

Overview of Heart Failure in Brazil over 15 Years of Analysis: Impacts and Perspectives for the Health System

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Abstract

Background: Heart failure (HF) remains one of the leading causes of hospital admissions and in-hospital mortality in Brazil. As the population ages, understanding how these hospitalizations have evolved over time is crucial for improving healthcare planning and reducing the burden on the public health system.

Objectives: To evaluate temporal trends in HF hospitalizations in Brazil from 2010 to 2024, considering factors such as time, region, patient profile, and hospital-related costs.

Methods: This observational study used data from the Brazilian Unified Health System's Hospital Information System (SIH/SUS). Hospitalization rates per 100,000 inhabitants were adjusted using population estimates from the Brazilian Institute of Geography and Statistics. Temporal trends were assessed using annual percent change (APC) and average annual percent change (AAPC), with statistical significance set at $p < 0.05$.

Results: Over 3 million HF hospitalizations were recorded during the study period. Annual admissions declined from 264,000 in 2010 to 205,000 in 2024, representing an average annual decrease of 1.8%. Adjusted rates fell from 135.3 to 94.3 per 100,000 inhabitants (AAPC: -2.55% ; $p < 0.001$). In-hospital mortality peaked in 2021, reaching 13.5%. The average cost per hospitalization more than doubled, rising from BRL 1,151.42 to BRL 2,459.57.

Conclusion: Despite a significant reduction in hospitalization rates, HF continues to pose a major challenge to Brazil's healthcare system due to its high case volume and the steadily rising economic burden.

Keywords: Heart Failure; Hospitalization; Health Services.

Introduction

Heart failure (HF) is a chronic and debilitating pathological condition characterized by a set of signs and symptoms resulting from cardiac dysfunction, which ultimately reduce longevity. Its prevalence and associated mortality rates have been increasing in parallel with demographic changes occurring not only in Brazil but also worldwide.¹⁻³

The main causes of this cardiovascular condition include ischemic, hypertensive, and valvular diseases.^{4,5} Major risk factors are coronary artery disease, arterial hypertension, diabetes mellitus, advanced age (≥ 65 years), obesity, chronic obstructive pulmonary disease, and renal dysfunction.^{4,5}

As a heterogeneous syndrome, HF can be stratified into risk profiles upon admission, which reflect the severity of

the patient's condition.⁶ Acute HF, whether with sudden (de novo) onset or as an acute decompensation of chronic HF, is associated with reduced cardiac output and/or elevated cardiac filling pressures, allowing classification of the patient's hemodynamic profile.⁷

Proper classification—based on left ventricular ejection fraction, ventricular filling pressures at rest or during exertion, and, in simplified terms, the patient's perfusion and congestion status—is essential for guiding appropriate therapeutic strategies and determining the need for hospitalization. This decision requires clinical judgement and responsibility, as it carries significant implications for healthcare system costs and the patient's quality of life.^{7,8}

Despite significant advances in clinical and therapeutic management, HF continues to affect over 23 million individuals worldwide.⁸ In Brazil alone, more than 3 million people are estimated to be living with HF, which remains the leading cause of hospitalization and in-hospital mortality within the Brazilian Unified Health System (*Sistema Único de Saúde*, SUS).^{8,9}

This cardiovascular disease shows increasing prevalence with advancing age and predominantly affects men over 65 years of age.^{9,10} In 2022, data from DATASUS indicated that expenditures related to hospitalization for HF reached

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Central Illustration: Overview of Heart Failure in Brazil over 15 Years of Analysis: Impacts and Perspectives for the Health System

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Heart Failure in Brazil (2010–2024)

Fewer hospitalizations, rising costs, and a concerning outlook

Timeline (Hospitalizations)

2010: 264,802

2021: 163,453
(lowest point)

2024: 205,278

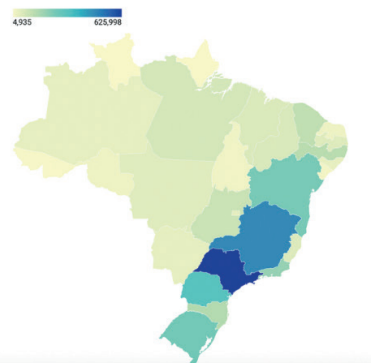
Adjusted average
annual decline:
–2.55%, despite an
aging population.

Rising Hospital Costs

2010: BRL 1,151

2024: BRL 2,459

Costs nearly doubled
over 15 years. Despite
fewer hospitalizations,
heart failure continues
to burden the Brazilian
public health system
(SUS).



Hospitalization Distribution

Most hospitalizations
occur in individuals
aged 70–79 (26.4%).

Southeast Region: High-
est absolute number of
cases.

North Region: Highest
proportional mortality.

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approximately 2 billion Brazilian reais (BRL), with an average cost exceeding BRL 1,725 per hospitalization.¹¹

Although HF is more prevalent among the elderly, young individuals are also affected, and work incapacity may become a significant consequence.¹² The impact on the Brazilian economy includes potential losses in the economically active population and an increase in disability retirements, leading to higher expenditures for the National Social Security Institute (INSS),^{13,14} which are ongoing challenges faced by Brazil.

The idiosyncratic pathophysiological diversity and multi-organ dysfunction¹⁵ associated with HF have intensified research into the impact of hospitalizations—both on patients and on public and private healthcare systems. This research supports the implementation of disease prevention strategies and the broader adoption of evidence-based optimized

therapies, including quadruple therapy (beta-blockers, diuretics, sodium-glucose cotransporter 2 [SGLT2] inhibitors, and renin-angiotensin-aldosterone system inhibitors), aiming to reduce healthcare costs and improve patient outcomes.

In this context, understanding HF hospitalizations in Brazil is crucial to assess the effectiveness of outpatient management, regional access to pharmacological therapies, and the impact of prevention strategies. This epidemiological study aimed to analyze HF hospitalization rates across Brazil from demographic, temporal, spatial, and financial perspectives within the public healthcare system. The findings are expected to provide meaningful insight into the social and economic burden of HF in the country. While further research is necessary to deepen understanding, the data presented here highlight the need for improved governmental strategies to

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reduce disparities in HF care and ultimately lower healthcare costs in both the public and private sectors.

Beyond its clinical impact, HF represents a growing economic burden. Increased longevity and advances in diagnostic methods have led to a higher prevalence of chronic cases, thereby expanding hospital and social security costs. National and international studies highlight that temporal analyses allow for the assessment of public policy effectiveness and the performance of primary care in reducing avoidable hospitalizations. Therefore, understanding the trends and regional distribution of hospital admissions is essential to support management decisions and resource allocation.

Methodology

Study type and data source

This is an observational, ecological, and time-trend study conducted in accordance with the STROBE Statement for observational research. Hospital admissions due to HF recorded in the Brazilian Unified Health System's Hospital Information System (SIH/SUS) were analyzed for the period from January 2010 to December 2024. All hospitalizations with a primary diagnosis of HF, as defined by the International Classification of Diseases, 10th Revision (ICD-10: I50.0 – congestive heart failure; I50.1 – left ventricular failure; I50.9 – heart failure, unspecified), were included. As this study is based

on secondary data obtained from official, publicly accessible databases, without individual identification of subjects, it did not require approval by a research ethics committee, in accordance with the guidelines of the Brazilian National Health Council Resolution No. 510/2016.

Study population and variables of interest

The study population comprised all hospital admissions with a primary diagnosis of HF recorded in the SIH/SUS between January 2010 and December 2024. The unit of analysis was the hospitalization episode rather than the individual patient, due to the aggregated nature of the data. Annual population estimates from the Brazilian Institute of Geography and Statistics (IBGE) were used to calculate population-standardized rates, applying the direct method of age standardization, with the 2010 Brazilian population as the reference. The variables analyzed included the total number of HF hospitalizations, number of in-hospital deaths, in-hospital mortality rate (%), mean length of hospital stay (in days), and average cost per hospitalization (in BRL). Stratified analyses were also performed by geographic region (North, Northeast, Southeast, South, and Central-West) and by age group (40 to 49, 50 to 59, 60 to 69, 70 to 79, and ≥ 80 years) (Figure 1). The normality assumption of the residuals was visually confirmed using the qqPlot function from the car package, which demonstrated that the points closely followed the reference line and remained within the confidence envelope (Figure 2).

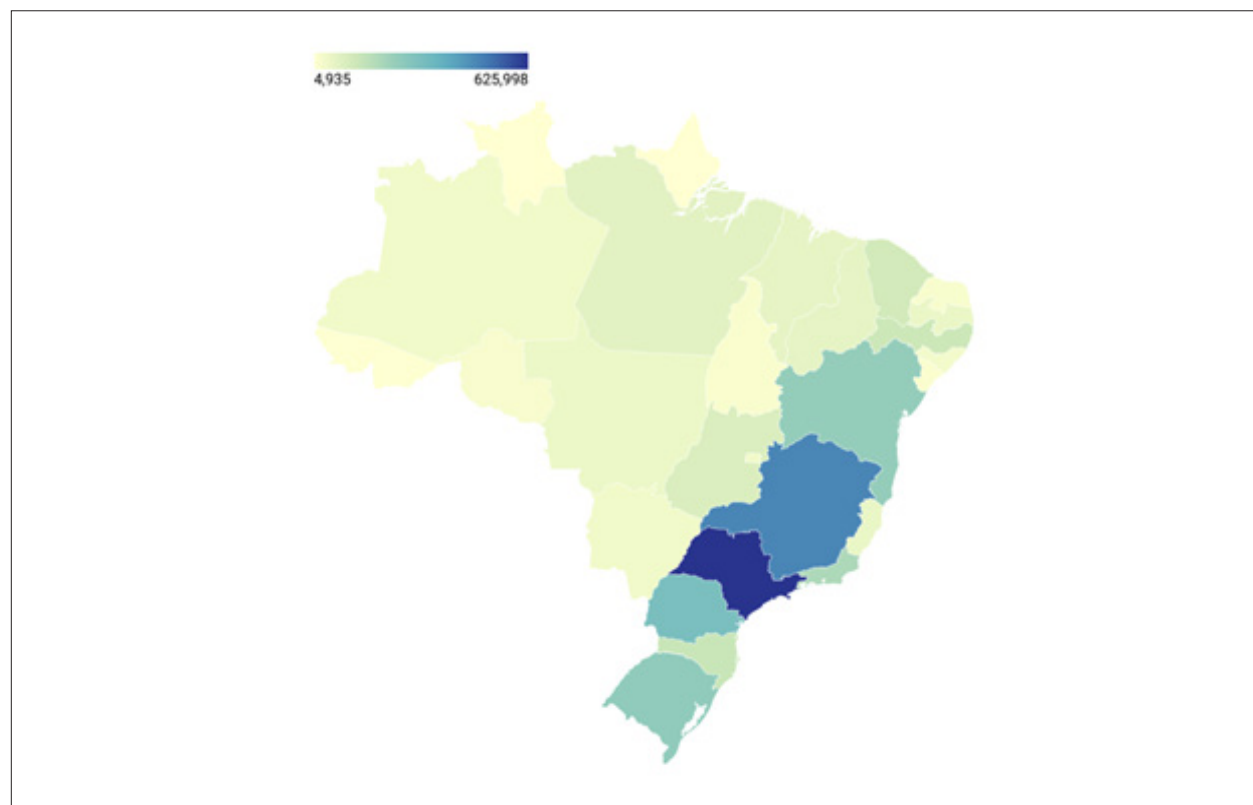


Figure 1 – Distribution of total hospitalizations for heart failure in Brazil (2010 to 2024) Source: Brazilian Ministry of Health – Hospital Information System of the Unified Health System (SIH/SUS). Prepared by the authors (2025). Created with Datawrapper.

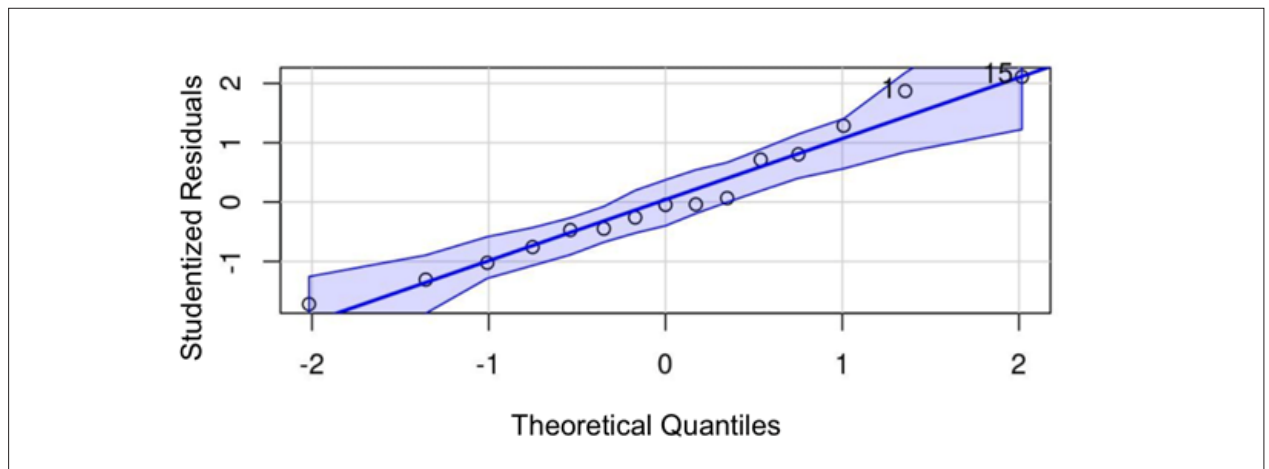


Figure 2 – Residual normality plot (cost model). Source: Brazilian Ministry of Health – Hospital Information System of the Unified Health System (SIH/SUS). Prepared by the authors (2025). Created with R software, version 4.3.2.

Data analysis

A descriptive analysis of the collected data was initially conducted, presenting the absolute number of hospitalizations due to HF, the number of in-hospital deaths, hospital mortality rate (%), average length of hospital stay (in days), and average cost per hospitalization (in BRL) over the years 2010 to 2024. Annual hospitalization rates per 100,000 inhabitants were calculated using official population estimates from the IBGE, based on the following formula: $(\text{Number of hospitalizations} / \text{Estimated population}) \times 100,000$. Subsequently, a temporal trend analysis was performed based on both the absolute number of hospitalizations and the population-adjusted rates. To assess trends, the annual percent change (APC) and the average annual percent change (AAPC) were calculated using the geometric progression formula: $((\text{Final value} / \text{Initial value})^{\frac{1}{n}} - 1) \times 100$, where n represents the number of years analyzed. The APC was applied to the absolute number of hospitalizations, and the AAPC was used for the population-adjusted hospitalization rates.

In addition, a statistical analysis was conducted using simple linear regression, with the natural logarithm of annual hospitalization rates as the dependent variable and year as the independent variable. The regression slope coefficient (β_1) was converted into AAPC using the formula: $\text{AAPC} = (\exp(\beta_1) - 1) \times 100$.

This method enabled the estimation of the AAPC along with its 95% confidence interval (CI) and p values, adopting a 5% significance level.

The assumptions of linear regression (linearity, independence, normality, and homoscedasticity) were visually assessed through residual inspection and graphical analysis of the dispersion between fitted and observed values. No anomalies or systematic patterns were identified that could compromise the validity of the model. The normality assumption of the residuals was visually confirmed using the qqPlot function from the car package, which

demonstrated that the points closely followed the reference line and remained within the confidence envelope.

In addition, line graphs were generated to illustrate the annual trends in hospital admissions and in-hospital mortality over the study period. To visually represent the geographic distribution of the hospitalization burden, a thematic map was constructed showing the cumulative number of hospitalizations by federative unit. All analyses, including modeling, diagnostics, and data visualization, were conducted using R software, version 4.3.2 (R Core Team, 2024). Initial data tabulation was performed in an electronic spreadsheet (Microsoft Excel®).

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Results

From 2010 to 2024, a total of 3,021,245 hospitalizations due to HF were recorded in Brazil. The highest number occurred in 2010, accounting for 8.76% of the total, while the lowest was observed in 2021, with 5.41%. Temporal trend analysis using APC, based on data from the SIH/SUS, revealed a decrease in hospitalizations from 264,802 in 2010 to 205,278 in 2024. The APC of -1.80% per year indicates a consistent average annual reduction of 1.8% in the absolute number of HF hospitalizations over the 15-year period. However, the Durbin–Watson test (dwtest from the lmtest package) rejected the hypothesis of independence of residuals ($p < 0.001$), indicating the presence of positive autocorrelation, a common limitation in time series data. The Central Illustration provides a summary of the study findings.

To account for population growth, annual hospitalization rates per 100,000 inhabitants were calculated using intercensal projections from IBGE. These rates declined from 135.3 per 100,000 in 2010 to 94.3 per 100,000 in 2024, corresponding to a relative reduction of over 30%. Despite an increase in

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the Brazilian population (from approximately 195 million to 218 million), a progressive and sustained decline in HF hospitalization rates was observed.

Based on the calculated hospitalization rates, the AAPC was determined using geometric progression. The resulting AAPC of -2.55% per year indicated a more pronounced proportional decline than that observed in the absolute numbers of hospitalizations. This finding highlights a consistent and sustained reduction in the population-adjusted hospital burden of HF over the study period.

Over the study period, a total of 346,551 hospitalizations due to HF resulted in in-hospital death, corresponding to an annual average of approximately 23,103 deaths. The highest absolute number of deaths occurred in 2022 (24,954) (Figure 3), with a hospital mortality rate of 12.37%. In contrast, the lowest number of deaths was recorded in 2020 (20,546), despite a comparable mortality rate of 12.11%. However, the highest hospital mortality rate was observed in 2021, reaching 13.48%, the same year in which the number of HF hospitalizations was at its lowest.

The average length of hospital stay for HF increased over time, ranging from 6.5 days in 2010 to 8.4 days between 2022 and 2024, with a mean duration of 7.46 days across the entire period (Table 1).

The average cost per hospitalization due to HF demonstrated a progressive increase, rising from BRL 1,151.42 in 2010 to BRL 2,459.57 in 2024. The overall average cost per admission during this time was BRL 1,692.23, reflecting the growing financial burden of HF management within the public healthcare system.

When stratified by geographic region, the Southeast exhibited the highest annual average number of hospitalizations (90,331), followed by the Northeast (49,872), South (47,322),

Central-West (15,441), and North (11,816) regions. This distribution aligns with regional population densities and healthcare infrastructure availability (Table 2).

In terms of age, individuals aged 70 to 79 years accounted for the highest number of hospitalizations (852,159), representing 26.4% of the total cases (Table 3). Conversely, individuals aged 40 to 49 years exhibited the lowest hospitalization rate, comprising only 6.9% of all admissions. These findings highlight the increasing burden of HF among older adults.

Discussion

This study analyzed the temporal trends of hospitalizations for HF in Brazil between 2010 and 2024, revealing a significant reduction in hospitalization rates adjusted per 100,000 inhabitants. The calculated AAPC of -2.55% (95% CI: -3.18 to -1.91 ; $p < 0.001$) indicates a consistent decline in the population-adjusted burden of HF hospitalization over the 15-year period. The APC and AAPC analyses estimate temporal associations rather than causal effects. Therefore, interpretations attributing the decline to specific interventions should be avoided in the absence of exposure measurements and an appropriate study design.^{16,17}

These findings are consistent with previous Brazilian studies. In 2015, Lentsck et al.¹⁸ documented a declining trend in hospitalization rates due to cardiovascular diseases in Brazil between 2001 and 2011 ($r^2 = 0.96$; $p < 0.001$), with reductions observed in both sexes and across age groups, though rates remained higher among males throughout the period. In a subsequent projection study published in 2020, Siqueira and de Souza¹⁹ estimated a continued decline in the risk of HF-related morbidity and hospitalizations by 2030. Their analysis forecasted



Figure 3 – Annual mortality in Brazil (2010 to 2024). Source: Brazilian Ministry of Health – Hospital Information System of the Unified Health System (SIH/SUS). Prepared by the authors (2025).

Table 1 – Summary of hospitalizations for heart failure in Brazil (2010 to 2024)

Year	Hospitalizations	Deaths	Mortality (%)	Average length of stay (days)	Average cost (BRL)
2010	264,802	23,752	8.97	6.5	1,151.42
2011	261,702	24,386	9.32	6.6	1,180.58
2012	244,413	23,119	9.46	6.7	1,228.61
2013	236,443	22,948	9.71	6.9	1,297.34
2014	224,377	22,052	9.83	7.1	1,406.26
2015	218,903	22,773	10.40	7.3	1,498.24
2016	214,460	23,615	11.01	7.4	1,558.96
2017	208,724	22,656	10.85	7.5	1,630.77
2018	200,833	22,337	11.12	7.7	1,686.93
2019	199,844	22,806	11.41	7.7	1,756.20
2020	169,693	20,546	12.11	7.5	1,891.81
2021	163,453	22,027	13.48	7.8	2,025.11
2022	201,793	24,954	12.37	8.4	2,207.24
2023	207,028	24,274	11.72	8.4	2,328.37
2024	205,278	24,312	11.84	8.4	2,459.57

Source: Brazilian Ministry of Health – Hospital Information System of the Unified Health System (SIH/SUS). Prepared by the authors (2025).

Table 2 – Hospitalizations by region (annual average, 2010 to 2024)

Region	Hospitalizations (annual average)
North	11,816
Northeast	49,872
Southeast	90,331
South	47,322
Central-West	15,441

Source: Brazilian Ministry of Health – Hospital Information System of the Unified Health System (SIH/SUS). Prepared by the authors (2025).

a reduction of approximately 6.1% in men and 6.2% in women, with APC = -5.0 (-5.6 ; -4.5) and APC = -5.5 (-6.0 ; -4.9), respectively.¹⁹

One possible explanation for the reduction in HF hospitalizations is the progressive advancement of pharmacological therapies for HF, particularly heart failure with reduced ejection fraction (HFrEF). The incorporation of beta-blockers, angiotensin-converting enzyme inhibitors or angiotensin receptor-neprilysin inhibitors (e.g., sacubitril/valsartan), mineralocorticoid receptor antagonists, and SGLT2 inhibitors has substantially altered the natural progression of

HFrEF by reducing both hospital admissions and mortality.²⁰ Landmark clinical trials, including DAPA-HF, EMPEROR-Reduced, and PARADIGM-HF, have consistently demonstrated significant reductions in adverse outcomes among patients receiving these therapeutic regimens.²¹

Despite advances in pharmacologic therapy, it is estimated that more than 64 million individuals worldwide are currently living with HF, and projections indicate an increase of more than 30% in the coming decades due to population aging, with individuals aged 70 to 79 years being the most clinically affected.^{20,21} In Brazil, HF remains one of the leading causes of cardiovascular morbidity and mortality, imposing a substantial burden on the SUS.^{3,20,22} According to the 2023 Cardiovascular Statistics report,²³ despite the declining trend in hospitalization rates, the total cost of HF-related admissions exceeded BRL 2 billion annually. Moreover, approximately 3% of federal expenditures were allocated to social security benefits associated with work disability due to HF.^{12,20}

The downward trend may reflect multiple factors beyond pharmacological treatment. First, the COVID-19 pandemic altered hospital bed availability and utilization, with a sharp reduction in admissions in 2020 and a minimum in 2021 (the year with the highest relative in-hospital mortality) suggesting a shift in the severity of admitted cases and a typical supply-shock pattern, with a change in case mix during the pandemic period. Second, changes in admission criteria and increased outpatient management may have reduced hospitalizations. Third, variations in coding within the SIH system may affect historical series. Fourth, demographic and

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Table 3 – Hospitalizations by age group (2010 to 2024)

Age group	Total hospitalizations	% of total
40 to 49 years	223,694	6.9
50 to 59 years	495,175	15.4
60 to 69 years	766,415	23.8
70 to 79 years	852,159	26.4
≥ 80 years	708,261	22.0

Source: Brazilian Ministry of Health – Hospital Information System of the Unified Health System (SIH/SUS). Prepared by the authors (2025).

comorbidity changes may shift age-specific risk. Fifth, regional heterogeneities in access, coverage, and care organization may explain distinct patterns among macro-regions.

In terms of macro-regional analysis, there remains a limited understanding of the prevalence and prognostic factors necessary for an accurate comparison of the burden of HF across different regions of Brazil. The country's continental size, ethnic heterogeneity, and marked social inequality pose substantial challenges to conducting comprehensive epidemiological analyses that encompass causes of decompensation, clinical outcomes, treatment quality, and regional healthcare expenditures.²⁰ Nevertheless, a study by Arruda et al.³ reported an upward trend in HF mortality in the North Region, which contrasts with the present study's finding that the Southeast recorded the highest number of hospitalizations—a pattern consistent with data from the BREATHE study.²² These findings suggest that, despite the availability of pharmacological therapies capable of modifying the clinical trajectory of HF, there remains an urgent need for effective public health strategies in underserved regions to ensure equitable access and adherence to treatment protocols. Such interventions have the potential to significantly reduce rehospitalizations and in-hospital mortality.²⁰

In comparison, the United States faces a similar but more costly scenario. HF is the leading cause of hospitalization among older adults and accounts for approximately 8.5% of cardiovascular deaths.²⁴ Its prevalence is projected to increase by 46% between 2012 and 2030, affecting nearly 1 in every 33 Americans. Correspondingly, the American Heart Association forecasts a sharp rise in direct medical costs associated with HF, from \$21 billion in 2012 to \$53 billion by 2030—figures significantly higher than those reported in Brazil.²⁵ In this context, hospitalizations represent the largest contributor to these expenses, accounting for approximately 49% to 73% of all direct medical costs related to the disease.²⁶

The discussion and results of this article describe temporal trends in hospital admissions and in-hospital mortality. As this is an ecological study based on administrative data without exposure measurements, causal interpretations are not supported.

Limitations

This study presents some limitations that must be considered when interpreting the results. First, the aggregated and administrative nature of the data precludes access to detailed clinical information about the patients, such as

functional class, ejection fraction, associated comorbidities, treatment adherence, specific causes of decompensation, and use of diagnostic and therapeutic technologies. The absence of such data limits the analysis of prognostic factors and hinders deeper understanding of the clinical outcomes of the disease. Similarly, the hospital mortality rate reported in this study refers only to the in-hospital period and does not allow for inferences regarding post-discharge mortality or hospital readmissions.

Additionally, although the macro-regional analysis is useful for visualizing geographical patterns, it does not fully capture socioeconomic, structural, and healthcare access disparities between states and municipalities. Important contextual factors such as the unequal distribution of specialized professionals, the availability of referral centers, and access to high-cost medications could not be assessed.

Despite these limitations, we emphasize the relevance of addressing HF from an ecological perspective in this study, particularly in assessing the burden of disease on the SUS. Analyzing hospitalizations as a major outcome of HF provides important input for the development of strategies aimed at organizing outpatient care, preventing clinical decompensations, and reducing hospital burden. Even in the absence of individual-level clinical data, this population-based approach remains a valuable tool for epidemiological monitoring and for guiding the development of more effective public policies to address HF in Brazil.

As this is an ecological study using aggregated administrative data, there is a risk of ecological fallacy. The mortality analyzed is in-hospital and does not capture post-discharge deaths or readmissions. There were no measures of therapeutic exposure, adherence to clinical guidelines, or policy implementation by location and year, thus preventing causal inferences.

Conclusion

The findings of this study indicate a progressive and statistically significant reduction in hospitalization rates for HF in Brazil between 2010 and 2024, with an AAPC of -2.55% . Given the ecological design and the absence of exposure measures, it is not possible to infer causality for this trend. The findings of this study reflect temporal associations. Variations related to the pandemic, changes in healthcare availability and organization, coding practices,

and demographic shifts may have been significant and should be further investigated in targeted studies.

Despite the decline in rates, HF remains a major public health challenge, requiring policies focused on prevention, timely diagnosis, and equity in access to care. Considering population growth and the progressive aging of Brazilian society, therapeutic advances, particularly in the pharmacological management of HFrEF, show a temporal association with the reduction in hospital burden caused by the disease.

Nevertheless, the absolute number of hospital admissions remains high, and hospitalization-related costs have nearly doubled over the period, highlighting that, despite the decrease in frequency, the economic and clinical impact of HF remains substantial. It is important to emphasize that, due to the study design and the data sources used, it is not possible to causally attribute the decline to specific interventions, as the findings reflect temporal associations.

Nevertheless, the absolute number of hospitalizations remains high, and the average cost per admission has nearly doubled over the period, underscoring the continued clinical and economic impact of HF. The age distribution of admissions highlights the vulnerability of the elderly population, particularly those aged 70 to 79 years, who accounted for the largest share of hospitalizations. Regionally, the Southeast recorded the highest volume of admissions, whereas other areas, such as the North, still experience elevated mortality rates, reflecting persistent disparities in access to diagnosis, treatment, and specialized follow-up.

Thus, although HF hospitalizations have declined in Brazil, HF remains a significant public health challenge due to its severity and economic burden. In view of an aging population and the complex nature of the disease, it is essential to invest in public policies that foster early diagnosis, therapeutic adherence, and equitable access to care. Additionally, expanding national and regional epidemiological data is crucial to inform targeted

interventions. Such efforts are fundamental to ensuring the sustainability of the Brazilian healthcare system and mitigating the future impact of HF.

Author Contributions

Conception and design of the research: Betez GDL, Gutierrez SL; acquisition of data and statistical analysis: Betez GDL; analysis and interpretation of the data: Betez GDL, Rossi EB; writing of the manuscript: Betez GDL, Gutierrez SL, Rossi EB, Gimenez NP, Moura GB; critical revision of the manuscript for intellectual content: Gutierrez SL, Rossi EB.

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No potential conflict of interest relevant to this article was reported.

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Study Association

This study is not associated with any thesis or dissertation work.

Ethics Approval and Consent to Participate

This article does not contain any studies with human participants or animals performed by any of the authors.

Use of Artificial Intelligence

The authors did not use any artificial intelligence tools in the development of this work.

Availability of Research Data

The underlying content of the research text is contained within the manuscript.

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