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Effect of seasonal and temperature variation on hospitalizations for stroke over a 10-year period in Brazil

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Abstract

Background: Seasonal variation in stroke incidence remains controversial.

Aims: We aimed to describe the pattern of seasonality in hospitalizations for stroke in Brazil.

Methods: We evaluated age-adjusted hospitalization rates for stroke per month using data from the Brazilian Unified Healthcare System and median monthly temperature data obtained from the National Institute of Meteorology. To detect a seasonality pattern in time series, we used seasonal-trend decomposition using LOESS. We calculated a seasonal strength statistic and used Kruskal–Wallis test to evaluate the presence of seasonality in Brazil and its five regions. We also assessed the association of temperature and stroke hospitalization rates using Spearman's rho correlation.

Results: We identified 1,422,496 stroke-related hospitalizations between 2009 and 2018. Mean age was 67 years, 51% were male and 77.5% of stroke diagnoses were not specified as ischemic or hemorrhagic. Median temperature was 23.8°C (IQR 22.3–24.4). Age-adjusted hospitalizations demonstrated significant seasonal variation during all the years analyzed, with increased rates during the winter. When regional differences were analyzed, seasonal behavior was present in the south, southeast and northeast regions of the country. These were also the regions with lower median temperatures during the winter months and greater amplitude of average temperatures between warmer and colder months.

Conclusions: In this large national cohort of stroke patients in Brazil, we demonstrated the presence of seasonal variation in the age-adjusted hospitalization rate, with peak rates during the winter months. The regional gradient of incidence of stroke was directly associated with colder winters and greater amplitude of temperature.

Keywords

Season, temperature, stroke, ischemic stroke, stroke prevalence, epidemiology, Brazil

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Introduction

The effect of seasonality on stroke incidence, stroke-related hospitalization and mortality remain controversial, especially in tropical countries.[1–6] The purpose of this study was to determine whether there are seasonal patterns in stroke-related hospitalizations in Brazil and if temperature variations across the country are associated with such patterns.

Methods

Study design and data sources

We extracted data from three databases available for public access. De-identified data on inpatient cause of admission, demographic characteristics, length of stay and patient outcome were obtained from the Public Hospital Information System (http://sihd.datasus.gov.br/). The population data are available at the IBGE

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database (www.ibge.gov.br) and temperature data obtained from the National Institute of Metereology (www.inmet.gov.br).

Study population and outcomes

We included data from January 2009 to December 2018 from all data sources. We evaluated hospital admissions for stroke and the association with in-hospital mortality using data from the admissions registry for the whole country and its five regions: North, Northeast, Center-west, Southeast and South. We included adult patients (over 20 years old) hospitalized with stroke diagnosis codes (ICD codes I60, I61, I63 and I64—Supplementary Table 1).[7] As outcomes, we identified the patient's ages at time of stroke and calculated the monthly rates of hospitalization per 100,000 inhabitants using age-adjustment via direct standardization.[8] Also, we considered the temperature per month as the median of the hourly average air temperature values for the whole country and each region. Winter in Brazil starts on 20 June and ends on 22 September.

Statistical analysis

We considered the age-adjusted hospitalization rates per month as time series over the study period for Brazil and its five regions. With seasonal-trend decomposition using LOESS (STL),[9] we obtained Trend, Seasonality, and Remainder components from the series. Trend and Seasonality strengths[10] were evaluated and we tested the presence of Seasonality, with a two-sided Kruskal–Wallis test (KW test).[11] The association of stroke age-adjusted hospitalization rates with the median air temperature values was assessed with the Spearman's rank correlation test. Statistical significance was defined as a p value less than 0.05. Analyses were performed in R 3.6.2.

Results

From 112,051,427 hospital admissions included in the database, 1.422.496 (1.3%) were admissions with a primary diagnosis associated with stroke codes and were included in the study. The age-adjusted case fatality rate remained stable during the study period, with an annual average of 21.3% (SD 0.5%) and a total of 305,572 in-hospital deaths in 10 years. Mean length of stay in the hospital was 7.6 (SD 8.8) days.

Age-adjusted hospitalizations demonstrated significant seasonal variation during all the years analyzed, with increased rates during the winter (Figure 1). Statistics are shown in Table 1. The region North presented the highest median hospitalization rates (13, IQR (11.7–14.8)), whereas the Southeast had the lowest rates (8.3, IQR (7.9–8.9)). With the KW-test, we observed the presence of modest but significant seasonality in regions Northeast, Southeast and South, with peak months in July or August. No seasonality was found for regions North and Center-West.

We analyzed the variations of median air temperature per month in each of the five regions in order to evaluate the association to the hospitalization rates (Table 2). Median temperatures were 24.5°C (IQR 21.7–27.9) and 19.8°C (IQR 15.9–23.5) in regions above and below the Tropic of Capricorn, respectively. We found greater amplitude of temperature variations in the South, Southeast and Northeast, located in tropical and subtropical regions. In these regions, the lowest average temperatures occurred in June or July, while hospitalization rates peaked in July or August. Regions North and Center-West demonstrated modest or no association between age-adjusted hospitalizations for stroke and the temperature.

Discussion

In this large retrospective study including all public hospital admissions for stroke in Brazil over a 10-year period, we demonstrated the presence of seasonal variation in the age-adjusted hospitalization rate, with peak rates during the winter months. We also showed that seasonality occurs predominantly in the South, Southeast and Northeast regions, while no seasonal variation was observed in regions North and Center-West. Although we demonstrated the relationship between temperature variation and hospitalizations, we cannot exclude that other factors may play a confounding role.

Data from studies on stroke incidence in Brazil and globally agree that the age-standardized incidence and mortality have decreased over the last decades.[7,12] On the other hand, the number of hospitalizations have increased, indicating a growing burden of stroke on populations from developed and developing countries. In addition, we observed significant seasonal variation in age-adjusted stroke-related hospitalizations in Brazil. Large studies from the US and Europe found no seasonality in stroke incidence and hospitalizations.[5,6] In contrast, cohorts from subtropical Argentina and tropical/subtropical Australia demonstrated consistent increases during winter months in stroke-related admissions and attack rates, respectively.[1,2] Our study confirms the findings of cohorts from southern hemisphere studies, where stroke hospitalizations increased in winter months.

Additionally, we demonstrated that seasonality was heterogeneous in Brazil and predominant in regions with lower temperatures during winter months.

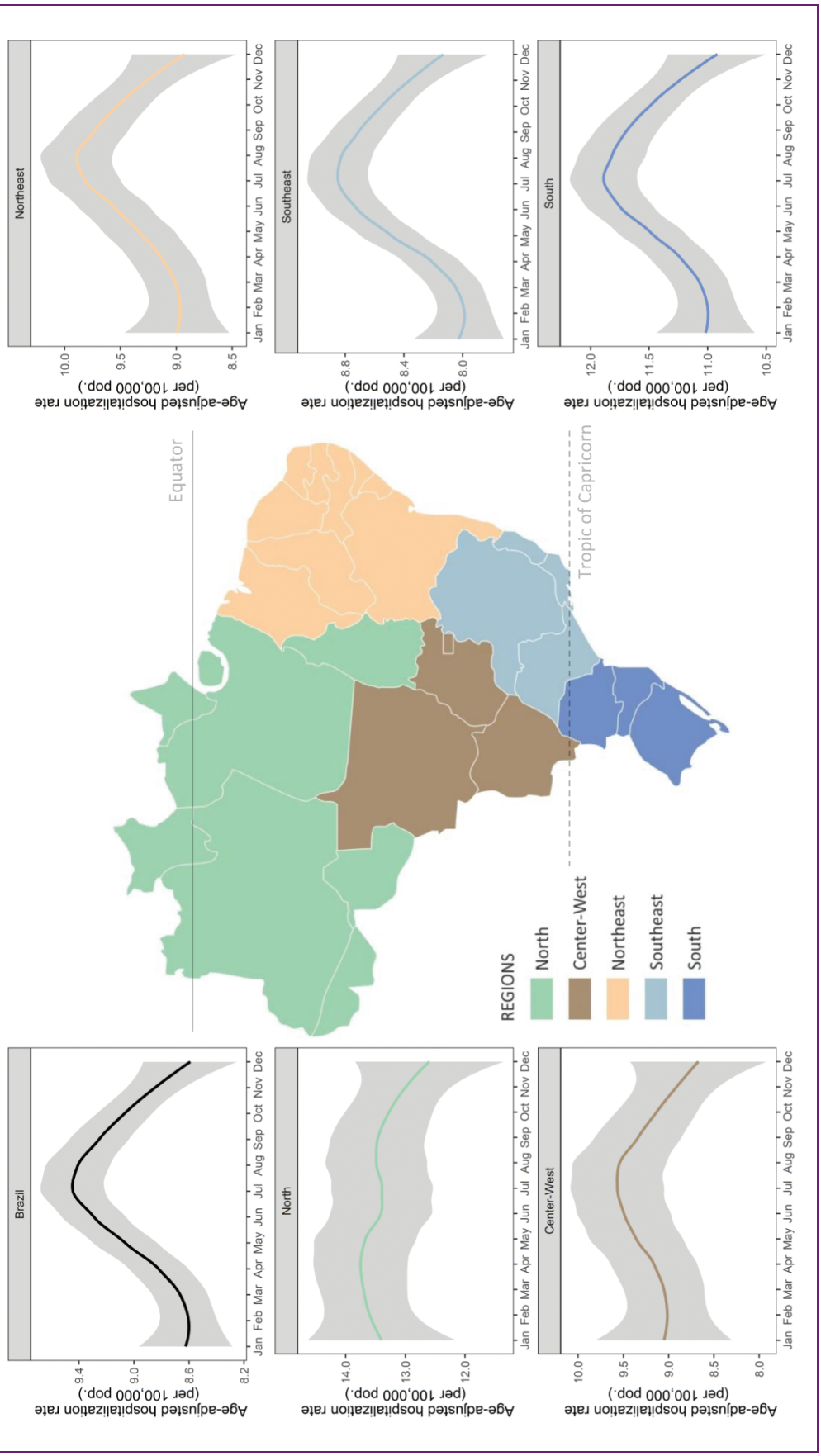

Figure 1. Variation of stroke age-adjusted hospitalization rates per month in Brazil and regions. Figure displays Brazil's map and the corresponding age-adjusted hospitalization rates variation in the period from 2009 to 2018. For Brazil and each region, the smoothed average values per month and their respective 95% confidence bands were estimated using LOESS.

Table 1. Statistics on age-adjusted hospitalization rates in Brazil and regions

	Stroke age-adjusted hospitalization rate (per 100,000 population)					
Region	Median [IQR]	Peak	Trend strength	Seasonality strength	KW	*p*
North	13 [11.7–14.8]	March	0.77	0.20	8.3	0.68
Northeast	9.2 [8.6–9.8]	August	0.75	0.52	24.2	0.01
Center-West	8.9 [8.2–10]	July	0.81	0.25	5.0	0.93
Southeast	8.3 [7.9–8.9]	July	0.78	0.73	42.1	<.001
South	11.2 [10.8–11.8]	August	0.75	0.62	36.3	<.001
Brazil	8.8 [8.5–9.5]	July	0.92	0.86	37.9	<.001

IQR: interquartile range; KW: Kruskal–Wallis statistic.

Table 2. Statistics on air temperature and association with stroke age-adjusted hospitalization rates

	Air temperature (Celsius)				
Region	Median [IQR]	Peak	Trough	Spearman's rho	*p*
North	25.5 [25.1–26.1]	September	February	−0.05	0.56
Northeast	25.7 [24.7–26.2]	December	July	−0.43	<.001
Center-West	23.9 [22.6–24.3]	October	July	−0.16	0.08
Southeast	22.1 [19.7–23.2]	February	July	−0.51	<.001
South	18.9 [15.8–21.8]	February	June	−0.44	<.001
Brazil	23.8 [22.3–24.4]	December	July	−0.49	<.001

IQR: interquartile range.

Hospitalizations peaked during winter months in the South, Southeast and Northeast regions, where lower median temperatures and higher amplitude were found. This association may be explained by various mechanisms. Colder temperatures have been linked to higher blood pressure, blood viscosity, and cholesterol levels, all of which can potentially lead to stroke.[5] Stroke has also been associated with bacterial and viral respiratory infections, which are more common in winter months.[13,14]

The strengths of our study include the nationally representative large sample of patients and the long period of 10 years of data collection. Our results will inform healthcare policy in southern hemisphere tropical and subtropical countries, both in stroke prevention campaigns and hospital network preparedness. However, some limitations are noteworthy. First, the study is based on an administrative data and miscoding may be present. However, we only included cases with a primary diagnosis of stroke. Second, coding did not differentiate ischemic from hemorrhagic stroke, which may limit comparisons to other published cohorts and pathophysiological interpretations. Third, we did not evaluate other environmental factors that may affect seasonality such as air quality or humidity. Future studies should aim to clarify pathophysiologic mechanisms underlying seasonal variability of stroke incidence, which may have implications in stroke prevention and treatment.

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Supplemental material

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