-scale immunization strategy. In 2025, the number of doses administered through August was 2,543,397. Although this figure is lower than the total for 2024, it is crucial to note that the 2025 data is partial, and the campaign was still ongoing at the time of collection.

Year	Doses administered
2024	4,020,626
2025	2,543,397
	6,564,023

Table2 - Number of doses of the dengue vaccine (attenuated) administered by the Unified Health System between 2024 and 2025

Source: Ministry of Health - National Vaccination Calendar (Ministry of Health, 2025b). *Partial results for 2025. Accessed on 08/05/2025

The comparison between the two years suggests continuity in the vaccination effort. The high number of doses administered in 2024 demonstrates the SUS's capacity to ope-

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rationalize and distribute the vaccine to priority groups. The continuity in 2025, even with partial numbers, indicates that vaccination has become a permanent tool in the arsenal to combat dengue, following the guidelines of the Ministry of Health.

The importance of these numbers goes beyond simply counting doses. Each dose administered represents a step forward in protecting the population against severe cases and the lethality of the disease. Targeted vaccination, as adopted in Brazil, aims to reduce the burden of disease in areas of high incidence and in groups at higher risk. The success of this strategy is not limited to the number of doses administered, but also to its ability to achieve the vaccination coverage necessary to generate a significant epidemiological impact.

According to the 2024 Dengue Vaccination Strategy of the CVE/CCD/SES-SP Immunization Division, vaccination coverage has remained low since the beginning of the program. The distribution of 6.4 million doses of the dengue vaccine (attenuated) was planned to begin vaccination of the target population in 2024, with a target of 90% coverage (City of São Paulo Health, 2024). There is still no data linking dengue immunization and a decrease or not in hospitalizations due to the disease. It is necessary to expand vaccination coverage and for regulatory agencies to promote the attenuated vaccine so that the population will have greater adherence to the campaign.

CONCLUSIONS

Dengue remains one of the main public health challenges in Brazil, with high morbidity and mortality rates and economic and social impact. Despite vector control efforts, these measures have proven insufficient, making vaccination an essential and promising strategy. The introduction of the Qdenga attenuated vaccine into the National Immunization Program marks a historic advance, but vaccination coverage is still low, reflecting a lack of information, mistrust regarding safety, and ignorance about its availability in the SUS. Success in combating dengue requires an integrated approach that combines vaccination, epidemiological surveillance, environmental control, social mobilization, and health education. In addition, gaps remain regarding the vaccine's effectiveness in specific groups and in the face of the circulation of the four serotypes, which requires continuous monitoring and the production of real-life data. Thus, vaccination should be understood as a central tool, but one that is linked to public policies supported by scientific evidence and to strengthening communication with the population, in order to increase adherence and consistently reduce the incidence, deaths, and costs of the disease in Brazil.

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