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Nationwide Trends in Hospitalization, In-Hospital Case Fatality, and Hospital Reimbursement for Skin and Soft-Tissue Infections in Brazil, 2000-2023: An Ecological Time-Series Analysis

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Abstract

Introduction

Skin and soft-tissue infections (SSTIs), including cellulitis, cutaneous abscess, and erysipelas, are a common cause of hospitalization, yet nationwide evidence on their long-term hospital burden in Brazil is limited.

Methods

This is a nationwide ecological time-series study of hospital admissions with a principal diagnosis of International Classification of Diseases, 10th revision (ICD-10) L00-L08 or A46 recorded in the Sistema de Informações Hospitalares do Sistema Único de Saúde (Hospital Information System of the Brazilian Unified Health System) (SIH/SUS), which covers admissions financed by the public health system, Brazil and its five macro-regions, 2000-2023. Hospitalization rates were standardized by age and sex to the 2022 Census population, and in-hospital case fatality by age and sex to the distribution of all admissions. Trends were estimated as annual percent changes (APC) by Prais-Winsten regression within two pre-specified sub-periods separated by the introduction of the unified SUS procedure table in January 2008 (2000-2007; 2009-2019, excluding the pandemic), which were the principal estimates, and over the full period as a summary of net change, with segmented regression as a supplementary analysis. Reimbursement (2008-2023) was deflated to 2023 Brazilian reais (R\$).

Results

There were 2,508,028 hospitalizations and 36,909 in-hospital deaths (case fatality 36,909/2,508,028, 1.47%). The age- and sex-standardized rate was 46.4 per 100,000 in 2000, dropping to 35.6 in 2008, the first year of the unified table, rising to 77.7 in 2019, falling by 24.6% in 2020 (157,709 to 120,143 admissions), and reaching 75.6 per 100,000 in 2023. The rate rose in 2009-2019 (APC +4.41% per year, 95% CI 3.42 to 5.41), with no significant trend observed between 2000 and 2007; the net average change over 2000-2023 was +2.64% per year (95% CI 1.54 to 3.75). The full-period rise was significant in the North, Northeast, Southeast, and South but not the Central-West. Crude case fatality rose from 0.74% (536 of 72,760) in 2000 to 1.78% (2,834 of 159,543) in 2023 (APC +3.53% per year, 95% CI 2.42 to 4.66); standardized for age and sex, it rose from 0.97% to 1.53% (APC +1.68% per year, 95% CI 0.72 to 2.65), and about half of the crude increase reflected the older age of admitted patients. Rates were higher in men, and the male-to-female ratio of rates standardized to a common age distribution widened from 1.21 to 1.46. Mean inflation-adjusted reimbursement per hospitalization fell from a 2010 peak of R\$978 to R\$685 in 2023 (APC -1.89% per year, 95% CI -2.92 to -0.85).

Conclusions

The recorded age- and sex-standardized rate of SUS-financed hospitalization for SSTIs and erysipelas in Brazil was nearly two-thirds higher in 2023 than in 2000, a descriptive comparison of two years; the rise was concentrated in 2009-2019 and varied between regions. In-hospital case fatality rose, about half of it because admitted patients became older, and inflation-adjusted reimbursement per admission declined. Because 2008 was a transition-year trough coinciding with the implementation of the unified procedure table, trend estimates from Brazilian hospital data that start in that year overstate the increase.

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Introduction

Skin and soft-tissue infections (SSTIs), from superficial pyodermas to deep, complicated cellulitis and abscesses, are among the most common bacterial infections in ambulatory and hospital practice [1,2]. Most episodes resolve without admission; hospitalization becomes necessary when infection is extensive, complicated by systemic signs, or occurs in patients with predisposing conditions such as diabetes, chronic venous insufficiency, lymphedema, or obesity [3,4]. Because SSTIs are common, often recurrent, and occasionally life-threatening, they place a substantial burden on hospital services. Hospitalization for SSTIs is, however, a health-service utilization outcome rather than a direct measure of disease occurrence: besides the frequency and severity of infection, it reflects access to ambulatory care, admission thresholds, bed availability, referral practices, diagnostic coding, and reimbursement rules. Trends in hospitalization therefore describe the hospital burden placed on a health system, not the incidence of disease in the population.

Administrative-database studies from the United States, Portugal, Spain, and Wales, and an intensive care registry covering Australia and New Zealand, have documented a substantial, and in several settings still-rising, hospitalization burden from SSTIs and erysipelas over the past two decades [5-10], including in children [11], with marked heterogeneity in case definition, comorbidity, cost, and outcomes [12]. Evidence from Brazil is sparse. The two most relevant Brazilian reports are conference abstracts using SIH/SUS data, one spanning 2014-2024 without a stated code list [13] and one restricted to cellulitis and abscess from 2010 to 2024 [14]; neither reports rates standardized to a reference population, formal trend estimation, or a macro-regional comparison. Neither could therefore show whether the increase in admissions exceeded population growth and ageing, whether it was uniform across regions, or how case fatality and reimbursement evolved alongside admissions. The present study was designed to address these gaps.

Brazil's continental size, its steep regional gradient in development and health care access, and its rapidly aging population make it an informative setting in which to examine these trends, and SIH/SUS records in-hospital mortality, length of stay, and reimbursement alongside admissions, so that the clinical and financial (reimbursement) dimensions of the burden can be examined together. We therefore set out to describe the trends in hospitalization for SSTIs and erysipelas in Brazil and its five macro-regions from 2000 to 2023 and to characterize the accompanying trends in in-hospital case fatality, length of stay, sex- and age-specific burden, and inflation-adjusted hospital reimbursement. The study is descriptive and does not test causal hypotheses.

Materials And Methods

Design and data sources

We conducted a nationwide ecological time-series study using publicly available, de-identified aggregate data from the Hospital Information System of the Brazilian Unified Health System (Sistema de Informações Hospitalares do Sistema Único de Saúde (SIH/SUS)), the administrative database of admissions authorized and reimbursed by the public health system, and population data from the Brazilian Institute of Geography and Statistics (IBGE). SIH/SUS records admissions financed by SUS, in public hospitals and in private or philanthropic hospitals contracted by SUS. Each admission generates a hospital admission authorization, completed by the hospital with the patient's sex, age, and municipality of residence, the principal diagnosis coded in the International Classification of Diseases, 10th revision (ICD-10), the procedure performed, the length of stay, the discharge status (including in-hospital death), and the amount approved for payment, and submitted monthly to the Ministry of Health for processing and reimbursement; the processed records are released by Departamento de Informática do Sistema Único de Saúde (Department of Informatics of the Brazilian Unified Health System) (DATASUS). Admissions financed by private health insurance or paid out of pocket are not recorded. The data therefore describe SUS-financed hospital care rather than all hospitalizations in Brazil, and because private insurance coverage differs between regions and has changed over time, the share of all admissions that SIH/SUS captures also differs; national and regional rates in this study refer to the SUS-financed component. The unit of analysis was the hospital admission authorization (Autorização de Internação Hospitalar (AIH)), aggregated by macro-region of residence (North, Northeast, Southeast, South, Central-West), sex, age group, and calendar year; no patient-level linkage was performed. The design is descriptive and ecological; no causal inference is intended.

Case definition

Hospitalizations with a principal diagnosis of ICD-10 L00-L08 (infections of the skin and subcutaneous tissue) or A46 (erysipelas) were included; the inclusion of A46 was specified before the analysis. Erysipelas is coded outside Chapter XII, but it shares its clinical spectrum, usual bacterial causes, predisposing conditions, and antibiotic management with cellulitis; the two diagnoses are not always distinguished consistently in practice, and they are routinely analyzed together [9,15,16]; a definition restricted to L00-L08 could therefore reflect shifts in code assignment between the two diagnoses as well as changes in disease.

Because the composite groups clinically heterogeneous diagnoses, trends were also examined separately for each main diagnostic group (see Statistical analysis). The L00-L08 block alone, the definition used by ICD-10 for infections of the skin and subcutaneous tissue, was analyzed as a sensitivity analysis; for this definition the data were available only as a region-by-year tabulation, without age, sex, or reimbursement detail.

Study period and known discontinuities

The period 2000-2023 is the full span over which the data sources overlap: SIH/SUS records with complete ICD-10 coding exist from 1998, and the IBGE projection supplies annual denominators from 2000. From the January 2008 billing period, the separate hospital and outpatient procedure tables were replaced by the unified Tabela de Procedimentos, Medicamentos, Órteses, Próteses e Materiais Especiais do SUS (Ministry of Health Ordinance GM/MS 2,848/2007) [17], and the Ministry of Health presents hospital production before and from 2008 as separate series. The unified table changed the procedure codes under which admissions are authorized, the rules of compatibility between procedures and ICD-10 diagnoses, and the values approved for payment, and it allowed some procedures previously billed as admissions to be performed and billed as outpatient care. Such changes can alter which episodes are recorded as admissions, the principal diagnosis assigned to them, and the amount reimbursed, and therefore admission counts, case fatality, and reimbursement for a given diagnostic group, particularly while hospitals and processing systems adapted during the first year. We therefore treated 2008 as a transition year and pre-specified two sub-periods of more comparable recording, 2000-2007 (before the unified table) and 2009-2019 (after the table and before the COVID-19 pandemic), in addition to the full period. Comparability of recording within each sub-period is an analytic assumption rather than an established fact: the 2000-2007 sub-period contains an undocumented discontinuity in 2001-2002 (see Results), which was not modelled as a separate period because no administrative change explains it and the resulting segment would be too short to estimate a trend. Its influence was examined instead by re-estimating the national trend from 2003 (see sensitivity analyses) and by repeating the comparison of age distributions with 2003-2006 as the early period. Because the value approved for each admission depends directly on the procedure table, the reimbursement analysis was restricted to 2008-2023.

Outcomes

The primary outcome was the annual hospitalization rate per 100,000 population, standardized by age and sex, for Brazil and each macro-region. Secondary outcomes were the crude rate; in-hospital case fatality (in-hospital deaths divided by hospitalizations), crude and standardized by age and sex; mean length of stay; sex-specific standardized rates; the age distribution of hospitalizations in the first (2000-2003) and last (2020-2023) four years; and, for 2008-2023, total reimbursement and mean reimbursement per hospitalization in nominal and constant 2023 Brazilian reais (R\$).

Denominators and standardization

Annual denominators by macro-region, sex, year, and five-year age group were taken from the 2024 revision of the IBGE population projections (2000-2070) [18]. The standard population was the resident population enumerated in the 2022 Demographic Census (203,080,756; 98,532,431 men and 104,548,325 women), by age and sex [19]; this is a fixed enumeration, distinct from the projection's modeled estimate for 2022 (about 210.9 million), which served only as that year's denominator. SIH/SUS and IBGE age categories were harmonized into 17 groups from 0-4 to 80 years and older. Rates were standardized by the direct method, by age and sex, to the 2022 Census population, applied uniformly to Brazil and all regions: the combined-sex rate used a joint weight for each of the 34 age-by-sex strata (Table 1), and the male and female rates were both standardized to the combined-sex age distribution of the same census (the sum of the male and female weights in each age group of Table 1), so that the two rates share one standard and their ratio is not affected by differences in age structure between the sexes. In-hospital case fatality was standardized by the direct method to the age-by-sex distribution of all hospitalizations in Brazil in 2000-2023 (Table 2), the natural reference for a proportion whose denominator is admissions rather than population, with the same standard for every region and year; sex-specific case fatality was age-standardized to the combined-sex age distribution of the same admissions. One admission with unrecorded age and four with unrecorded sex were excluded from the stratified analyses.

Sex	Age group	Population, n	Joint weight, w(age, sex)
Male	0-4 years	64,61,689	0.031818
Male	5-9 years	70,11,282	0.034525
Male	10-14 years	69,92,746	0.034433
Male	15-19 years	73,17,515	0.036033
Male	20-24 years	77,67,306	0.038247
Male	25-29 years	76,27,458	0.037559

Male	30-34 years	75,37,285	0.037115
Male	35-39 years	78,27,333	0.038543
Male	40-44 years	77,81,059	0.038315
Male	45-49 years	65,49,109	0.032249
Male	50-54 years	60,14,391	0.029616
Male	55-59 years	54,19,505	0.026686
Male	60-64 years	46,05,834	0.02268
Male	65-69 years	35,88,052	0.017668
Male	70-74 years	26,15,350	0.012878
Male	75-79 years	16,57,786	0.008163
Male	80 years and older	17,58,731	0.00866
Female	0-4 years	62,43,171	0.030742
Female	5-9 years	67,38,158	0.03318
Female	10-14 years	66,82,215	0.032904
Female	15-19 years	70,58,427	0.034757
Female	20-24 years	76,99,157	0.037912
Female	25-29 years	78,42,265	0.038616
Female	30-34 years	79,35,832	0.039077
Female	35-39 years	83,45,458	0.041094
Female	40-44 years	82,91,111	0.040827
Female	45-49 years	70,91,003	0.034917
Female	50-54 years	65,84,190	0.032422
Female	55-59 years	61,49,601	0.030282
Female	60-64 years	53,38,555	0.026288
Female	65-69 years	42,88,180	0.021116
Female	70-74 years	32,43,186	0.01597
Female	75-79 years	21,89,593	0.010782
Female	80 years and older	28,28,223	0.013927
Male	All ages	9,85,32,431	0.485188
Female	All ages	10,45,48,325	0.514812
Both sexes	All ages	20,30,80,756	1

TABLE 1: Standard population and joint age-by-sex weights used for the combined-sex standardized hospitalization rate: resident population of Brazil, 2022 Demographic Census

The joint weight of each of the 34 age-by-sex strata is its share of the total enumerated population (203,080,756); the weights sum to 1. The combined-sex standardized rate for each region and year is the sum, over the 34 strata, of the stratum-specific hospitalization rate multiplied by its joint weight. The male and female rates were both standardized to the combined-sex age distribution, whose weight for each age group is the sum of the male and female joint weights in this table. Census age bands 80-84, 85-89, 90-94, 95-99, and 100 years and older were combined into a single band (80 years and older) to match the SIH/SUS tabulation.

Source: Brazilian Institute of Geography and Statistics (IBGE), 2022 Demographic Census, universe results, resident population by sex and age (SIDRA Table 9514).

Sex	Age group	Hospitalizations, 2000-2023, n	Weight, w(age, sex)
Male	0-4 years	1,87,173	0.07463
Male	5-9 years	93,645	0.037338
Male	10-14 years	70,955	0.028291
Male	15-19 years	75,128	0.029955
Male	20-24 years	85,458	0.034074
Male	25-29 years	77,237	0.030796
Male	30-34 years	73,572	0.029335
Male	35-39 years	75,287	0.030018
Male	40-44 years	78,676	0.03137
Male	45-49 years	83,630	0.033345
Male	50-54 years	87,290	0.034804
Male	55-59 years	86,587	0.034524
Male	60-64 years	80,785	0.032211
Male	65-69 years	71,718	0.028595
Male	70-74 years	60,906	0.024284
Male	75-79 years	48,069	0.019166
Male	80 years and older	62,638	0.024975
Female	0-4 years	1,66,509	0.066391
Female	5-9 years	68,935	0.027486
Female	10-14 years	46,059	0.018365
Female	15-19 years	54,870	0.021878
Female	20-24 years	52,724	0.021022
Female	25-29 years	46,709	0.018624
Female	30-34 years	46,872	0.018689
Female	35-39 years	48,446	0.019316
Female	40-44 years	53,007	0.021135
Female	45-49 years	58,507	0.023328
Female	50-54 years	63,099	0.025159
Female	55-59 years	64,296	0.025636
Female	60-64 years	65,305	0.026038
Female	65-69 years	64,738	0.025812
Female	70-74 years	62,383	0.024873
Female	75-79 years	56,227	0.022419
Female	80 years and older	90,583	0.036117
Male	All ages	13,98,754	0.557712
Female	All ages	11,09,269	0.442288
Both sexes	All ages	25,08,023	1

TABLE 2: Standard distribution used for the age- and sex-standardized in-hospital case fatality: hospitalizations for skin and soft-tissue infections and erysipelas, Brazil, 2000–2023, by sex and age

The weight of each of the 34 age-by-sex strata is its share of all hospitalizations with recorded age and sex in 2000-2023 (2,508,023; one admission with unrecorded age and four with unrecorded sex excluded); the weights sum to 1. Standardized case fatality for each region and year is the sum, over the 34 strata, of the stratum-specific case fatality multiplied by its weight; sex-specific case fatality (Table 7) uses the combined-sex age distribution of the same admissions. Case definition: principal diagnosis of ICD-10 L00–L08 or A46.

Source: Hospital Information System of the Brazilian Unified Health System (SIH/SUS), Ministry of Health, Brazil.

Reimbursement

The SIH/SUS reimbursement value (valor total da AIH) is the amount approved for payment under the procedure table, not the economic cost of care, and is reported as reimbursement. Nominal values for 2008–2023 were deflated to constant 2023 Brazilian reais (R\$) with the national consumer price index (IPCA) [20].

Statistical analysis

Trends were quantified as the annual percent change (APC) with 95% confidence intervals (CI) from Prais-Winsten generalized least-squares regression of the log10-transformed annual value on calendar year, with first-order autoregressive correction for serial correlation [21];

$$APC = (10^{\beta} - 1) \times 100$$

and two-sided $P < 0.05$ was considered significant. Trends were estimated over 2000–2023, 2000–2007, and 2009–2019, separately for Brazil and each region. Because the series contains a documented change in recording in 2008 and the disruption of the COVID-19 pandemic in 2020–2021, the estimates within the two pre-specified sub-periods were treated as the principal description of trend; the 2000–2023 APC averages across periods that were not comparable and is reported only as a descriptive summary of net average change, not as an estimate of a constant underlying trend. To examine whether the data showed changes in trend near the pre-specified boundaries, segmented (joinpoint) log-linear regression of the standardized rate [22] was fitted as a supplementary analysis. The model was

$$\log_{10}(\text{rate}) = b_0 + b_1 \cdot \text{year} + \sum_k c_k \cdot \max(0, \text{year} - \tau_k)$$

where τ_k are the joinpoint years; because each joinpoint enters only through the hinge term $\max(0, \text{year} - \tau_k)$, the fitted line is continuous, that is, adjacent segments meet at the joinpoint and the slope changes there without a jump in level. The slope of each segment is b_1 plus the sum of c_k over the preceding joinpoints. For every admissible number (0 to 3) and combination of joinpoint years, the model was fitted by ordinary least squares, and the model with the lowest Bayesian information criterion,

$$BIC = n \cdot \ln \left(\frac{SSE}{n} \right) + p \cdot \ln(n)$$

where p is the number of regression coefficients, was selected [23]. The investigators imposed, before fitting, a minimum of two annual observations, excluding the joinpoint, between a joinpoint and either end of the series and between consecutive joinpoints; each segment therefore contains at least three annual observations, counting the joinpoint year it shares with the adjacent segment, and segments are labelled from joinpoint to joinpoint (Table 3). The procedure was implemented in our own code rather than in dedicated joinpoint software.

Macro-region	Joinpoints, year	Segment	Annual observations in segment, n	APC, % per year (95% CI)
Brazil	2008, 2018, 2021	2000–2008	9	+1.15 (–1.23 to 3.60)
Brazil	2008, 2018, 2021	2008–2018	11	+5.34 (3.48 to 7.23)
Brazil	2008, 2018, 2021	2018–2021	4	–10.35 (–16.77 to –3.44)
Brazil	2008, 2018, 2021	2021–2023	3	+16.40 (0.77 to 34.44)
North	2005, 2008, 2013	2000–2005	6	+7.99 (0.05 to 16.57)

North	2005, 2008, 2013	2005-2008	4	-14.40 (-23.49 to -4.24)
North	2005, 2008, 2013	2008-2013	6	+18.62 (11.61 to 26.08)
North	2005, 2008, 2013	2013-2023	11	-0.60 (-3.53 to 2.42)
Northeast	2008, 2018, 2021	2000-2008	9	+1.95 (-0.66 to 4.64)
Northeast	2008, 2018, 2021	2008-2018	11	+8.81 (6.73 to 10.94)
Northeast	2008, 2018, 2021	2018-2021	4	-7.69 (-14.84 to 0.07)
Northeast	2008, 2018, 2021	2021-2023	3	+15.03 (-1.64 to 34.52)
Southeast	2002, 2018, 2021	2000-2002	3	-6.34 (-15.46 to 3.76)
Southeast	2002, 2018, 2021	2002-2018	17	+2.70 (1.75 to 3.65)
Southeast	2002, 2018, 2021	2018-2021	4	-10.16 (-15.50 to -4.50)
Southeast	2002, 2018, 2021	2021-2023	3	+17.10 (3.29 to 32.76)
South	2008, 2018, 2021	2000-2008	9	-0.26 (-3.08 to 2.64)
South	2008, 2018, 2021	2008-2018	11	+5.06 (2.84 to 7.33)
South	2008, 2018, 2021	2018-2021	4	-13.12 (-20.53 to -5.01)
South	2008, 2018, 2021	2021-2023	3	+21.02 (1.79 to 43.88)
Central-West	2018, 2021	2000-2018	19	+1.57 (0.60 to 2.55)
Central-West	2018, 2021	2018-2021	4	-14.56 (-20.53 to -8.15)
Central-West	2018, 2021	2021-2023	3	+16.45 (0.17 to 35.37)

TABLE 3: Segmented (joinpoint) regression of the standardized hospitalization rate with model selection by the Bayesian information criterion, Brazil and macro-regions, 2000-2023

Segmented log-linear regression of log10(standardized rate) on calendar year, continuous at the joinpoints. Model:

log10(rate) = b0 + b1 · year + ∑k ck · max (0, year − τk),

fitted by ordinary least squares for every admissible number (0 to 3) and combination of joinpoint years tk; the hinge terms make the fitted line continuous, so adjacent segments meet at the joinpoint. The model with the lowest Bayesian information criterion,

BIC = n · ln (SSE / n) + p · ln(n).

was selected. The investigators required at least two annual observations, excluding the joinpoint, between a joinpoint and either end of the series and between consecutive joinpoints. Because the model is continuous, adjacent segments share the joinpoint year, and each segment is labelled from joinpoint to joinpoint; the number of annual observations in each segment includes the shared joinpoint year(s). Segment APC = (10slope − 1) × 100, with ordinary-least-squares 95% confidence intervals and no autoregressive correction; the analysis describes where the trend changes and does not replace the primary estimates in Table 5. For Brazil, models placing the first joinpoint in 2002, 2009, or 2007 instead of 2008 had BIC values higher by 0.3, 0.9, and 1.6, so the location of the first joinpoint is not sharply determined; the best model with two joinpoints (2018, 2021) had a BIC higher by 2.6.

Rates were standardized by the direct method, jointly by age and sex, to the population enumerated in the 2022 Brazilian Demographic Census. Case definition: hospital admissions with a principal diagnosis of ICD-10 L00-L08 (infections of the skin and subcutaneous tissue) or A46 (erysipelas). Source: Hospital Information System of the Brazilian Unified Health System (SIH/SUS), Ministry of Health, Brazil.

Because 2008 was pre-specified, the support for a joinpoint in that year was assessed by comparing the BIC of the selected model with that of the best models placing the first joinpoint elsewhere; this analysis does not replace the primary estimates. To quantify how much of the change in crude case fatality reflected the changing age and sex composition of admitted patients, the difference between 2000 and 2023, and between 2009 and 2019, was decomposed by the method of Kitagawa [24] into a composition component (change in the age-by-sex distribution of admissions) and a rate component (change in stratum-specific case fatality). No interaction tests between region or sex and year were performed, so differences in APC between strata

are descriptive, and no adjustment for multiple comparisons was applied. Three sensitivity analyses were pre-specified: repetition of the crude-rate and case-fatality trends under the narrower L00-L08 definition; re-estimation of the national trend for series starting in 2000, 2003, 2008, 2009, and 2010, each ending in 2023 and in 2019; and re-estimation with two alternative age-by-sex standards (the 2000 and the pooled 2000-2023 national populations) through the same procedure. In addition, national crude rates were examined separately for each main diagnostic group (A46, L03, L02, L08, and L05), and the male and female rates were recomputed with each sex standardized to its own age distribution, as in the previous version of this analysis. All analyses were performed with custom scripts written for this study in Python 3.11.15 (pandas 3.0.2, NumPy 2.4.4, SciPy 1.17.1; figures with matplotlib 3.10.9; Python Software Foundation, Wilmington, DE), which implement the iterative Prais-Winsten estimator, segmented regression, direct standardization, and decomposition from their published formulas; the code and the aggregated input data are openly available as described under Data Availability.

Ethics

This study analyzed only publicly accessible, anonymized, aggregate data from DATASUS and IBGE. Under Article 1, sole paragraph, items II, III, and V, of Resolution No. 510 of April 7, 2016, of the Brazilian National Health Council, research that uses publicly accessible information (under Law No. 12,527/2011), public-domain information, or databases whose information is aggregated without the possibility of individual identification is not registered or evaluated by the research ethics committee system (CEP/CONEP). Ethics committee review and informed consent were therefore not required.

Data availability

The analysis code (Python scripts that reproduce every estimate, table, and figure) and the aggregated input data extracted from DATASUS and IBGE are openly available in Zenodo at <https://doi.org/10.5281/zenodo.23320337>.

Results

Study population

Between 2000 and 2023, 2,508,028 hospitalizations met the case definition, with 36,909 in-hospital deaths (case fatality 36,909/2,508,028, 1.47%) and a mean length of stay of 5.86 days (Table 4). Cellulitis (L03, 820,102, 32.7%) and erysipelas (A46, 815,365, 32.5%) accounted for two-thirds of admissions, followed by cutaneous abscess (L02, 356,582, 14.2%), other localized infections (L08, 291,968, 11.6%), pilonidal cyst (L05, 152,504, 6.1%), and impetigo (L01, 49,653, 2.0%). The share of admissions coded as erysipelas was 20.2% (14,685 of 72,760) in 2000, 39.5% (24,858 of 62,949) in 2008, and 32.4% (51,637 of 159,543) in 2023. The Southeast contributed 1,005,125 of 2,508,028 admissions (40.1%); the North had the highest standardized rate in every year except 2008, and the Southeast the longest mean stay (Table 4).

Macro-region	Hospitalizations, n	Share of national total, %	In-hospital deaths, n	Case fatality, %	Mean length of stay, days	Standardized rate, 2000 ^a	Standardized rate, 2019 ^a	Standardized rate, 2023 ^a
Brazil	2,508,028	100.0	36,909	1.47	5.86	46.4	77.7	75.6
North	316,046	12.6	2,453	0.78	5.26	69.3	134.7	121.9
Northeast	720,689	28.7	10,962	1.52	5.91	40.4	97.4	96.7
Southeast	1,005,125	40.1	17,562	1.75	6.20	47.8	65.2	64.7
South	283,356	11.3	4,208	1.49	5.52	38.0	57.9	57.0
Central-West	182,812	7.3	1,724	0.94	5.37	56.5	65.8	59.4

TABLE 4: Hospitalizations for skin and soft-tissue infections and erysipelas in the Brazilian Unified Health System, by macro-region, 2000-2023

Values are cumulative counts and period means for 2000-2023; standardized rates are shown for the first year, the pre-pandemic peak year, and the last year of the series. Case fatality is in-hospital deaths divided by hospitalizations.

^aAge- and sex-standardized hospitalization rate per 100,000 population. Rates were standardized by the direct method, jointly by age and sex, to the population enumerated in the 2022 Brazilian Demographic Census (Table 1). Case definition: hospital admissions with a principal diagnosis of ICD-10 L00-L08 (infections of the skin and subcutaneous tissue) or A46 (erysipelas).

Source: Hospital Information System of the Brazilian Unified Health System (SIH/SUS), Ministry of Health, Brazil.

Shape of the series

The national standardized rate did not follow a single course (Figure 1A). It was 46.4 per 100,000 in 2000, fell to 32.6 in 2002 and recovered to 45.8 in 2003, drifted to 49.6 in 2007, fell by 28.3% to 35.6 in 2008 (85,423 to 62,949 admissions), the first year of the unified procedure table, and then rose almost without interruption to 77.7 in 2019. The two troughs differed in composition. The 2001-2002 trough was confined to cutaneous abscess (L02, 17,517 admissions in 2000 to 10,375 in 2001) and other localized infections (L08, 15,615 in 2001 to 5,637 in 2002), while cellulitis and erysipelas rose sharply in 2003 (L03 from 14,335 to 27,903; A46 from 13,399 to 20,906), and case fatality rose from 0.73% (473 of 64,637) in 2001 to 1.17% (612 of 52,245) in 2002. The 2008 trough spared erysipelas (24,858 admissions, up from 22,748) and pilonidal cyst but removed 45% of cellulitis admissions (34,560 to 19,094) and halved their case fatality (from 1.41%, 488 of 34,560, to 0.65%, 125 of 19,094) for a single year. All-cause admission authorizations processed by SIH/SUS also fell in 2008, from 11,739,258 in 2007 to 11,107,155 (-5.4%), and recovered to 11,516,099 in 2009, whereas admissions for SSTIs and erysipelas fell by 26.3% (85,423 to 62,949). Segmented regression placed the national joinpoints at 2008, 2018, and 2021 (Table 3): no significant trend from 2000 to 2008 (APC +1.15% per year, 95% CI -1.23 to 3.60), +5.34% per year from 2008 to 2018 (95% CI 3.48 to 7.23), -10.35% per year from 2018 to 2021 (95% CI -16.77 to -3.44), and +16.40% per year from 2021 to 2023 (95% CI 0.77 to 34.44; three annual observations). The three-joinpoint model had a lower BIC than the best model with two joinpoints (2018 and 2021; BIC higher by 2.6) and than a model without joinpoints (higher by 5.1), but the location of the first joinpoint was not sharply determined: models placing it in 2002, 2009, or 2007 instead of 2008 had BIC values higher by only 0.3, 0.9, and 1.6. A joinpoint in 2008 was also selected in the North, Northeast, and South, whereas the selected model placed the first joinpoint in 2002 in the Southeast and had no joinpoint before 2018 in the Central-West (Table 3).

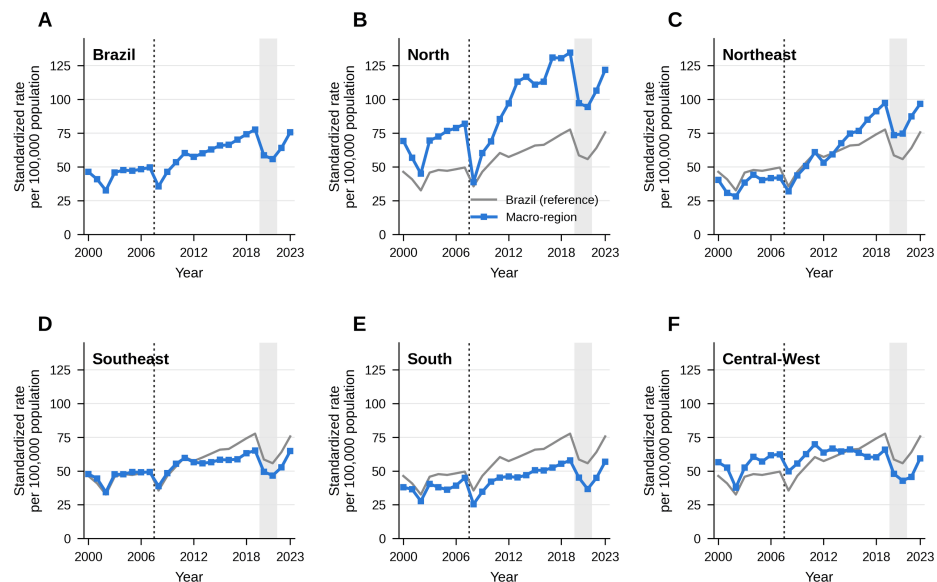


FIGURE 1: Standardized hospitalization rates for skin and soft-tissue infections and erysipelas, Brazil and its five macro-regions, 2000-2023

Rates per 100,000 population, standardized by the direct method, jointly by age and sex, to the population enumerated in the 2022 Brazilian Census, with the same national standard applied to every region. Panel A, Brazil; B, North; C, Northeast; D, Southeast; E, South; F, Central-West. In panels B to F the regional series is shown in blue (filled squares) and the national series is repeated in grey as a reference; axes are identical in all panels. The vertical dotted line marks January 2008, when the unified procedure table of the Unified Health System came into force and the recording of hospital admissions changed; the shaded band marks the COVID-19 pandemic years 2020-2021.

Primary outcome

Within the pre-specified sub-periods, the national standardized rate showed no significant trend in 2000-2007 (APC +3.08% per year, 95% CI -1.52 to 7.89) and rose from 46.4 per 100,000 in 2009 (the same value, to one decimal place, as in 2000) to 77.7 in 2019 (APC +4.41% per year, 95% CI 3.42 to 5.41; Table 5), the principal estimate of trend in this study. Comparing the two ends of the series, the rate in 2023 (75.6 per 100,000) was 63.1% higher than in 2000 (46.4); this endpoint comparison is descriptive, and the corresponding net average change over 2000-2023 was +2.64% per year (95% CI 1.54 to 3.75). The rate then fell by 24.6% in a single year, from 77.7 in 2019 to 58.5 per 100,000 in 2020 (157,709 to 120,143 admissions), the largest year-on-year decline in the series apart from 2008, remained low in 2021 (55.8), and reached 75.6 per 100,000 in 2023. Over the full period the rise was significant in the North (+3.49% per year), Northeast (+5.02% per year), Southeast (+1.39% per year), and South (+1.90% per year), but not the Central-West (+0.18% per year, 95% CI -1.28 to 1.65), whose rate in 2023 (59.4 per 100,000) was close to its value in 2000 (56.5); within 2009-2019 the point estimate was larger than over the full period in every region, and the trend was significant in all regions except the Central-West (among these, APCs from +2.06% per year in the Southeast to +8.15% per year in the North), and no region showed a significant trend within 2000-2007 (Table 5, Figure 1B-F). The North had the highest rate in every year except 2008, reaching 134.7 per 100,000 in 2019, compared with 57.9 in the South; its increase was concentrated in 2008-2013 (+18.62% per year, 95% CI 11.61 to 26.08) with no significant trend from 2013 to 2023 (-0.60% per year, 95% CI -3.53 to 2.42) (Table 3).

Macro-region	Standardized rate, 2000-2007, APC (95% CI) ^a	Standardized rate, 2009-2019, APC (95% CI) ^a	Standardized rate, 2000–2023, APC (95% CI) ^b	Crude case fatality, 2000–2023, APC (95% CI)	Age- and sex-standardized case fatality, 2000-2023, APC (95% CI) ^c	Length of stay, 2000–2023, APC (95% CI)
Brazil	+3.08 (-1.52 to 7.89)	+4.41 (3.42 to 5.41)	+2.64 (1.54 to 3.75)	+3.53 (2.42 to 4.66)	+1.68 (0.72 to 2.65)	+0.74 (0.33 to 1.15)
North	+5.56 (-0.56 to 12.06)	+8.15 (4.29 to 12.15)	+3.49 (1.50 to 5.53)	+2.97 (1.44 to 4.52)	+1.23 (-0.14 to 2.62)	+0.89 (0.18 to 1.60)
Northeast	+3.56 (-2.14 to 9.58)	+7.83 (6.67 to 8.99)	+5.02 (3.75 to 6.30)	+4.42 (2.16 to 6.72)	+1.97 (0.05 to 3.93)	+1.60 (1.06 to 2.14)
Southeast	+2.34 (-1.70 to 6.54)	+2.06 (0.85 to 3.28)	+1.39 (0.41 to 2.38)	+3.76 (3.01 to 4.51)	+2.42 (1.76 to 3.09)	+0.43 (0.13 to 0.74)
South	+2.82 (-1.07 to 6.86)	+4.12 (2.93 to 5.33)	+1.90 (0.74 to 3.08)	+3.11 (1.31 to 4.94)	+1.11 (-0.35 to 2.60)	+0.46 (-0.23 to 1.16)
Central-West	+3.54 (-2.10 to 9.50)	+0.39 (-1.17 to 1.97)	+0.18 (-1.28 to 1.65)	+3.86 (2.50 to 5.25)	+2.01 (0.68 to 3.36)	+0.15 (-0.53 to 0.83)

TABLE 5: Annual percent change in the standardized hospitalization rate, in-hospital case fatality, and length of stay, by macro-region, Brazil, 2000-2023

Values are annual percent changes with 95% confidence intervals; an interval that excludes zero indicates a statistically significant trend at the two-sided 0.05 level. APC, annual percent change, from Prais-Winsten regression of the log10-transformed annual value on calendar year with first-order autoregressive correction; 95% CI, 95% confidence interval.

^aPre-specified sub-periods of more comparable recording and principal estimates of trend: 2000-2007 precedes the SUS unified procedure table (in force from January 2008); 2009-2019 follows the table's first year and precedes the COVID-19 pandemic. The transition year 2008 and the years 2020–2023 are excluded from both sub-periods.

^bNet average change over the whole period, which spans the 2008 transition and the pandemic; reported as a summary, not as an estimate of a constant trend.

^cCase fatality standardized by the direct method to the age-by-sex distribution of all hospitalizations in Brazil, 2000-2023 (Table 2).

Rates were standardized by the direct method, jointly by age and sex, to the population enumerated in the 2022 Brazilian Demographic Census (Table 1). Case definition: hospital admissions with a principal diagnosis of ICD-10 L00-L08 (infections of the skin and subcutaneous tissue) or A46 (erysipelas).

Source: Hospital Information System of the Brazilian Unified Health System (SIH/SUS), Ministry of Health, Brazil.

The estimated national APC depended on the first year of the series (Table 6). Series ending in 2023 gave +2.64% per year from 2000, +2.54% per year from 2003, +3.79% per year (95% CI 1.03 to 6.64) from 2008, +2.42% per year (95% CI 0.26 to 4.63) from 2009, and +1.72% per year (95% CI -0.39 to 3.87) from 2010; series ending in 2019 gave +3.52% per year from 2000, +6.18% per year from 2008, and +4.41% per year from 2009. Starting the trend analysis in 2008, the year of the administrative trough, therefore produced APCs 40% to 76% higher than starting in 2000 or 2009.

Analysis window	Years, n	APC, % per year (95% CI)	P value
2000-2023	24	+2.64 (1.54 to 3.75)	<0.001
2000-2019	20	+3.52 (2.42 to 4.63)	<0.001
2003-2023	21	+2.54 (1.14 to 3.96)	0.001
2003-2019	17	+3.63 (2.21 to 5.08)	<0.001
2008-2023	16	+3.79 (1.03 to 6.64)	0.010
2008-2019	12	+6.18 (3.79 to 8.63)	<0.001
2009-2023	15	+2.42 (0.26 to 4.63)	0.031
2009-2019	11	+4.41 (3.42 to 5.41)	<0.001
2010-2023	14	+1.72 (-0.39 to 3.87)	0.102
2010-2019	10	+3.73 (3.17 to 4.30)	<0.001

TABLE 6: Sensitivity of the national trend in the standardized hospitalization rate to the first and last year of the series, Brazil

Each row re-estimates the trend of the national standardized rate over the stated window with the same Prais-Winsten model. Windows ending in 2019 exclude the COVID-19 pandemic; windows starting in 2009 or later exclude the 2008 transition year of the SUS unified procedure table; the 2008–2023 window corresponds to the period used in an earlier version of this analysis.

APC, annual percent change, from Prais-Winsten regression of the log10-transformed annual value on calendar year with first-order autoregressive correction; 95% CI, 95% confidence interval. Rates were standardized by the direct method, jointly by age and sex, to the population enumerated in the 2022 Brazilian Demographic Census.

Case definition: hospital admissions with a principal diagnosis of ICD-10 L00-L08 (infections of the skin and subcutaneous tissue) or A46 (erysipelas).

Source: Hospital Information System of the Brazilian Unified Health System (SIH/SUS), Ministry of Health, Brazil.

Case fatality and length of stay

Crude in-hospital case fatality rose from 0.74% (536 of 72,760) in 2000 to 1.78% (2,834 of 159,543) in 2023 (APC +3.53% per year, 95% CI 2.42 to 4.66), significantly in all five regions (from +2.97% per year in the North to +4.42% per year in the Northeast; Table 5, Figure 2). Part of the increase was a step in 2002 (0.73%, 473 of 64,637, to 1.17%, 612 of 52,245) that coincided with the 2001-2002 trough described above; case fatality then rose from 0.93% (588 of 62,949) in 2008 to 1.67% (2,639 of 157,709) in 2019 and peaked at 2.06% (2,377 of 115,657) in 2021. Standardized for age and sex, case fatality rose from 0.97% in 2000 to 1.53% in 2023 (APC +1.68% per year, 95% CI 0.72 to 2.65; 2009-2019, +1.47% per year, 95% CI 0.03 to 2.93), about half the crude slope (Figure 2). In the decomposition, the crude increase of 1.04 percentage points between 2000 and 2023 comprised 0.52 points from the change in the age-by-sex composition of admissions and 0.52 points from higher case fatality within age-by-sex strata (50% each; between 2009 and 2019 the composition component was also 50%). The standardized trend remained significant in the Southeast (+2.42% per year), Central-West (+2.01% per year), and Northeast (+1.97% per year), but not in the North (+1.23% per year, 95% CI -0.14 to 2.62) or the South (+1.11% per year, 95% CI -0.35 to 2.60) (Table 5). Mean length of stay increased from 4.95 to 6.28 days (APC +0.74% per year, 95% CI 0.33 to 1.15), significantly in the North, Northeast, and Southeast (APCs from +0.43% per year in the Southeast to +1.60% per year in the Northeast) and without significant change in the South or Central-West (Table 5).

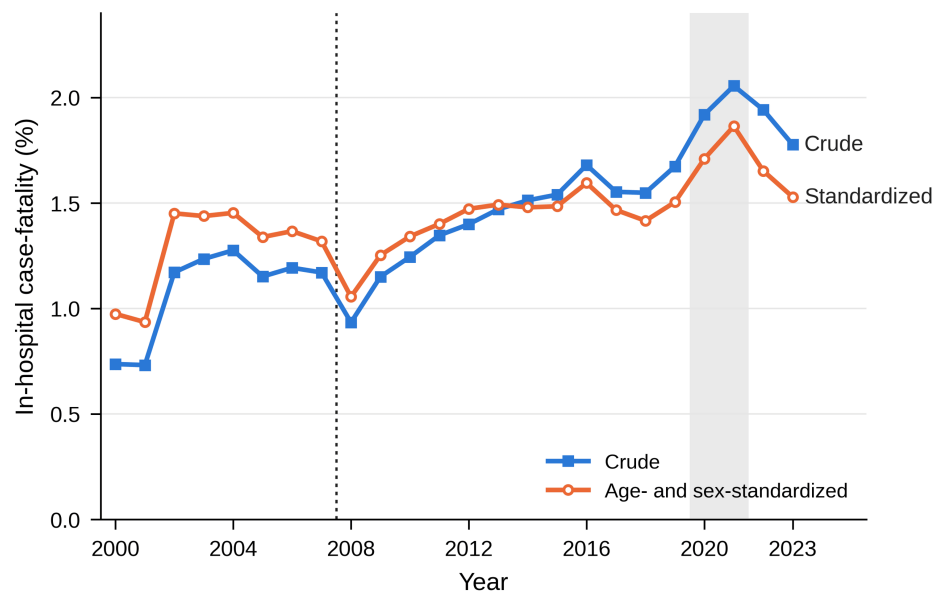


FIGURE 2: In-hospital case fatality of hospitalizations for skin and soft-tissue infections and erysipelas, crude and age- and sex-standardized, Brazil, 2000-2023

Case fatality is the number of in-hospital deaths divided by the number of hospitalizations in each year, expressed as a percentage; crude values (blue, filled squares) and values standardized by the direct method to the age-by-sex distribution of all hospitalizations in 2000–2023 (orange, open circles). The vertical dotted line marks January 2008, when the unified procedure table of the Unified Health System came into force; the shaded band marks the COVID-19 pandemic years 2020–2021. The step between 2001 and 2002 coincides with the 2001–2002 recording discontinuity described in the text.

Sex and age

Standardized rates were higher in men than in women in every year (1,398,754 male vs. 1,109,270 female hospitalizations; male-to-female ratio 1.26). With both sexes standardized to the same age distribution, the male rate rose from 50.8 to 90.7 per 100,000 (APC +3.06% per year, 95% CI 1.91 to 4.21) and the female rate from 42.1 to 62.0 (APC +2.17% per year, 95% CI 1.11 to 3.24), and the male-to-female ratio of standardized rates was 1.21 in 2000 and 1.46 in 2023 (Figure 3, Table 7); within 2009–2019 the estimates were +4.84% per year and +3.96% per year. Crude case fatality was 1.63% in women (18,095 of 1,109,270) and 1.35% in men (18,814 of 1,398,754); hospitalized women were older (339,236 of 1,109,269, 30.6%, aged 60 years or older, vs. 324,116 of 1,398,754, 23.2%, of men), and age-standardized case fatality was 1.43% in women and 1.49% in men (Table 7); no statistical comparison between the sexes was performed. Between 2000 and 2003 and 2020–2023 the share of admissions among children younger than 5 years fell from 14.0% (36,732) to 12.8% (67,540), the share among people aged 15–29 years from 21.6% (56,784) to 12.6% (66,465), and the share among adults 60 years and older rose from 20.3% (53,340) to 31.0% (163,936) (Table 8; 263,247 and 529,028 hospitalizations with recorded age in the two periods); using 2003–2006 as the early period, to avoid the 2001–2002 discontinuity, gave a similar starting share (22.0%, 68,856 of 312,775).

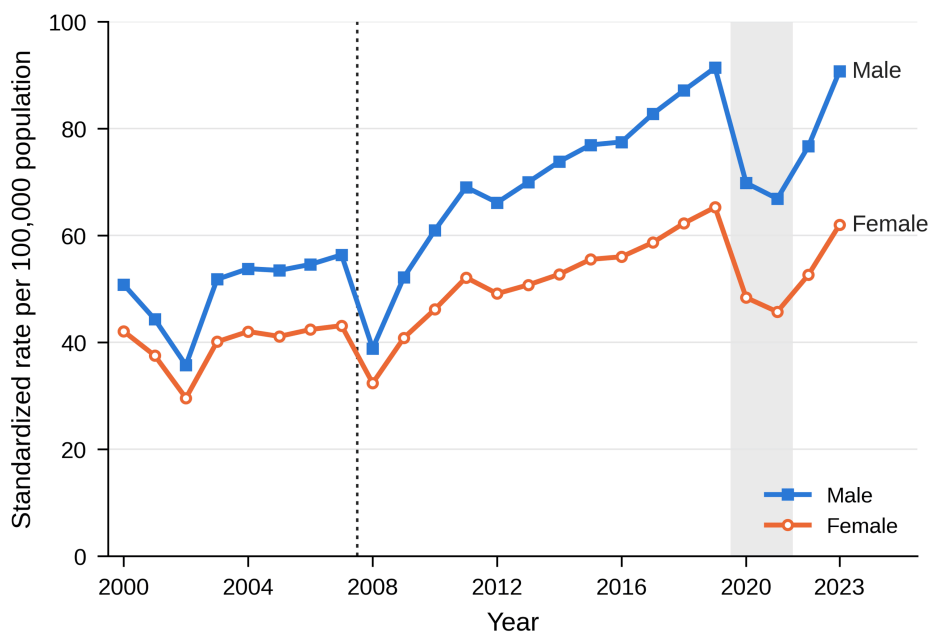


FIGURE 3: Standardized hospitalization rates for skin and soft-tissue infections and erysipelas by sex, Brazil, 2000-2023

Rates per 100,000 population; both sexes were standardized by the direct method to the same age distribution, that of the combined male and female population enumerated in the 2022 Brazilian Census (male, blue, filled squares; female, orange, open circles). The vertical dotted line marks January 2008, when the unified procedure table of the Unified Health System came into force; the shaded band marks the COVID-19 pandemic years 2020-2021.

Sex	Hospitalizations, n	In-hospital deaths, n	Case fatality, crude, %	Case fatality, age-standardized, % ^a	Standardized rate, 2000 ^a	Standardized rate, 2023 ^b	APC 2000-2023, % per year (95% CI)	APC 2009-2019, % per year (95% CI)
Male	13,98,754	18,814	1.35	1.49	50.8	90.7	+3.06 (1.91 to 4.21)	+4.84 (3.78 to 5.92)
Female	11,09,270	18,095	1.63	1.43	42.1	62	+2.17 (1.11 to 3.24)	+3.96 (3.00 to 4.93)

TABLE 7: Hospitalizations, in-hospital case fatality (crude and age-standardized), and standardized hospitalization rates by sex, Brazil, 2000-2023

Male-to-female ratio of total hospitalizations, 2000-2023: 1.26. Four hospitalizations with unrecorded sex are excluded.

^aCase fatality standardized by the direct method to the combined-sex age distribution of all hospitalizations in 2000-2023 (Table 2); one hospitalization with unrecorded age is excluded.

^bAge-standardized rate per 100,000 population, sex-specific: the age-specific rates of each sex were standardized to the same age distribution, that of the combined male and female population enumerated in the 2022 Census (Table 1), so that the male and female rates are directly comparable.

APC, annual percent change, from Prais-Winsten regression of the log10-transformed annual value on calendar year with first-order autoregressive correction; 95% CI, 95% confidence interval. Case definition: hospital admissions with a principal diagnosis of ICD-10 L00-L08 (infections of the skin and subcutaneous tissue) or A46 (erysipelas).

Source: Hospital Information System of the Brazilian Unified Health System (SIH/SUS), Ministry of Health, Brazil.

Age group	2000–2003, n	2000–2003, %	2020–2023, n	2020–2023, %
0–4 years	36,732	14	67,540	12.8
5–9 years	18,088	6.9	29,281	5.5
10–14 years	13,412	5.1	20,625	3.9
15–19 years	19,578	7.4	20,871	3.9
20–24 years	20,760	7.9	23,283	4.4
25–29 years	16,446	6.2	22,311	4.2
30–34 years	14,792	5.6	22,959	4.3
35–39 years	14,436	5.5	25,744	4.9
40–44 years	14,388	5.5	29,969	5.7
45–49 years	14,604	5.5	31,767	6
50–54 years	14,039	5.3	34,315	6.5
55–59 years	12,632	4.8	36,427	6.9
60–64 years	12,472	4.7	36,043	6.8
65–69 years	11,601	4.4	33,827	6.4
70–74 years	10,885	4.1	30,205	5.7
75–79 years	8,202	3.1	24,947	4.7
80 years and older	10,180	3.9	38,914	7.4
All ages	2,63,247	100	5,29,028	100

TABLE 8: Age distribution of hospitalizations in the first (2000–2003) and last (2020–2023) four years of the study period, Brazil

Values are the number and percentage of hospitalizations (both sexes) in each age group; one hospitalization with unrecorded age is excluded. Case definition: hospital admissions with a principal diagnosis of ICD-10 L00–L08 (infections of the skin and subcutaneous tissue) or A46 (erysipelas).

Source: Hospital Information System of the Brazilian Unified Health System (SIH/SUS), Ministry of Health, Brazil.

Reimbursement, 2008–2023

Total inflation-adjusted reimbursement rose from R\$49.9 million in 2008 to R\$117.7 million in 2019, fell to R\$82.6 million in 2021, and reached R\$109.3 million in 2023, without a significant trend (APC +3.32% per year, 95% CI -0.30 to 7.08) (Table 9, Figure 4). Mean inflation-adjusted reimbursement per hospitalization rose from R\$792 in 2008 to a peak of R\$978 in 2010 and then declined to R\$685 in 2023, 30% below the peak (APC 2008–2023 -1.89% per year, 95% CI -2.92 to -0.85), a decline that was significant in all five regions (APC from -1.28% per year in the Southeast to -2.22% per year in the Northeast).

Macro-region	Total reimbursement, nominal R\$ million	Total reimbursement, 2023 R\$ million ^a	Total reimbursement, APC (95% CI)	Mean reimbursement per hospitalization, 2008, 2023 R\$ ^a	Peak mean reimbursement, 2023 R\$ (year) ^a	Mean reimbursement per hospitalization, 2023, 2023 R\$ ^a	Mean reimbursement per hospitalization, APC (95% CI)
Brazil	1,075.9	1,562.6	+3.32 (-0.30 to 7.08)	792	978 (2010)	685	-1.89 (-2.92 to -0.85)
North	130.6	188.1	+6.94 (-0.64 to 15.10)	775	952 (2010)	620	-2.16 (-3.60 to -0.70)
Northeast	313.2	444.2	+5.18 (1.77 to 8.71)	757	930 (2010)	624	-2.22 (-3.30 to -1.13)
Southeast	436.5	642.1	+1.71 (-1.30 to 4.82)	819	997 (2010)	773	-1.28 (-2.25 to -0.30)
South	129.3	189.1	+3.23 (-1.33 to 8.00)	798	1,115 (2010)	703	-2.09 (-3.50 to -0.65)
Central-West	66.2	99.0	-0.25 (-2.64 to 2.20)	761	879 (2009)	601	-1.80 (-2.46 to -1.13)

TABLE 9: Hospital reimbursement for skin and soft-tissue infections and erysipelas in the Brazilian Unified Health System, by macro-region, 2008–2023

Reimbursement is the value approved for payment for each hospital admission under the SUS procedure table (valor total da AIH), not the economic cost of care. The analysis is restricted to 2008–2023, the period of the unified procedure table, because values before and after January 2008 are not comparable.

^aNominal values deflated to constant 2023 Brazilian reais (R\$) with the national consumer price index (IPCA, IBGE). APC, annual percent change, from Prais-Winsten regression of the log10-transformed annual value on calendar year with first-order autoregressive correction; 95% CI, 95% confidence interval. Case definition: hospital admissions with a principal diagnosis of ICD-10 L00–L08 (infections of the skin and subcutaneous tissue) or A46 (erysipelas).

Source: Hospital Information System of the Brazilian Unified Health System (SIH/SUS), Ministry of Health, Brazil. IPCA: Brazilian Institute of Geography and Statistics (IBGE).

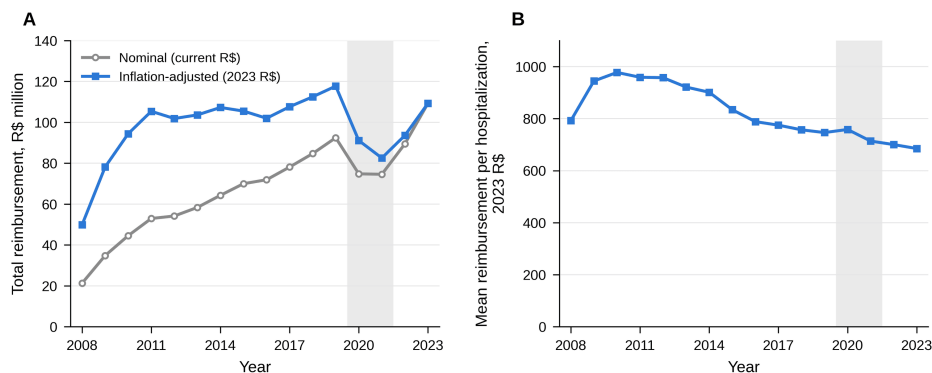


FIGURE 4: Hospital reimbursement for skin and soft-tissue infections and erysipelas in the Brazilian Unified Health System, 2008–2023

Reimbursement is the value approved for payment for each hospital admission under the SUS procedure table, not the economic cost of care. Panel A, total annual reimbursement in nominal reais (grey, open circles) and in constant 2023 reais after adjustment with the national consumer price index (IPCA; blue, filled squares). Panel B, mean inflation-adjusted reimbursement per hospitalization in constant 2023 reais. The series begins in 2008, the first year of the unified procedure table, because values before and after that date are not comparable; the shaded band marks the COVID-19 pandemic years 2020–2021.

Sensitivity analyses

Under the narrower L00–L08 definition (1,692,663 of 2,508,028 admissions, 67.5%), the crude rate rose from 33.2 to 51.0 per 100,000 (APC +2.55% per year, 95% CI 1.35 to 3.77; 2009–2019, +5.39% per year, 95% CI 4.40 to 6.39), concordant with the main analysis. Case fatality under this definition rose from 0.66% (384 of

58,075) in 2000 to 1.26% (1,357 of 107,906) in 2023, but the trend did not reach significance over 2000–2023 (APC +1.78% per year, 95% CI -0.03 to 3.62; $P=0.053$) or 2009–2019 (+1.32% per year, 95% CI -0.36 to 3.03) and was significant only for a series starting in 2008 (+3.36% per year, 95% CI 1.62 to 5.12). The choice of standard did not affect the national trend (APC +2.64% per year with the 2022 Census, +2.77% per year with the 2000 population, +2.68% per year with the pooled population; direction and significance unchanged in every sub-period). Standardizing each sex to its own age distribution, as in the previous version, gave a male-to-female ratio of 1.16 in 2000 and 1.40 in 2023, with unchanged direction and significance of both sex-specific trends (+3.04% per year and +2.16% per year). Within 2009–2019 the crude rate rose for each main diagnostic group: erysipelas (A46, +4.27% per year, 95% CI 3.23 to 5.33), cellulitis (L03, +5.17% per year, 95% CI 4.15 to 6.21), cutaneous abscess (L02, +6.11% per year, 95% CI 5.40 to 6.83), and other localized infections (L08, +8.71% per year, 95% CI 4.37 to 13.23), but not pilonidal cyst (L05, +0.94% per year, 95% CI -1.89 to 3.84).

Discussion

In this 24-year national analysis of SUS-financed admissions, the age- and sex-standardized hospitalization rate for SSTIs and erysipelas in Brazil was 63% higher in 2023 than in 2000, but the increase was neither steady nor uniform: it was concentrated in the decade after the introduction of the unified procedure table (2009–2019), preceded by eight years without a detectable trend, interrupted by a one-year fall of one quarter at the onset of the pandemic, and followed by recovery to near the pre-pandemic peak. It was accompanied by rising in-hospital case fatality, about half of which reflected the older age of admitted patients, a modest increase in length of stay, a higher standardized rate in men throughout, and, since 2008, a decline in inflation-adjusted reimbursement per admission while total reimbursement showed no significant trend. These findings describe the use of SUS hospital services; because the design is ecological and descriptive, they do not identify individual risk factors or the causes of the trends, and the explanations discussed below are hypotheses.

Two features of the data condition every other interpretation. First, the series contains two troughs, in 2001–2002 and in 2008, whose composition points to recording rather than disease. The 2008 trough coincides with the first year of the unified procedure table, spared erysipelas and pilonidal cyst, and removed nearly half of cellulitis admissions, halving their case fatality, for a single year; all-cause admissions processed by SIH/SUS fell by 5.4% in the same year and recovered in 2009. These features are consistent with a transition-year effect of the administrative change, plausibly through the recoding of procedures, new rules of compatibility between procedures and diagnoses, and the shift of some procedures to outpatient billing, but we found no document that quantifies its effect on SSTI admissions specifically, and we therefore describe 2008 as an apparent recording-related, transition-year trough rather than as an established artefact. The 2001–2002 trough was confined to abscess and "other localized infection" codes, with cellulitis and erysipelas rising sharply the following year, a pattern more consistent with reclassification among codes than with a change in disease. We found no documented administrative change for 2001–2002 and describe it as an empirical discontinuity, plausibly related to reclassification of minor procedures between hospital and outpatient billing, without claiming a cause. Second, the long-run estimate depends on where the series begins: starting the analysis in 2008, the APC is 3.8% per year (6.2% per year if it ends in 2019), 40% to 76% higher than from 2000 or 2009. Earlier Brazilian reports [13,14], and an earlier version of this analysis, began at or after 2008, and any trend that starts there overstates the increase. Segmented regression was compatible with the pre-specified boundary but does not independently confirm it: 2008 was the preferred location of the first national joinpoint, but models placing it in 2002, 2007, or 2009 fitted almost as well, and a joinpoint in 2008 was selected in three of the five regions. The case for 2008 as a boundary rests on the documented administrative change, not on the segmented regression. For these reasons, the sub-period estimates, not the single 2000–2023 slope, are our principal summary of trend.

Within 2009–2019, the period of most comparable recording, the national increase (about 4.4% per year) was larger than the gradual rise in Portugal's national registry between 2000 and 2016 (47.5 to 53.5 per 100,000) [7], and closer to the steep early-2000s rise in the United States [5,6] than to the plateau of more recent US cohorts [2,12], although such comparisons are limited by differences in case definition, health-system organization, and data source. The full-period figure of 2.6% per year averages over periods with different recording; it remains useful as a descriptive summary, comparable with studies that report a single long-term trend, but is not an estimate of a constant underlying rate of increase. Point estimates of the 2009–2019 APC were larger in the North and Northeast than in the South and Southeast, and the Central-West showed no significant trend; because no interaction tests were performed, these regional differences are descriptive and do not establish that the regional trends differ. Hypotheses that could account for them, none of which was measured here, include differential expansion of hospital beds and SUS coverage in historically underserved regions, regional changes in private insurance coverage, climate, and regional differences in the prevalence of diabetes, obesity, and chronic venous or lymphatic disease [3,4]. The North's increase was concentrated in 2008–2013, and its rate has since shown no significant trend.

The 24.6% fall between 2019 and 2020 was the largest year-on-year decline apart from 2008 and the only large decline not coinciding with a coding event. Its timing, the concurrent fall in admissions for other non-COVID conditions in Brazil [25], and the complete recovery by 2023 suggest disruption of access and demand

as the most plausible explanation, although these data cannot separate a true fall in incidence from deferred or displaced admission. The peak in case fatality in 2021 (crude 2.06%, 2,377 of 115,657; standardized 1.86%), the year with the fewest admissions since 2013, persisted after standardization and is consistent with a higher threshold for admission concentrating severe cases, but other mechanisms would produce the same pattern.

The rise in crude case fatality must be read alongside the ageing of the hospitalized population: the share of admissions at 60 years or older rose from 20.3% (53,340 of 263,247) in 2000–2003 to 31.0% (163,936 of 529,028) in 2020–2023 (Table 8), and about half of the crude increase between 2000 and 2023 was attributable to this change in composition. The remainder, a rise of 1.68% per year in age- and sex-standardized case fatality, was significant nationally and in the Southeast, Central-West, and Northeast, including the Central-West, where admissions did not rise. Possible explanations, which these data cannot test, include increasing comorbidity, later presentation, and a rising threshold for admission; standardized case fatality is not a measure of clinical severity, and its rise does not establish that SSTIs became more severe in the population. Two further cautions apply: part of the full-period increase is a step in 2002 that coincides with reclassification, and under the narrower L00–L08 definition the full-period trend in crude case fatality did not reach significance. Rising in-hospital mortality for bacterial SSTI despite predicted improvement was also reported in Portugal [7], and in Wales and Spain case and severity were driven by length of stay and case complexity rather than antimicrobial cost [8,9].

A decline in inflation-adjusted reimbursement per admission, while total reimbursement showed no significant trend, has not, to our knowledge, been described for this disease group in Brazil; broadly similar patterns have been reported for bed-day and antimicrobial reimbursement in Wales and the United States and, from the demand side, in a US emergency-department cohort [8,16,26,27]. Where reimbursement values are set by an administratively fixed table updated less often than prices rise, a declining real value per admission is structurally plausible; whether it reflects tariff stagnation, a shift toward shorter or less resource-intensive admissions, or both cannot be determined from aggregate data. Because reimbursement is an administrative payment, not the cost of care, its decline should not be read as a decline in the resources actually used or available for these patients. The mean value per admission also rose between 2008 and 2010, so the decline is from a 2010 peak rather than from the first year of the table.

Standardized rates were higher in men than in women throughout, and the male-to-female ratio rose from 1.21 to 1.46 with both sexes standardized to the same age distribution; no test of the sex-by-year interaction was performed, so this change is descriptive. A male excess in cellulitis admissions was also reported in Spain, together with higher case fatality in women [9]. Here crude case fatality was higher in women (18,095 of 1,109,270, 1.63%, vs. 18,814 of 1,398,754, 1.35%), but hospitalized women were older, and age-standardized case fatality was similar (1.43% vs. 1.49%); no statistical comparison was made. Explanations for the male excess, such as differences in occupational exposure, trauma, comorbidity, or care-seeking, are hypotheses that could not be examined with these data. The shift of admissions away from adolescents and young adults and toward adults aged 60 years and older is consistent with Brazil's demographic transition and with the age-related risk factors for cellulitis and its recurrence [3,4].

Bellini and Cruz reported 1,012,358 SIH/SUS hospitalizations for "skin infections" in 2014–2024, with the Southeast contributing the largest share and expenditure, consistent with our regional distribution, but without a code list, standardized rates, or trend estimation [13]. Machado and Stocki, restricting to cellulitis and abscess in 2010–2024, reported a mean stay of 4.9 days, case fatality of 0.8%, and a reduction after 2020 [14]; their lower case fatality probably reflects their narrower definition, and our sensitivity analysis with a similarly narrow definition, which found a concordant rise through 2023, suggests that their post-2020 reduction reflects a series ending in the pandemic dip before the rebound captured here. The analysis by diagnostic group also showed that the increase in the composite was not driven by a single code.

These findings do not establish a causal driver and do not by themselves justify a change in clinical guidelines. If confirmed by studies with patient-level data, they would support region-targeted rather than uniform strategies to strengthen ambulatory management of SSTIs, including outpatient parenteral antimicrobial pathways shown elsewhere to reduce avoidable admission [26]; routine surveillance of case fatality alongside admission counts, standardized for age and sex, since case fatality rose even where admission volume did not; dedicated investigation of whether the decline in real reimbursement reflects tariff stagnation or case mix; and, methodologically, that trend analyses of SIH/SUS data should not begin in 2008 and should report their sensitivity to the starting year.

Strengths and limitations

We identified no previous Brazilian study of SSTI hospitalizations that combined a 24-year national series, explicit identification of recording discontinuities with pre-specified sub-periods examined by segmented regression, autocorrelation-corrected trend estimation, standardization by age and sex to a contemporary census, age- and sex-standardized case fatality, region-specific estimates, and joint analysis of admissions, in-hospital case fatality, length of stay, and inflation-adjusted reimbursement, with openly available code. Its limitations are those of its design and data. First, it is ecological: associations are estimated on aggregated strata, and neither individual risk factors nor the causes of the trends can be inferred. Second,

SIH/SUS records only SUS-financed admissions; the findings cannot be generalized to privately financed hospitalizations, and because private insurance coverage varies between regions and over time, the share of all admissions captured varies as well. Third, hospitalization is a utilization outcome: changes in access to ambulatory care, bed availability, admission thresholds, referral practices, and reimbursement rules over 24 years may have changed admission rates independently of disease incidence. Fourth, diagnoses are recorded for billing and were not validated against clinical records, so diagnostic misclassification and changes in coding practice over time are possible; the series contains two recording discontinuities, of which the 2008 break is documented and was handled by pre-specified sub-periods, although its effect on SSTI admissions specifically is inferred rather than documented, whereas the 2001-2002 break is undocumented and lies within the 2000-2007 sub-period, which should be read as a period without a detectable trend rather than as a stable baseline; full-period estimates average across both and are reported only as descriptive summaries of net change. Fifth, the data contain no patient-level clinical measures, such as vital signs, laboratory results, depth of infection, organ dysfunction, microbiology, antimicrobial treatment, or comorbidity burden, and no socioeconomic information; case fatality, even when standardized for age and sex, is therefore not a measure of clinical severity. Sixth, SIH/SUS counts admissions, not patients, so readmissions are counted repeatedly, to a degree that may have changed as the hospitalized population aged. Seventh, the pandemic-era decline and rebound cannot be attributed with confidence to a change in incidence [25]. Eighth, the composite case definition reduces comparability with L00-L08-only studies, and the case-fatality trend under the narrower definition was not significant over the full period. Ninth, the reimbursement value is an administrative approval amount, not the cost of care or a measure of the resources available, so its decline is reported descriptively and only for the period of a single procedure table. Finally, no interaction tests were performed, so regional and sex differences in trend are descriptive.

Conclusions

In SUS-financed hospital data, the recorded age- and sex-standardized hospitalization rate for SSTIs and erysipelas in Brazil was nearly two-thirds higher in 2023 than in 2000, a descriptive comparison of two years. The increase in trend was concentrated in 2009-2019, after the change in the national procedure table and before the pandemic, and its size varied between regions. Recorded in-hospital case fatality increased, about half of it because admitted patients became older, and length of stay increased modestly, while inflation-adjusted reimbursement per admission declined. Administrative discontinuities had a major influence on trend estimates: the estimated long-run increase depends on the first year of the series, and trend analyses of SIH/SUS data should not start in 2008. These findings describe the use of hospital services and do not establish its causes.

Additional Information

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