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ECONOMIC EVALUATION OF DENGUE DISEASE IMPACT: AN ANALYSIS FOR SÃO PAULO CONTEXT

Ana Flávia Barbosa Gabriel, Msc
Doutoranda
ORCID: https://orcid.org/0000-0002-7643-7298
Lattes: http://lattes.cnpq.br/4538424488673789
Instituto de Ciências Ambientais, Químicas e Farmacêuticas
UNIFESP - Universidade Federal de São Paulo
Programa de Pós-Graduação em Biologia Química
E-mail: ana.gabriel@unifesp.br

Daniela Debone, PhD
Doutora
ORCID: https://orcid.org/0000-0001-5316-5130
Lattes: http://lattes.cnpq.br/7629935378330825
Instituto de Ciências Ambientais, Químicas e Farmacêuticas
UNIFESP - Universidade Federal de São Paulo
Programa de Pós-Graduação em Análise Ambiental Integrada
ARIES, Antimicrobial Resistance Institute of São Paulo, São Paulo, Brazil.
E-mail: d.debone@unifesp.br

Ronan Adler Tavella, PhD
Doutor
ORCID: https://orcid.org/0000-0003-2436-4186
Lattes: http://lattes.cnpq.br/4022822237800112
Instituto de Ciências Ambientais, Químicas e Farmacêuticas
UNIFESP - Universidade Federal de São Paulo
Programa de Pós-Graduação em Análise Ambiental Integrada
ARIES, Antimicrobial Resistance Institute of São Paulo, São Paulo, Brazil.
E-mail: ronan.adler@unifesp.br

Simone Georges El Khouri Miraglia, PhD
Professor Doutor
ORCID: https://orcid.org/0000-0001-9482-602X
Lattes: http://lattes.cnpq.br/6423311971848669
Instituto de Ciências Ambientais, Químicas e Farmacêuticas
UNIFESP - Universidade Federal de São Paulo
Programa de Pós-Graduação em Biologia Química
Programa de Pós-Graduação em Análise Ambiental Integrada
ARIES, Antimicrobial Resistance Institute of São Paulo, São Paulo, Brazil.
E-mail: simone.miraglia@unifesp.br

Abstract

Dengue is an arboviral disease with a high incidence in tropical regions, exerting a substantial burden on public health and healthcare systems. In recent years, the municipality of São Paulo has experienced a progressive rise in the number of dengue cases and related hospitalizations. This study aims to examine the temporal evolution of dengue incidence, hospital admissions, and associated healthcare costs in São Paulo from 2007 to 2025. An observational, ecological, time-series design was employed, utilizing publicly available secondary data. Epidemiological indicators, hospitalization records, and cost-related data were obtained from the Hospital Information System of the Brazilian Unified Health System (SIH/SUS). Trends in case counts, incidence rates, hospital admissions, total expenditures, and hospital service costs were systematically analyzed. The results are presented through descriptive tables and graphical representations. The findings reveal a marked increase in both the absolute number of dengue cases and incidence rates over the study period, with an epidemic peak observed in 2024. A concomitant rise in the frequency and complexity of hospitalizations was identified, resulting in a substantial escalation of hospital-related expenditures. The emergence and co-circulation of multiple dengue virus serotypes, coupled with elevated levels of immunological susceptibility within the population, contributed to the severity of recent outbreaks. Dengue continues to pose a critical public health challenge in São Paulo, with growing implications for healthcare infrastructure and the financial sustainability of the Unified Health System. The implementation of integrated vector control measures, enhanced epidemiological surveillance, and expanded vaccination coverage is imperative to curb the spread of the disease, reduce the burden of hospitalizations, and mitigate associated economic costs.

Key words: Hospitalizations; Costs and Cost Analysis; Public health

1. Introduction

Dengue is the most common arboviral disease worldwide and is considered a major public health challenge due to its social and economic impacts. In recent

years, a substantial increase in dengue cases has been reported globally, accompanied by the expansion of its geographic range, with the disease emerging in previously unaffected regions and re-emerging in areas where incidence had previously declined. (Messina et al., 2014; Schaffner & Mathis, 2014; Salehi et al., 2025).

Dengue is endemic in more than 120 countries, primarily affecting the Americas, the Southeast Asia region, and the Western Pacific region (Colón-González, 2021). Historically, in the Americas, Brazil accounts for the highest proportion of suspected cases, representing up to 84% of all reported cases (Brasil, 2024a). Between 1990 and 2024, the country experienced multiple epidemics, totaling more than 25.7 million reported cases. These epidemics have shown a cyclical pattern, characterized by inter-epidemic periods ranging from 3 to 4 years. However, in recent years, these intervals have shortened, accompanied by more intense epidemic peaks (Andrioli, 2020). In 2024, there was an approximate 400% increase in dengue cases compared to the previous year, with more than 6.6 million reported cases and over 6,000 deaths (Brasil, 2024b), surpassing the numbers recorded in 2015, a year previously marked by one of the largest dengue epidemics in the country's history. The surge in cases may be associated with anomalies in temperature and rainfall patterns resulting from the impacts of the El Niño climate phenomena (Brasil, 2024a). According to the Arbovirus Monitoring Panel of the Ministry of Health (Brasil, 2024b), in that year, the state of São Paulo accounted for approximately 33% of probable cases, with an incidence rate of 4,742.3 per 100,000 inhabitants.

The increasing number of cases, hospitalizations, and deaths poses significant challenges for the Brazilian Unified Health System (SUS) and the national economy, due to the strain on healthcare services and the economic losses resulting from work absenteeism, premature deaths, and excessive expenditures on patient care (Medeiro, 2024). In this context, analyzing the temporal trends of cases and hospitalizations, as well as the associated costs, is essential to support evidence-based decision-making for efficient resource allocation and to guide preventive actions.

2. Theoretical Framework

2.1. Health Economic Evaluation

Health systems and services face numerous challenges, as resources are limited while demand continues to grow due to population aging, the increasing burden of disease, and the technological development of new diagnostic and therapeutic strategies that require financial resources for their acquisition, thereby straining health budgets (Silva, 2016a). Consequently, decision-making must be grounded in rigorous evaluations that consider both clinical and economic aspects, with the goal of optimizing the allocation of health resources (Vanni et al., 2009). In this context, health economic evaluation emerges as a key tool, aiming to identify, measure, value, and compare the costs and consequences of alternative interventions (Drummond et al., 2005).

Health economic evaluations can be classified as partial or full. Partial economic evaluations involve the description or analysis of costs and, in some cases, the performance of a given health intervention or program. They are characterized by the absence of a structured comparison between alternatives and by not integrating costs and consequences of different interventions (Brasil, 2014). In contrast, full economic evaluations encompass the comparison of at least two alternatives and assess both the costs and the consequences associated with each. Thus, full economic evaluations are considered essential tools to support the incorporation or replacement of new technologies within the health system (Brasil, 2014).

There are several approaches to partial economic evaluations, with the most common being cost-consequence studies, which measure the costs incurred by a technology or health condition and the associated consequences (health outcomes), presenting them separately without combining these aspects into a single metric or ratio; and cost-of-illness studies, which aim to describe and quantify all costs attributable to a specific health condition, thereby providing an estimate of the financial burden it represents for the health system, patients, families, and society as a whole (Drummond et al., 2005; Brasil, 2014).

Full economic evaluations, in turn, encompass four types of studies: cost-effectiveness, cost-utility, cost-benefit, and cost-minimization analyses. **Table 1** provides a summary of the main characteristics of each type.

Table 1. Summary of full economic evaluation types.

Type of Analysis	Cost Measure	Outcome Measure
Cost-minimization	Monetary value	Equivalence of outcomes for the compared interventions
Cost-benefit	Monetary value	Converted into monetary value
Cost-effectiveness	Monetary value	Clinical measure (life-years gained)
Cost-utility	Monetary value	Quality-adjusted life years (QALYs)

Source: Adapted from Brasil, 2014

The conduct of an economic evaluation is structured around six steps: defining the analytical perspective, establishing the time horizon, identifying and measuring costs, selecting the method for cost valuation, and applying temporal adjustments (Silva et al., 2016b).

The analytical perspective defines the guiding context of the economic evaluation, as each perspective provides a distinct view of the costs and benefits associated with the health intervention, thereby influencing the resulting conclusions and recommendations (Drummond et al., 2005; Brasil, 2014; Jo, 2014; Silva et al., 2016b). Different perspectives can be adopted, and the key ones are presented below:

- **SUS Perspective:** This perspective considers all direct costs covered by the public health system, regardless of the level of care or service delivery setting. It includes costs related to treatments, medical examinations, hospitalizations, medications, social services, and the administration of public health campaigns.

- **Societal Perspective:** This is the broadest perspective, encompassing all costs and benefits regardless of who bears the expenses. It includes direct healthcare system costs, patient expenditures, and indirect costs associated with productivity losses.

- **Payer Perspective:** Under this perspective, costs and benefits are borne by a specific payer, such as a public health system, a private health plan, or an insurance company.

The time horizon, also referred to as the analytical horizon, represents the period adopted for estimating the costs and outcomes associated with a health intervention, taking into account the natural clinical course of the disease or event under analysis. In contexts involving chronic diseases or conditions with a substantial impact on mortality, it is essential that the life expectancy of affected individuals serves as the primary parameter for defining this horizon. Conversely, for acute events, a shorter period is recommended, provided it is sufficient to comprehensively capture all relevant costs and consequences resulting from the intervention (Brasil, 2014; Silva et al., 2016b).

In the identification stage, the selection of costs is carried out, guided directly by the perspective adopted in the study. Subsequently, a comprehensive description of the selected costs is provided (Silva et al., 2016b). There are three types of costs considered in economic evaluations: direct costs, indirect costs, and intangible costs. Direct costs are further subdivided into medical and non-medical direct costs. Medical direct costs refer to expenditures related to healthcare, such as payment for medications, healthcare professional fees, diagnostic tests, and hospital stays (Brasil, 2014; Oliveira, 2014). Non-medical direct costs include expenses such as patient transportation, special diets, and home environment adaptations (Brasil, 2014). Indirect costs are associated with productivity losses due to absenteeism and premature death (Silva et al., 2016b). Intangible costs refer to losses in quality of life, particularly related to pain, suffering, and social exclusion (Silva et al., 2016b).

In the cost measurement stage, the unit of measurement for cost items is defined, which may be expressed in unit terms or as a percentage of the aggregate cost, depending on data availability and the desired level of detail (Silva et al., 2016b). Regarding valuation methods, for direct costs, two main approaches are

used: gross-costing and micro-costing. In gross-costing, costs are identified in an aggregated manner, providing an overall view of expenditures, whereas in micro-costing, each resource item is estimated and assigned a unit cost, allowing for more precise estimates (Tan, 2009). Additionally, cost assessment can follow either a top-down or bottom-up approach. The former estimates the average cost per patient/user, while the latter estimates individual-level costs (Tan, 2009). For indirect costs, estimates can be obtained using the human capital method or the friction-cost method (Silva et al., 2016b).

2.2. Economic Burden of Dengue

The global economic burden of dengue remains poorly characterized, with few studies, numerous limitations, and often conflicting results due to inconsistent assumptions; while regional and multinational estimates exhibit wide methodological variations that hinder comparison (Beatty et al., 2011; Akbar et al., 2020).

A recent study estimated that the cumulative societal cost of Aedes-transmitted arboviruses was US$ 94.7 billion (adjusted to 2022 USD) for the period 1975–2020, of which US$ 76.5 billion (79%) was attributable to dengue (Roiz et al., 2024). By region, the Americas and Asia accounted for the highest cumulative costs, at US$ 44.9 billion and US$ 47.8 billion respectively, over the same period (Roiz et al., 2024).

Brazil contributed substantially to the economic burden in the Americas, accounting for approximately 41% of the total estimated cost of dengue between 2000 and 2007 (Shepard et al., 2011). In that study, the annual aggregate cost in the Americas was US$ 2.1 billion, of which 60% corresponded to indirect costs, predominantly productivity losses (Shepard et al., 2011). A multicenter study conducted in 2012–2013 across six capitals in four endemic regions of Brazil, Goiânia (Central-West), Belo Horizonte and Rio de Janeiro (Southeast), Teresina and Recife (Northeast), and Belém (North), estimated the economic burden of dengue at US$ 468 million. From the public health system perspective, costs were US$ 164 million, rising nearly threefold when the societal perspective, including premature death, was considered (Martelli et al., 2015). In 2016, dengue generated

R$ 176 million in direct medical costs and R$ 293 million in indirect costs (Teich et al., 2017).

Despite gaps in the literature, evidenced by the paucity of studies and insufficient data, these estimates underscore the high direct and indirect costs of dengue epidemics, which disproportionately affect the most vulnerable countries and populations.

3. Methods

This was an observational, analytical ecological time-series study. Such an investigation uses aggregated, publicly available secondary data to analyze trends and variations over time in a defined population.

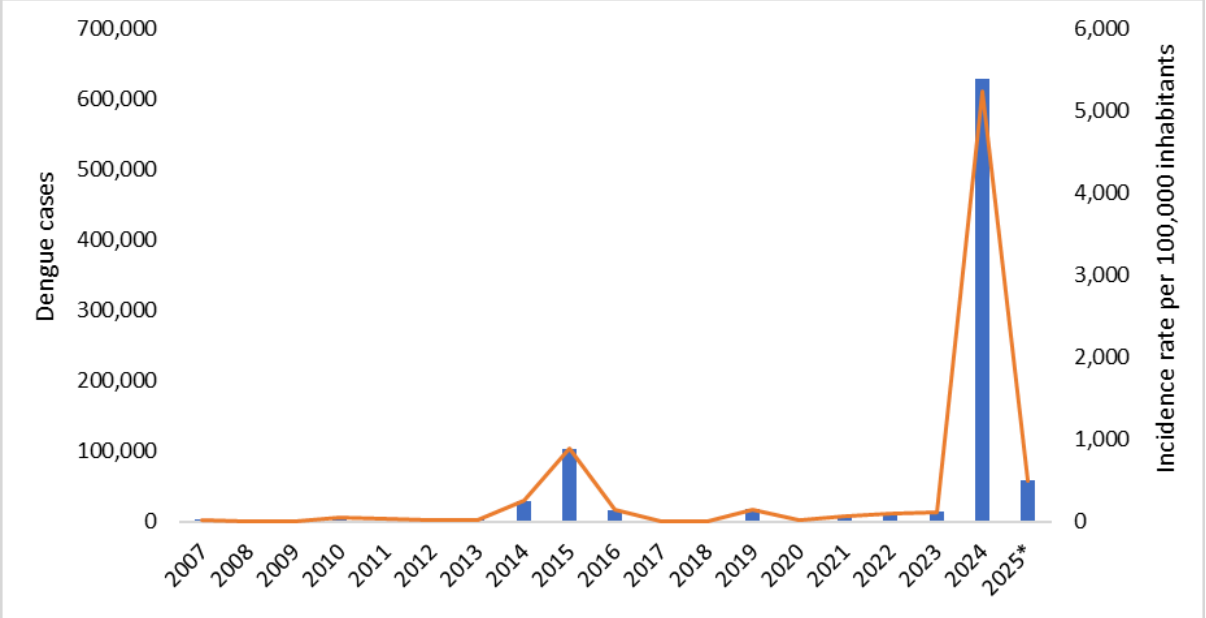
The municipality of São Paulo, capital of the state of São Paulo, is the most populous city in Brazil, with an estimated 11.9 million inhabitants in 2024 according to the Brazilian Institute of Geography and Statistics (IBGE). It covers approximately 1,521.202 km² and has a population density of 7,528.26 inhabitants per km². According to the Köppen climate classification, the municipality falls under type Cwa, characterized by a subtropical highland climate with a rainy summer and a dry winter.

Dengue case counts and incidence rates were obtained from the São Paulo Municipal Health Secretariat website for the period 2007 through early July 2025. Hospitalizations and associated costs were retrieved from the Hospital Information System of the Brazilian Unified Health System (SIH-SUS). SIH-SUS is a database covering all hospitals using the SUS, managed by the Department of Informatics of the Unified Health System (DATASUS) (Lessa et al., 2000). This system collects information on hospital admissions, including patient demographics, diagnostic codes, procedures performed, and amounts paid via Hospital Admission Authorizations (AIH). Key AIH variables include patient identification, hospital and management entity, resources paid for the admission, nature of the event, length of stay, and patient outcome (Mendes et al., 2000).

4. Results and Discussion

Figure 1 shows the temporal trend of dengue cases in the municipality of São Paulo between 2007 and 2025. Clear fluctuations can be seen over time, with distinct epidemic peaks and intervals of lower incidence, reflecting the influence of environmental, virological and social determinants (Souza & Romano, 2022; Fujita et al., 2023).

Figure 1. Temporal evolution of confirmed dengue cases in the municipality of São Paulo, Brazil, 2007–2025.



Source: Prepared by the author using data provided by the São Paulo Municipal Health Secretariat. Available at: <https://prefeitura.sp.gov.br/web/saude/w/vigilancia_em_saude/boletim_covisa/245603>.

Between 2007 and 2025, approximately 906 000 dengue cases and 630 deaths were reported in the city. From 2014 onwards, there was a rapid increase in dengue incidence, peaking in 2015 with more than 100 000 confirmed cases, coinciding with the water crisis that affected primarily the state of São Paulo (Marengo et al., 2015). This situation led the population to resort to improvised water

storage methods, increasing the abundance of artificial breeding sites for *Aedes aegypti* (Marcondes & Ximenes, 2016).

In the following years, incidence declined significantly, only to rise again in 2019, when an increase of nearly 3,000% in confirmed cases was observed compared to the previous year, totalling more than 16,000 dengue cases. In 2020, around 2,000 cases were confirmed, a significant reduction relative to 2019, likely related to the COVID-19 pandemic due to decreased household visits by health agents and reduced public attention to dengue (Souza & Romano, 2022).

In 2021, 2022 and 2023, 7,400, 11,800 and 14,400 dengue cases were confirmed, respectively. A gradual increase is observed, following the relaxation of COVID-19 restrictions and the resumption of health services (diagnosis and notification of other infectious diseases). Furthermore, climatic changes may also have favoured the rise in dengue cases in São Paulo, since the summer of 2023 was marked by above-average rainfall and temperatures conducive to *A. aegypti* proliferation and DENV transmission. In that period, cumulative rainfall (908.2 mm) was about 14% higher than the historical seasonal average (1991–2020) of 799.2 mm (Fujita et al., 2023).

In 2024, a 488% increase in dengue cases was observed compared to 2015, making it the year with the highest number of dengue cases and deaths in the historical series. By early July 2025, approximately 58 300 dengue cases had already been reported. Following the pattern of the state of São Paulo, hospitalizations for dengue presented a similar trajectory, reaching almost 7,000 admissions in 2024, a 245% rise compared with 2015 (Table 2). According to grey literature, in the private network of the capital, dengue hospitalizations grew by 89% in the first half of March 2025 compared to January. This increase is related both to wider circulation of the virus (especially new serotypes) and to climatic conditions favourable to *A. aegypti* proliferation.

Total hospitalization expenditures ranged from R$ 2 339.80 to R$ 3 886 856.14. It is worth noting that these figures are used for administrative and planning purposes and do not necessarily represent the amounts actually transferred to hospitals, as withholdings, incentives or other payments may apply. Nonetheless, it is clear that increasing dengue incidence imposes a substantial economic impact.

Table 2. Number of hospitalizations and associated expenditures in the municipality of São Paulo, 2007–2025.

Year	Number of hospitalizations	Total expenditure (R$)	Hospital service costs (R$)	Professional service costs (R$)	Average cost per hospitalization (R$)	Average length of stay (days)	Death	Mortality rate
2007	8	2,339.80	1,929.88	409.92	292.48	10.9	4	50
2008	110	43,516.89	35,846.12	7,670.77	395.61	5.2	8	7.27
2009	57	18,075.83	14,551.35	3,524.48	317.12	4.0	-	-
2010	340	115,573.36	94,307.93	21,265.43	339.92	4.4	1	0.29
2011	295	114,854.93	94,513.24	20,341.69	389.34	3.8	4	1.36
2012	132	53,212.10	43,934.25	9,277.85	403.12	4.1	1	0.76
2013	209	70,556.53	57,593.93	12,962.60	337.59	3.2	3	1.44
2014	938	379,127.79	311,747.54	67,380.25	404.19	3.8	1	0.11
2015	2.027	772,094.73	634,106.43	137,988.30	380.91	3.8	17	0.84
2016	577	221,404.29	183,131.04	38,273.25	383.72	4.1	13	2.25
2017	101	44,266.62	36,933.23	7,333.39	438.28	4.5	4	3.96
2018	78	32,282.78	26,719.47	5,563.31	413.88	3.3	1	1.28
2019	371	182,755.23	153,572.41	29,182.82	492.60	3.7	4	1.08
2020	61	33,167.18	28,053.21	5,113.97	543.72	3.8	1	1.64
2021	113	50,536.46	42,386.95	8,149.51	447.23	3.6	-	-
2022	121	55,560.22	47,377.93	8,182.29	459.18	3.7	2	1.65
2023	181	105,425.39	89,447.08	15,978.31	582.46	4.1	2	1.1
2024	6.987	3,886,856.14	3,278,817.17	608,038.97	556.30	3.8	136	1.95
2025*	1.127	553,073.90	468,026.46	85,047.44	490.75	3.3	24	2.13

*2025 – Data up to early July 2025.

5. Conclusion

The analysis of dengue case trends in the municipality of São Paulo from 2007 to 2025 reveals a marked increase in both absolute case numbers and incidence rates, particularly in recent years. This rise is linked to multiple factors, including the simultaneous circulation of different viral serotypes, climatic conditions favorable to Aedes aegypti proliferation, and challenges in sustaining continuous vector control efforts.

Hospitalizations for dengue have mirrored this upward trend, placing greater demand on the municipal health system and driving a significant rise in hospital-related expenditures. These findings underscore the value of integrating epidemiological data with financial information from SIH-SUS to achieve a more comprehensive understanding of dengue's public health impact at the local level. Furthermore, it is imperative to strengthen strategies encompassing epidemiological surveillance, vector control, health education, and expanded vaccination coverage, measures that are essential to reduce dengue burden, minimize hospital admissions, and mitigate associated economic costs, thereby safeguarding population health and the sustainability of São Paulo's health system.

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