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Mortality from Stroke in Pará, Brazilian Amazon: a Joinpoint Analysis

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Abstract

Introduction: Stroke is a significant cause of death worldwide. Temporal studies show a downward trend in mortality rates in recent decades, with variability between countries. The State of Pará, in northern Brazil, has a low human development index and high mortality from stroke; however, little research is reported.

Objective: This study aims to analyze the trend in stroke mortality in the adult population of Pará, between 2000 and 2021.

Method: This is an ecological, time series study based on official secondary population data. Joinpoint regression models were used to identify the trend of each coefficient segment of the mortality rate and years of potential life lost.

Results: There were 49,259 deaths in this period, with an absolute increase in fatalities during the time series and an increase in the age group. The mortality coefficient showed a stationary mortality trend of 0.4% between 2000 and 2021 (p=0.576); however, after 2008, the trend decreased -1.0% (p=0.003). In the stratified analysis, a decreasing mortality trend was detected: -2.3% between 30 and 39 years old (p<0.001), -2.8% between 40 and 49 years old (p<0.001), -2.1% between 50 and 59 years old (p<0.001) and -1.4% between 60 and 69 years old (p<0.001), between the year 2000 and 2021. In the other age groups, the trend decreased -2.5% between 20 and 29 years old after 2006 (p= 0.003), -1.8% between 70 and 79 years old after 2008 (p=0.001), and -5.1% among 80 years old and over after 2016 (p=0.010).

Conclusion: The mortality trend attributed to stroke among adults in Pará State remained stable from 2000 to 2021. Despite this stability, the absolute number of deaths remained consistently high, underscoring the critical need to mitigate risk factors and enhance the care and management of affected individuals.

Keywords: Stroke, mortality, trend, Pará, Amazônia Legal.

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Authors summary

Why was this study done?
The present study aimed to analyze mortality and identify possible variations in time trends in stroke mortality rates in the state of Pará. It also aimed to provide concrete and updated information on the epidemiological outcome, assisting in planning and making strategic public health decisions to mitigate the severe impact caused by stroke in the state.

What did the researchers do and find?
An epidemiological study was carried out with an ecological design, with sequential time series, based on secondary data from DATASUS to analyze mortality trends from stroke in the adult population of Pará between 2000 and 2021. The coefficients of mortality stratified by sex and age group and years of potential life lost due to stroke were calculated. Joinpoint regression models were used to determine time trends. There was a progressive increase in the absolute number of deaths from stroke throughout the time series and with advancing age. The mortality trend was stationary between 2000 and 2021; however, after 2008, there was a declining trend. The highest mortality coefficient rates occurred in older age groups and males. The trend in years of potential life lost increased throughout the time series. These data revealed fundamental information for directing preventive public policies and highlighting the need for quality hospital care in the acute moment of a stroke.

What do these findings mean?
The findings show that the absolute number of deaths from stroke in the state of Pará is high, especially in males and in age groups above 60 years old. Despite this, the mortality trend remained stationary between 2000 and 2021, but with a downward trend after 2008. The number of deaths and years of potential life lost due to stroke increased progressively during the time series, revealing the socioeconomic impact and demonstrating the need to implement measures for the prevention and treatment of risk factors, as well as for adequate care in the acute phase, minimizing deaths and sequelae of affected individuals.

Highlights
The trends in mortality caused by stroke in the adult population of the state of Pará were stationary between 2000 and 2021; however, after 2008, the mortality coefficients and the analysis stratified by age group showed decreasing tendencies.
Disparities between the sexes were observed, with males having higher mortality rates, except in the year 2000.
Analysis by age group showed higher mortality rates in age groups above 60 years old.
An increasing trend was observed throughout the entire time series when evaluating the years of potential life lost due to stroke.

INTRODUCTION

Stroke is characterized as a neurological deficit attributed to an acute focal injury of the central nervous system, of vascular cause, including cerebral infarction, subarachnoid hemorrhage and intracerebral hemorrhage [1]. Together with ischemic heart disease, they represent the leading causes of death and disability around the world [2, 3]. In 2019, around 6.55 million lives were claimed by stroke worldwide [4, 5].

Official data from the World Health Organization in 2019 [6] and the Brazilian Ministry of Health in 2016 [7] revealed that cerebrovascular diseases were the second most significant cause of death in the country, with around 107 thousand deaths in 2022[8], being surpassed only by ischemic heart disease. Similar findings are observed in the state of Pará, where cerebrovascular diseases were responsible for more than 3 thousand deaths in 2022[8], demonstrating that such pathologies present themselves as a serious public health problem.

Recent research has shown a global time trend of decline in mortality rates from ischemic and hemorrhagic stroke in recent years[8-12]. Part of this advance can be explained by improved outpatient and hospital care and progress in understanding and treating modifiable risk factors [5,13,14]. Despite this, considering individual life expectancy and the fact that stroke is one of the main causes of morbidity and mortality, incidence and mortality rates remain high, causing social and economic impact, given the high number of hospitalizations, deaths, sequelae, and years of potential life lost [5,15,16].

Although stroke mortality rates have reduced in several countries around the world, little information is published in countries and locations with less socioeconomic development and less technological capacity [15]. Temporal studies carried out on the total Brazilian population [12] and in the states of the south and southeast regions, with better socioeconomic development [17], showed similar downward trends. However, in the states of the northeast region with lower development rates, the same findings were not found [18], suggesting that socioeconomic differences and access to health services could influence the epidemiology of stroke.

The State of Pará is located in the northern region of Brazil. It is the most populous in the region but has one of the lowest human development indexes in the country [19]. Epidemiological studies in the state are scarce [20]. Still, it is necessary to understand the trend in stroke mortality and plan strategies to mitigate the impact based on local, current, and concrete evidence. In a survey carried out by Rezende et al., between 2016 and 2020 on the epidemiological profile of patients hospitalized for stroke in the capital of the state of Pará, a predominance of males above 60 years was observed, but with a tendency to decrease the number of hospitalizations and deaths throughout the time series [20].

Therefore, this study aims to analyze the trend in mortality due to stroke in the adult population of the state of Pará between 2000 and 2021.

METHODS

Design

This epidemiological study uses an ecological design with sequential time series based on secondary data from the adult population of Pará, Brazil, between 2000 and 2021[21].

Figure1: A: Left tes

Location and population studied.

Information on the number of deaths and demographic data were obtained for the state of Pará, located in the northern region of Brazil, Brazilian Legal Amazônia. The state has a demographic density of 6.51 inhabitants/km² and a human development index of 0.69 [19]. The studied population consisted of adult residents of both sexes aged over 20, separated by age groups for the calendar years between 2000 and 2021.

Data source and extraction

Study data were collected from public and official sources from the Brazilian Ministry of Health. The number of deaths by sex and age group in the period from 2000 to 2021 were extracted from the database of the Department of Informatics of the Unified Health System - DATASUS (https://datasus.saude.gov.br/informacoes-de -saude-tabnet/). Information on population counts was extracted from the DATASUS database (https://datasus.saude.gov.br/populacao-residente) by sex and age group for the period between 2000 and 2021. Exclusions were carried out for data registered as 'ignored' for sex and age group. Two trained researchers carried out data extraction. In case of any discrepant results, corrections were made by consensus between both parties.

Study variable

The study variable was stroke as the primary cause of death occurring in adult residents of the state of Pará. Stroke was constituted by codes I60 (subarachnoid hemorrhage), I61 (intracerebral hemorrhage), I63 (cerebral infarction), and I64 (not specified as ischemic or hemorrhagic), according to the International Classification of Diseases version 10 (ICD-10) [22]. The stroke variable was extracted for the population over 20 years of age and stratified by sex (male and female) and age groups (20 - 29 years, 30 - 39 years, 40 - 49 years, 50 - 59 years, 60 - 69 years, 70 - 79 years and 80 years and over) for calendar years between 2000 and 2021.

Data analysis

Information on the number of deaths from stroke, deaths from all causes and population, with stratification by sex and age group, was extracted using the file transfer system from the DATASUS database to a file in separate values format by comma or Comma-Separate-Values (CSV).

The crude mortality rate was calculated by dividing the number of adult deaths due to stroke by the total adult population or stratified by sex and age group and the division quotient was multiplied by 100 thousand inhabitants. The mortality rate ratio between the sexes was calculated by dividing the male mortality rate by the female mortality rate [23].

Years of potential life lost

The years of potential life lost were determined by the number of deaths multiplied by the value of the difference between the central age of the age group and life expectancy at birth, as published by the Brazilian Institute of Geography and Statistics (IBGE)[24]. The years of potential life lost per 100,000 inhabitants were calculated by the years of potential life lost divided by the population quantity in each age group, and the quotient was multiplied by 100,000. For each year between 2000 and 2021, the mortality rate due to stroke, mortality rate ratio between sexes, years of potential life lost, and years of potential life lost per 100,000 inhabitants were calculated in a Microsoft Office Excel spreadsheet [23].

Joinpoint regression model

The time trend in the mortality rate, years of potential life lost, and years of potential life lost per 100,000 inhabitants due to stroke was evaluated by joinpoint regression, with the help of the Joinpoint Regression Program (version 5.0.2, 2023) developed by the National Cancer Institute, Rockville, MD, USA[25]. Joinpoint regression models were applied to identify change points in the time series and the trend of each segment of the mortality coefficient, years of potential life lost, and years of potential life lost per 100,000 inhabitants from 2000 to 2021.

The models were analyzed for the population and stratified by sex and age group. In each model, the dependent variable was the mortality coefficient or the years of potential life lost or years of potential life lost per 100,000 inhabitants. The independent variable was the year. The options of heteroscedastic errors with constant variation, the maximum number of 4 joinpoints, and the log-linear model were chosen to analyze the models. The Bayesian Information Criterion method (BIC) was applied to the model selection. The annual percentage change (APC) and the average annual percentage change (AAPC) with 95% confidence intervals estimated by the parametric method indicated the direction and magnitude of time trends. When there was no segment trend in the period, the APC was similar to the AAPC. Joinpoint regression models with a p-value equal to or less than 5% are considered an annual change.

Legal and ethical aspects of research

The present study used secondary data available in a public domain database, without intervention to individuals or groups of people. Therefore, the opinion of the Research Ethics Committee was waived.

RESULTS

Between the years 2000 and 2021, the total reported number of deaths from stroke in the adult population of the state of Pará was 49.259. There were five records excluded from the gender variable because they were recorded as ignored. The absolute number of deaths increased progressively in the period from 2000 to 2016, with slight fluctuations after that but remaining at high levels. The crude mortality coefficient, comparing the years 2000 and 2021, revealed an increase from 44.36 to 46.06 per 100,000 inhabitants with fluctuations during the time series and higher coefficients from 2006 to 2018, but mainly in the years 2008 (55. 92) and 2016 (54.19) (table 1).

The absolute number of deaths from stroke between 2000 and 2021 revealed that males were more affected (26,033) compared to females (23,221). Mortality

coefficients by sex also showed the same findings, except in 2000, when females were more affected (44.59) than males (44.14). In the last year studied, men had a mortality rate of 50.14 and women 42.04 per 100,000 inhabitants. The male/female mortality coefficient ratio in 2021 was 1.19, demonstrating that men had 19% more deaths compared to women (table 1).

Mortality stratified by age group is presented in Table 2. Between 2000 and 2021, there was a gradual increase in the total number of deaths with advancing age. During this period, 536 deaths were identified in the 20 to 29 age group, 1.257 in the 30 to 39 age group, 3.300 in the 40 to 49 age group, 5.912 in the 50 to 59 age group, 9.475 in the 60 to 69 age group, 13.167 in the 70 to 79 age group and 15,612 deaths in the 80 years old and over age group. Regarding the number of years of potential life lost (YPLL) due to stroke, an increase was detected from 10.099 years in 2000 to 21.754 years in 2021. When adjusting the YPLL for the population, there was also an increase from 314.84 in the year 2000 to 377.78 years of potential life lost per 100.000 inhabitants in 2021 (table 2).

Table 1: Number of deaths and mortality rate from stroke in the adult population in the state of Para, Brazil, 2000 to 2021.

	Deaths			Mortality Coefficient*			Mortality Coefficient Ratio: Male / Female
	All	Male	Female	All	Male	Female	
2000	1423	714	709	44.36	44.14	44.59	0.99
2001	1477	745	732	44.35	44.37	44.34	1.00
2002	1498	797	701	43.35	45.75	40.90	1.12
2003	1657	845	812	46.23	46.79	45.66	1.02
2004	1612	867	745	43.40	46.36	40.40	1.15
2005	1687	881	805	43.88	45.54	42.15	1.08
2006	2014	1060	954	50.66	53.02	48.28	1.10
2007	2185	1137	1048	53.22	55.10	51.32	1.07
2008	2369	1214	1155	55.92	57.06	54.78	1.04
2009	2341	1237	1104	53.61	56.45	50.75	1.11
2010	2295	1215	1080	51.03	53.88	48.16	1.12
2011	2382	1263	1119	51.67	54.71	48.62	1.13
2012	2393	1248	1145	50.68	52.84	48.51	1.09
2013	2439	1340	1098	50.45	55.49	45.38	1.22
2014	2565	1379	1184	51.84	55.86	47.76	1.17
2015	2712	1445	1267	53.56	57.26	49.89	1.15
2016	2802	1529	1273	54.10	59.29	48.95	1.21
2017	2644	1379	1265	49.91	52.33	47.51	1.10
2018	2776	1449	1327	51.26	53.83	48.71	1.11
2019	2590	1367	1222	46.81	49.76	43.87	1.13
2020	2746	1491	1255	48.62	53.22	44.10	1.21
2021	2652	1431	1221	46.06	50.14	42.04	1.19

Source: DATASUS database. Ministry of Health. Brazil.

* Mortality coefficient per 100.000 inhabitants.

Table 2: Number of deaths by age group and years of potential life lost due to stroke in the adult population of the state of Pará, Brazil, 2000 to 2021.

	Age Group								
	20 - 29 years old	30 - 39 years old	40 - 49 years old	50 - 59 years old	60 - 69 years old	70 - 79 years old	80 years and over	YPLL*	YPLL* per 100,000
2000	15	43	133	210	313	370	339	10099	314.84
2001	21	60	136	203	312	363	382	11255	337.98
2002	19	46	134	221	333	391	354	11345	328.27
2003	25	59	159	241	331	440	402	13380	373.31
2004	20	56	150	213	345	429	399	12769	343.80
2005	19	51	117	237	363	441	459	12501	325.17
2006	37	55	177	259	414	537	535	16235	408.41
2007	28	61	178	269	454	573	622	16516	402.28
2008	30	72	160	314	443	627	723	18016	425.28
2009	27	58	130	310	426	648	742	16271	372.59
2010	21	53	156	259	466	608	732	16601	369.12
2011	26	54	137	290	458	640	777	17178	372.63
2012	26	51	142	286	450	620	818	17362	367.67
2013	29	63	149	285	502	607	804	18996	392.92
2014	30	63	149	319	435	663	906	19452	393.13
2015	25	55	156	271	507	751	947	19397	383.10
2016	23	80	165	284	457	773	1020	20833	402.22
2017	27	57	154	278	494	679	955	20422	385.50
2018	22	63	165	273	508	783	962	21378	394.71
2019	23	53	129	327	474	731	853	21026	380.00
2020	23	51	166	300	470	764	972	21957	388.80
2021	20	53	158	263	520	729	909	21754	377.78

Source: Prepared by the authors, 2023, from the DATASUS database. Ministry of Health. Brazil. * Years of Potential Life Lost.

When evaluating mortality coefficients per 100,000 inhabitants, according to age group, the highest coefficients are notable for the older age groups, especially after 60 years of age. In the sequential time analysis of this variable, there were periods of rise and fall, with greater emphasis on the age group of 80 years and over (figure 1). In 2008 and 2016, there were, respectively, peaks of 1.195, 81 and 1.224,70 in the age group of 80 years and over; 427,81 and 387,18 in the 70 to 79 age group; 153,43 and 115,49 in the 60 to 69 age group and progressive reduction for the other groups reaching values of 2,09 and 1,50 between 20 and 29 years.

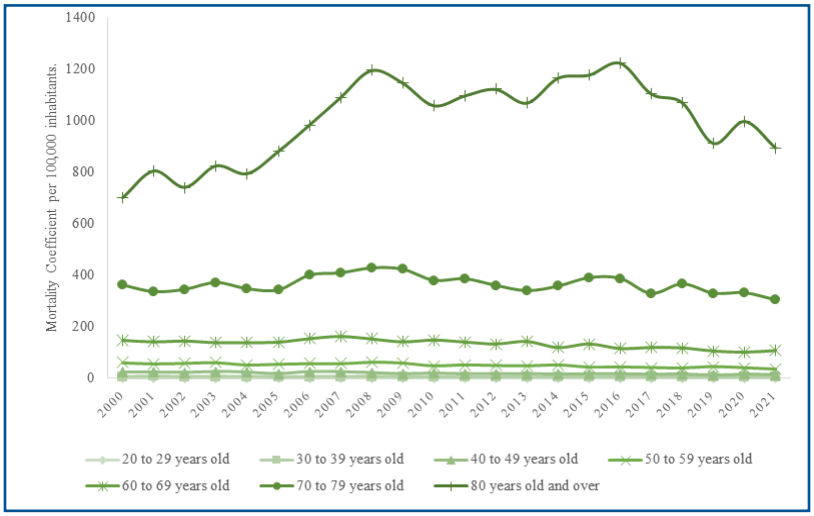

Figure 1: Mortality coefficient due to stroke by age group in the adult population of the state of Pará, Brazil, 2000 to 2021.

The statistical analysis of the AAPC between 2000 and 2021 revealed a stationary trend of 0.4% for stroke mortality coefficients (p=0.576) in the adult population of the state of Pará. However, in the analysis of the time series, 2 joinpoints were observed (2004 and 2008), and from 2008 onwards the mortality trend was decreasing by -1.0% (CI: 95%, [- 1.6; -3.6]; p = 0.003). Regarding the sex variable between 2000 and 2021, there was an increasing trend in mortality for males of 0.9% (p=0.006) and a stationary trend of 0.1% (p=0.940) for females. One joinpoint was observed for men in 2009, when the trend was stationary at 0.7% (p=0.100), and 2 joinpoints for women, when from 2009 onwards the trend showed a decrease of -1.2 % (p=0.002) (table 3).

Table 3: Annual percentage change and average annual percentage change in the mortality rate of stroke disease in the adult population of the state of Pará, Brazil, 2000 to 2021.

	Year	APC* (CI 95%)	p	AAPC** (CI 95%)	p	Interpretation
All						
	2000-2021			0.4 (-0.9; 1.6)	0.576	Stationary
	2000-2004	-0.4 (-3.9; 3.3)	0.838			
	2004-2008	5.6 (-0.2; 11.8)	0.059			
	2008-2021	-1.0 (-1.6; -3.6)	0.003			
Sex						
Male						
	2000-2021			0.9 (0.3; 1.6)	0.006	Increasing
	2000-2009	3.2 (1.8; 4.5)	<0.001			
	2009-2021	-0.7 (-1.5; 0.1)	0.100			
Female						
	2000-2021			-0.1 (-2.1; 2.0)	0.940	Stationary
	2000-2004	-2.3 (-6.5; 2.2)	0.286			
	2004-2007	8.3 (-6.0; 24.7)	0.247			
	2007-2021	-1.2 (-1.8; -0.5)	0.002			

*APC: Annual percentage change; **AAPC: Average annual percentage change.

When stratifying the series by age group between 2000 and 2021, mortality trends according to the average annual percentage change were decreasing from -2.3% for the 30 to 39 age group (p < 0.001), -2.8% for the 40 to 49 age group (p < 0.001), -2.1% for the 50 to 59 age group (p < 0.001) and -1.4% for the 60 to 69 age group (p < 0.001). For the other age groups, the trends were stationary in the period from 2000 to 2021, however the average percentage evaluation showed 1 joinpoint in 2006 for the age group from 20 to 29 years old (p=0.003), 1 joinpoint in 2008 for the age group from 70 to 79 years (p<0.001) and 1 joinpoint in 2016 for the age group of 80 years and over (p=0.010), from which mortality trends were equally decreasing (table 4).

In the assessment of the years of potential life lost due to stroke, through the annual percentage change, an increasing trend of 3.8% (p<0.001) was observed in the period from 2000 to 2021. In the analysis of the time series, 2 joinpoints were highlighted with increasing trend of 6.8% (p<0.001) in the period from 2000 to 2007 and 2.3% (p<0.001) in the period from 2007 to 2021 (figure 2).

Table 4: Annual percentage change and average annual percentage change in the mortality rate of stroke disease in the adult population by age group in the state of Pará, Brazil, 2000 to 2021 .

	Year	APC* (CI 95%)	p	AAPC** (CI 95%)	p	Interpretation
Age group						
20 – 29 age						
	2000-2021			-0.1 (-2.1; 1.9)	0.911	Stationary
	2000-2006	6.1 (-0.3; 13.0)	0.062			
	2006-2021	-2.5 (-4.0; -1.0)	0.003			
30 – 39 age						
	2000-2021	-2.3 (-3.2; -1.5)	<0.001	-2.3 (-3.2; -1.5)	<0.001	Decreasing
40 - 49 age						
	2000-2021	-2.8 (-3.5; -2.1)	<0.001	-2.8 (-3.5; -2.1)	<0.001	Decreasing
50 - 59 age						

Continuation - Table 4: Annual percentage change and average annual percentage change in the mortality rate of stroke disease in the adult population by age group in the state of Pará, Brazil, 2000 to 2021 .

	Year	APC* (CI 95%)	p	AAPC** (CI 95%)	p	Interpretation
	2000-2021			-2.1 (-3.1; -1.1)	<0.001	Decreasing
	2000-2008	-0.1 (-2.3; 2.2)	0.960			
	2008-2021	-3.4 (-4.4; -2.3)	<0.001			
60 - 69 age						
	2000-2021			-1.4 (-2.2; -0.7)	<0.001	Decreasing
	2000-2008	1.2 (-0.6; 2.9)	0.170			
	2008-2021	-3.0 (-3.8; -2.2)	<0.001			
70 - 79 age						
	2000-2021			-0.2 (-1.1; 0.7)	0.684	Stationary
	2000-2008	2.5 (0.4; 4.6)	0.021			
	2008-2021	-1.8 (-2.7; -0.8)	0.001			
80 years old and over						
	2000-2021			1.2 (-0.1; 2.6)	0.065	Stationary
	2000-2008	6.0 (4.0; 8.0)	<0.001			
	2008-2016	0.7 (-1.5; 3.0)	0.508			
	2016-2021	-5.1 (-8.7; -1.5)	0.010			

*APC: Annual percentage change; **AAPC: Average annual percentage change.

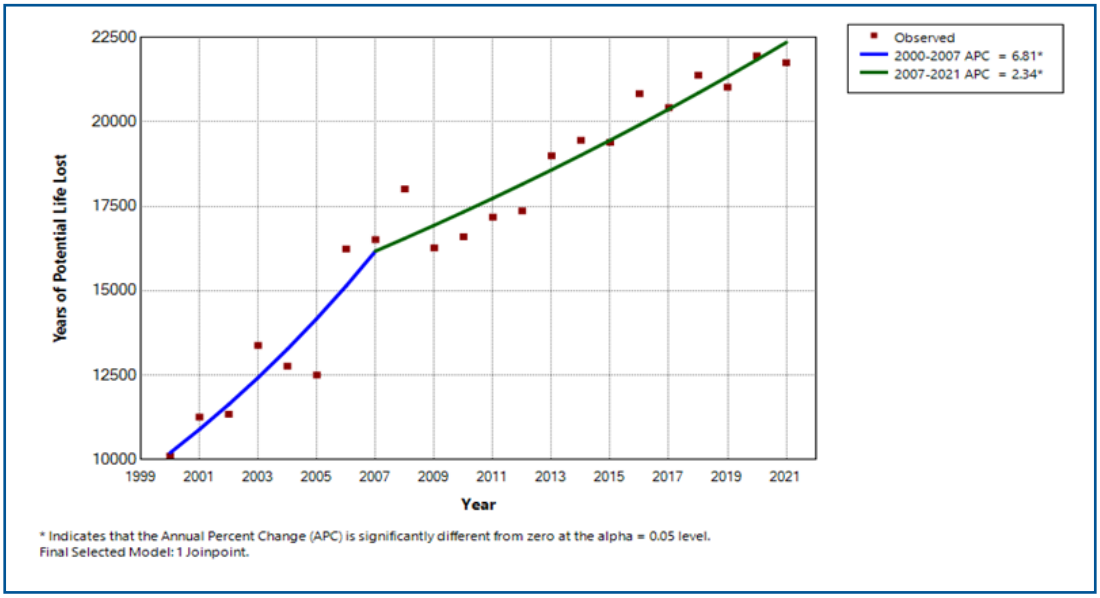

Figure 2: Annual percentage change in years of potential life lost due to stroke disease in the adult population of the state of Pará, Brazil, 2000 to 2021.

DISCUSSION

The trend in stroke mortality in the adult population of the state of Pará proved to be stationary at 0.4% between 2000 and 2021. However, the Joinpoint regression model observed a decreasing trend of -1.0% after 2008 (p=0.003). The number of deaths increased over the years of the time series, given the absolute increase from 1.432 to 2.652 deaths and the increase in the mortality coefficient from 44.36 to 46.06 per 100,000 inhabitants comparing the years 2000 and 2021. There was an increase in the number of deaths with increasing age, with the age groups 60 to 69 years old, 70 to 79 years old, and 80 years old and over being the ones with the highest coefficients.

The stratified analysis revealed a decreasing trend in mortality for the age groups of 30 to 39 years, 40 to 49 years, 50 to 59 years, and 60 to 69 years throughout the study period (p<0.001). However, when analyzing the joinpoints, equally decreasing trends were observed for the age group from 20 to 29 years old after 2006 (p=0.003), from 70 to 79 years old after 2008 (p=0.001), and from 80 years and over after 2016 (p=0.010). Males had the highest mortality rates, except in 2000. After 2007, there was a downward trend of -1.2% (p=0.002) for women; after 2009, the trend was stationary at -0.7 % (p=0.100) for men.

In recent years, there has been a downward trend in stroke mortality rates in the adult population worldwide,

in both sexes, mainly in developed regions such as the 28 countries of the European Union between 1996 and 2015[10], and in the United States of America (USA) between 1975 and 2018 [9]. Moreira *et al.* [12] investigating the trend in stroke mortality throughout Brazil (between 2000 and 2018) and De Moraes Bernal *et al.* [17] in developed Brazilian regions (between 2008 and 2018), also observed similar trends. The results found in this study after 2008 coincide with the downward trend for all age groups, except those aged 80 and over, which occurred after 2016.

Research indicates that decreasing trends in stroke mortality are related to better knowledge and control of risk factors [9], the development of cerebral reperfusion techniques, such as venous thrombolysis and mechanical thrombectomy [26], as well as the diffusion of units specializing in the treatment of stroke [27]. However, Access to these resources is strongly related to each nation's development level. A study of stroke mortality trends in Latin America and the Caribbean, with data extracted from 1979 to 2015 for men and women with no age limit, detected a more significant reduction in stroke mortality in high-income countries compared to middle-income countries [28] .

Soto *et al.* [10], studying the stroke mortality rate on the European continent between 1996 and 2015, detected a drop of -4.2% in the 28 countries studied; however, between 2012 and 2015, there was an increase for some countries in the northern region. These findings suggest a downward trend in stroke mortality in general, although with variations between different countries and areas of the world. Brazilian time series carried out between 2008 and 2018 confirm the same variability, with a decreasing trend of -3.48% for ischemic stroke and -3.84% for hemorrhagic stroke in more developed states [17] and an increasing trend of mortality in less developed states [18]. In Pará, the mortality trend was stationary in the analysis of the entire period but with a decreasing trend after 2008.

The state of Pará ranks 23rd in the human development index among the 26 states of the federation and the federal district [19]. In this study, the absolute number of deaths increased with the years of the time series and with age (tables 1 and 2). Considering the large territorial extensions and the difficulties in accessing health services for monitoring risk factors and acute treatment of stroke, it is suspected that these socioeconomic and public health issues may justify the high absolute numbers of deaths and a slight trend reduction in mortality after 2008 (-1%) compared to other Brazilian states with better health conditions and which presented better outcomes [17].

The highest stroke mortality rates were found in older age groups, mainly over 60 years old. Worldwide data demonstrate similar findings with higher stroke mortality with advances in age [5]. In a study carried out by Purroy *et al.* [29], from data extracted from the Spanish Stroke Registry, almost 1 in 3 stroke patients were 80 years of age and over. These findings corroborate those found in this study. They may be related to the increase in life expectancy in recent decades and the higher number of comorbidities and risk factors accumulated with aging, with the elderly population being at greater risk for stroke.

Rexrode *et al.* [30], studying the impact of sex on stroke in the USA, describe that women have worse outcomes in relation to mortality and quality of life. Still, studies carried out in other parts of the world have observed higher mortality for men. When analyzing mortality trends by sex resulting from stroke in these same time series, a decreasing trend is evident for both sexes [9-12]. In the state of Pará, however, the decreasing trend in stroke mortality was only seen in females. The male sex showed an increasing trend until 2009 and subsequently remained stationary. This is associated with the fact that in 2021, males had 19% more deaths compared to females, requiring temporal monitoring to assess the maintenance of this trend.

Regarding the years of potential life lost, in the statistical analysis using the average annual percentage change, an increasing trend in the number of YPLL is observed as the years of the time series advance ($p < 0.001$). Data from the World Bank between 1990 and 2019 showed a substantial increase in YPLLs due to stroke from 91.5 million to 125 million [5]. Given this, it is clear that the socioeconomic impact generated by stroke, both regionally and globally, is still growing.

The study was motivated by the representativeness of the number of deaths from stroke in Brazil and to better understand the health processes in the northern region, considering the scarcity of epidemiological data on this disease in the state of Pará. Based on this, this time series study was carried out, and a stationary trend in stroke mortality was found during the entire period. These findings show that despite advances in the health sector in the last 20 years, stroke continues to generate significant impacts, which appear to be more pronounced in areas of less economic power.

Regarding the study's limitations, it is recognized that research on mortality trends only describes the trend and does not aim to explain it. Furthermore, it is emphasized that ecological studies such as this, using secondary data, do not allow access to individual information, considering the population group as a whole and not the particular differences of each individual. Another factor to be considered is the possibility of mistakes or delays in the cataloging of stroke cases by health professionals who provide care in the acute episode, as well as failures in the database's operational system by the country's official bodies.

CONCLUSION

The trend in stroke mortality in the adult population of the state of Pará was stationary in the time series from 2000 to 2021; however, after 2008, the mortality coefficients and the analysis stratified by age group showed decreasing mortality trends. Despite this, the absolute number of deaths and years of potential life lost are high, reinforcing the socioeconomic impact of stroke.

The study contributes to a better knowledge of the epidemiological outcomes of stroke in Pará. This allows comparison with other federation states, reiterating the need for public actions to implement a healthy lifestyle and early and effective outpatient treatment of modifiable

stroke risk factors. It also demonstrates the importance of adequate hospital care in acute events, which can minimize the consequences for affected individuals and reduce mortality rates.

Author's contributions:

Gabriel Marim Roni: participated in data analysis, discussion of results, writing and final version of the text Alexandre Castelo Branco Araújo: participated in study design, data collection and evaluation, and statistical analysis. Helder Mauad: participated in study design, data collection and evaluation, and statistical analysis. Matias Noll: participated in study design, data collection and evaluation, and statistical analysis. Hugo Macedo de Souza Jr: participated in study design, data collection and evaluation, and statistical analysis. Marcelo Ferraz de Campos: participated in study design, data collection and evaluation, and statistical analysis. Orivaldo Florencio de Souza: participated in study design, data collection and evaluation, and statistical analysis.

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Conflict of interests

The authors have no conflict of interest in this work.

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Resumo

Introdução: o acidente vascular cerebral (AVC) é uma importante causa de morte mundialmente. Estudos temporais evidenciam tendência de queda nos coeficientes de mortalidade nas últimas décadas com variabilidade entre países. O Estado do Pará, norte do Brasil, possui baixo índice de desenvolvimento humano e elevada mortalidade por AVC, entretanto poucas pesquisas são reportadas.

Objetivo: analisar a tendência da mortalidade por AVC na população adulta do estado do Pará, entre 2000 e 2021.

Método: trata-se de um estudo ecológico, de série temporal, para análise das tendências de mortalidade por AVC entre 2000 e 2021 a partir de dados secundários populacionais oficiais. Modelos de regressão Joinpoint foram utilizados para identificar a tendência de cada segmento do coeficiente de mortalidade e dos anos potenciais de vida perdidos.

Resultados: houve 49.259 mortes no período, com aumento absoluto de mortes durante a série temporal e o aumento da faixa etária. O coeficiente de mortalidade evidenciou tendência de mortalidade estacionária de 0,4% entre 2000 e 2021 (p=0,576), entretanto após 2008 a tendência foi decrescente de -1,0% (p=0,003). Na análise estratificada detectou-se tendência de mortalidade decrescente de -2,3% entre 30 e 39 anos (p<0,001), -2,8% entre 40 e 49 anos (p<0,001), -2,1% entre 50 e 59 anos (p<0,001) e -1,4% entre 60 e 69 anos (p<0,001) entre 2000 e 2021. Nos demais grupos etários a tendência foi decrescente de -2,5% entre 20 e 29 anos após 2006 (p= 0,003), -1,8% entre 70 e 79 anos após 2008 (p=0,001) e -5,1% entre 80 anos e mais após 2016 (p=0,010).

Conclusão: a tendência da mortalidade por acidente vascular cerebral na população adulta do estado do Pará foi estacionária, entre 2000 e 2021. O número absoluto de óbitos se manteve elevado ressaltando a importância de minimizar os fatores de risco e otimizar o manejo dos acometidos.

Palavras-chave: acidente vascular cerebral, mortalidade, tendência, Pará, Amazônia legal.