

Trends in Cerebrovascular Disease Mortality in Northeast Brazil: An Ecological Study (2014–2023)

Tendências na mortalidade por doenças cerebrovasculares no Nordeste do Brasil: um estudo ecológico (2014–2023).

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ABSTRACT

Introduction: Cerebrovascular diseases (CVD) represent one of the leading causes of death and disability in Brazil, imposing high social and economic costs, especially in regions with significant healthcare inequalities.

Objective: To analyze the temporal trend and epidemiological profile of mortality from cerebrovascular diseases in the Northeast Region of Brazil (2014–2023).

Methods: An epidemiological time-series study with a quantitative approach. Mortality data from SIM/DATASUS and population projections from IBGE were used. Mortality rates per 100,000 inhabitants were calculated, stratified by state, sex, and age group. Trend analysis was performed using the Prais-Winsten linear regression model to calculate the Annual Percent Change (APC).

Results: 278,696 deaths were recorded during the period. Most occurred in individuals over 70 years old (68.21%) and in males (50.37%). Piauí had the highest average rate (179.53/100k) and Rio Grande do Norte the lowest (106.52/100k). A decreasing trend was observed in the total rate (148.69 in 2014 to 127.64 in 2023), as well as in seven states. Bahia and Sergipe showed stationary trends. There was a significant decline for both sexes (APC: -1.83% males; -2.56% females) and in age groups over 50, while the 40-49 group remained stable.

Conclusion: Although CVD mortality is declining in most of the Northeast, the stability in certain states and the high burden on the elderly highlight regional disparities. Strengthening Primary Care and the neurological emergency network is urgent to mitigate these indicators.

Keywords: Cerebrovascular Disorders; Mortality; Time Series Studies; Epidemiology; Brazil.

RESUMO

Introdução: As doenças cerebrovasculares (DCV) representam uma das principais causas de óbito e incapacidade no Brasil, impondo elevados custos sociais e econômicos, especialmente em regiões com desigualdades assistenciais marcantes.

Objetivo: Analisar a tendência temporal e o perfil epidemiológico da mortalidade por doenças cerebrovasculares na Região Nordeste do Brasil (2014–2023).

Métodos: Estudo epidemiológico de série temporal com abordagem quantitativa. Utilizaram-se dados de óbitos do SIM/DATASUS e projeções populacionais do IBGE. Foram calculadas taxas de mortalidade por 100.000 habitantes, estratificadas por estado, sexo e faixa etária. A análise de tendência foi realizada pelo modelo de regressão linear de Prais-Winsten para cálculo da Variação Percentual Anual (APC).

Resultados: Registraram-se 278.696 óbitos no período. A maior parte ocorreu em indivíduos acima de 70 anos (68,21%) e no sexo masculino (50,37%). O Piauí apresentou a maior taxa média (179,53/100 mil) e o Rio Grande do Norte a menor (106,52/100 mil). Observou-se tendência decrescente na taxa total (148,69 em 2014 para 127,64 em 2023), assim como em sete estados. Bahia e Sergipe apresentaram tendências estacionárias. Houve declínio significativo para ambos os sexos (APC: -1,83% homens; -2,56% mulheres) e em faixas etárias acima de 50 anos, enquanto o grupo de 40-49 anos permaneceu estável.

Conclusão: Embora a mortalidade por DCV apresente queda na maioria do Nordeste, a estabilidade em certos estados e o elevado ônus em idosos evidenciam disparidades regionais. É urgente o fortalecimento da Atenção Primária e da rede de urgência neurológica para mitigar esses indicadores.

Palavras-chave: Transtornos Cerebrovasculares; Mortalidade; Estudos de Séries Temporais; Epidemiologia; Brasil.

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INTRODUCTION

Cerebrovascular diseases (CVD), a group of disorders within cardiovascular diseases, represent a global health problem and one of the leading causes of death in Brazil¹. Stroke, the primary representative of CVD, ranks as the second leading cause of death and the third leading cause of combined death and disability worldwide². In Brazil, CVD imposes a significant economic and social burden, accounting for high costs associated with hospitalizations and increased mortality among the working-age population³.

Generally, the impact of these pathologies is more severe in the elderly population, especially in individuals over 80 years of age, among whom stroke is a frequent cause of permanent functional limitation and death. It is estimated that approximately 30% of all cerebrovascular events occur in people over 85 years old, making the management of hypertension and cardiometabolic comorbidities an absolute priority for public health^{4,5}.

In the Brazilian context, mortality trends for CVD show striking regional variations. While the South and Southeast regions have historically demonstrated the highest absolute numbers of deaths and a downward trend in hemorrhagic forms, the North and Northeast regions have shown an increase in mortality rates for both ischemic and hemorrhagic diseases in recent decades⁶. This phenomenon is likely linked to economic and social inequalities, as well as the epidemiological transition and improvements in death records, which have reduced the proportion of ill-defined causes^{6,8}.

The occurrence of cerebrovascular events is also influenced by sociodemographic and clinical factors. Cardiometabolic multimorbidity, which includes the coexistence of diabetes and hypertension, has a significant prevalence among the Brazilian elderly and is associated with factors such as male sex and the presence of dyslipidemia⁵. In a heterogeneous country, transformations in the demographic profile and unequal access to health services can modify the incidence and mortality rates of these diseases over time^{6,8}.

Therefore, periodic epidemiological studies are fundamental to understanding the temporal characteristics of mortality and to assist in the formulation of control and prevention strategies aimed at areas of greater social vulnerability. Specifically, ecological studies constitute a robust tool for analyzing aggregated data and formulating explanatory hypotheses at the population level, contributing to the effectiveness of health surveillance policies⁹. In this context, the objective of this study was to estimate the temporal trend of mortality rates for cerebrovascular diseases in Northeast Brazil from 2014 to 2023.

MATERIALS AND METHODS

This is a time-series epidemiological study with a quantitative approach, regarding CVD deaths in the nine

states of the Northeast Region of Brazil (Alagoas, Bahia, Ceará, Maranhão, Paraíba, Pernambuco, Piauí, Rio Grande do Norte, and Sergipe), from 2014 to 2023. Mortality data were extracted from the Mortality Information System (SIM)¹⁰, accessed via the TABNET platform of the Department of Informatics of the Unified Health System (DATASUS), while population projection data were collected from the IBGE Automatic Recovery System (SIDRA)¹¹. Deaths classified according to the Tenth Revision of the International Classification of Diseases (ICD-10) were selected, using the grouping for Cerebrovascular Diseases, comprised of codes I60 to I69. The variables evaluated in the study included year of death, state of residence, sex (male and female), and age group (40-49, 50-59, 60-69, 70-79, and 80 years or older).

Mortality rates were calculated annually per 100,000 inhabitants and, to characterize the period, the average mortality rate was determined through the simple arithmetic mean of the annual rates. The variability of this estimate was determined by calculating the 95% Confidence Interval (95% CI), using Student's t-distribution for $n-1$ degrees of freedom, considering the standard error of the mean. For the temporal trend analysis, the Prais-Winsten autoregressive linear regression model was used, adopting the base-10 logarithm of the mortality rates as the dependent variable and the years of the period as the independent variable. This method allowed for the correction of first-order serial autocorrelation, ensuring the robustness of the coefficients found.

Based on the slope of the regression line, the Annual Percent Change (APC) and its respective 95% CI were calculated. The trend was classified as increasing when the APC was positive and the p -value < 0.05 ; decreasing when the APC was negative and the p -value < 0.05 ; and stationary when the p -value was ≥ 0.05 or its 95% confidence interval included zero. Analyses were performed in Python 3.12.13 (via Google Colab) with the support of the Pandas, Statsmodels, and Scipy libraries, using a significance level of 5%.

Records with incomplete or missing information in the variables were excluded from the stratified analyses to ensure the reliability of specific rate calculations. This criterion is justified by the persistent disparities in the quality and completeness of Death Certificates in the North and Northeast regions of Brazil, which can generate inconsistencies between the total number of records and the sum of demographic variables¹².

Following the ethical precepts of Resolution No. 466/2012 of the National Health Council, the study waived approval by a Research Ethics Committee, as it was based on aggregated, publicly accessible data without nominal identification of individuals.

RESULTS

Between 2014 and 2023, 278,696 deaths from CVD were recorded in the Northeast Region of Brazil. Regarding

the geographical distribution by states, Bahia concentrated the largest volume of occurrences, with 24.91% (n=69,414) of the total, followed by Pernambuco with 17.41% (n=48,511) and Ceará with 15.74% (n=43,870). The states of Sergipe and Rio Grande do Norte showed the lowest relative shares, with 3.57% and 4.89%, respectively. Regarding the demographic profile, a balanced distribution between sexes was observed, with males representing 50.37% of the victims. In relation to age groups, there was a clear predominance of deaths in the population aged 80 years or older (41.23%), evidencing that more than two-thirds of the deaths (68.21%) occurred in individuals over 70 years old.

The average annual mortality rates and trend analysis by state can be observed in Table 1. The highest average mortality rate in the period was identified in Piauí (179.53 per 100,000 inhabitants; 95% CI: 171.51–187.55), while the lowest rate was recorded in Rio Grande do Norte (106.52 per 100,000 inhabitants; 95% CI: 101.46–111.58). In the temporal trend analysis, Bahia and Sergipe presented a stationary pattern. In contrast, the states of Alagoas, Ceará, Maranhão, Paraíba, Pernambuco, Piauí, and Rio Grande do Norte demonstrated decreasing trends in their mortality rates.

Table 1 - Epidemiological indicators and temporal trend of mortality from cerebrovascular diseases according to State, Northeast Region, Brazil, 2014-2023.

State	n	%	Mean Annual Incidence Rate* (95% CI)	APC (95% CI)	p-value	Trend
AL	18271	6.56%	166.07 [157.27; 174.87]	-2.79 [-3.38; -2.19]	< 0,0001	Decreasing
BA	69414	24.91%	127.51 [125.12; 129.89]	-0.12 [-0.77; 0.54]	0,7364	Stationary
CE	43870	15.74%	136.14 [125.06; 147.22]	-3.74 [-4.47; -3.00]	< 0,0001	Decreasing
MA	34666	12.44%	164.00 [155.63; 172.36]	-2.27 [-3.09; -1.44]	0,0011	Decreasing
PB	19722	7.08%	132.49 [122.31; 142.67]	-3.09 [-4.28; -1.88]	0,0016	Decreasing
PE	48511	17.41%	140.72 [131.06; 150.37]	-3.12 [-3.54; -2.70]	< 0,0001	Decreasing
PI	20652	7.41%	179.53 [171.51; 187.55]	-1.94 [-2.52; -1.35]	0,0003	Decreasing
RN	13632	4.89%	106.52 [101.46; 111.58]	-1.89 [-2.81; -0.96]	0,0055	Decreasing
SE	9958	3.57%	127.85 [118.87; 136.84]	-0.50 [-4.69; 3.88]	0,8271	Stationary

Source: SIM/DATASUS¹⁰ and IBGE/SIDRA¹¹.

Note: APC: Annual Percent Change; 95% CI: 95% confidence interval; *per 100,000 inhabitants; AL: Alagoas; BA: Bahia; CE: Ceará; MA: Maranhão; PB: Paraíba; PE: Pernambuco; PI: Piauí; RN: Rio Grande do Norte; SE: Sergipe.

Table 2 presents the average annual rates and trend analysis stratified by sex and age groups. In the breakdown by sex, average rates were higher in the male group (152.38 per 100,000 inhabitants; 95% CI: 146.29–158.47) compared to the female group (127.95 per 100,000 inhabitants; 95% CI: 120.93–134.98). Both sexes showed decreasing trends (APC: -1.83% for men and -2.56% for

women). Regarding age, average mortality rates rose progressively with advancing senescence, reaching a peak of 1,092.35 deaths per 100,000 inhabitants in the 80 years or older group. A significant decreasing trend was observed in the age groups 50-59, 60-69, 70-79, and ≥ 80 years, while the 40-49 age group remained stationary.

Table 2 - Epidemiological indicators and temporal trend of mortality from cerebrovascular diseases according to sex and age group, Northeast Region, Brazil, 2014-2023.

Gender	n	%	Mean Annual Incidence Rate* (95% CI)	APC (95% CI)	p-value	Trend
FEM	138298	49.63%	127.95 [120.93; 134.98]	-2.56 [-3.13; -1.98]	0,0001	Decreasing
MASC	140376	50.37%	152.38 [146.29; 158.47]	-1.83 [-2.27; -1.39]	0,0001	Decreasing
Age range						
40-49	13814	4.96%	18.59 [17.70; 19.49]	-0.99 [-2.80; 0.86]	0,3265	Stationary
50-59	27273	9.79%	48.19 [45.77; 50.61]	-2.08 [-2.67; -1.50]	0,0002	Decreasing
60-69	47506	17.05%	127.18 [120.65; 133.72]	-2.51 [-3.03; -1.98]	<0,0001	Decreasing
70-79	75206	26.98%	350.50 [330.90; 370.11]	-2.61 [-3.27; -1.94]	0,0001	Decreasing
≥ 80	114897	41.23%	1092.35 [1020.84; 1163.86]	-3.08 [-3.44; -2.73]	<0,0001	Decreasing

Source: SIM/DATASUS¹⁰ and IBGE/SIDRA¹¹.

Note: FEM: female; MASC: male; APC: Annual Percent Change; 95% CI: 95% confidence interval; *per 100,000 inhabitants.

Figure 1 details the evolution of the annual mortality rate from CVD in the Northeast according to age group and sex. A downward trajectory in rates was observed for both sexes throughout the period, with the total index falling from 148.69 in 2014 to 127.64 in 2023. In the temporal breakdown, a continuous reduction stands out between 2017 and 2018 (from 145.93 to 136.75 per 100,000 inhabitants), maintaining the downward trend between 2020 and 2021 (from 131.29 to 129.91 per 100,000 inhabitants). After a slight increase in 2022 (132.41), the series ended the period with the lowest recorded value in 2023.

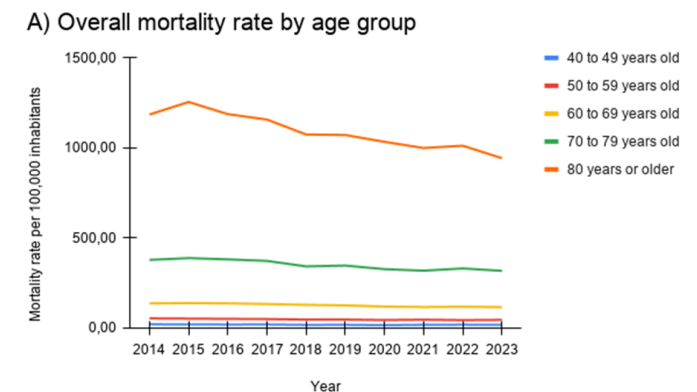
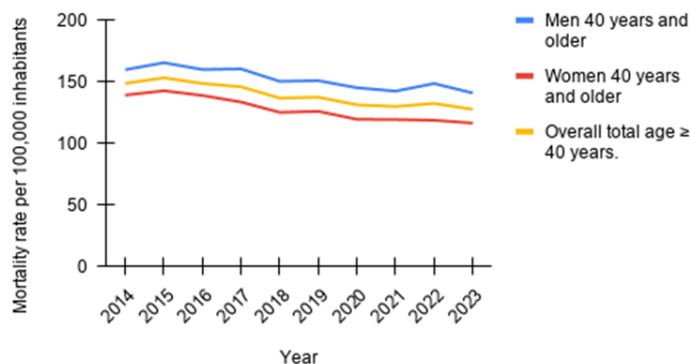


Figure 1 - Temporal evolution of the mortality rate per 100,000 inhabitants from cerebrovascular diseases according to age group and sex, Northeast, Brazil, 2014-2023.

B) Mortality rate by sex



Source: SIM/DATASUS¹⁰ and IBGE/SIDRA¹¹.

DISCUSSION

Between 2014 and 2023, 278,696 deaths from cerebrovascular diseases (CVD) were recorded in the Northeast Region of Brazil, with a progressive reduction in the age-specific mortality rate for the population aged 40 years and older, declining from 148.69 to 127.64 deaths per 100,000 inhabitants. This substantial volume of occurrences reflects the magnitude of CVD as a critical public health problem, consistent with global data indicating that stroke is the second leading cause of death and the third leading cause of disability worldwide². The declining pattern observed across the Northeast as a whole converges with national analyses demonstrating reductions in mortality rates across the country's macroregions^{6,13}. However, population-based investigations conducted by McBenedict et al.¹⁴ revealed that the Northeast initially experienced a phase of increasing age-associated mortality rates before beginning its downward trajectory; this behavior differs from the pattern observed in the South and Center-West regions, which sustained a stable and continuous decline throughout earlier historical series¹⁴. Additionally, Souza et al.⁶ highlighted that the pace of reduction in the North and Northeast regions was marked by an increase and redistribution in the recording of well-defined ischemic and hemorrhagic forms, associating this dynamic with the marked economic and social inequalities that characterize these portions of the national territory.

The state-level analysis revealed marked heterogeneity in temporal trends, with Bahia and Sergipe exhibiting a stationary pattern, while the remaining Northeastern states demonstrated a decreasing trajectory. This interstate variability is consistent with national evidence evaluating the correlation between socioeconomic development indicators and CVD mortality profiles, demonstrating that the Social Vulnerability Index (SVI) and local poverty indices directly modulate the pace of reduction observed across different regions^{1,15}. The disparity identified between Piauí, which presented the highest average rate for the period, and Rio Grande do Norte, with the lowest

recorded rate, reinforces the need for regionalized epidemiological analyses that consider the local context of each state. Nationally or regionally aggregated indicators carry the intrinsic limitation of masking deep geographical asymmetries, which may compromise strategic planning and health resource allocation¹⁶.

Regarding the sex-based profile, a slight predominance in the absolute volume of deaths was observed among males (50.37%), with higher average rates among men (152.38 per 100,000) compared to women (127.95 per 100,000). Although both sexes exhibited a declining trend, the reduction was statistically more pronounced among women (annual percentage change of -2.56% versus -1.83% among men), corroborating findings of asymmetric decline reported in the temporal projection literature^{14,17}. This finding is consistent with clinical discussions describing how traditional risk factors tend to exert a greater impact on the male population, while sex hormone-related factors confer a particular risk profile on women throughout their biological lifespan¹⁷.

On the other hand, specific methodological approaches reveal important distinctions in data interpretation: investigations conducted in other Brazilian cohorts indicate that, although absolute stroke mortality rates tend to be higher among men, proportional mortality may be higher among women in regional subgroups, demonstrating that the method of outcome measurement and modeling directly influences the interpretation of sex-based disparities. Additionally, care quality registries demonstrate that inequalities in access to and quality of immediate hospital-phase care — including the likelihood of receiving acute interventions and early rehabilitation — play a crucial role in long-term institutional outcomes between sexes^{18,19}.

The striking concentration of deaths in the age group of 80 years and older (41.23%), with a mortality rate reaching 1,092.35 deaths per 100,000 inhabitants in this group, can be explained by the convergence of multiple biological and structural factors. From a pathophysiological standpoint, progressive neurovascular aging induces severe structural changes in cerebral vessels, impairing baseline perfusion and homeostatic tissue repair mechanisms, critically expanding vulnerability to fatal ischemic or hemorrhagic events. Epidemiologically, this age group accumulates greater chronic exposure to modifiable risk factors, with hypertension and diabetes standing out as predictors strongly associated with stroke incidence and subsequent cognitive decline in aging populations^{4,5}. This scenario directly reflects the demographic transition and accelerated population aging observed in recent decades in Brazil, a phenomenon closely associated with the substantial increase in the absolute number of deaths from age-related chronic conditions²⁰.

The high prevalence of modifiable risk factors — such as physical inactivity, hypertension, and diabetes — identified in screenings of stroke patients in the Northeast

corroborates the findings of this study regarding the central role of these comorbidities in determining the regional mortality profile^{21,22}. In this regard, the consolidation of primary care programs aimed at controlling and screening for these chronic conditions has operated as one of the drivers of the declining trend observed in most Northeastern states. However, assessments of the financing model and performance of Primary Health Care (PHC) in Brazil raise a structural concern: although the Northeast stands out positively in achieving maternal and child health targets, care indicators specifically related to the clinical management and systematic monitoring of patients with hypertension and diabetes remain far from ideal targets in recent national evaluations. This scenario suggests that the potential for further reductions in CVD mortality in the region depends critically on strengthening chronic care and longitudinal follow-up in primary care settings²³.

With regard to access to emergency and urgent care networks, health audit data in Brazil have demonstrated critical scenarios of inequality, such as the complete absence of stroke thrombolysis procedures in certain territories and extreme variations in hospital mortality rates (ranging from 5.0% to 39.0%) across different microregions¹⁶. This care gap directly contributes to the maintenance of stationary rates in states with large territorial extensions or significant healthcare voids^{16,19}. International comparisons between the Brazilian health system and high-income nations have also evidenced lower proportional rates of acute stroke hospitalization in Brazil, which may reflect both barriers to immediate hospital diagnosis and underreporting of acute events in the public network. To overcome these logistical challenges, digital health strategies become essential; the implementation of telemedicine-based stroke care programs in the Northeast, exemplified by the structured emergency network experience in Piauí, illustrates this potential by significantly expanding access to essential thrombolytic treatments and establishing a scalable model to mitigate regional disparities in areas with limited health resources²⁴.

Finally, it should be noted that the data used in this study were extracted from secondary mortality databases, subject to inherent limitations regarding completeness and coding of records. A scoping review on the Brazilian Mortality Information System (SIM) indicated that, although substantial improvements in system quality and a 68.5% reduction in ill-defined causes have occurred in recent decades, the North and Northeast regions still maintain lower performance indicators in terms of coverage and reliability compared to other regions of the country¹². From an epidemiological perspective, the historical reduction in ill-defined causes in the SIM drives a systematic migration of previously unclassified deaths to well-defined specific causes, which would theoretically produce an artificial increase or stabilization of CVD mortality rates⁶. Therefore, the fact that the Northeast Region recorded a real and sustained declining trend concurrent with the

qualification and auditing process of Death Certificate completion confers considerable robustness to the findings of this study. SIM data¹⁰ represent the best available tool for continuous epidemiological monitoring, proving indispensable for grounding public policies focused on equity and the reduction of regional health asymmetries.

CONCLUSION

The study revealed that mortality from cerebrovascular diseases in Northeast Brazil represents a persistent public health challenge, with 278,696 deaths recorded between 2014 and 2023. Despite the downward trend observed in most states, the stationary pattern identified in Bahia and Sergipe, combined with the elevated rates in Piauí, exposes substantial regional disparities that reflect the structural socioeconomic inequalities of the region. The concentration of deaths among males and in the oldest age groups reinforces the need for interventions targeting higher-risk populations, particularly given the ongoing demographic transition. In this context, strengthening chronic disease management in primary care, expanding stroke care networks, and ensuring continuous epidemiological monitoring based on quality data systems prove indispensable for guiding more equitable and effective public policies aimed at reducing the regional burden of cerebrovascular diseases.

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