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ORIGINAL ARTICLE

Rise of Chikungunya in Minas Gerais: An Epidemiological Perspective between 2014 and 2024

Ascensão dos casos prováveis de Chikungunya em Minas Gerais: Uma Perspectiva Epidemiológica entre 2014 e 2024

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ABSTRACT

Introduction: Chikungunya fever was introduced to Brazil in 2014, with a rapid increase in cases. Caused by a virus of the *Togaviridae* family, transmitted by the *Aedes aegypti* and *Aedes albopictus* mosquitoes, it is characterized by high fever and intense arthralgia, and can evolve into chronic forms. **Objective:** To analyze the epidemiological profile and temporal evolution of Chikungunya in Minas Gerais between 2014 and July 2024, identifying the most affected mesoregions, the population groups at highest risk, and the seasonality of the disease. Methods: Descriptive ecological time-series study based on secondary data obtained from the Notifiable Diseases Information System (SINAN), the Arbovirus Monitoring Panel, and historical series from the Ministry of Health. **Results:** Minas Gerais presented the highest incidences of the disease in recent years, concentrating 53.3% of national notifications in 2023 and 51.7% up to July 2024. The mesoregions of Vale do Rio Doce, Vale do Mucuri, and Norte de Minas registered the highest incidence rates. Seasonality was observed with peaks between December and March, a period of higher temperatures and greater rainfall. There was a statistically significant variation in the distribution of sociodemographic variables over the years (p<0.05), maintaining a predominance of females, individuals between 20 and 59 years old, and a self-declared mixed-race population. **Conclusion:** The study identifies priority areas and groups, reinforcing the need to strengthen epidemiological surveillance, preventive actions, and regional research to contain the disease. Despite statistically significant differences, the epidemiological profile remained relatively stable; however, these findings should be interpreted considering the inherent limitations of using secondary data.

Keywords: Chikungunya; Epidemiological surveillance; Arbovirus; Public health.

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RESUMO

Introdução: A febre Chikungunya foi introduzida no Brasil em 2014, com rápida expansão dos casos. Causada por um vírus da família *Togaviridae*, transmitido pelos mosquitos *Aedes aegypti* e *Aedes albopictus*, caracteriza-se por febre alta e artralgia intensa, podendo evoluir para formas crônicas. **Objetivo:** Analisar o perfil epidemiológico e a evolução temporal da *Chikungunya* em Minas Gerais entre 2014 e julho de 2024, identificando as mesorregiões mais afetadas, os grupos populacionais de maior risco e a sazonalidade da doença. **Métodos:** Estudo ecológico descritivo de série temporal, baseado em dados secundários obtidos do Sistema de Informação de Agravos de Notificação (SINAN), Painel de Monitoramento das Arboviroses e séries históricas do Ministério da Saúde. **Resultados:** Minas Gerais apresentou as maiores incidências da doença nos últimos anos, concentrando 53,3% das notificações nacionais em 2023 e 51,7% até julho de 2024. As mesorregiões Vale do Rio Doce, Vale do Mucuri e Norte de Minas registraram os maiores coeficientes de incidência. Observou-se sazonalidade com picos entre dezembro e março, período de temperaturas mais elevadas e maior pluviosidade. Houve variação estatisticamente significativa na distribuição das variáveis sociodemográficas ao longo dos anos (p<0,05), mantendo-se predominância do sexo feminino, indivíduos entre 20 e 59 anos e população autodeclarada parda. **Conclusão:** O estudo identifica áreas e grupos prioritários, reforçando a necessidade de fortalecimento da vigilância epidemiológica, ações preventivas e pesquisas regionais para contenção da doença. Apesar das diferenças estatisticamente significativas, o perfil epidemiológico manteve-se relativamente estável, devendo tais achados ser interpretados considerando-se as limitações inerentes ao uso de dados secundários.

Palavras-chave: Chikungunya; Vigilância epidemiológica; Arbovirose; Saúde pública.

Introduction

"Chikungunya," in the Makonde language spoken in East Africa, means "one who bends over," which is the main characteristic associated with the joint symptoms of the disease[1]. Starting in the 1950s, a new viral fever transmitted by *Aedes aegypti*, similar to dengue, was described on the African continent[1]. Since then, the disease has caused successive epidemics on the African and Asian continents, until it was introduced in the Americas in 2013[1]. In 2014, its autochthonous presence was confirmed for the first time in Brazil[2]. Since then, Chikungunya fever has been a serious public health problem, as the number of cases has skyrocketed in subsequent years, from no autochthonous cases to more than 3.000 in less than a year[2]. In 2023, Minas Gerais recorded an increase in notifications, becoming the state with the highest number of cases in the country. This increase continued in 2024, causing the state to remain prominent in terms of the incidence of Chikungunya fever[3].

Chikungunya virus is a positive-sense, single-stranded RNA virus of the Togaviridae family, genus *Alphavirus*, transmitted by the bite of female *Aedes aegypti* and *Aedes albopictus* mosquitoes, both urban species whose proliferation and dissemination are favored by environmental and climatic conditions typical of tropical regions. Case notifications are concentrated in rainy and warm months, when the mosquito's life cycle is shortened and more breeding sites become available for oviposition, favoring viral replication and intensifying transmission[1,4]. It is very similar to other diseases also transmitted by the vector, such as dengue and Zika, drawing the attention of authorities due to the possibility of misdiagnosis and/or underreporting, causing

damage to the real epidemiological situation in the country[5]. It can be classified into four strains: (i) West African; (ii) East/Central/South African; (iii) Asian; and (iv) Indian Ocean[6]. The clinical picture is characterized by high fever (>38°C) lasting 2 to 3 days, mainly associated with severe arthralgia, headache, and myalgia. It can also present with red spots on the body, itching, and pain behind the eyes, as well as symptoms such as nausea, vomiting, sore throat, and diarrhea. The disease can progress to acute, post-acute, or chronic phases, depending on the duration of symptoms[7]. In more than 50.0% of cases, arthralgia becomes chronic and can persist for years, which has caused concern in the medical community, as there is little data in the literature on effective and specific therapies for the various phases of arthropathy[8,9]. Joint complaints are the most important, becoming incapacitating in most cases[10]. A previous study indicates that, even in patients who show significant initial improvement, relapses affect up to 70% of cases, with arbovirus being most associated with rheumatological manifestations[11].

In addition, the study showed that 77.0% of infected patients experience a reduction in their daily activities, while 27.0% are unable to return to work[11]. Despite the extensive scientific production on Chikungunya in Brazil, most studies focus on genomic analyses or national time series, with a scarcity of detailed investigations on regional epidemiological behavior and its intra-state dynamics. Thus, the objective of this study was to describe the spatiotemporal evolution and epidemiological profile of Chikungunya in Minas Gerais between 2014 and July 2024, given its national prominence as the epicenter of arbovirus disease. Additionally, the most affected mesoregions, the population groups at highest risk, and the seasonality of the disease were identified in order to provide updated information for epidemiological surveillance and the targeting of vector control actions in the state.

Methods

Study design and period

This is a descriptive ecological time series study covering the period from 2014 to July 2024. The year 2014 was defined as the starting point because it corresponds to the confirmation of the first autochthonous cases of Chikungunya fever in Brazil, a fundamental epidemiological milestone for the beginning of viral circulation in the national territory.

The time frame up to July 2024 is due to the fact that, at the time of collection (June 2024), the most recent data available in the Notifiable Diseases Information System (SINAN) and the Ministry of Health's Arbovirus Monitoring Panel referred only to the first half of that year. Thus, the analyses were finalized based on the most up-to-date and consolidated period available at the time, which coincides with the end of the main seasonal cycle of arbovirus transmission in the state. This limitation aims to preserve the comparability and consistency of the data.

Study location

Minas Gerais is located in the southeastern region of Brazil, divided into 853 municipalities, with a population of 20.538.718 inhabitants[12]. Due to the high number of municipalities and the size of the territory, it is divided into 12 mesoregions, grouped according to geographical, climatic, and cultural characteristics, namely: Northwest Minas, North Minas, Jequitinhonha, Vale do Mucuri, Triângulo Mineiro, Central Mineira, Belo Horizonte Metropolitan Area, Vale do Rio Doce, West Minas, South Minas, Campo das Vertentes, and Zona da Mata[13]. The state's vegetation cover is divided into Cerrado, Atlantic Forest, Caatinga, and some regions of Campos Rupestres. As for the climate, despite the semi-arid strip in the north, it is predominantly tropical, with two well-defined seasons: hot and rainy from October to March; cold and dry between April and September, with variations related to altitude[14].

Source and data collection

The data were collected from the National Notifiable Diseases System (SINAN)[15], the Historical Series - Probable Cases of Chikungunya[16], and the 2010 and 2022 Demographic Censuses[12,13], using information related to Minas Gerais.

With regard to the years studied, data for the period from 2014 to 2016 were obtained from the Historical Series -Probable Chikungunya Cases provided by the Ministry of Health[16]. As for the data from 2017 through July 2024 were extracted from the Arbovirus Monitoring Panel, a platform updated in real time based on SINAN notifications. The population information used to calculate the incidence coefficients was obtained from the 2010 and 2022 Demographic Censuses and IBGE intercensal estimates. Data collection took place in July 2024, using the most up-to-date versions available at the time.

After extraction, the data were organized into spreadsheets and subjected to standardization procedures for the variables (year, month of notification, municipality, and sociodemographic variables), as well as consistency checks between the different databases used. The integration of the databases was carried out based on the municipality code (IBGE), ensuring compatibility between the systems. No duplicate records were identified, since the databases used have complementary time periods.

Incidence rates per 100,000 inhabitants (cases/100,000 inhabitants) were calculated for each municipality and subsequently aggregated by geographic mesoregion, considering the years 2017, 2023, and 2024. For this, the estimated resident population for each period was used as the denominator, based on IBGE data. The incidence rate was calculated using the formula:

Incidence rate = (number of new cases in the period / resident population in the same period) × 100,000

The data were initially analyzed at the municipal level and subsequently aggregated by mesoregions, respecting the official geographical division. The temporal analysis

considered the annual and monthly distribution of cases, allowing the identification of seasonal patterns.

Records classified as ignored or blank in the sociodemographic variables were kept in the analysis and presented as a specific category in order to preserve the integrity of the information and avoid exclusion bias. No imputation of missing data was performed.

The analysis was descriptive in nature, including the calculation of absolute and relative frequencies, as well as incidence measures. The data were organized and analyzed using spreadsheets (Microsoft Excel®).

Study variables

In the data Historical Series - Probable Cases of Chikungunya, the number of cases per year and per month from 2014 to 2016 was analyzed. Data recorded in the SINAN for Chikungunya fever began in 2017. Thus, the following variables for Minas Gerais were analyzed from this system for the period from 2017 to June 2024: municipality of notification, year of notification, month of notification, age group, race, sex, and evolution.

According to the operational definition of the Ministry of Health in force during the period analyzed, probable cases of Chikungunya were considered, which includes cases with clinical and epidemiological criteria, with or without laboratory confirmation. The variable “evolution” was categorized according to the options available in SINAN: cure, death from Chikungunya, death from other causes, and unknown/blank.

Analysis of epidemiological factors

Incidence rates per 100,000 inhabitants (cases/100,000 inhabitants) were calculated for each municipality, grouping them into their respective geographic mesoregions, and also for each of the mesoregions of Minas Gerais in 2017, 2023, and 2024, using population estimates[12,13].

A classification was adopted for the incidence coefficients of Chikungunya, both for the mesoregions and for the municipalities of Minas Gerais[17]. This classification was divided into 6 ranges for the mesoregions and 9 ranges for the municipalities, due to differences in population densities. Thus, the incidence rates in the mesoregions of Minas Gerais were grouped in the following order: 1st band (above 1,000 cases/100,000 inhabitants); 2nd band (between 500 and 1,000 cases/100000 inhabitants); 3rd band (between 200 and 500 cases/100000 inhabitants); 4th range (between 100 and 200 cases/100000 inhabitants); 5th range (between 50 and 100 cases/100000 inhabitants) and 6th range (between 0 and 50 cases/100000 inhabitants). In turn, the incidence rates in the municipalities of Minas Gerais were grouped and ordered as follows: 1st band (above 2,000 cases/100000 inhabitants); 2nd band (between 1,000 and 2,000 cases/100000 inhabitants); 3rd range (between 500 and 1,000 cases/100000 inhabitants); 4th range (between 100 and 500 cases/100000 inhabitants); 5th incidence range (between 50 and 100 cases/100000 inhabitants); 6th range (between 25 and 50 cases/100000 inhabitants); 7th range (between 10 and 25 cases/100000 inhabitants); 8th range (0 and 25 cases/100000 inhabitants) and 9th range (equal to 0 cases/100000 inhabitants).

Statistical Analysis

To assess the differences in the distribution of sociodemographic and clinical variables over the years, Pearson's chi-square test was applied, considering a significance level of 5% (p<0.05). The analyses were performed using contingency tables constructed with absolute frequencies. For the variable "evolution," categories with low frequency were grouped to meet the assumptions of the test.

Considering the high number of observations and the ecological nature of the study, the inferential results were interpreted with caution, being analyzed in conjunction with the magnitude of the differences observed.

Ethical aspects

As this research involves the analysis of secondary data from publicly accessible databases, it is exempt from submission to the Research Ethics Committee System under the terms of Law No. 12.527/2011 and Resolution No. 466/2012 of the National Health Council.

Results

Based on the data obtained, Minas Gerais ranks as the Brazilian state with the highest number of reported cases of Chikungunya fever in the last two consecutive years. In 2023, it accounted for about 53.3% of cases, followed by Bahia with 9.5%. By July 2024, Minas Gerais had reached 51.7% of notifications. During the period under review, the years 2017, 2023, and 2024 stood out for the number of cases (Figure 1). In 2017, there were 20,860 cases, with an incidence rate of 106.4/100000 inhabitants. In 2023, the state had 130,443 notifications of Chikungunya, with an incidence rate of 469.3/100000 inhabitants, an increase of 659.5% compared to the previous year. By July 2024, the state still held the same prominent position, with 150,410 reported cases and an incidence rate of 754.3 per 100000 inhabitants.

Data from 2017, 2023, and 2024 were analyzed in detail, verifying the incidence of Chikungunya in Minas Gerais by geographic mesoregions (Table 1, Figure 2).

Analysis of incidence rates in 2017 showed that the Vale do Mucuri (mesoregion 10) and the Vale do Rio Doce (mesoregion 11) ranked second in terms of incidence, with 971.9 and 780.8/100000 inhabitants, respectively. The Jequitinhonha mesoregion (mesoregion 3) ranked fourth in incidence, with 134.6/100000 inhabitants. The other mesoregions did not reach 50 new cases per 100000 inhabitants (Figure 2B). Figure 3 illustrates the incidence of Chikungunya by municipality in 2017 (A), 2023 (B), and 2024 (C). In 2017, considering the municipalities of the Vale do Rio Doce mesoregion, Mathias Lobato had the highest incidence, with 6528.2 cases per 100000 inhabitants.

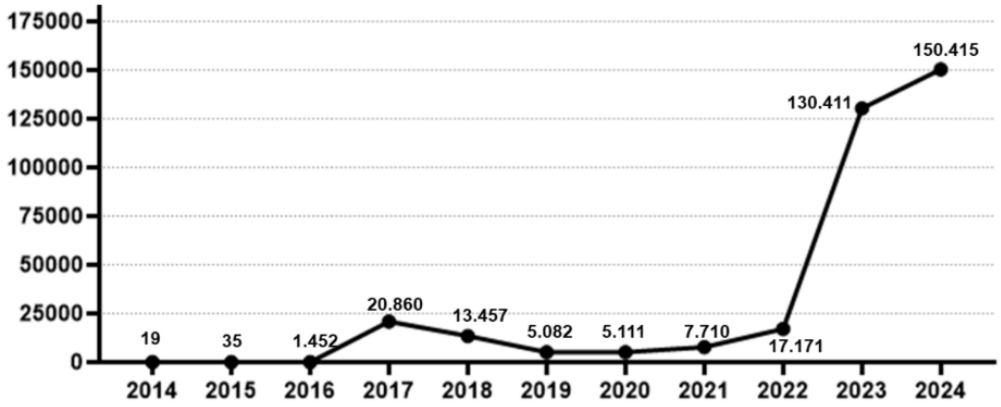


Figure 1. New cases of Chikungunya recorded in MG per year between 2014 and 2024.

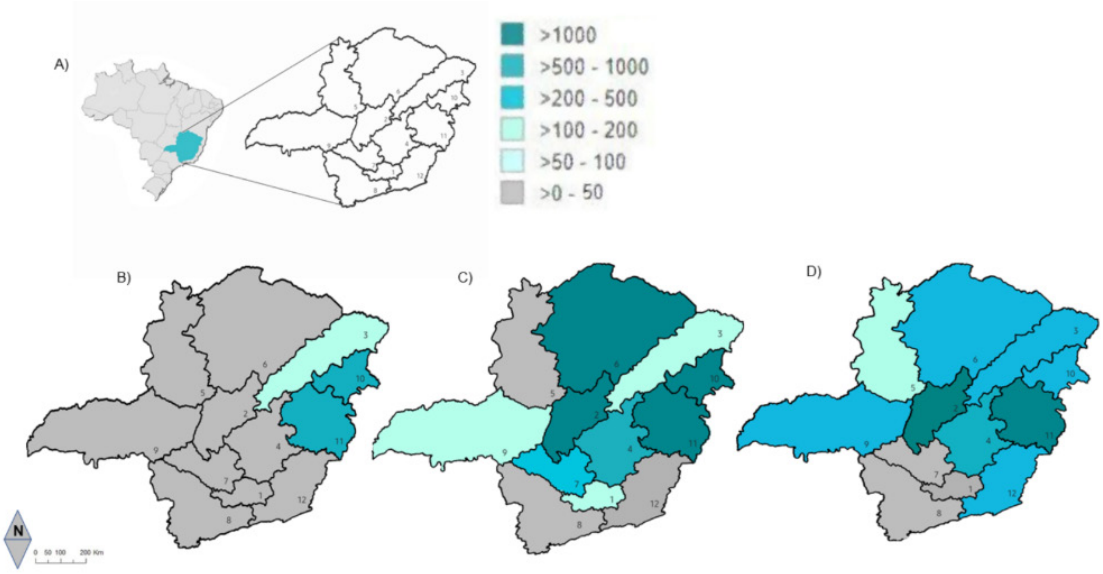


Figure 2. A: MG and its mesoregions in the national panorama; **B.** Incidence of Chikungunya in Minas Gerais by geographic mesoregions: 1- Campo das Vertentes; 2- Central Mineira; 3- Jequitinhonha; 4- Belo Horizonte Metropolitan Area; 5- Northwest Minas; 6- North Minas; 7- West Minas; 8- South Minas; 9- Triângulo Mineiro; 10- Vale do Mucuri; 11- Vale do Rio Doce; 12- Zona da Mata - in 2017; **C.** 2023; **D.** 2024.

Table 1. Incidence of Chikungunya cases in MG by mesoregion in 2017, 2023, and 2024.

MESOREGIONS	2017	2023	2024
Noroeste de Minas	2.7	3.5	144.8
Norte de Minas	3.9	2698.4	332.9
Jequitinhonha	134.6	155.8	259.3
Vale do Mucuri	780.8	1527.5	384.2
Triângulo Mineiro	10.3	108.8	356.5
Central Mineira	12.1	1068.3	1110.1
Metropolitana de Belo Horizonte	10.7	543.8	760.6
Vale do Rio Doce	971.9	1315.8	4362.6
Oeste de Minas	4.7	302.4	20.7
Sul de Minas	5.1	11.8	20.7
Campo das Vertentes	2.2	135.3	46.0
Zona da Mata	6.6	43.7	286.5

In Vale do Mucuri, Teófilo Otoni had the highest incidence, with 1,911.7 cases per 100000 inhabitants. In the Jequitinhonha mesoregion, Salto da Divisa had an incidence of 2,711.7 per 100000 inhabitants (Figure 3A).

In 2023, four mesoregions were classified in the first incidence range for Chikungunya: Northern Minas Gerais (mesoregion 6), Vale do Mucuri, Vale do Rio Doce, and Central Minas Gerais (mesoregion 2; Figure 2C). The incidence rates were 2,698.5/100000 inhabitants in Northern Minas Gerais; 1,527.5/100000 inhabitants in the Vale do Mucuri; 1,315.8/100000 inhabitants in the Vale do Rio Doce; and 1,068.3/100000 inhabitants in Central Minas Gerais. The Belo Horizonte Metropolitan Region (mesoregion 4) and Western Minas Gerais (mesoregion 7) also stood out, ranking 2nd and 3rd in incidence, with 543.8/100000 inhabitants and 302.4/100000 inhabitants, respectively. In the Belo Horizonte Metropolitan Region, there was an increase from 10.8 in 2017 to 543.8 cases per 100000 inhabitants in 2023. Northwest Minas (mesoregion 5), Zona da Mata (mesoregion 12), and South Minas (mesoregion 8) were included in the last incidence range, with 3.5/100000 inhabitants and 11.8/100000 inhabitants. This year, the city with the highest incidence of Chikungunya in Northern Minas Gerais was Jaíba, with 8,794.1 cases per 100000 inhabitants (Figure 3B). In the Vale do Mucuri, Franciscópolis had the highest incidence, with 2,996 cases

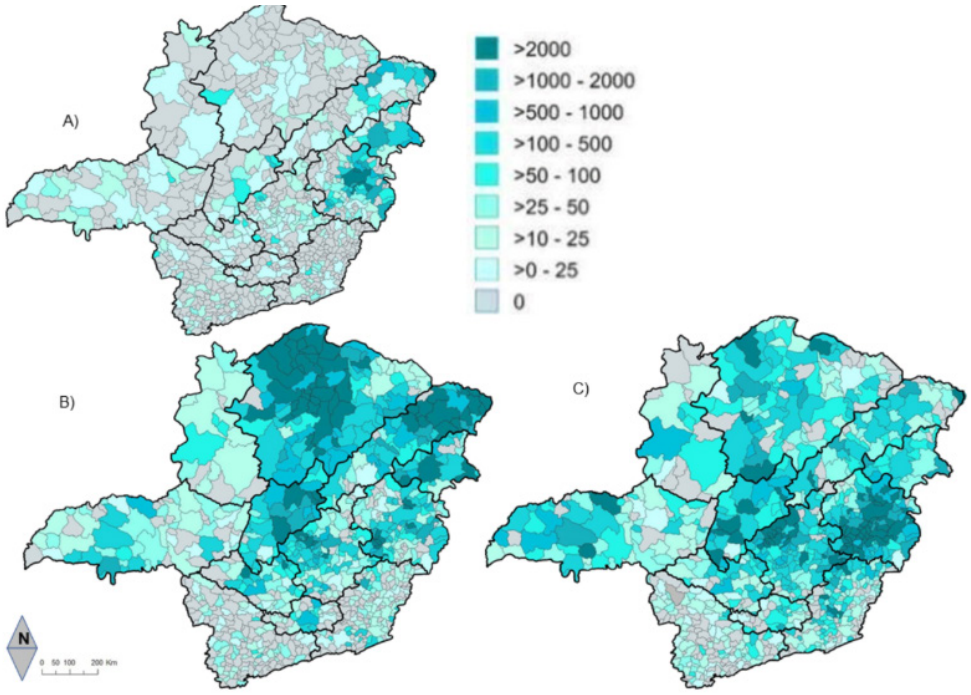


Figure 3. A: Incidence of Chikungunya in Minas Gerais by municipality in 2017; **B.** 2023; **C.** 2024. Geographic mesoregions: 1- Campo das Vertentes; 2- Central Mineira; 3- Jequitinhonha; 4- Belo Horizonte Metropolitan Area; 5- Northwest Minas; 6- North Minas; 7- West Minas; 8- South Minas; 9- Triângulo Mineiro; 10- Vale do Mucuri; 11- Vale do Rio Doce; 12- Zona da Mata.

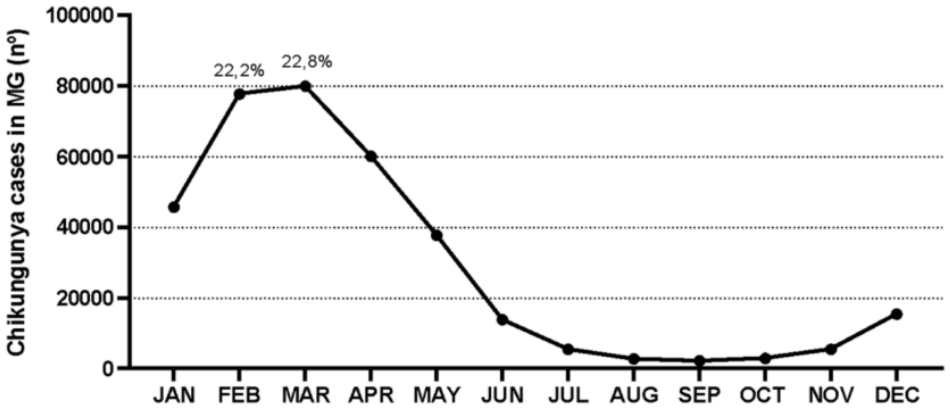


Figure 4. Total number of Chikungunya cases per month from 2014 to 2024 in MG.

per 100000 inhabitants. In the Vale do Rio Doce, Mathias Lobato remained prominent, with an incidence coefficient of 1,0748.6/100000 inhabitants, and finally, Corinto, in Central Minas Gerais, was the municipality with the highest incidence of Chikungunya, with 4,414.5 cases/100000 inhabitants.

In 2024, until July, the Vale do Rio Doce and Central Mineira mesoregions remained prominent in the state, with incidence rates of 4,362.6 and 1,110.1 cases per 100000 inhabitants, respectively (Figure 2D). Next, the Belo Horizonte Metropolitan Region had an incidence rate of 760.6 cases per 100000 inhabitants. In turn, Campo das Vertentes (mesoregion 1), Southern Minas Gerais, and Western Minas Gerais were classified as areas with the lowest incidence, with 46.0/100000 inhabitants, 20.7/100000 inhabitants, and 20.7/100000 inhabitants, respectively. An analysis of the cities with the highest incidence by mesoregion in 2024 showed Joanésia (33,094.8/100000 inhabitants) in Vale do Rio Doce, Santo Hipólito (1,4809.1/100000 inhabitants) in Central Minas Gerais, and Fortuna de Minas (2,4531.9/100000 inhabitants) in the Belo Horizonte Metropolitan Area (Figure 3C). The evolution of Chikungunya cases per 100000 inhabitants in the 12 mesoregions in 2017, 2023, and 2024 is illustrated in Figure 2E.

Figure 4 illustrates the sum of the number of Chikungunya notifications per month over the last 10 years. It was observed that the number of cases is concentrated in the summer, a period that extends from December to March, accounting for 62.5% of the total cases in the years analyzed. The increase begins in December, continues in January, and culminates in February and March, which accounted for 22.2% and 22.8% of cases, respectively.

Table 2 shows the sociodemographic profile of the population that contracted Chikungunya in Minas Gerais from 2017 to 2024. It was observed that 59.2% of cases were female (n=20,7229); 63.4% of cases were concentrated between 20 and 59 years of age (n=22,2274); children aged 0 to 4 years represented the least affected population (2.3%, n=8,145), followed by elderly people over 80 years of age (2.4%, n=8,504). There was a higher incidence of the disease in the self-declared mixed-race population, representing 60.3% of cases (n=21,1203); while the indigenous population was the least affected, totaling 0.2% of cases (n=725). Analysis of the evolution of cases showed that 72.9% of affected individuals (n=25,5397) recovered, while 0.0% died from the disease (n=147).

A statistically significant difference was observed in the distribution of sociodemographic and clinical variables over the years analyzed. There was variation in the distribution by sex (χ^2=284.6; df=14; p<0.0001), age group (χ^2=1734; df=77; p<0.0001), race/skin color (χ^2=15508; df=35; p<0.0001), and case evolution (χ^2=8498; df=14; p<0.0001). Despite the statistical significance, a predominance of females was observed, with a concentration of cases in the 20-59 age group and a higher frequency in the self-declared mixed-race population throughout the period. Most cases resulted in cure, with a low proportion of deaths.

Table 2. Sociodemographic profile of patients affected by Chikungunya in Brazil between 2017 and 2024, according to the year of notification.

Year of notification	2017	2018	2019	2020	2021	2022	2023	2024	TOTAL
Total number of cases	20860 (100)	13457 (100)	5082 (100)	5110 (100)	7710 (100)	17169 (100)	130411 (100)	150414 (100)	350217 (100)
Gender									
Female n(%)	12738 (61.1)	8279 (61.5)	3206 (63.1)	3057 (59.8)	4637 (60.1)	10260 (59.8)	76970 (59.0)	88082 (58.6)	207229 (59.2)
Male n(%)	8102 (38.8)	5173 (38.4)	1872 (36.8)	2053 (40.2)	3070 (39.8)	6895 (40.2)	53149 (40.8)	62231 (41.4)	142545 (40.7)
Blank n(%)	20 (0.1)	5 (0.0)	4 (0.1)	1 (0.0)	3 (0.0)	16 (0.1)	292 (0.2)	102 (0.1)	443 (0.1)
Age group (years)									
<1 n(%)	155 (0.7)	158 (1.2)	53 (1.0)	67 (1.3)	98 (1.3)	211 (1.2)	832 (0.6)	909 (0.6)	2483 (0.7)
1 – 4 n(%)	314 (1.5)	168 (1.2)	98 (1.8)	68 (1.3)	106 (1.4)	333 (1.9)	2246 (1.7)	2289 (1.5)	5622 (1.6)
5 – 9 n(%)	789 (3.8)	397 (3.0)	161(3.2)	143 (2.8)	249 (3.2)	647 (3.7)	4839 (3.7)	5419 (3.6)	12644 (3.6)
10 – 14 n(%)	1142 (5.5)	650 (4.7)	260 (5.0)	234 (4.6)	282 (3.7)	891 (5.1)	7025 (5.4)	7479 (5.0)	17963 (5.1)

continued...

... continuation Table 2

Year of notification	2017	2018	2019	2020	2021	2022	2023	2024	TOTAL
15 – 19 n(%)	1572 (7.5)	1011 (7.4)	359 (7.1)	291 (5.7)	425 (5.4)	1055 (6.0)	8448 (6.5)	9343 (6.2)	22504 (6.4)
20 – 39 n(%)	7082 (33.9)	4349 (32.1)	1929 (37.9)	1800 (35.1)	2701 (34.9)	6054 (35.2)	42632 (32.7)	45318 (30.0)	111865 (31.9)
40 – 59 n(%)	6381 (30.5)	4430 (32.8)	1586 (31.1)	1735 (34.0)	2652 (34.3)	5227 (30.3)	40386 (31.0)	48012 (31.8)	110409 (31.5)
60 – 64 n(%)	1153 (5.5)	806 (6.0)	247 (4.8)	280 (5.5)	395 (5.1)	899 (5.1)	7417 (5.7)	9882 (6.5)	21079 (6.0)
65 – 69 n(%)	802 (3.8)	583 (4.3)	196 (3.9)	180 (3.5)	340 (4.4)	697 (4.1)	6051 (4.6)	8152 (5.4)	17001 (4.9)
70 – 79 n(%)	1034 (5.0)	655 (4.9)	148 (2.9)	216 (4.2)	320 (4.2)	816 (4.7)	7252 (5.6)	9616 (6.4)	20057 (5.7)
≥80 n(%)	428 (2.1)	247 (1.8)	45 (0.9)	92 (1.8)	141 (1.8)	337 (2.0)	3244 (2.5)	3970 (2.6)	8504 (2.4)
Blank n(%)	8 (0.0)	3 (0.0)	0 (0.0)	4 (0.1)	1 (0.0)	2 (0.0)	39 (0.0)	25 (0.0)	82 (0.0)
Race/skin color									
White n(%)	2623 (12.6)	2838 (21.3)	1764 (35.1)	1633 (32.0)	2084 (27.0)	2.465 (14.4)	16704 (12.8)	25651 (17.4)	55762 (15.9)
Black n(%)	1043 (5.0)	964 (7.4)	414 (8.5)	493 (9.6)	650 (8.4)	1039 (6.1)	7058 (5.4)	9526 (6.5)	21187 (6.0)
Yellow n(%)	138 (0.7)	203 (1.7)	41 (1.2)	40 (0.8)	54 (0.7)	186 (1.1)	944 (0.7)	1185 (0.9)	2791 (0.8)
Mixed-race n(%)	8619 (41.5)	8437 (62.9)	2363 (46.9)	2625 (51.3)	4050 (52.5)	11931 (69.7)	83958 (64.4)	89220 (59.8)	211203 (60.3)
Indigenous n(%)	47 (0.2)	16 (0.2)	7 (0.2)	9 (0.2)	9 (0.1)	27 (0.2)	374 (0.3)	236 (0.2)	725 (0.2)
Blank n(%)	8390 (40.2)	999 (7.4)	493 (9.9)	311 (6.1)	863 (11.2)	1523 (8.9)	21373 (16.4)	24597 (16.6)	58549 (16.7)
Progression									
Recovery n(%)	16323 (78.2)	12397 (92.1)	3634 (71.5)	4062 (79.5)	6730 (87.3)	14592 (85.0)	97653 (74.9)	100006 (66.5)	255397 (72.9)
Death due to the condition n(%)	15 (0.1)	2 (0.0)	1 (0.0)	0 (0.0)	1 (0.0)	2 (0.0)	53 (0.0)	73 (0.0)	147 (0.0)
Death due to other causes n(%)	33 (0.2)	6 (0.0)	6 (0.1)	9 (0.2)	9 (0.1)	15 (0.1)	45 (0.0)	27 (0.0)	150 (0.0)
Death under investigation n(%)	0 (0.0)	1 (0.0)	1 (0.0)	1 (0.0)	0 (0.0)	2 (0.0)	18 (0.0)	30 (0.0)	53 (0.0)
Blank n(%)	4489 (21.5)	1051 (7.8)	1440 (28.3)	1039 (20.3)	970 (12.6)	2560 (14.9)	32642 (25.0)	50279 (33.4)	94470 (27.0)

Discussion

This study investigated the incidence of Chikungunya in Minas Gerais, its spatial-temporal dynamics, and the characterization of its sociodemographic profile over the last 10 years. Based on a preliminary analysis, Minas Gerais stands out as having the highest number of reported cases of Chikungunya fever in recent years, differing from the trend in other states in the country[17]. Historical analysis revealed significant peaks in 2017, 2023, and 2024, with a significant increase in incidence, especially in the mesoregions of Vale do Rio Doce, Vale do Mucuri, and Central Mineira. Mathias Lobato, Itaobim, and Itinga recorded the highest incidence rates in 2023, and Joanésia in 2024. The seasonal pattern showed a higher concentration of cases in the summer, and the epidemiological profile revealed a higher incidence among women, adults between 20 and 59 years of age, and the mixed-race population.

Regarding sociodemographic variables, the inferential analysis revealed statistically significant variations throughout the study period. However, these differences should be interpreted considering the high number of observations and the ecological nature of the study, which increase the sensitivity of statistical tests to detect variations of small magnitude. In this sense, although statistically significant differences were identified, the pattern of the epidemiological profile remained relatively stable. These findings suggest that, although there are temporal fluctuations in proportions, no substantial change is observed in the profile of the most affected individuals over the years analyzed. It is important to emphasize that the joint analysis of descriptive and inferential results reinforces that the observed statistical significance should be contextualized by the magnitude of the differences and the methodological limitations of the study, prioritizing the epidemiological interpretation of the identified trends. This approach contributes to a more robust understanding of the dynamics of Chikungunya in the state, without overestimating variations that may reflect, in part, characteristics of the information system itself.

In the three years analyzed, there was an increasing number of Chikungunya cases in Minas Gerais. Since 2016, Brazil has been the country in the Americas with the highest number of cases. The first reports occurred in the Northeast region, with the East/Central/South African strain, and in the North region, with the Asian strain. Since then, the virus has spread inland throughout the country[18]. In Minas Gerais, cases of Chikungunya began to be reported in the first half of 2016, both of autochthonous origin and from East/Central/South African strains imported from the Northeast region[6]. In 2023, Minas Gerais once again emerged as the epicenter of the disease, registering 350 cases per 100000 inhabitants in epidemiological week 23[19]. In that same year, the state accounted for 53.3% of cases in the country[20]. In this context, it is known that after an odd year following the outbreak, cases tend to decrease due to the immune response acquired by the population[6]. In the current study, this pattern was observed only after the first epidemic peak in 2017, with 11,759 cases recorded in 2018. In the 2023-2024 biennium, this trend did not continue. A study conducted in Ceará concluded that the recurrence of the Chikungunya virus resulted from the introduction of a new strain of the virus, which was not controlled by the population's previous immunity[17]. Thus, one of the possibilities for the increase in cases in Minas Gerais may be due to the importation of a new strain of the virus, since previous immunization in 2023 did not reduce the impact of the disease in 2024, although this hypothesis cannot be confirmed by the data in the present study, which does not include genomic analysis. In contrast, other regions of Brazil showed the opposite trend in this period. Northeastern states, such as Pernambuco and Bahia, which were previously among the most affected, recorded a decline in cases after the epidemic peaks in 2016 and 2017[20,21]. Amapá, the first state to report the circulation of the virus in the country, also showed a decline in notifications in recent years, reflecting a pattern observed in other areas that faced early outbreaks[22].

The division of Minas Gerais into 12 mesoregions allows municipalities to be grouped according to regional, climatic, and sociodemographic characteristics, factors relevant to the analysis of arbovirus epidemics[14]. In 2017, cases of Chikungunya were concentrated in the mesoregions of Vale do Mucuri, Vale do Rio Doce, and Jequitinhonha, both in the northeastern part of the state.

In 2023, the epidemic outbreak reached nine mesoregions with an incidence of over 50/100000 inhabitants, and among these, four mesoregions were classified in the first incidence bracket, notably Vale do Mucuri and Vale do Rio Doce, which were previously in the second bracket in 2017. These data show the intense advance of Chikungunya in the state, which still had a large unsensitized population. In 2024, even with limited data until July, mesoregions previously classified in the lowest incidence range, between 0 and 50/100000 inhabitants, began to reach significant incidences, such as the Northwest of Minas Gerais and Zona da Mata. These areas were not very susceptible, but became relevant in terms of incidence, a phenomenon similar to that observed in study on Ceará[17]. Future updates, including complete 2024 data, are necessary to confirm the persistence of the observed epidemiological trends.

In terms of national comparisons, Minas Gerais stood out as one of the main transmission centers in the years 2017, 2023, and 2024, following the trend of the spread and spatial expansion of Chikungunya in Brazil. In 2017, although the national focus was concentrated in Ceará[17], which was the epicenter of the epidemic during that period, Minas Gerais already showed consistent growth in transmission, albeit on a smaller scale. The spatiotemporal dynamics of the disease in the country have been marked by cycles of high transmission in different regions, followed by dissemination to previously less affected areas[17]. In this context, in 2023, Minas Gerais assumed greater relevance in the national scenario, with a significant increase in the number of cases and expansion of high-incidence areas, reflecting a pattern similar to that previously described in Ceará[17]. In 2024, the consolidation of this process is observed, with expansion to previously little-affected mesoregions, evidencing not only the persistence of transmission but also the change in the pattern of disease dissemination. This behavior may reinforce the dynamic and recurrent nature of Chikungunya in Brazil, in which different states take center stage at different epidemic points, depending on the availability of susceptible population and conditions favorable to transmission. In general, the dynamics of the disease in the country occurred in a heterogeneous manner, with the states of the Northeast acting as initial centers of dissemination and subsequent expansion to other regions, including the Southeast, where Rio de Janeiro and Espírito Santo recorded a significant increase in cases in subsequent years[17]. While Minas Gerais accounted for more than 50% of national cases in 2023 and 2024, states such as Bahia and Pernambuco, which experienced epidemic peaks between 2016 and 2017, registered a sustained reduction in incidence in subsequent years, evidencing a distinct pattern of re-emergence in the

Minas Gerais scenario[20,21]. Thus, the behavior observed in Minas Gerais in 2023 and 2024 aligns with the national dynamic, assuming a prominent role after periods of greater concentration in other states, with expansion to previously less affected areas. This alternation between regions reinforces the notion of epidemic recurrence and spatial heterogeneity of the disease in the country, suggesting that the availability of susceptible individuals, combined with environmental factors and the presence of the vector, determines the emergence of new epicenters over time.

The climatic factor may explain the lower incidence rates in the three years analyzed in the southern mesoregions of the state, such as Campo das Vertentes, Oeste de Minas, and Sul de Minas, where lower temperatures predominate. Vale do Rio Doce, which remained prominent during the years evaluated in this study, has characteristics typical of a humid tropical climate, with average annual temperatures ranging from 23°C to 26°C. The rainfall pattern is marked by concentration in the summer, with significant annual precipitation[23]. It is known that rising temperatures reduce the incubation period of *Aedes aegypti,* in addition to increasing the oviposition rate, making mosquito reproduction more efficient, which explains the contrast between regions. In addition to the influence of temperature, increased rainfall or irregular water supply favors the vector's oviposition rate[24]. Studies involving a comprehensive analysis of the country have pointed to a correlation between climate patterns of temperature and precipitation and the timing and intensity of Chikungunya and dengue epidemics[25]. Thus, hot and rainy seasons, such as summer, become more conducive to an increase in the incidence of the disease, as observed in this study, accounting for 62.5% of cases from 2014 to 2024.

It is interesting to note that the Central Mineira mesoregion showed a significant increase in cases in 2023 and 2024 compared to 2017, possibly due to the susceptible population volume. On the other hand, in 2023, it was found that 31 (34.8%) municipalities in the north of Minas Gerais reached the first incidence range. This event did not repeat itself in the following year, when four municipalities occupied the same range. Another atypical pattern was observed in the Vale do Rio Doce mesoregion, which stood out in terms of number of cases in the three years analyzed. Since 2015, this region has suffered changes in its microenvironment due to the collapse of the Fundão Dam in Mariana. The loss of vegetation in the Rio Doce basin caused changes in the microclimate, in addition to the destruction of habitats for various species and an increase in the presence of disease vectors, resulting in an outbreak of Yellow Fever[26]. Although these environmental factors may contribute to the vulnerability of the region, it is not possible to establish a direct causal relationship between the impact of the ore slurry and the proliferation of *Aedes aegypti*. More specific studies are needed to robustly assess this possible association in the context of Minas Gerais.

In 2017, the municipalities with the highest incidence of cases were located in the same mesoregions that led in this regard. Also in that year, there were a large number of cities in the lowest incidence range, suggesting little or no previous population contact with the virus. From 2023 onwards, the spread of Chikungunya into the interior and the predominance of municipalities concentrated between the 3rd and 5th incidence ranges are clear, while the South of Minas Gerais and Zona da Mata still had municipalities with no recorded cases. Itinga, Jacinto, and Itaobim reached the 1st incidence range in 2023. These municipalities are located in the Vale do Jequitinhonha, a mesoregion known for its large regional inequalities and high social vulnerability[27].

In addition to average temperature and precipitation patterns, interannual climate variability and extreme weather events also play a significant role in the epidemiological dynamics of arboviral diseases. In the present study, it was observed that 62.5% of Chikungunya cases between 2014 and 2024 were concentrated in the period from December to March, with peaks in February (22.2%) and March (22.8%), reinforcing the strong influence of climatic seasonality on viral transmission, consistent with patterns described in the literature[23,25]. Phenomena such as prolonged periods of drought, followed by heavy rains, can temporarily alter the availability of breeding sites, favoring both household water storage and the formation of artificial containers conducive to vector oviposition, as previously described[24]. Additionally, temperature fluctuations influence not only vector density but also vector competence and the rate of viral replication in the mosquito, directly impacting transmission potential[25]. This pattern is corroborated by the findings of this study, in which the years 2023 and 2024 showed high incidence rates (469.3 and 754.3 cases per 100000 inhabitants, respectively), coinciding with periods of greater heat and precipitation. In this context, years with atypical climatic conditions may present more intense outbreaks or a temporal shift in the epidemic peak, reinforcing the importance of incorporating climatic variables into predictive models and epidemiological surveillance strategies, especially in regions with environmental heterogeneity such as Minas Gerais.

The epidemiological profile of Chikungunya cases with higher incidence in women suggests a possible relationship with behavioral and social factors. A previous study analyzed three epidemic waves in Ceará, showing an incidence two to three times higher in women aged 20 to 59 than in men of the same age[17]. The concentration of cases in individuals aged 20 to 59 reflects the prevalence of Chikungunya in the economically active population, and although it is not possible to establish direct causes, greater mobility and time spent in workplaces and public transportation may contribute to greater exposure to the vector. This condition can impact individuals' productivity, affecting both the family economy and the state's economic management. The increase in costs for the health and social security system may also be significant, considering the chronicity of symptoms and the possible sequelae of the chronic phase of the disease[28]. Regarding race/skin color, a higher prevalence of Chikungunya was found among self-declared mixed-race individuals, which may be associated with the socio-spatial inequalities present in Minas Gerais, where

mixed-race majority communities often reside in areas with poor infrastructure, irregular water supply, and waste accumulation, conditions that favor the reproduction of *Aedes aegypti*[28]. These observations reinforce that local social and environmental determinants play a central role in the dynamics of the disease in the state and that understanding these inequalities is essential to guide public prevention and control policies. Clinical evolution revealed a cure rate of 72.9%, indicating that most cases have a favorable outcome, with a relatively low mortality rate. However, complications and long-term sequelae can significantly compromise patients' quality of life, even after clinical cure, impacting their daily activities[29]. Follow-up and rehabilitation become essential. In addition, early identification of severe cases and strengthening treatment are fundamental to prevent avoidable fatal outcomes[28].

Among the limitations of this study is the absence of complete data for the second half of 2024, since this period was not yet included in the databases used at the time of its execution. This may have led to an underestimation of the annual incidence and may limit direct comparisons with previous years that were fully analyzed. Furthermore, the inherent limitations of using secondary data, subject to underreporting, inconsistencies in records, and a high proportion of missing fields, should also be considered. Moreover, the lack of control over potential confounding factors and the impossibility of causal inference, characteristics of the ecological design, restrict the interpretation of the findings to observational associations. In addition, the absence of seroprevalence analyses in the population and genomic studies limits the understanding of the collective immune response and its influence on the recurrence of outbreaks, as well as the confirmation of possible viral variations. This gap makes it difficult to verify the hypothesis raised about the introduction or circulation of a new lineage in the state and restricts the interpretation of the observed temporal trends. Another aspect is the difficulty in establishing direct causal relationships between the incidence of the disease and socio-environmental factors, in addition to bias in the notification and classification of cases, especially due to the simultaneous circulation of the dengue virus and the chikungunya virus.

Despite these limitations, this study makes significant contributions to the understanding of the epidemiological dynamics of chikungunya in Minas Gerais, revealing that the state has had the highest incidence of the disease in Brazil in recent years, highlighting the progression of incidence by mesoregions and municipalities, data that is unprecedented in the literature in the format presented. The advance into new areas, combined with the increase in the number of cases, may suggest failures in vector control mechanisms, epidemiological surveillance, and the need for more efficient prevention strategies. We suggest conducting seroepidemiological and genomic studies to confirm the circulation of new strains and the true extent of population immunity, as well as research to evaluate the effectiveness of specific vector control interventions in Minas Gerais. The study also highlights the influence of socioeconomic and environmental determinants on the spread of Chikungunya, reinforcing the need for intersectoral interventions that integrate environmental management, improvements in basic sanitation, and health education actions for vector control. The findings of this study, although specific to Minas Gerais, may be applicable to other Brazilian regions with similar climatic, urban, and entomological conditions.

This study showed that Chikungunya expanded significantly in Minas Gerais between 2014 and 2024, with a concentration of cases in the mesoregions of Vale do Rio Doce, Vale do Mucuri, and Central Mineira, strong seasonality in the warmer months, and greater incidence in adult mixed-race women. These findings directly respond to the proposed objective by outlining the epidemiological profile of the disease in the state, identifying priority areas and population groups for control actions. The results reinforce the need for more robust surveillance strategies, intersectoral prevention interventions, and complementary studies focused on the regional aspect, including serological and genomic analyses, to contain the spread of the virus and mitigate its social and economic impacts.

Authors' Contributions

We describe contributions to the papers using the taxanomy (CRediT) provided below:

Conceptualization, Data curation, Formal analysis, Investigation, Methodology, Project management, Resources, Visualization, Writing—original draft, Writing—revision and editing: LC Coutinho. *Conceptualization, Data curation, Formal analysis, Investigation, Methodology, Project management, Resources, Visualization, Writing—original draft, Writing—revision and editing*: GCD Gonçalves. *Conceptualization, Formal Analysis, Methodology, Project Management, Resources, Supervision, Visualization, Writing – original draft, Writing – review and editing*: NA Velloso. *Conceptualization, Formal Analysis, Methodology, Project Management, Resources, Supervision, Visualization, Review – original draft, Writing – revision and editing*: VLA Almeida.

All authors designed the study, analyzed and interpreted the results, and drafted and critically revised the manuscript. All authors approved the final version of the manuscript and are responsible for all aspects of it, including ensuring its accuracy and integrity.

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References

1. Donalisio MR, Freitas ARR. Chikungunya no Brasil: um desafio emergente. Rev Bras Epidemiol. 2015;18(1):283-5.

2. Ministério da Saúde (BR), Secretaria de Vigilância em Saúde. Monitoramento dos casos de dengue e febre de Chikungunya até a Semana Epidemiológica 15, 2015 [Internet]. Bol Epidemiol. 2015; [access in 2025 Oct 11]; 46(14). Available from: http://portalsaude.saude.gov.br/images/pdf/2015/maio/04/2015-016---Boletim-Dengue-SE15-2015.pdf

3. Pereira GSB, Vicente MPL, Gomes RDFM, Bernardes TE. Estudo epidemiológico da febre Chikungunya no estado de Minas Gerais no decurso dos anos de 2020 a 2024 [Internet]. In: Anais do 16º Congresso Internacional da Rede Unida; 2024; [cited 2025 Oct 11]. Available from: https://doity.com.br/anais/16congressointernacionaldaredeunida/trabalho/375583

4. Zhao T, Chen T, Zhang J, Li C, Qin C. Chikungunya virus: current situation and future challenges. Biosaf Health. 2025;7(6):348-56.

5. Agência Brasil. Diferença entre dengue, zika e Chikungunya é sutil, diz especialista [Internet]. Agência Brasil; 2016; [cited 2025 Oct 11]. Available from: https://agenciabrasil.ebc.com.br/geral/noticia/2016-03/diferenca-entre-dengue-zika-e-chikungunya-e-sutil-diz-especialista

6. Fritsch H, Giovanetti M, Xavier J, Adelino TER, Fonseca V, de Jesus JG, et al. Retrospective genomic surveillance of Chikungunya transmission in Minas Gerais State, Southeast Brazil. Microbiol Spectr. 2022;10(5):e01285-22.

7. Ministério da Saúde (BR), Secretaria de Vigilância em Saúde, Departamento de Vigilância das Doenças Transmissíveis. Chikungunya: manejo clínico. Brasília: Ministério da Saúde; 2017. 65 p.

8. Borgherini G, Poubeau P, Jossaume A, Gouix A, Cotte L, Michault A, et al. Persistent arthralgia associated with Chikungunya: a study of 88 adult patients on Reunion Island. Clin Infect Dis. 2008;47(4):469-75.

9. Marques CDL, Alcântara-Neves NM, Duré RM, Mota LMH, Pileggi G, Rocha FAC, et al. Recomendações da Sociedade Brasileira de Reumatologia para diagnóstico e tratamento da febre Chikungunya. Parte 1 – Diagnóstico e situações especiais. Rev Bras Reumatol. 2017;57(5):421-37.

10. Chopra A, Anuradha V, Ghorpade R, Saluja M. Acute Chikungunya and persistent musculoskeletal pain following the 2006 Indian epidemic: a 2-year prospective rural community study. Epidemiol Infect. 2012;140(5):842-50.

11. Javelle E, Ribera A, Degasne I, Gauzere BA, Marimoutou C, Simon F. Specific management of post-Chikungunya rheumatic disorders: a retrospective study of 159 cases in Reunion Island from 2006–2012. PLoS Negl Trop Dis. 2015;9(3):e0003603.

12. Instituto Brasileiro de Geografia e Estatística (IBGE). Censo Demográfico 2022 [Internet]. Rio de Janeiro: IBGE; 2022; [access in 2025 Oct 11]. Available from: https://www.ibge.gov.br/cidades-e-estados/mg.html

13. Instituto Brasileiro de Geografia e Estatística (IBGE). Censo Demográfico 2010 [Internet]. Rio de Janeiro: IBGE; 2010; [access in 2025 Oct 11]. Available from: https://censo2010.ibge.gov.br/sinopse/index.php?dados=29&uf=31

14. Governo de Minas Gerais. Geografia [Internet]. MG.GOV.BR; [access in 2025 Oct 11]. Available from: https://www.mg.gov.br/pagina/geografia

15. Sistema de Informação de Agravos de Notificação (SINAN). Dados epidemiológicos [Internet]. [s.l.]: [s.n.]; [access in 2025 Oct 11]. Available from: https://portalsinan.saude.gov.br/dados-epidemiologicos-sinan

16. Ministério da Saúde (BR). Série histórica - Casos prováveis de Chikungunya (2014-2023) [Internet]. Brasília: Ministério da Saúde; [access in 2025 Oct 11]. Available from: https://www.gov.br/saude/pt-br/assuntos/saude-de-a-z/c/chikungunya/situacao-epidemiologica/serie-historica-casos-provaveis-de-chikungunya-2014-2023/view

17. de Souza WM, de Lima STS, Simões Mello LM, Candido DS, Buss L, Whittaker C, et al. Spatiotemporal dynamics and recurrence of Chikungunya in Brazil: an epidemiological study. Lancet Microbe. 2023;4(5):e319-29.

18. William E, Hunsperger E, Muñoz-Jordán J, Clapham HE, Salje H, Johansson MA, et al. Chikungunya: a decade of burden in the Americas. Lancet Reg Health Am. 2024;30:100673.

19. Ferreira I, Carvalho MS, Cruz OG, Wu J, Gómez LF, Braga C, et al. The expansion of Chikungunya in Brazil. Lancet Reg Health Am. 2023;25:100571.

20. Ministério da Saúde (BR). Boletim Epidemiológico - Situação da Chikungunya no Brasil até a Semana Epidemiológica 23 de 2023 [Internet]. Brasília: Secretaria de Vigilância em Saúde; 2023; [access in 2025 Oct 11]. Available from: https://www.gov.br/saude/pt-br/assuntos/saude-de-a-z/c/chikungunya/boletins-epidemiologicos

21. Lourenço J, Monteiro M, Valdez T, Rodrigues F. Impacto das medidas de controle vetorial na incidência de Chikungunya no Nordeste do Brasil. Rev Bras Epidemiol. 2021;24:e210021.

22. Oliveira SR, Mendes AB, Costa LM. Declínio dos casos de Chikungunya no estado do Amapá: fatores associados e estratégias de controle. Cad Saúde Pública. 2022;38(5):e00012322.

23. Instituto Nacional de Meteorologia (INMET). Clima [Internet]. Gov.Br; [access in 2025 Oct 11]. Available from: https://clima.inmet.gov.br/NormaisClimatologicas/1961-1990/precipitacao_acumulada_mensal_anual

24. Silva M. A epidemia de arboviroses em Minas Gerais (2023): análise a partir da dimensão da geografia da saúde [Internet]. [s.l.]: [s.n.]; [cited 2025 Oct 11]. Available from: https://www.civil.uminho.pt/planning/Pluris2024/Atas/Papers/Paper1116.pdf

25. Araujo EC, Codeço CT, Loch S, Vacaro LB, Freitas LP, Lana RM, et al. Large-scale epidemiological modeling: scanning for mosquito-borne diseases spatio-temporal patterns in Brazil [Internet]. 2024; [cited 2025 Oct 11]. Available from: https://arxiv.org/abs/2407.21286

26. Silva RA, Gomes JR. Desastres ambientais e os impactos da mineração: uma análise do rompimento da barragem de Mariana (Minas Gerais). Rev Bras Geogr Meio Ambiente. 2017;29(3):193-206.

27. Fonseca SF, Aguiar HH. Autocorrelação espacial entre indicadores socioeconômicos nos vales do Jequitinhonha e Mucuri. Geousp Esp Tempo (Online). 2019;23(3):619-39.

28. Santos LM, Pereira RS. Impactos sociodemográficos das arboviroses no Brasil. Pluris Proc. 2024;11(16):135-48.

29. Silva JR, Souza PF, Almeida MC. Dinâmica de transmissão da Chikungunya em regiões urbanas. J Infect Sci Trop Med. 2021;10(3):245-57.

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