2024 International Virtual Science Symposium

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School: Minas Gerais Science Club

1.TITLE

"The strong El Niño tells the story of arbovirus epidemics in Brazil and in the carioca capital."

Figure 1.: *The relationship between mosquito outbreak and El Niño.*

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2. ABSTRACT

During Brazilian summers, there is traditionally concern about arboviruses. However, in the last years of the past decade, specifically during the periods of 2015/2016 and 2023/2024, this concern was exacerbated by the strong El Niño phenomenon. The interaction between rising temperatures and the occurrence of intense rainfall, typical characteristics of El Niño, contribute to heightened activity of *Aedes aegypti*, the vector of arboviruses, which tends to seek more human blood in environments with higher temperatures. The possibility of an epidemic becomes even more alarming in these El Niño conditions, exacerbating concerns about public health.

The goal of this study is to conduct a review of data and literature on arboviruses and their occurrences in Brazil over the last decade, focusing on epidemics of dengue, Zika, and chikungunya, and their correlation with periods of strong El Niño occurred in 2015/2016 and 2023/2024. The research investigates how climatic changes (increased rainfall and heat) during strong El Niño affect the role of the *Aedes aegypti* mosquito, the main vector of arboviruses in Brazil. Additionally, it analyzes the relationship between arbovirus epidemics and socio-environmental factors such as urbanization, population density, and sanitation conditions, as the mosquito is urban and lives inside human households.

The methodology employed focused on analyzing the major arbovirus epidemics documented in Brazil, particularly in Rio de Janeiro, over the past decade, alongside an examination of the incidence of the strong El Niño climatic phenomenon. This research utilized data sourced from various repositories, including GLOBE, GLOBE Observer, the Global Mosquito Observations Dashboard (mosquitodashboard.org), epidemiological bulletins from Rio de Janeiro, Ministry of Health reports, and the LIRAA (Rapid Index Survey for *Aedes aegypti*), IBGE, INMET, CLIMATEMPO, NOAA and others.

Our analysis has shown that several vulnerabilities make Brazil, with a focus on Rio de Janeiro city, particularly susceptible to the multifaceted impacts of climate change. Notably, outbreaks of arboviruses such as the Zika and Dengue fever epidemic in 2015/2016 and the Dengue fever outbreak in 2023/2024 in Brazil have been partially attributed to the prevailing of strong El Niño conditions during those years. *Aedes aegypti*, as the primary vector of Zika and dengue, exhibits a preference for hot and humid climates as arose in extreme events during strong El Niño.

Our conclusions indicate that extreme events associated with the strong El Niño phenomenon, as experienced in 2015/2016 and 2023/2024, contribute to heightened infestations of *Aedes aegypti* and the epidemic of dengue cases in Brazil. *Aedes aegypti* exhibits increased reproduction rates and longevity in higher temperatures, leading to amplified proliferation, as evidenced by the collected data.

Keywords: *Aedes aegypti*, arboviruses, epidemics, strong El Niño, climate change.

3. INTRODUCTION

Figure 2.: *Mosquito outbreak in the world. Source: encontroudetudo.app.br*

Arboviruses are diseases caused by viruses primarily transmitted by mosquitoes, with the female *Aedes aegypti* mosquito species being the predominant agent. This group of diseases includes urban yellow fever, dengue, chikungunya, Zika virus, among others, and has raised significant concern in the realm of global public health. *Aedes aegypti* is a predominantly cosmopolitan insect, found in tropical and subtropical regions worldwide.

Brazil represents a country with optimal environmental conditions for the permanence and dissemination of vector mosquitoes, such as *Aedes aegypti*. Brazil has a tropical climate characterized by regularly distributed rainfall throughout the year, with moderate levels in winter and high levels in summer. Thus, in Brazilian regions where heat prevails for most of the year and there are frequent rains, conditions are favorable for the proliferation of *Aedes aegypti*, the arboviruses' vector.

The introduction of *Aedes aegypti* to Brazil dates back to the colonial period, presumably during the slave trade, through maritime transportation. This mosquito is often associated with domestic environments, although it has also been identified in rural areas, where it lodges in containers containing eggs or larvae.

In recent years, the incidence of diseases caused by arboviruses has shown a relevant global increase, which is correlated to factors such as faster and more geographically extensive dispersion of viruses due to the intensive growth of global transportation systems, adaptation of vectors to increasing urbanization, inability to contain the mosquito population, and changes in environmental factors.

In addition to the factors favoring the spread of diseases mentioned, global warming contributes to the more frequent occurrence of climatic phenomena such as El Niño and La Niña, leading to increased rainfall and heatwaves, thereby disrupting the climate worldwide and the mosquito proliferation.

Epidemics refer to a significant increase in the number of cases of a specific disease in a particular geographic area and during a specific period of time. They can occur anywhere in the world and affect populations of different sizes, from local communities to entire populations.

DENGUE, ZIKA, AND CHIKUNGUNYA

Vector-borne diseases cause approximately 700,000 deaths annually worldwide and account for about 17% of the global burden of all infectious diseases. Mosquitoes are the primary vectors, transmitting a variety of diseases such as malaria, dengue, yellow fever, Zika, chikungunya, Japanese encephalitis, and West Nile fever (WHO, 2017b). Diseases transmitted by mosquitoes of the *Aedes* genus are commonly referred to as arboviruses, among which dengue virus (DENV), Zika virus (ZIKV), and chikungunya virus (CHIKV) stand out, responsible for major epidemics in tropical and subtropical countries worldwide (GOULD et al., 2017).

DENGUE

Dengue exhibits endemicity within the borders of Brazil, indicating its consistent occurrence on an annual basis, typically manifesting during the wet season characterized by elevated population densities of *Aedes* mosquitoes and optimal precipitation levels conducive to their breeding. Inhabitants serve as facilitators for mosquito proliferation not solely through blood meals but also by inadvertently providing suitable water-holding containers for egg deposition.

Moreover, Brazil faces periodic susceptibility to epidemic outbreaks of dengue, denoting instances of rapid transmission affecting a considerable portion of the population within a compressed timeframe. Such outbreaks necessitate the confluence of abundant vector mosquitoes and a sizable contingent of individuals lacking immunity against one or more of the four serotypes of the virus. As evidenced by the reported accumulation of over 10 million dengue cases in Brazil until the year 2024, the nation presently holds the unenviable distinction of harboring the highest incidence rate of this disease globally.

CLIMATIC PHENOMENA

El Niño and La Niña are climatic phenomena that occur periodically in the Equatorial Pacific Ocean and have significant impacts on global weather patterns. El Niño is characterized by abnormal warming of surface waters in the Equatorial Pacific Ocean, leading to changes in atmospheric circulation and precipitation patterns worldwide. These changes can result in drought conditions in some regions and flooding in others, affecting agriculture, fishing, vector proliferation, and climate in distant areas of the Pacific.

On the other hand, La Niña is the opposite of El Niño, characterized by abnormal cooling of surface waters in the Equatorial Pacific. This also leads to changes in atmospheric circulation and precipitation patterns, often resulting in extreme weather conditions such as severe droughts or heavy rains, depending on the affected region. Both phenomena have significant impacts on agriculture, water resources, public health, and the global economy, and are closely monitored by meteorologists and scientists to predict and mitigate their adverse effects.

4. RESEARCH QUESTION AND HYPOTHESIS

QUESTION

" Does the occurrence of strong El Niño events in the last decade influence arbovirus epidemics in Brazil?"

HYPOTHESIS

Because strong El Niño events in the last decade are associated with extreme weather events in regions of Brazil, leading to changes in temperature and precipitation patterns, they can create favorable conditions for increased mosquito proliferation, such as the *Aedes aegypti*, responsible for transmitting arboviruses and causes epidemic outbreaks.

Figure 4: *Comic trip from Minas Gerais Science Club student*

5. MATERIALS AND METHODS

The methodology employed in this study focused on analyzing the data collected from mosquito traps in schools in Minas Gerais (visualized on the GLOBE platform) to verify that the major arbovirus epidemics documented in Brazil, especially in Rio de Janeiro, over the past decade are related to the incidence of the strong El Niño climatic phenomenon. This research utilized data from various sources, including GLOBE, GLOBE Observer, the Global Mosquito Observations Dashboard (mosquitodashboard.org), epidemiological bulletins from Rio de

Janeiro, Ministry of Health reports, LIRAa (Rapid Index Survey for *Aedes aegypti*) IBGE, INMET and others.

STUDY AREA

Rio de Janeiro, the city where Minas Gerais Science Club is located has a latitude of 22°57'S, and a longitude of 43°11'W. The capital of the state has an estimated population of 6.748 million inhabitants, and is considered a megalopolis, a city primarily for housing, commerce and tourism, and is located between the mountains and the Atlantic Ocean.

Rio de Janeiro is part of the Southeast Region of Brazil, inserted in the Atlantic Forest biome, which is the most endangered forest in the country, with only 12.5% of its area preserved. The climate of the city is predominantly humid tropical, influenced by the moist air masses coming from the Atlantic Ocean. Its average temperatures and air humidity are high throughout the year and the rains are regular and well distributed.

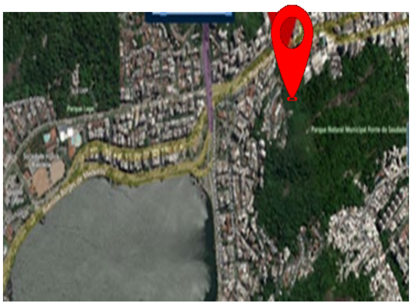


Figure 6.: *Study area, in Rio de Janeiro – Humaitá. Source: Google Earth*

DATA COLLECTION

Figure 7. Captive traps (transparent 1,5 L PET bottle traps filled with fish food)

The data collection research utilized data collected from experiments conducted in two different locations: the Minas Gerais School and the meeting place of the Science Club, both situated in the city of Rio de Janeiro. Traps were installed to capture the *Aedes aegypti* mosquito, the female of which is the main transmitter of diseases such as Dengue, Chikungunya, and Zika. Additionally, precipitation and temperature data were collected. These traps were monitored once a month, and the net of traps was installed to cover the entire length of the school and the science club area. Temperature and precipitation data were collected every five days, but the research utilized monthly data. Mosquito Habitat application, the GLOBE website, and Official data sources were used for data visualization and tables, which included monthly rainfall (mm) and temperature (°C) data collected from the Alerta Rio system Ministry of Health reports, and the LIRAa (Rapid Index Survey for *Aedes aegypti*) and devices located at the school.

After the data collection phase, an analysis and interpretation of the results were carried out through comparative graphs, spreadsheets, and research on websites such as FIOCRUZ and NASA, as well as disease incidence reports from the Municipal Health Department.

The research was conducted using data collected from December 2015 to February 2016 and from December 2023 to February 2024 (during the Strong El Niño cycle) which was obtained from our previous projects and stored on the GLOBE data platform.

A total of 198 data collections were conducted using information stored on the GLOBE platform (temperature, precipitation, and mosquito habitat). This meticulous data collection process was essential for establishing correlations between arboviruses, epidemics, and strong El Niño events.

EL NIÑO 2015/2016

Generally, in Brazil, one of the main effects of El Niño tends to be a drier climate in the North and Northeast, causing droughts, and rain in the South region, enabling the emergence of floods. In the Central-South and Southeast, El Niño typically causes warmer weather, which can lead to increased precipitation and heat.

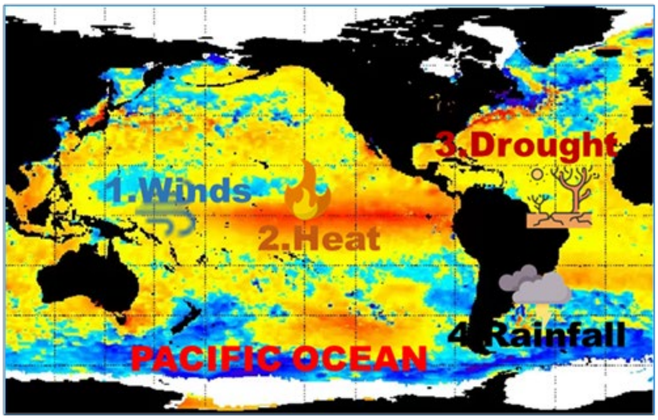


Figure 8. Effects of El Niño in Brazil

1. The increase in temperature in the Tropical Pacific Ocean occurs when trade winds – which blow from east to west in the tropical region – become weaker and are unable to push hot water, which has been heated by the sun's rays.
2. The slowdown in winds causes surface waters in the Pacific Ocean to overheat.
3 and 4. Overheating of water and weak winds alter air circulation in the atmosphere and the distribution of rainfall, causing temporary droughts in the Tropical Region.
Source: Registration of the Satellite Image Analysis and Processing Laboratory (Lapis)

In a statement, NASA (the American Space Agency) compared the 2015-2016 El Niño to previous episodes of strong activity of the phenomenon in 1982-1983 and 1997-1998, considered the most impactful of the last century. This parallel was confirmed, with the peak of El Niño occurring in December 2015, leading to extreme events such as a significant increase in rainfall and temperatures.

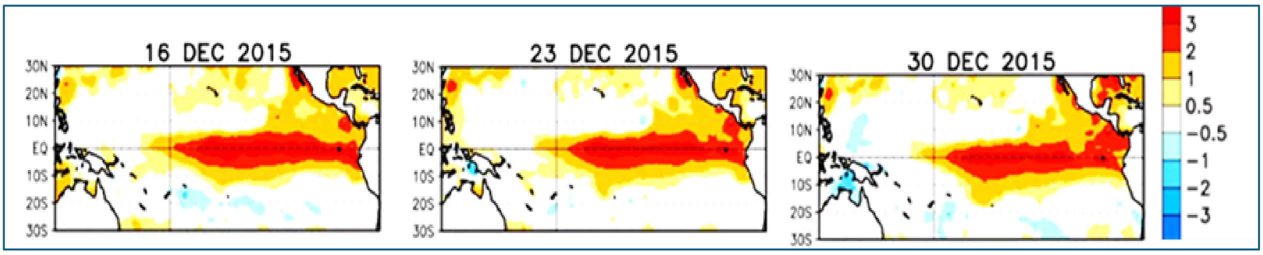


Figure 9.: The *peak of El Niño occurring in December 2015. Source: NOAA/CLIMATEMPO*

However, throughout 2016, there was a general reduction in rainfall levels across Brazil, with variations observed regionally. Data obtained from INMET meteorological stations indicated that the strong El Niño event (2015/2016) exacerbated drought conditions in the Northeast, while also causing prolonged dry spells in the North and central-north regions of the country. Nevertheless, there were numerous instances of flooding in the South and Southeast, characterized by landslides and inundations, exacerbated by elevated temperatures.

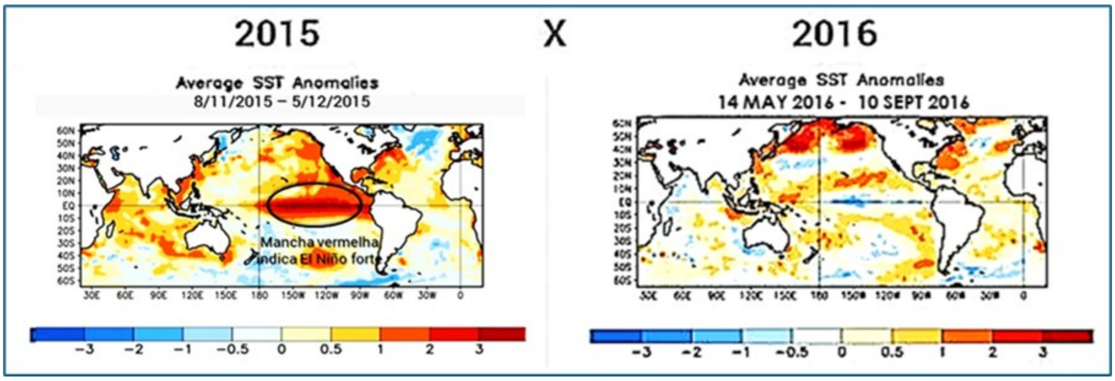


Figure 10.: *The shades of red represent a positive anomaly, when sea water is above normal (El Niño). The blue tones represent a negative anomaly when sea water is below normal (La Niña). Source: NOAA/CLIMATEMPO*

The intensity of the phenomenon began to wane in May 2016, attributed to the negative anomaly of Sea Surface Temperature (SST) in the Central Equatorial Pacific, persisting in a neutral condition from June to December.

DATA SUMMARY AND ANALYSIS STRONG EL NIÑO AND ARBOVIRUSES EPIDEMIC 2015/2016 – BRAZIL

With the approach of summer and in a year marked by El Niño, attention to climate forecasts has intensified. The 2015/2016 phenomenon, considered one of the strongest of all time, has been identified as the primary influencer of weather patterns in South America, potentially resulting in frequent rainfall and flooding in parts of Brazil during this season.

Figure 11.: The impact of the climatic phenomenon El Niño (2015/2016) in Brazil. Source: cdn.noticiasagricolas.com.br

Frequent storm systems have led to multiple episodes of flooding in important regions of southern Brazil during the spring months, and this pattern was expected to persist throughout the summer. The accumulated volume of rainfall has exceeded the average by 100 to 250% for the period between August and mid-October. On the other hand, in other areas, less frequent and irregular rainfall, as observed in the Central region of Brazil during this spring, may have offered little or no relief to areas already affected by drought in the country. For most of Brazil, temperatures were higher, particularly in the Central region (figure 1b). In the South, temperatures were slightly lower.

During the strong El Niño event of 2015/2016, there were various impacts on weather patterns, temperatures, and ecological conditions, which affected mosquito larvae populations. Here's a general overview of what typically happened during the El Niño event and how it might relate to mosquito larvae.

The significant increase in the number of dengue, Zika, and Chikungunya cases in Brazil may be related to favorable climatic conditions. During periods of strong El Niño, extreme weather changes can occur, with temperatures and rainfall patterns creating conducive environments for the proliferation of the *Aedes aegypti* mosquito and the spread of these diseases (figure 12e; 1d). This phenomenon may have contributed to the rise in cases, especially in regions like Rio de Janeiro state, where significant occurrences of Zika and Chikungunya have been observed, as highlighted in figure 12e.

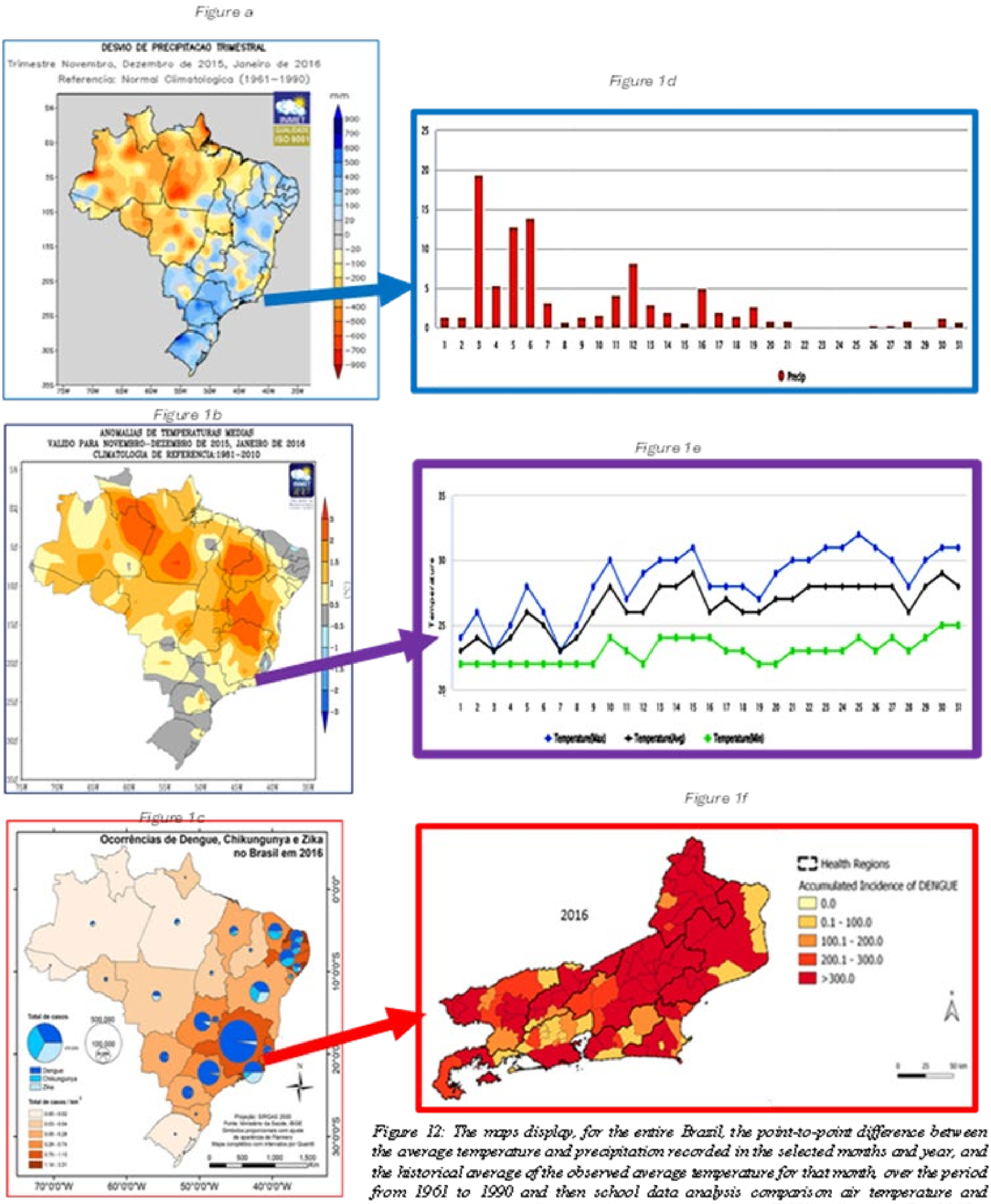


Figure 12: The maps display, for the entire Brazil, the point-to-point difference between the average temperature and precipitation recorded in the selected months and year, and the historical average of the observed average temperature for that month, over the period from 1961 to 1990 and then school data analysis comparison air temperature and precipitation, mosquito larvae and time projecting strong El Niño effect from Dec 2015 to November 2016 from study area collect data. Source: https://portal.inmet.gov.br/and and

The spread of Dengue, Zika, and Chikungunya in Brazil 2015/2016.

Diseases transmitted by the *Aedes aegypti* mosquito have become a major public health problem worldwide, with dengue being the most significant in the Americas. In Brazil, these urban diseases are part of a complex epidemiological scenario, with all four serotypes of the dengue virus circulating simultaneously, along with the Chikungunya virus (CHIKV) since 2014 and the Zika virus (ZIKV) since 2015. Despite efforts by the three levels of the Unified Health System (SUS), explosive epidemics of arboviruses and, mainly, dengue have become increasingly common, especially in large urban centers.

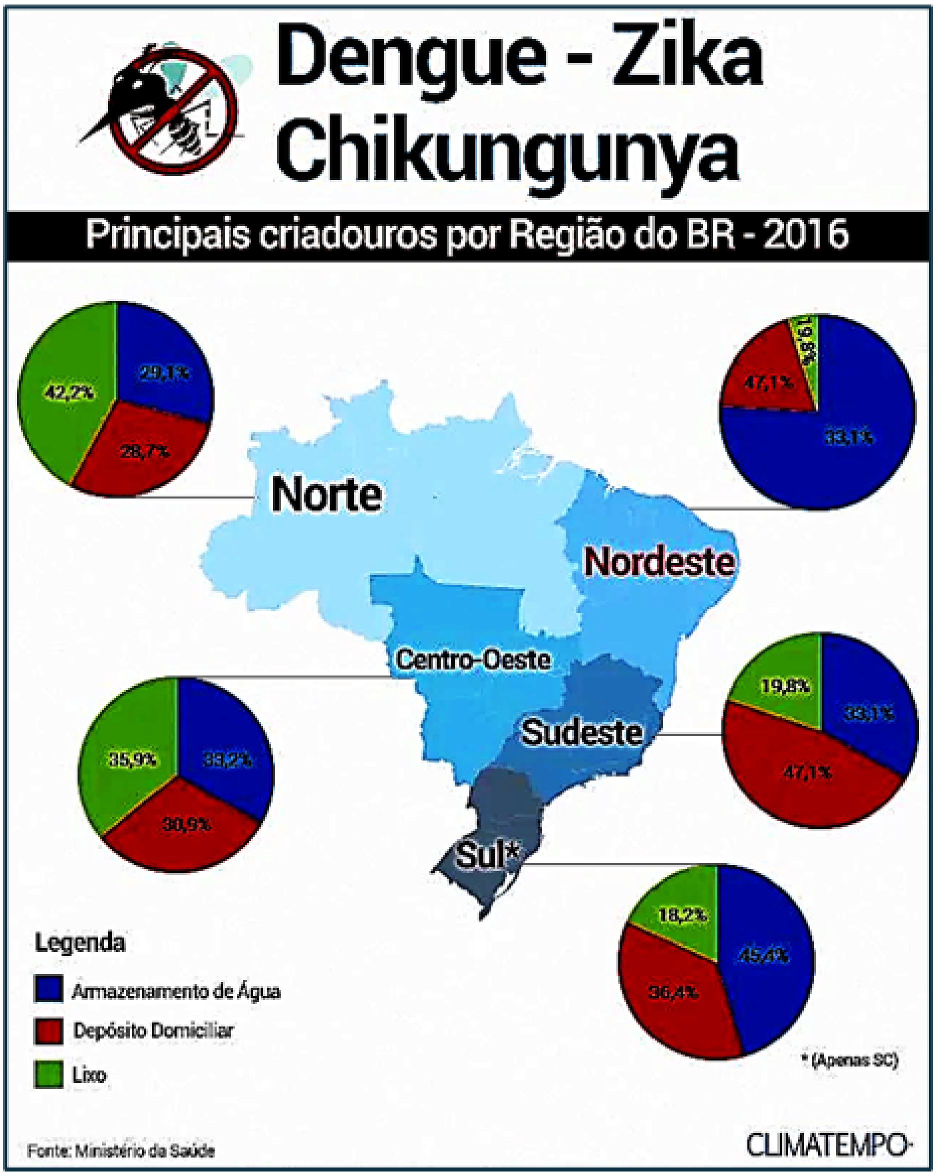


Figure 13: Mosquito breeding sites 2016.
Source: Ministério da saúde/Climatempo

But where are the mosquito breeding sites in Brazil regions? Health agents regularly visit residents and obtain a sample of the municipality. With this methodology, it is possible to know the percentage of Aedes in neighborhoods and the types of containers that are generating mosquito breeding sites. In the mapping of the 2016 LIRAa, the Northeast Region appeared prominently in first place with a large number of *Aedes aegypti* breeding sites due to inadequate water storage. In the North, the greatest focus of mosquito larvae comes from accumulated garbage. Below are the main breeding sites of *Aedes aegypti* separated by Region in Brazil (figure 14).

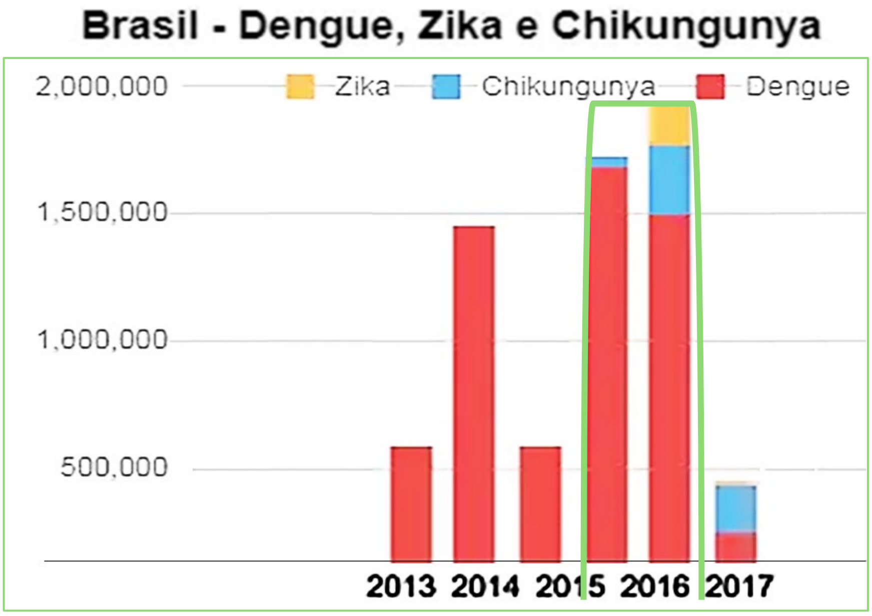


Figure 14: Notified Dengue cases in Brazil, from 2008 to 2017.Source: https://bvsms.saude.gov.br/bvs/publicacoes/health_brazil_2015_2016.pdf.

Arboviroses in Rio de Janeiro

Rio de Janeiro has the highest number of reported dengue cases in Brazil. The capital, Rio de Janeiro city, serves as a significant hub for the spread of DENV and other arboviruses across the country. Dengue outbreaks, caused by various serotypes, have occurred since 1986, with DENV-3 causing a notable epidemic in 2001. The state also experienced severe epidemics in 2007-2008. All four dengue serotypes currently circulate in Rio de Janeiro. Zika and chikungunya epidemics were detected in the city in 2015 and 2016, respectively.

The graphical representation of arbovirus incidence in Rio de Janeiro (Figure 15) reveals a significant increase during the peak of the strong El Niño phenomenon, especially in December 2015 and the first two months of 2016, characterizing periods of epidemic as defined by the Rio de Janeiro Municipal Health Secretariat (SMS), where the number of cases exceeded the metric considering an average of 500 cases per 100,000 inhabitants.

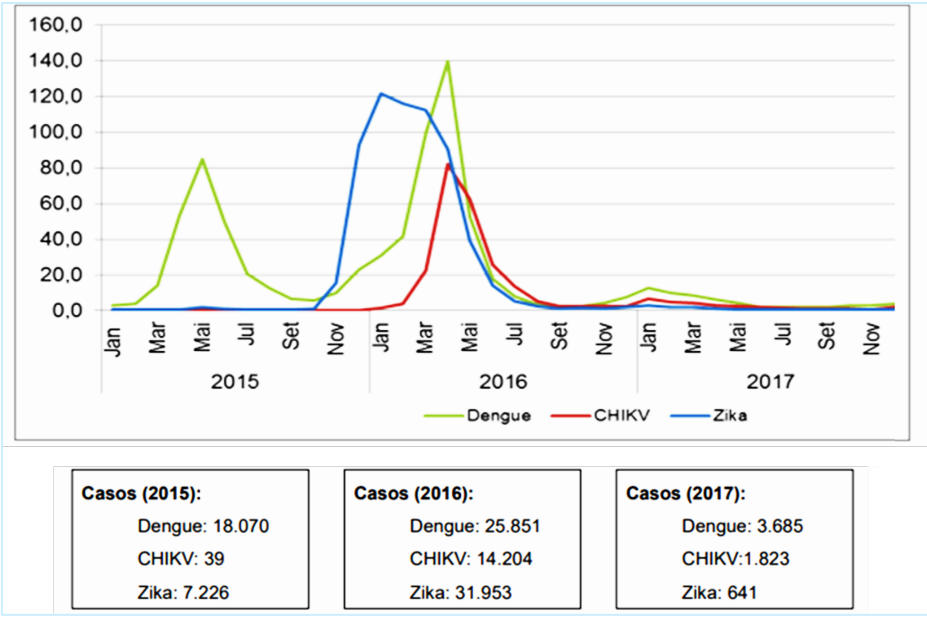


Figure 15 - Incidence rate of notified suspected cases of dengue, chikungunya, and Zika, by month of symptom onset, State of Rio de Janeiro, years 2015, 2016, and 2017.

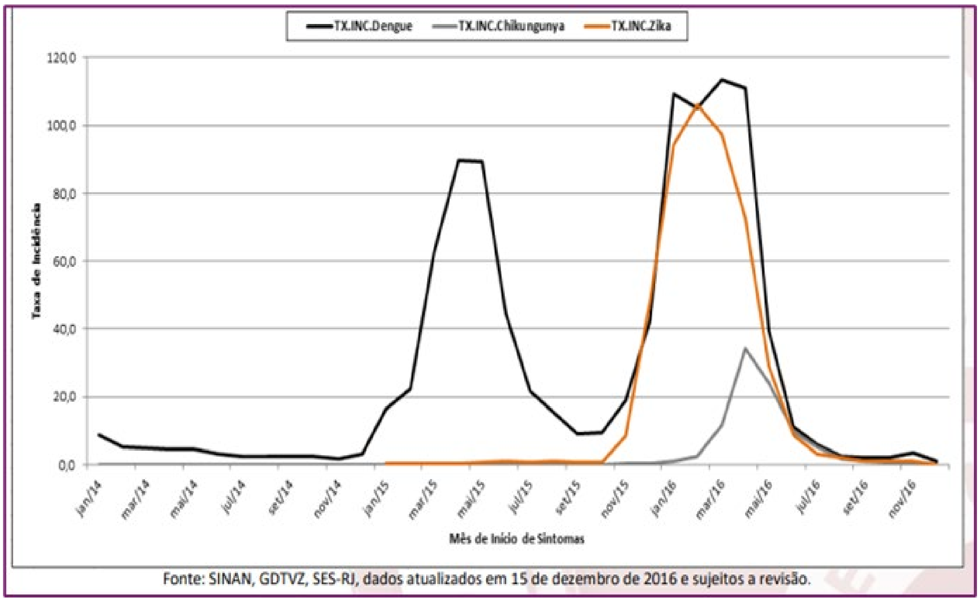


Figure 16 - Incidence rate of notified suspected cases of dengue, chikungunya, and Zika, by month of symptom onset, State of Rio de Janeiro, years 2014, 2015, and 2016. Source: Ministerio da Saúde do Brasil.

The figure 16 illustrates the monthly incidence rates of three arboviruses in Rio de Janeiro, reflecting the emergence of Chikungunya in 2014 and Zika in 2015. While Dengue and Zika exhibit similar patterns in 2016, Chikungunya shows a distinct peak between April and May of that year, followed by a downward trend. This pattern persisted into 2017.

In Rio de Janeiro state, Dengue, Chikungunya, and Zika circulated simultaneously in 2015 and 2016, posing diagnostic challenges due to their similar clinical presentations. Healthcare professionals must consider these diseases when assessing patients with similar symptoms and employ specific laboratory tests for accurate diagnosis and management.

Figure 17 - outlines the main clinical symptoms of CHIKV, DENV, and ZIKV Source: Ministerio da Saúde do Brasil.

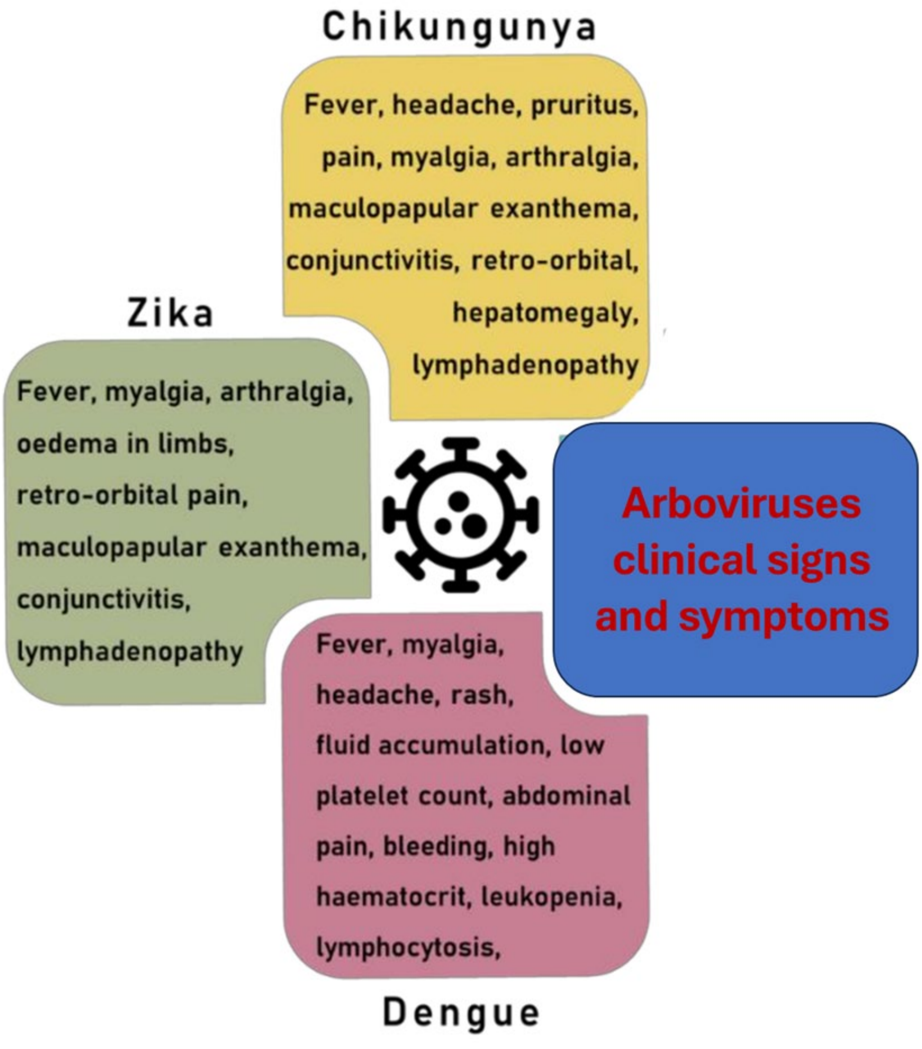


Figure 17b- outlines the main clinical symptoms of CHIKV, DENV, and ZIKV Source: Ministerio da Saúde do Brasil.

Figure 17 and 17b outlines the main clinical symptoms of CHIKV, DENV, and ZIKV, which typically manifest 4–7 days after exposure. Although DENV is reported as more lethal, ZIKV and CHIKV may exhibit severe long-term effects. Co-occurring outbreaks strain public health systems, underscoring the importance of accurate diagnosis and treatment for both single and co-infection cases.

DATA SUMMARY AND ANALYSIS STRONG EL NIÑO AND ARBOVIRUSES EPIDEMIC 2015/2016 – RIO DE JANEIRO

The data collection research was conducted at two locations: Minas Gerais School and Science Club in Rio de Janeiro. Traps were set up to capture *Aedes aegypti* larvae, the primary vectors of Dengue, Chikungunya, and Zika. Rainfall and temperature data were collected using devices at both sites.

Our study identified clusters of dengue, Zika, and chikungunya in densely populated areas with low socioeconomic status in Rio de Janeiro, correlated with positive temperature anomalies. The strong El Niño phenomenon (Figure 18f) contributed to increased temperatures across all studied areas, particularly noticeable in regions lacking vegetation cover (Figure 18d). Furthermore, areas with high temperatures (heat islands) experienced elevated rainfall, landslides, and storms, all positively associated with arbovirus prevalence (Figure 18c).

Overall, higher vegetation cover was linked to lower arbovirus incidence rates (Figure 18a; 18g). The identified clusters were primarily situated in areas with abundant vegetation and medium demographic density (Figure 18b). During the study period, the number of larvae collected was higher due to the elevated temperatures characteristic of a strong El Niño (Figure 18a; 18g). Notably, data from the school project, collected using traps, did not include rainfall data (Figure 18b). However, clusters were also observed in neighborhoods with high demographic density and low vegetation cover, consistent with reported high arbovirus indices in Rio de Janeiro. Therefore, the collected and analyzed data suggest that the increased risk of dengue may be attributed to recent urban growth without adequate infrastructure, positively associated with the strong El Niño phenomenon (Figure 18a; 18g).

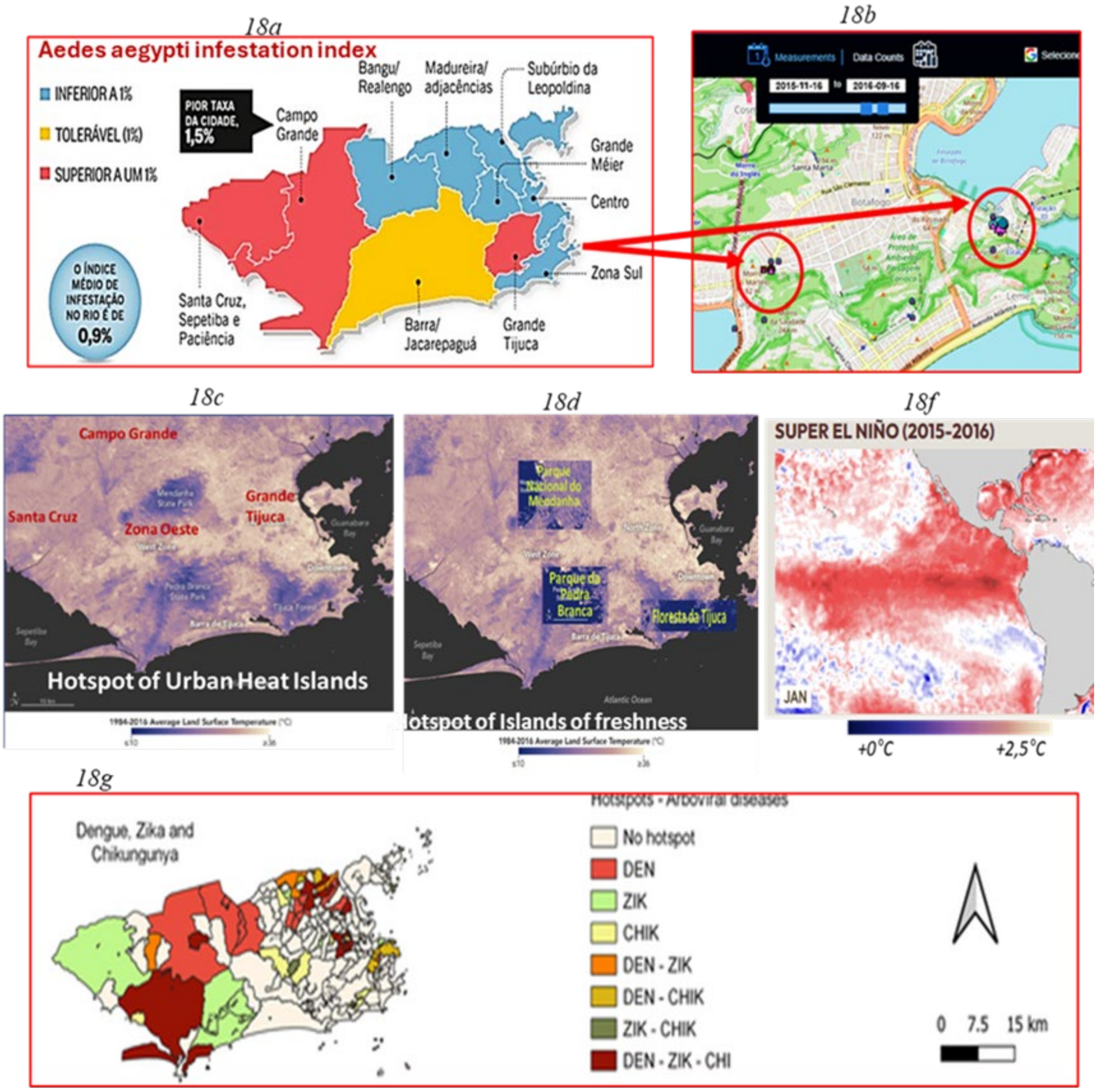


Figure 18 - Aedes aegypti infestation index and arboviruses notified cases in the city of Rio de Janeiro and GLOBE data form Minas Gerais study area from December 2015 and February 2016 at the height of the El Niño climate phenomenon. Source: LIRAa, alert Rio, journals.plos.org, infographics. O Globo and GLOBE platform 2015/2016.

DATA SUMMARY AND ANALYSIS STRONG EL NIÑO AND ARBOVIRUSES EPIDEMIC 2023/2024 – BRAZIL

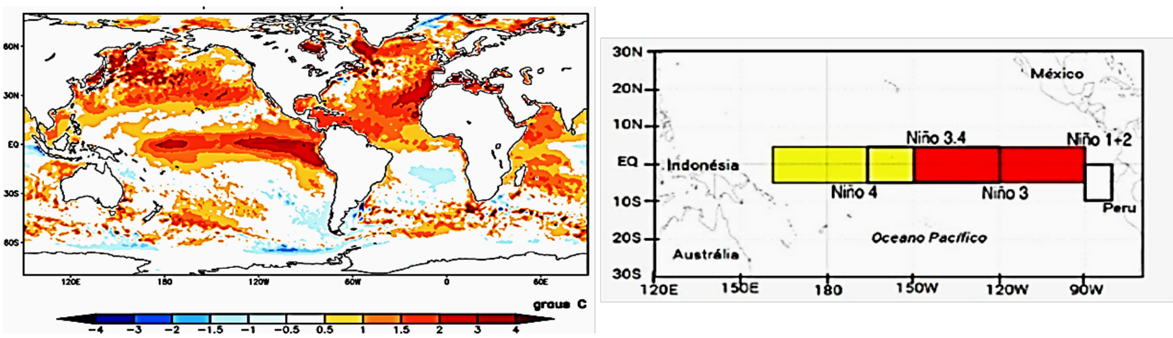


Figure 19 – Sea surface temperature anomaly (SST) in Nov. of 2023. Source: CPTEC and INPE.

The pattern of sea surface temperature (SST) anomalies and winds in the central Equatorial Pacific Ocean, near the International Date Line (180°), continues to intensify. SST anomalies have ranged from 1.5°C in the Niño 4 region to 2.1°C in the Niño 3 region in the last week. Subsurface water temperatures in the same region have also increased, with positive anomalies ranging between 2°C and 6°C in the five-day period centered on November 14, 2023 (Figure 19).

Coupled ocean-atmosphere models and oceanic models predict the continuation of the El Niño phenomenon in the equatorial Pacific, with peak intensity anticipated between December 2023 and January 2024. These predictions align with observed sea surface temperature conditions since June 2023, indicating a typical pattern of a strong El Niño.

Regarding precipitation anomalies for the period from December 20 to January 18, 2024, forecasts suggest wetter-than-normal conditions in much of the North, Northeast, Midwest, and parts of the Southeast (MG, RJ, and ES). Conversely, other regions of the country are expected to experience predominantly drier-than-normal conditions.

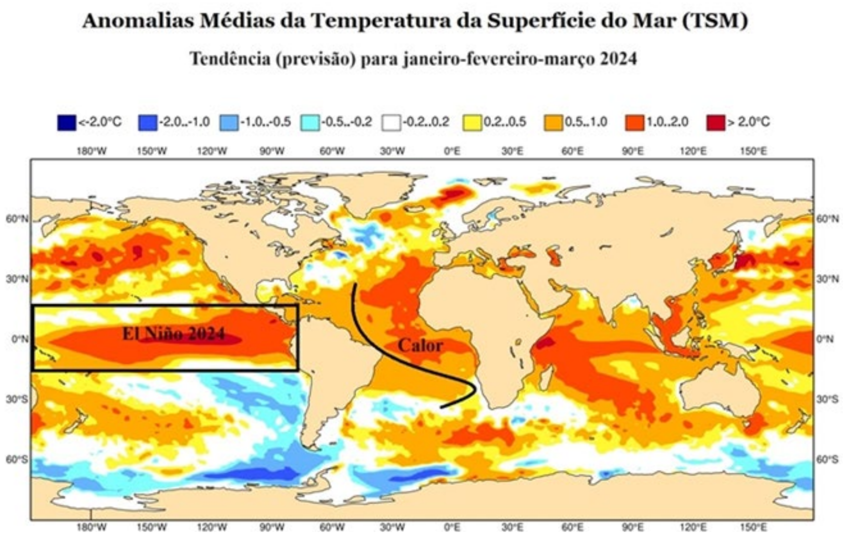


Figure 20: El Niño 2024 to jan. fev and mar. 2024. Source: Reproduction / Inmet

The climate forecast for January-February-March 2024 (Figure 20) suggests a higher likelihood of below-normal rainfall in portions of the North and Northeast regions of Brazil. Conversely, Roraima, southwest Amazonas, eastern Acre, and southern Rio Grande do Sul are expected to experience above-normal rainfall. These patterns, including positive anomalies in parts of the South and negative anomalies in the North and Northeast, are consistent with typical El Niño characteristics. (https://portal.inmet.gov.br/uploads/notastecnicas/Painel-El-Ni%C3%B1o-Boletim-dezembro-No-04.pdf)

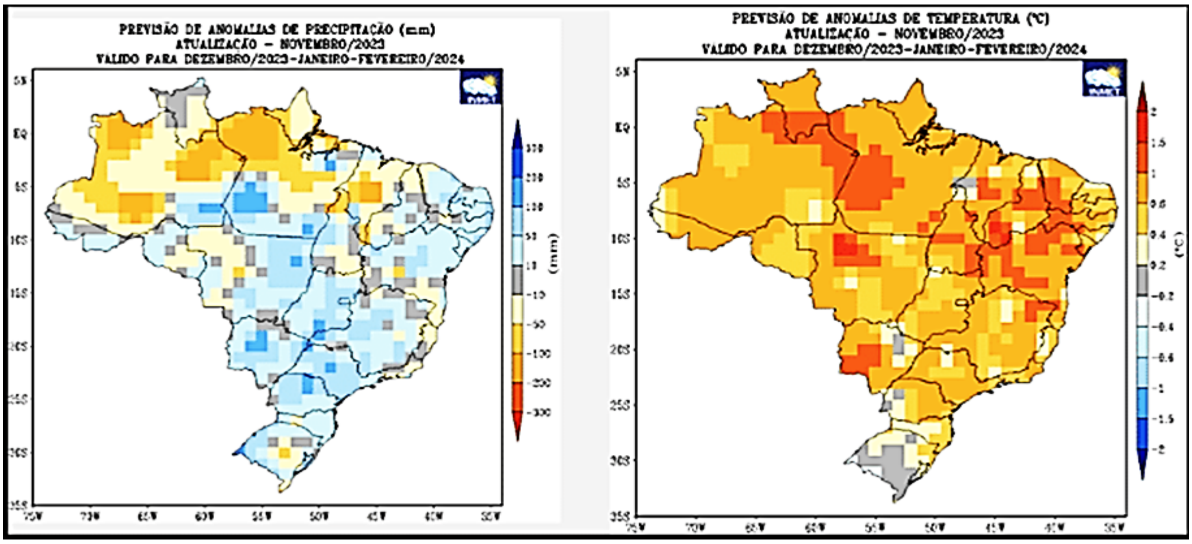


Figure 21: Inmet maps show rainfall forecasts (left) and temperature (right) from December 2023 to February 2024 during strong El Niño. Source: Reproduction / Inmet

The spread of Dengue, Zika, and Chikungunya in Brazil 2023/2024.

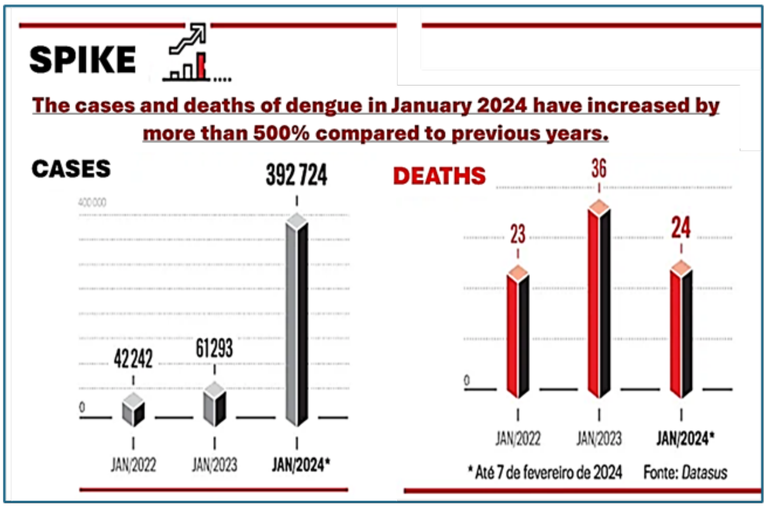
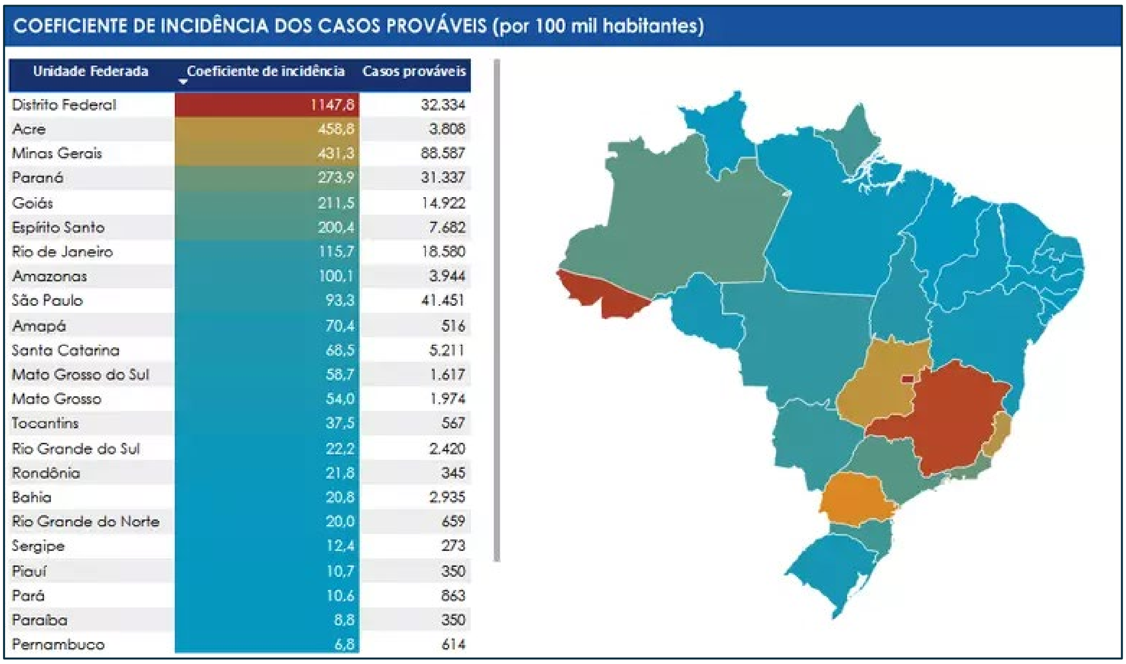


Figure 22: Cases and deaths of dengue in January 2022,2023 and 2024. Source: Datasus
Figure 22a: Cases and deaths of dengue in the end of February 2024. Source: Datasus

The states with the highest incidence of dengue are Distrito Federal (Federal District); Minas Gerais; Acre; Paraná; Goiás; Espírito Santo and Rio de Janeiro (Figure 23). In general terms, the probable cases of dengue for January 2024 are equivalent to the total cases recorded in entire years in Brazil. For instance, in 2017 and 2018, during the La Niña phenomenon period, the country registered 239,389 and 262,594 cases of dengue, respectively. (Figure 22;23; 25).

According to the latest update from the Ministry of Health in the end of February 2024, Brazil currently reports over **1 million probable cases of dengue,** marking a fivefold increase compared to the last epidemiological week of January the previous year (Figure 22 and 22a).

The situation is particularly concerning in the Federal District, which has the highest incidence of cases among Brazilian states (Figure 23). With 1,147.8 probable cases of dengue per 100,000 inhabitants, a total of 32,334 individuals are suspected of having the disease in the region. Following the Federal District, states with the highest incidence rates of dengue cases include Acre, Minas Gerais, Paraná, Goiás, and Espírito Santo.


COEFICIENTE DE INCIDÊNCIA DOS CASOS PROVÁVEIS (por 100 mil habitantes)

Unidade Federada	Coeficiente de incidência	Casos prováveis
Distrito Federal	1147,8	32.334
Acre	458,8	3.808
Minas Gerais	431,3	88.587
Paraná	273,9	31.337
Goiás	211,5	14.922
Espírito Santo	200,4	7.682
Rio de Janeiro	115,7	18.580
Amazonas	100,1	3.944
São Paulo	93,3	41.451
Amapá	70,4	516
Santa Catarina	68,5	5.211
Mato Grosso do Sul	58,7	1.617
Mato Grosso	54,0	1.974
Tocantins	37,5	567
Rio Grande do Sul	22,2	2.420
Rondônia	21,8	345
Bahia	20,8	2.935
Rio Grande do Norte	20,0	659
Sergipe	12,4	273
Piauí	10,7	350
Pará	10,6	863
Paraíba	8,8	350
Pernambuco	6,8	614

Figure 23: Mosquito breeding sites per state. Source: Rapid Survey of Aedes aegypti Infestation Index (LIRAa).

The Rapid Survey of *Aedes aegypti* Infestation Index (LIRAa) and the Sample Index Survey (LIA) indicate that, in 2023, 74.8% of dengue mosquito breeding sites are found in households. These breeding sites include areas such as flowerpots and plant saucers, returnable bottles, drip trays, defrosting containers in refrigerators, water coolers, small ornamental fountains, and materials in construction sites (stocked toilets, pipes).

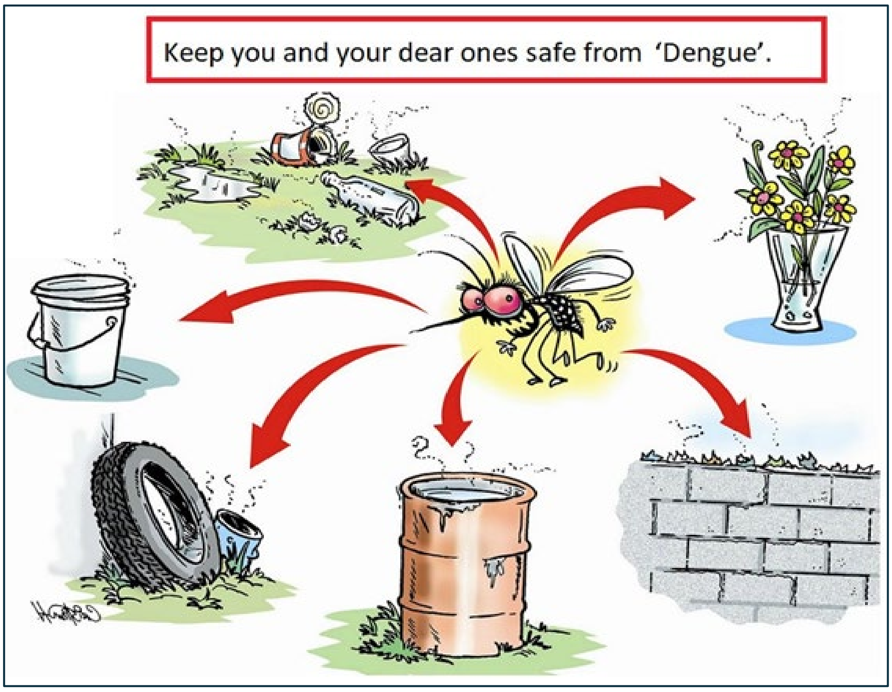


Figure 24: Mosquito breeding sites. Source: Rapid Survey of Aedes aegypti Infestation Index (LIRAa).

DATA SUMMARY AND ANALYSIS STRONG EL NIÑO AND ARBOVIRUSES EPIDEMIC 2023/2024 – BRAZIL AND RIO DE JANEIRO *DENGUE FEVER*

The resurgence of dengue following the COVID-19 pandemic, along with the circulation of the four arbovirus strains, previously suppressed during the pandemic lockdowns, has emerged actively and is a significant concern (Figure 28). This is especially true in regions like Brazil, where the tropical climate favors the reproduction of the *Aedes aegypti* mosquito, the disease vector. The reduction in vector control activities during the pandemic, due to restrictions and resource prioritization for COVID-19 combat, may have contributed to the revival of dengue.

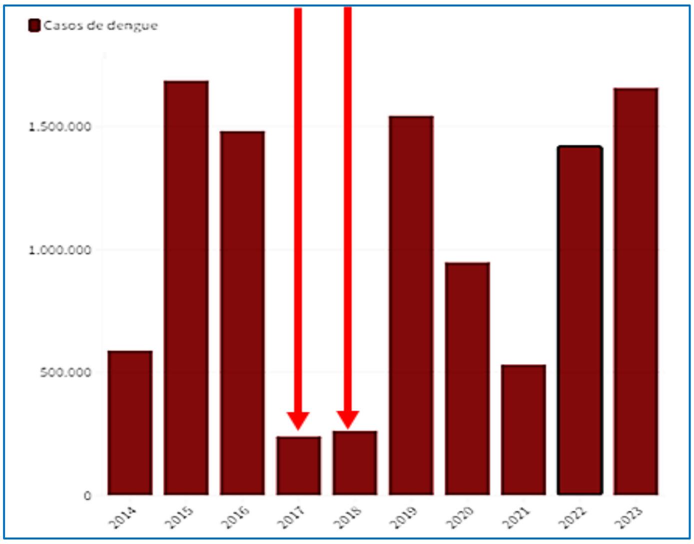


Figure 25: Dengue cases in Brazil in the last decade. Source: Ministério da Saúde

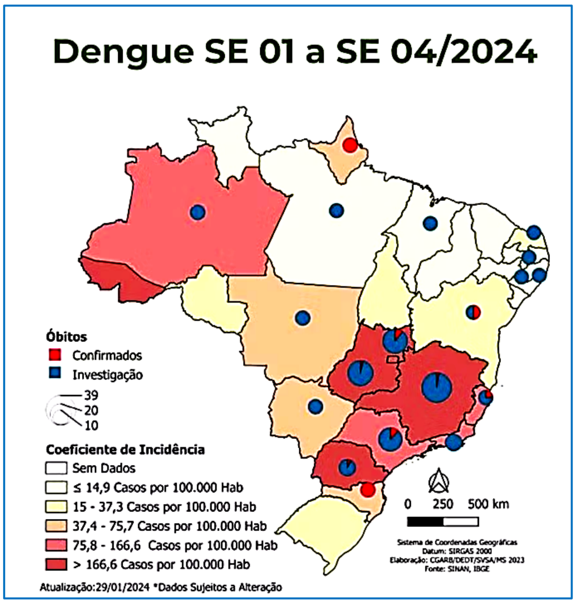


Figure 26: Dengue cases in Brazil cases of dengue in the four weeks of January 2024 Source: Ministério da Saúde

In early 2024, the city of Rio de Janeiro experienced heavy rainfall, with the Alert Rio System reporting precipitation exceeding 200 mm in 24 hours in certain neighborhoods. These episodes of heavy rain, common in the Rio metropolitan area, can be attributed to various meteorological phenomena, including influences from El Niño.

The changes in weather patterns, largely driven by the strong El Niño, also play a crucial role. The presence of low atmospheric pressure near the coast of Rio de Janeiro induces a circulation of winds that transports more maritime humidity inland, while the high temperature of ocean waters promotes increased evaporation and subsequent rise in atmospheric humidity.

Measurements by the National Institute of Meteorology indicated an accumulation of 282.2 mm of precipitation between January 1st and 9 a.m. on January 14th. Although precipitation decreased in February, it remained above average for Rio de Janeiro. At the end of the month, the western zone experienced heavy rainfall and storms, with temperatures remaining high, ranging from around 24°C to 38°C.

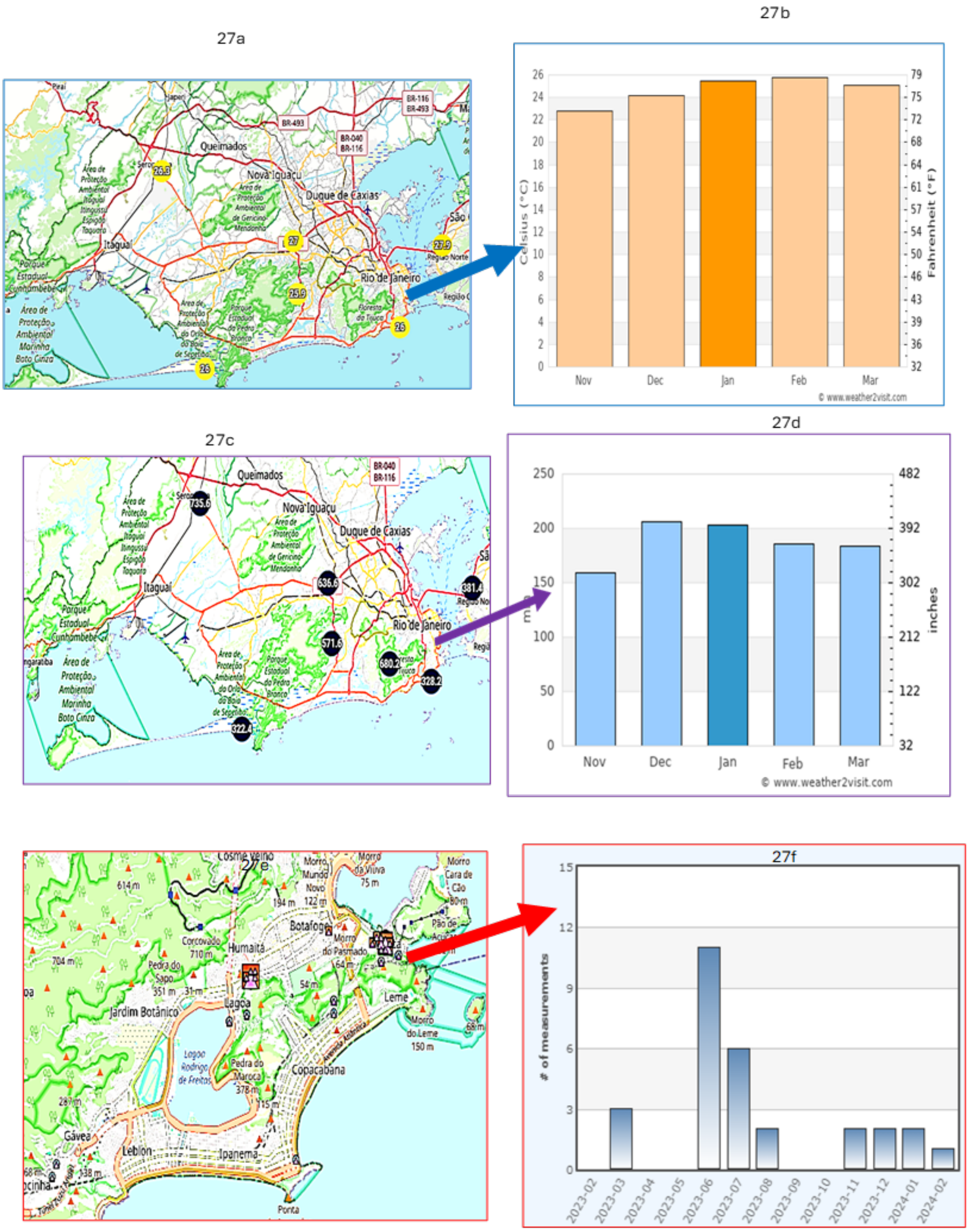


Figure 27 – maps show rainfall forecasts (left) and temperature (right) from December 2023 to February 2024 during strong and Globe data collected at the same time in zona Sul (area of school collected data) during El Niño in Rio de Janeiro city Source: GLOBE gov; Alert Rio System; CPTEC and INPE

In January 2024, the state of Rio de Janeiro recorded 17,544 cases of dengue, marking a substantial increase compared to the same period in 2023 (Figure 28). Among the 92 municipalities in the state, 14 exhibited an incidence rate exceeding 500 cases per 100,000 inhabitants, with notable figures observed in Itatiaia, Macacu, Mangaratiba, and Barra do Piraí. Rio de Janeiro ranks seventh on the list with the highest incidence of dengue.

Figure 28.: The region of Campo Grande and Guaratiba are among those with the highest number of dengue cases in the city of Rio de Janeiro 2023/2024 — Photo: Reproduction/ Rio City Hall

In the capital city of Rio de Janeiro, the number of hospitalizations in January reached the highest level in the city's history (Figure 29), according to the Municipal Health Department, prompting Mayor Eduardo Paes to launch a series of measures to contain the dengue epidemic in the city. These measures include domestic interventions and the deployment of 16 vehicles equipped with fumigation capabilities in areas with the highest incidence of the disease. Due to El Niño, it is expected that dengue will peak in March, with a subsequent decline in infections influenced by a reduction in temperature.

Escola Minas Gerais : 23KPQ846599 Data Table

Start Date	Data Count	Cumulative Data Count
2024-02	1	29
2024-01	2	28
2023-12	2	26
2023-11	2	24
2023-10	0	22
2023-09	0	22
2023-08	2	22
2023-07	6	20
2023-06	11	14
2023-05	0	3
2023-04	0	3
2023-03	3	3
2023-02	0	0

Figure 29: The region of Campo Grande and Guaratiba are among those with the highest number of dengue cases in the city of Rio de Janeiro and Globe data collected at the same time in zona Sul (area of school collected data) — Photo: Reproduction/ Rio City Hall and GLOBE.gov

5. RESULTS

Analysis of data collected and studied by the Science Club of Minas Gerais on air temperature, precipitation, mosquito larvae count, and habitats, from two strong El Niño events in the last decade: December 2015 to February 2016 and December 2023 to February 2024(Figure 30,31,32). The aim was to observe and analyze the effects of strong El Niño climate pattern changes on mosquito proliferation in breeding sites, thus leading to the emergence of dengue, Zika, and chikungunya epidemics in Brazil (Figure 32). It was observed, in the collected data and analyzed spreadsheets, that during periods of increased rainfall and air temperature (data collected during strong El Niño periods), there is an increase in mosquito proliferation in collection areas, leading to the appearance of arbovirus epidemics, mainly dengue. It can also be stated that the emergence of the Zika virus in Brazil, especially in Rio de Janeiro, occurred during the strong El Niño period of 2015/2016. (Figure 31)

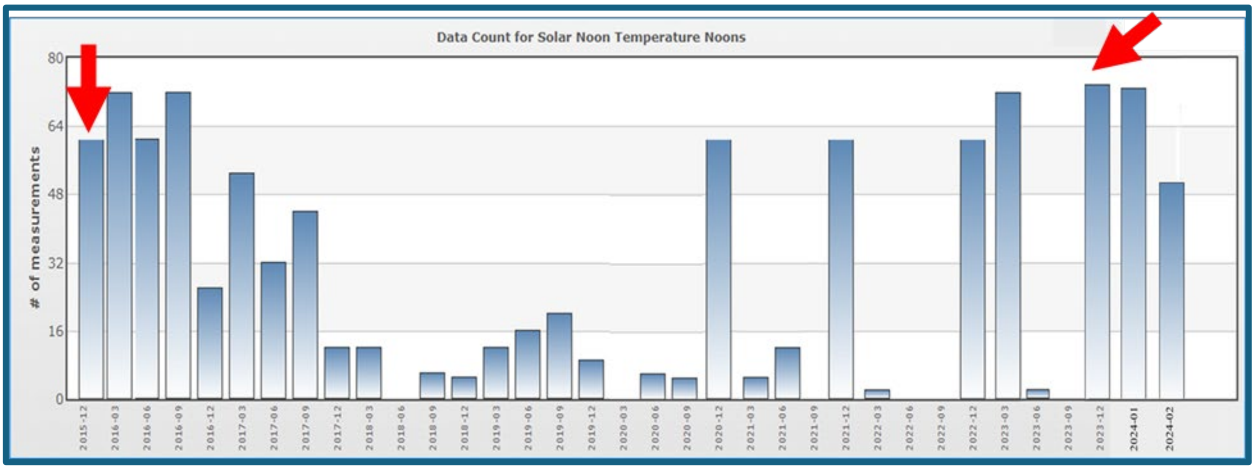


Figure 30: Air temperature data collected during strong El Niño periods in Rio de Janeiro in the last decade. Source: GLOBE.gov

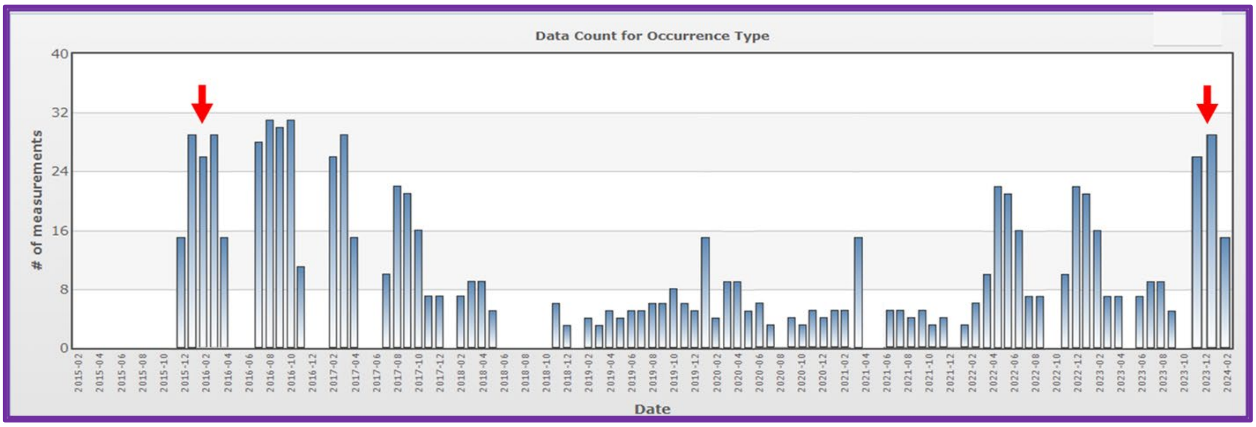


Figure 31: Rainfall data collected during strong El Niño periods in Rio de Janeiro in the last decade. Source: GLOBE.gov

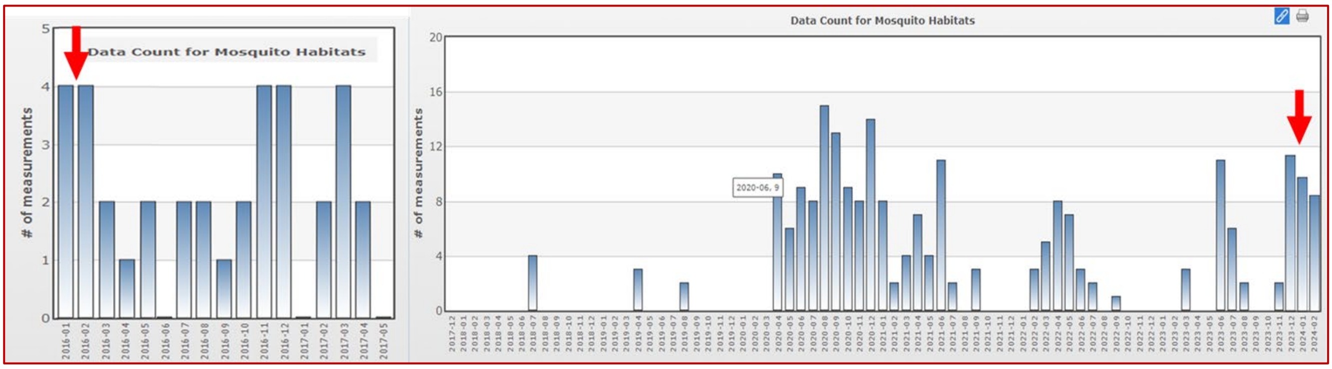


Figure 32: Mosquito habitat data collected during strong El Niño periods in Rio de Janeiro in the last decade. Source: GLOBE.gov

Throughout the study, an increased prevalence of mosquito habitats was observed in the data collected from artificial breeding sites and from the literature reviewed during the periods from December 2015 to February 2016 and December 2023 to February 2024. These periods coincided with pronounced El Niño phenomena characterized by heightened precipitation and elevated temperatures (Figures 31 and 30). This heightened prevalence was notably evident when compared with similar time frames during neutral or La Niña seasons.

The tabulated data (Figures 30, 31, and 32) outline a significant increase in mosquito incidence within the sampled datasets, attributed to fluctuations in precipitation and temperature patterns resulting from robust El Niño occurrences during the examined periods.

Furthermore, an overarching pattern in the circulation dynamics of these arboviruses across the decade (Figure 33) indicates the introduction of the chikungunya arbovirus in December 2013, clearly observed in 2014. Similarly, following the emergence of Zika in Brazil in 2015, widespread viral dissemination was observed within the same year. Nevertheless, the dominance of dengue circulation persisted throughout the decade.

During the periods 2015/2016 and 2023/2024, the city of Rio de Janeiro experienced arbovirus epidemics and dengue fever as the number of cases surpassed 500 cases per 100,000 inhabitants.

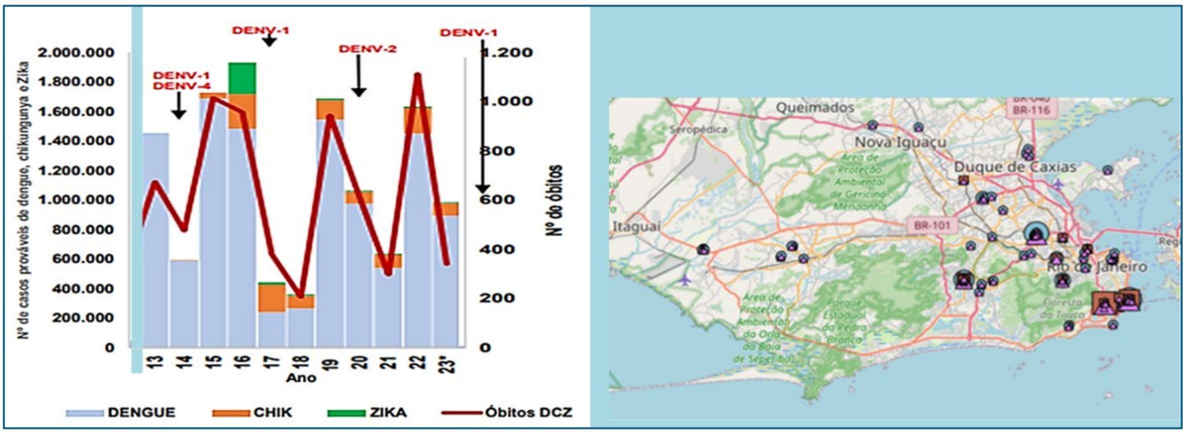


Figure 33: Cases and Deaths from Dengue, Chikungunya, and Zika in Brazil (2013 to 2023) https://www.gov.br/saude/pt-br/assuntos/noticias/2023/maio/arquivos/campanha-de-arboviroses.pdf and breeding sites from data Globe collection Rio de Janeiro city from 2015 to 2024.soruce: GLOBE data and Mhttps://www.gov.br/saude/pt-br/assuntos/noticias/2023/maio/arquivos/campanha-de-arboviroses.pdf. Source: ALERTA RIO.

Despite a significant number of days with elevated temperatures, graphical representations show no simultaneous increase in mosquito larvae abundance (Figures 32 and 33). It is essential to highlight the importance of zero, as it acts as a decisive factor in outlining the emergence or resurgence of *Aedes aegypti* mosquito populations in the vicinity of the educational institution.

6. HYPOTHESIS ANALYSIS

After data collection, the results were analyzed and interpreted through comparative graphics, tables, spreadsheets, and research on various websites, including FIOCRUZ, GLOBE, reports of disease incidence from the Municipal Health Department and the Ministry of Health, as well as the LIRAA (Rapid Index Survey for *Aedes aegypti*), IBGE, INMET, Climatempo, NOAA, among others. Diseases transmitted by the *Aedes aegypti* mosquito, such as Dengue, Chikungunya, and Zika, can be fatal. The mosquito initiates its reproductive cycle during the warmer months when rainfall is more abundant, particularly proliferating in stagnant water. There is a peak in disease incidence during the summer, and during periods of strong El Niño, this situation worsens.

Our findings confirm the hypothesis that strong El Niño brings about changes in climate patterns across all regions, resulting in serious consequences in Brazil, with a particular focus on Rio de Janeiro. This includes rising temperatures and more frequent and intense rainfall, negatively impacting the proliferation of the *Aedes aegypti* mosquito (figure). As a result, the health of the Brazilian and Carioca population is affected, with evidence of arbovirus epidemics, as demonstrated by the number of cases exceeding 500 per 100,000 inhabitants (figure 34 and 35).

Figure 35: In the year 2023/2024, Rio de Janeiro city experienced epidemics of dengue fever as the number of cases surpassed 500 cases per 100,000 inhabitants. Source: ALERTA RIO.

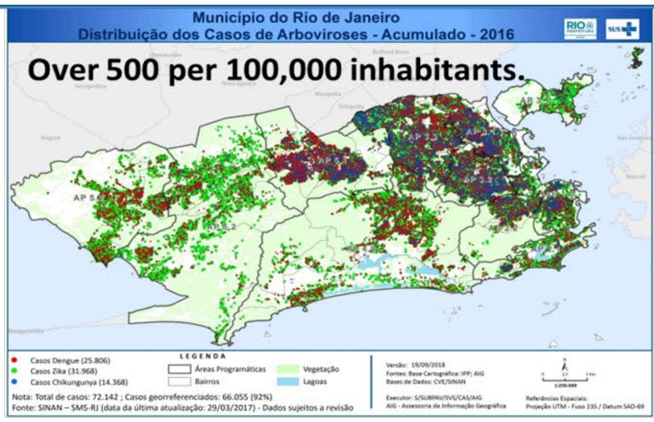


Figure 34: In the year 2016, Rio de Janeiro city experienced epidemics of arboviruses as the number of cases surpassed 500 cases per 100,000 inhabitants. Source: ALERTA RIO.

7. DISCUSSION

Dengue is considered by the Brazilian Ministry of Health as the most prevalent urban arbovirus in the Americas, mainly in Brazil, being transmitted by the bite of the female *Aedes aegypti* mosquito. During periods of higher temperatures, the mosquito increases its search for human blood to produce eggs, resulting in a larger population of disease-transmitting mosquitoes. During the heat, the mosquito's reproductive cycle accelerates, it deposits eggs, which are hydrated by rain, allowing the larvae to develop. Thus, the larvae hatch, mature with the return of heat, and transform into another mosquito, continuing the cycle (Figure 36) (Ujvari, Stefan Cunha; The History of Epidemics).

When we compare the collected data on mosquito proliferation with climatic factors, especially during strong El Niño summers in Rio de Janeiro, we observe a significant increase in the development of *Aedes aegypti*, responsible for transmitting diseases such as Dengue, Chikungunya, and Zika (Figure 37). The summers of 2015/2016 and especially 2023/2024 experienced very intense heatwaves. These findings are consistent with existing literature (Ujvari, Stefan Cunha; The History of Epidemics).

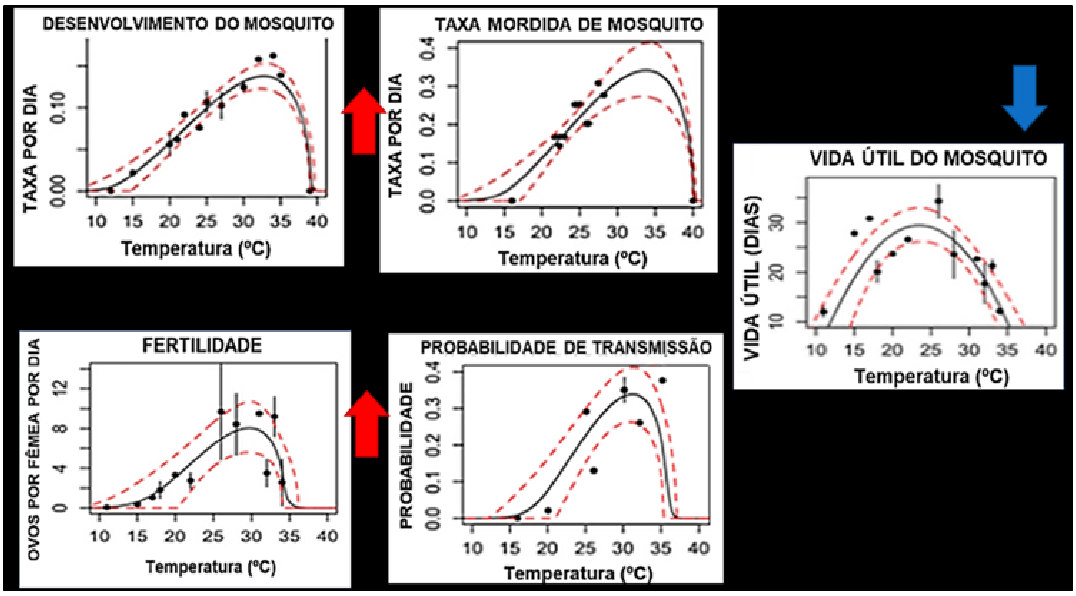
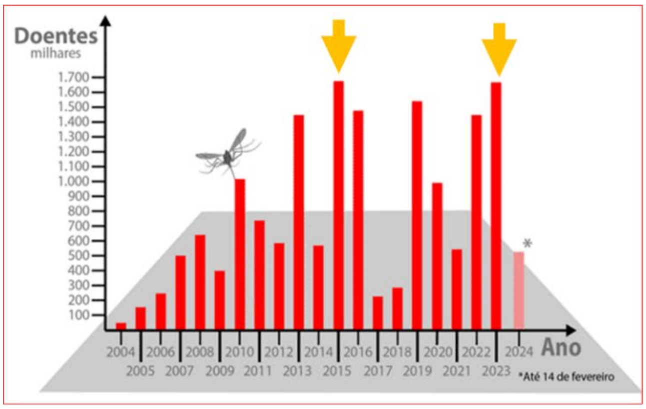


Figure 36: What changes in the mosquito's metabolism with the increase in temperature to 30º C to 32º C. Mordecai EA, Cohen JM, Evans MV, Gudapati P, Johnson LR, et al. (2017) Detecting the impact of temperature on transmission of Zika, dengue, and chikungunya using mechanistic models. PLOS Neglected Tropical Diseases 11(4): e0005568.

Furthermore, it is essential to highlight that the oscillating warming and cooling pattern, known as the ENSO cycle, directly affects rainfall distribution in the tropics, including Brazil. El Niño and La Niña represent the extreme phases of this cycle, and between them is a third phase called ENSO-neutral. These insights align with previous meteorological studies (Figure 38).

Therefore, understanding that changes in climate patterns, especially the effects of strong El Niño events, is essential to implement effective measures for controlling and preventing dengue and other mosquito-borne diseases.



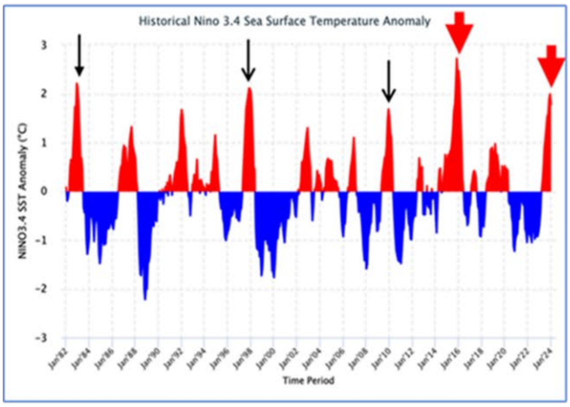


Figure 37: Cases and Deaths from Dengue, Chikungunya, and Zika in Brazil (2004 to 2024) Source: https://www.gov.br/saude/pt-br/assuntos/noticias/2023/maio/arquivos/campanha-de-arboviroses.pdf

Figure 38: Alternance El Niño historic index from January 1982. Source: http://enos.cptec.inpe.br/

8. CONCLUSION

The data presented in the graphs reveal a significant increase in dengue cases, a disease transmitted by the *Aedes aegypti* mosquito, during periods of climatic phenomena occurrences, as observed in previous summers and during the analyzed periods of climate changes influenced by pronounced El Niño (Figures 38 and 39). However, it is important to note that other factors may influence the number of cases.

A complex association between strong El Niño events and arbovirus epidemics can be inferred. The *Aedes aegypti* mosquito tends to reproduce more rapidly in regions with higher temperatures and during periods of heavy rainfall, especially in the coastal areas of Northeast and Southeast Brazil. Conversely, cooler climates in the southern regions of the country and severe droughts may disrupt its reproductive cycle. This variation in climatic conditions results in variations in the occurrence and spread of diseases associated with *Aedes aegypti* in different Brazilian states. Additionally, it is worth mentioning that the eggs of these mosquitoes can remain dormant for up to 500 days.

Figure 39. The marked bars are related to a strong El Niño. The conditions favorable to mosquito breeding sites, and mosquito risks to population. Epidemics X El Niño the resume conclusion. Source: O globo/Climatempo

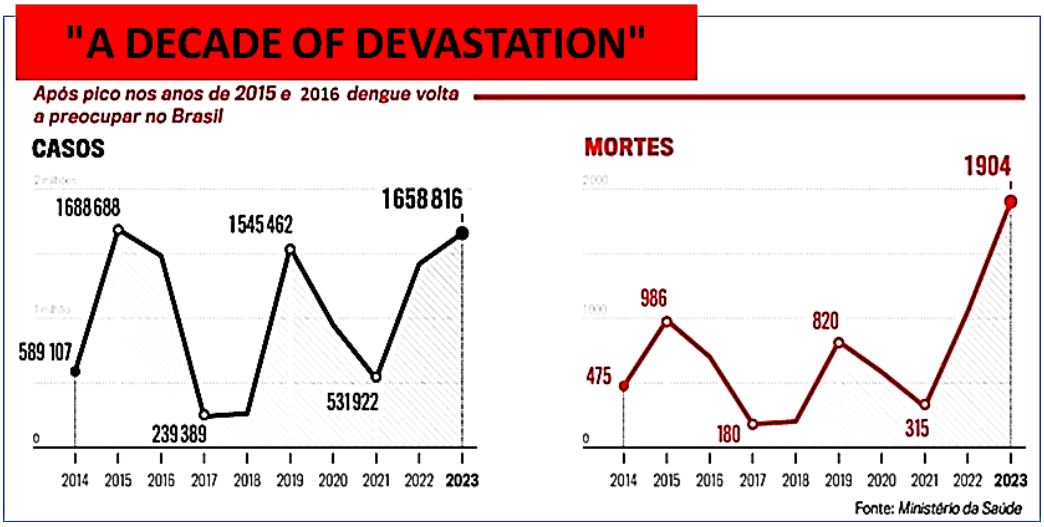


Figure 40: "A decade of devastation" - After the peak of devastation in 2015, arboviruses, particularly dengue fever, resurface as a concern for the Brazilian population. Source: Ministerio da saude.

In conclusion, extreme weather events, such as strong El Niño, play a significant role in the spread of arbovirus epidemics, such as dengue, in Brazil. This study highlighted the complex interaction between changes in climate patterns, the proliferation of the *Aedes aegypti* mosquito, and the incidence of diseases transmitted by it. Understanding these patterns and influencing factors is crucial for implementing effective control and prevention measures, mitigating the impacts on public health. Therefore, it is essential to continue monitoring and studying these phenomena to protect the population against the risks associated with arbovirus epidemics during extreme weather events, as observed in the dengue outbreaks in 2015/2016 and 2023/2024, characterized by an incidence of more than 500 cases per 100,000 inhabitants (Figures 39 and 40).

9. PREVENTION AND SOLUTION

Government initiatives have emphasized the importance of eliminating potential breeding sites for the *Aedes aegypti* mosquito, while public awareness campaigns have encouraged proactive measures within households (Picinato et al., 2015). Advances in diagnostic technologies and the development of vaccines against dengue (Durbin, 2016) have also been noteworthy, along with efforts in biological control through genetically modified mosquitoes (Carvalho et al., 2015). These strategies align with models used in combating malaria and other mosquito-borne diseases in tropical regions.

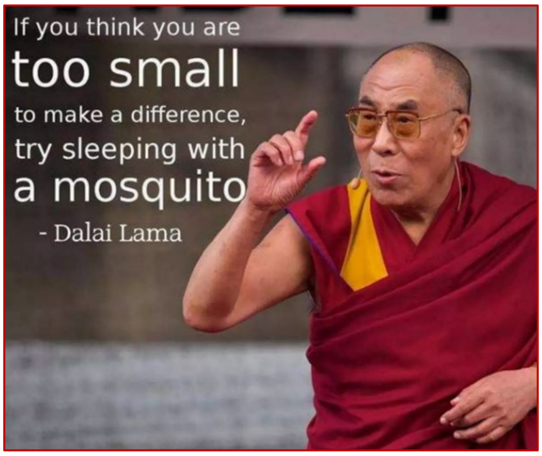


Figure 41: comic Dalal Lama. Source: facebook.com/pagemedicinahttps://scontent.fsdu25-

To address arbovirus epidemics in Brazil, a variety of preventive and control measures have been implemented. The Ministry of Health distributed approximately 30 tons of insecticides to municipalities across Brazil as part of a comprehensive vector control program. These insecticides are crucial for targeting both larvae and adult mosquitoes, reinforcing surveillance efforts, and combating endemic diseases, with a particular focus on arboviruses. Additionally, health education initiatives have been launched to increase awareness of preventive measures, such as the use of repellents, installation of screens on doors and windows, and elimination of mosquito breeding sites (Figure 42).

Figure 42: Preventive measures: vector control, elimination of Aedes aegypti breeding sites, use of repellents, appropriate medical care as vaccine and fluids. Source: Google images

Furthermore, effective monitoring and epidemiological surveillance strategies are vital for early detection of mosquito-borne disease outbreaks and rapid implementation of control measures. This includes collecting and analyzing data on arbovirus cases, as well as monitoring the presence and distribution of vector mosquitoes.

Investments in research are crucial for exploring new approaches to arbovirus prevention and control, including the development of vaccines and more sustainable vector control methods.

The Ministry of Health has taken significant steps to address the challenges of arbovirus epidemics in Brazil. In December 2023, it announced the incorporation of the dengue vaccine, Qdenga, into the Unified Health System (SUS). Developed by the Japanese laboratory Takeda Pharmacom, Qdenga has demonstrated an efficacy of 87% in preventing dengue-related hospitalizations.

10. ACKNOWLEDGEMENTS

We thank Minas Gerais, Principal Tania Campos, FIOCRUZ (Elimina dengue Project), Go Mosquito Community, GLOBE Mission Mosquito, Dr. Russanne Low and from Institute for Global Environmental Strategies, AEB Brazilian Space Agency, Aline Veloso and Erick Luiz Silva.

Figure 43-https://gifer.com/pt/Z2sq

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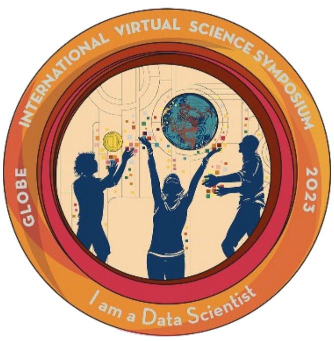
12. OPTIONAL BADGES FOR SCIENTIST SKILLS

Collaboration

- Through concerted teamwork and mutual support, they collectively contributed to delivering a work of commendable quality. As the project progressed, each student had the chance to shine and demonstrate their individual strengths and expertise. This environment fostered a sense of camaraderie and allowed for the cultivation of a diverse range of skills. Whether it was through innovative problem-solving, effective communication, or creative thinking, every member of the team made valuable contributions.
- Juliana Villela, and Andrea Silva: data collect research, project summary, video elaboration, theoretical part, and research on the subject.
- Camille Santos and Luis Eduardo Freitas: collection and production of exploitable data.
- Luiz Eduardo Freitas and Juliana Vilela: art and preparation of the video.
- Juliana Vilela, Andrea Silva, Camille Santos: drafting of the project.
- All group: Video Presentation.

Community impact

Using local data from the GLOBE Mosquito Habitat Mapper app and GLOBE site data collected in the southern zone of Rio de Janeiro, compared to official data, allows for characterizing the number of breeding sites and their mitigation, and comparing them to periods of increased rainfall and heat during strong El Niño events. The utilization of GLOBE data from other locations in Brazil and data from the Municipal Health Department enables us to demonstrate and compare that the southern zone of Rio is an area where the *Aedes aegypti* mosquito is present and underscores the importance of zero data to control mosquito development in the district. The dissemination of information is crucial for combating the *Aedes aegypti* mosquito and preventing its diseases among the population of Rio de Janeiro, particularly during summers with strong climatic phenomena like El Niño, which can lead to arbovirus epidemics, particularly dengue fever.



Data scientist

The project relied on data collected by students using the GLOBE Mosquito Habitat Mapper app, research on the GLOBE platform, and official data from Brazil. These data were crucial for understanding vector propagation patterns during extreme weather events, such as strong El Niño, historically associated with epidemics of mosquito-borne diseases like dengue, yellow fever, chikungunya, and Zika. Analyzing this data enabled students to identify areas at higher risk during El Niño periods, allowing for a more effective response in preventing and controlling epidemic outbreaks. Additionally, students also gathered meteorological data, such as air temperature and precipitation, to better understand the environmental conditions favoring vector proliferation during these extreme weather events. This data-driven approach was essential for informing public health policies and intervention strategies during periods of strong El Niño, aiming to mitigate the impacts of epidemics on affected communities.

I am a storyteller.

In recent years, there has been an observed association between climatic events, particularly strong occurrences of El Niño, and the emergence of arbovirus epidemics, including dengue, Zika, and chikungunya, both on a national scale and in Rio de Janeiro.

During the summer of 2016, El Niño unleashed its fury, creating ideal conditions for the proliferation of disease-transmitting mosquitoes, especially the notorious *Aedes aegypti*. With rising temperatures and intermittent rainfall, the mosquito population exploded across Brazil. Consequently, the country found itself engulfed in widespread epidemics of arboviruses. From bustling cities to remote regions, no corner of Brazil escaped the dominance of these arbovirus-transmitted diseases.

Likewise, in 2024, a similar scenario may have unfolded. A new episode of strong El Niño could have contributed to the emergence of a new dengue epidemic in the region. These favorable climatic events provide ideal conditions for the reproduction of the mosquito vector and, consequently, for the spread of the diseases. Therefore, it is essential to be attentive to climatic patterns and vector control measures during these periods in order to mitigate the impacts of arbovirus epidemics on the population.

Dengue News: Combating the villains!!

Editors: 7º grade e Profª Inês Mauad - E.M. Minas Gerais - 2023

EDITORIAL

Dengue now is death matter!

First we have to meet this relentless enemy that takes advantage of the little water remaining in our so polluted planet: Dengue fever, caused by a virus, is transmitted by the Aedes Aegypti mosquito which breeds in still and clean water.

The AEDES AEGYPTI that attacks in urban areas. The AEDES is the size of a culex, a common mosquito, but with two differences: body and feet and painted only bites from the sunset. It has a range of up to 150 m flight, so a single focus of bottle with standing water can contaminate an entire block.

Prevention Is The Lesson!!

** Do not leave water in tires and bottles **
** Don't let water in potted plant **
** Don't let water boxes unclosed **
** If you find mosquito "nest", first remove the larva and then throw the water out * * if you do not clean the edges of the pots, boxes, bottles and tires they eggs hatch in thousands of new mosquitoes *

TO THE URCA'S PEOPLE!!

Unfortunately the Dengue fever has arrived with voracity in Urca, where were found in 10 cases surrounding streets to our school. Students of Minas Gerais School in affirmative action to combat the Dengue Villains visited homes in the neighborhood and promoted the application of a questionnaire - diagnosis and distribution of fliers prepared by the students of the 7th grade with orientation and correct procedures where prevention is the greatest lesson for population!

The team interviews also guided to the residents around the school, the need to open the door to the controller's agents to festroy the "Aedes aegypti" focus and so decrease the cases of Dengue in the neighborhood of URCA.

wanted the Dengue's Villains AEDES AEGYPTI and his masks

MOSQUITINHO BEIRA MAR

MOSQUITINHO

The cycle of the MosquitO Killer

Postura dos ovos

1º e 2º estágios das larvas

3º e 4º estágios das larvas

Pupa

adulto

Dengue fever is an infectious disease limited to warm regions all over the world. In Rio de Janeiro, the dengue fever rose to the South with full force! The neighborhoods that have the highest indices are: Gloria, catete, Laranjeiras, URCA.

Figure 44-Aedes News – News elaborated from science club students.