Stroke and Myocardial Infarction: Effects of the "Hiperdia" and "Mais Médicos" Programs on the Hospitalizations Trends in Brazil

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Abstract

Background: Stroke and acute myocardial infarction (AMI) are cardiovascular diseases commonly characterized by the development of atheromatous plaques associated with major complications and high mortality rates.

Objective: To identify an epidemiological trend in hospitalizations due to stroke and AMI and to analyze the relationship between health programs applied in Primary Health Care, gender and the Federative Unit.

Methods: Ecological study with a time series design between 1998 and 2018, collecting data from all federal units in Brazil stratified by, gender and place of residence. There were analyzed Hospitalization Authorizations (AIH) for stroke and MI, consulting the Hospital Admissions System (SIH) of the Informatics Department of the National Health Service with p <0.05.

Results: From 1998 to 2018, the rate of hospitalization for AMI increased in Brazil approximately 42.58 events per 100 thousand inhabitants annually (p<0.001), while hospitalizations for stroke declined 32.17 cases (p=0.03). This pattern was observed in both sexes in AMI and stroke. There is also evidence of the effect of the Hiperdia (p<0.001) and Mais Médicos (p=0.001) program in reducing stroke and Hiperdia cases in mitigating the evolution of AMI cases (p = 0.0001).

Conclusion: Although these diseases remain as an important cause of death, stroke hospitalization has reduced significantly in the period evaluated. National programs as the Hiperdia and Mais Médicos showed an impact in the acute cases of strokes and AMI.

Keywords: Stroke; Myocardial Infarction; Hospitalizations; Hiperdia, Primary Health Care; Medically Underserved Area.

Introduction

Stroke and acute myocardial infarction (AMI) are considered cardiovascular diseases (CVD) and their pathophysiological process is generally characterized by the development of atherosclerotic plaques in vessels, whose detachment and/or rupture lead to lumen occlusion, interrupting blood flow in the brain or heart and this process being influenced by several risk factors, notably systemic arterial hypertension (SAH).[1]

CVDs are currently the largest cause of mortality in the world,[2] in addition to being among the diseases with the greatest financial impact.[1] Its prevalence is linked to the increase in life expectancy, which causes more people to reach the age groups at risk for developing such diseases.[3]

AMI is the most frequent and fatal manifestation among cardiovascular diseases[4] and, when it does not result in death, it can generate physical repercussions and psychosocial impacts.[5] Annually, more than 2.4 million deaths are registered in the United States and more than 3.9 million in Europe.[6,7] In Brazil, the standardized average mortality rate was 108.14 deaths for 10^5 men and 61.49 women between 1980-2009,[8] with an economic impact of R$ 22.4 billion.[9]

Ischemic stroke produces a high rate of morbidity and mortality and sudden neurological dysfunction with

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severe motor, sensory and psychocognitive sequelae,[10] being the second leading cause of death globally, with 5.5 million deaths in 2016 and a prevalence of 80.1 million people, showing a similar occurrence between the genders up to 55 years and significantly higher in men between 55 and 75 years.

These health conditions are associated with modifiable risk factors that can be the focus of specific actions to expand medical and pharmaceutical assistance, as well as non-specific health promotion, especially in Primary Health Care (PHC) services. As an example, in the context of the *Sistema Único de Saúde* (SUS), the programs *Hiperdia*, *Mais Médicos* and the *Programa de Acesso e Melhoria da Qualidade* (PMAQ) can be mentioned. Due to the need to monitor and implement public policy strategies for prevention, this study seeks to estimate the trend of cases of ischemic stroke and AMI hospitalization in the Brazilian population and, in the absence of stationarity, to specify the influence that health programs developed in Primary Health Care (PHC).[11]

Method

This is an ecological study with a design of time series and analytical approaches between the years 1998 and 2018. The information collected comprises all the federative units (FU) in Brazil. In order to study the number of hospitalizations for ischemic stroke and AMI, the Hospitalization Authorizations (HA) resulting from the disease were analyzed.

Thus, the study was carried out by consulting the *Sistema de Informação Hospitalar* (SIH) of the *Departamento de Informática do* SUS (DATASUS),[12] which contains secondary data without the patients' personal identification. It is noteworthy that the SIH information is available to the public, thus exempting the appraisal of the ethics committee.

In order to obtain the number of hospitalization cases due to stroke and AMI, the functions of epidemiological information and general hospital morbidity by place of residence were used for the codifications of the International Classification of Diseases in its 10th version, which are: G45 (cerebrovascular accident transient ischemic and related syndromes), I66 (occlusion and stenosis of cerebral arteries that do not result in cerebral infarction), I65 (occlusion and stenosis of pre-cerebral arteries that do not result in cerebral infarction), I63 (cerebral infarction); and I21 (acute myocardial infarction). Demographic data were collected from the database of the *Instituto Brasileiro de Geografia e Estatística* (IBGE).[13]

Statistical Analysis

There was a stratification of data about hospitalizations for stroke and AMI according to Federative Unit (UF) and gender. The incidence rate was obtained by means of the ratio between the number of stroke cases and AMI per year and the estimated population for each year, on a scale for each 100,000 (10^5) inhabitants. To avoid possible errors in the collection of information, an audit was carried out by a second group of researchers in a random sample from the bank. Because of this, the outcomes were defined as the incidence of hospitalization due to stroke and the incidence of hospitalization due to AMI for the estimated population for the years of the study time series.

A polynomial sequence and regression graph was constructed to analyze data trends, which aims to discover the best outcome curve (Y), with the independent variable year (X). In order to prevent serial correlation between the coefficients of the equation, it was preferred to use the difference between the year and the midpoint of the historical series, rather than the gross values of the years, and the Prais-Winsten method of regression. Therefore, considering the period between 1998 and 2018, the adjusted year (X-2008) constituted the independent variable. Each equation had estimated the adjusted determination coefficient (R^2_{ajus}) that reveals the explanatory proportion of the model.

To estimate the impact of programs developed in PHC in SUS, three national policies were taken into account: *Hiperdia*, which was implemented in 2002 and expanded medical and pharmaceutical assistance to people with hypertension and diabetes, being used in this study, mainly, as confusion control since there is already evidence of its effectiveness;[14] the *Mais Médicos* program, which started in 2013 and aimed to increase the number of medical professionals in PHC in the municipalities; and PMAQ, which also started the first cycle in 2013, aspiring to evaluate, monitor and stimulate the quality of services provided at PHC via technical and financial support.
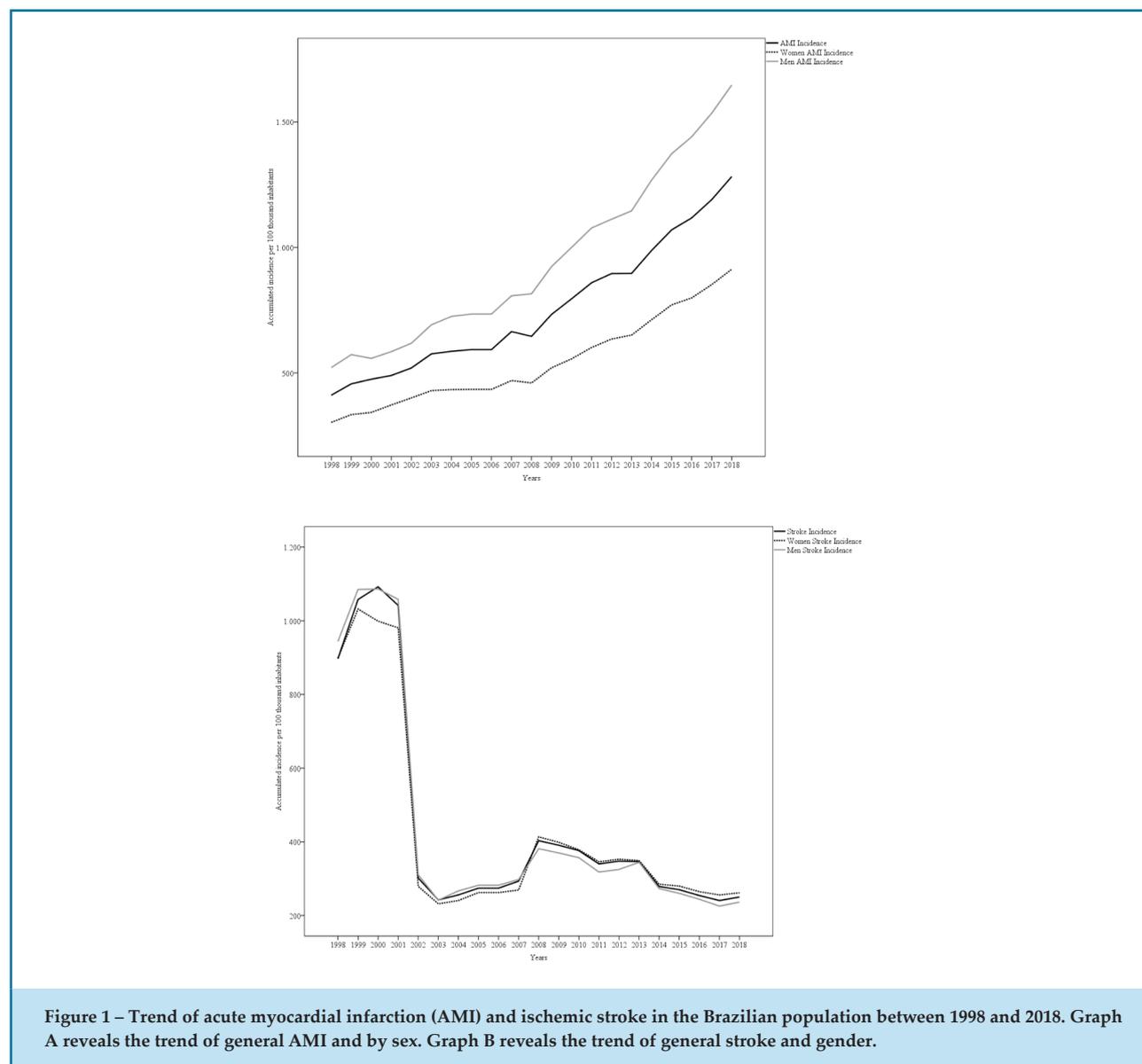
Each program consisted of a dichotomous variable (before/after) the implementation and was independent of the trend of hospitalizations for stroke and AMI in Brazil. Its effects were estimated using the Generalizable Estimation Equations, an extension of the Generalizable

Linear Models (MLG) for correlated data. A robust covariance matrix and an autoregressive work correlation matrix (ARIMA) were used to estimate the effects of independent variables, depending on the quality of the model based on the model's Quasi-Likelihood Criteria (QIC). The gamma link function was used to connect the independent variables and the outcome in the model. The observation of the sign of the model coefficients (B) would allow identifying the effect of the independent variables and their significance being estimated by Wald's chi-square test ($\chi2$). $R^{\circledR}$ was used to adjust the polynomial curves and construct the MLG. A significance level of 5% was considered to minimize a type I error in the curve adherence and modeling processes.

Results

The analysis of hospitalizations in Brazil reveals an increase in those resulting from AMI with an incidence rate of 42.58 cases per 100 thousand inhabitants per year. Among the genders (Figure 1A), there are also increasing rates, with 30.14 cases per 100 thousand inhabitants per year for women and, to a greater extent, men with a rate of 55.96 cases per 100 thousand inhabitants per year. The equation has excellent adherence to the almost linear growth of cases, $R^2_{ajus} > 0.80$ (Table 1).

In this context, hospital admissions for stroke in Brazil decreased in the period studied (Figure 1B), with a decline rate of 32.17 cases per 100 thousand inhabitants per year.

Figure 1 – Trend of acute myocardial infarction (AMI) and ischemic stroke in the Brazilian population between 1998 and 2018. Graph A reveals the trend of general AMI and by sex. Graph B reveals the trend of general stroke and gender.

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Table 1 – Modeling the trend of total hospitalizations according to sex for acute myocardial infarction and stroke in Brazil between 1998 and 2018

		AMI				Stroke			
		Model	Trend	p	R^2_{adjus}	Model	Trend	p	R^2_{adjus}
Brazil	Men	55.96x+1009.11	Crescent	<0.001	0.81	-34.67x+464.34	Decrescent	0.02	0.23
	Woman	30.14x+574.10	Crescent	<0.001	0.81	-30.33x+457.15	Decrescent	0.04	0.20
	Total	42.58x+781.42	Crescent	<0.001	0.85	-32.17x+462.67	Decrescent	0.03	0.21

AMI: Acute myocardial infarction; p: probability; R^2_{adjus}: Adjusted coefficient of determination.

This decreasing trend is also observed in both genders, for women the reduction is 30.33 cases annually for every 100 thousand inhabitants. Among male individuals, there is a reduction of 34.67 cases annually for every 100 thousand inhabitants. Stroke cases showed an abrupt decline after 2002 without linearity, R^2_{ajus}<0.30 (Table 1).

Among the FUs, almost all of them had an increasing trend of hospitalizations for AMI, except for Amapá. Among those that grew the most were Santa Catarina, Piauí and Rio Grande do Sul, which respectively increased 2.53, 2.43 and 2.35 cases per 100 thousand inhabitants per year. For stroke cases, the FUs that most declined were Rio Grande do Sul, Santa Catarina and Tocantins with 6.17, 3.57 and 2.80 cases per 100 thousand inhabitants each year (Table 2).

The incidence of hospitalizations for stroke and AMI are affected by health programs developed in primary care (Table 3). It can be seen that the reduction in stroke cases was influenced by the Mais Médicos program (p<0.0001) and more strongly by Hiperdia (p<0.0001), regardless of the actions produced by the PMAQ (p=0.35). Regarding AMI, despite its increasing tendency, Hiperdia (p=0.03) mitigates the evolution of cases as well as there is a marginal significance of the influence of the Mais Médicos Program (p=0.059). There was, again, no significant impact of the PMAQ (p=0.35).

Discussion

Few studies analyze the incidence of cerebrovascular diseases in the Brazilian population over long time series. This study covers the entire national territory and uses data from a 20-year time series (1998-2018) of SUS relevant for monitoring the outcomes studied. As a result, it was shown that hospitalizations for AMI increased throughout the series and, conversely, stroke cases declined. Although there was an antagonistic scenario of the outcomes, it can be inferred that the national programs of Hiperdia and Mais Médicos influenced the mitigation of acute cases of both stroke and AMI after their implementation.

The psychological, financial, social and quality of life impact caused by CVDs is undeniable, causing investments in the area to end up generating greater welfare for the population and economy for the state. Stevens B. et al.,[9] analyzed the costs of cardiovascular diseases in Brazil and AMI had the greatest impact among the diseases surveyed, with a cost of 22.4 billion reais compared to 56.2 billion spent on cardiac conditions and the average cost for each case of AMI was of 7,777.[9]

This contrasts with the reduction in hospitalizations for stroke, which was also observed by other researchers. Ramirez et al. found that hospitalizations for ischemic stroke and age-adjusted had a reduction,[14] as well as Johnson et al.,[11] found that the global incidence and mortality of stroke adjusted for age decreased 8.1% and 36.2%, respectively, from 1990 to 2016 in the United States.[11] In Brazil, a decline in hospitalization for ischemic stroke was observed from 2002, year of the implementation of Hiperdia. Between 1998 and 2001, the incidence was $37.87/10^5$ inhabitants, being $9.98/10^5$ between 2002 and 2005, a reduction of 73.64%.[15]

The study by Dantas et al.,[16] analyzed hospitalizations for stroke in the period from 2009 to 2016 through AIH in DATASUS and observed an increase in absolute numbers of 12.1%, explained by the population increase in the period (8.2%), extended life expectancy and aging of the population. However, in this same study, data adjusted for age showed an average reduction of 11.8%

Table 2 – Modeling the trend of hospitalization for acute myocardial infarction and stroke in the states of Brazil between 1998 and 2018								
	Acute Myocardial Infarction (AMI)				**Stroke**			
FU	**Model**	**Tend**	**p**	**R^2_{adjus}**	**Model**	**Tend**	**p**	**R^2_{adjus}**
AC	0.89x+14.50	Crescent	<0.001	0.71	-1.14x+18.49	Stationary	0.12	0.02
AL	0.88x+16.42	Crescent	<0.001	0.51	-1.92x+24.00	Stationary	0.12	0.03
AM	1.57x+20.54	Crescent	<0.001	0.68	1.69+18.73	Crescent	0.001	0.40
AP	0.24x+10.52	Stationary	0.06	0.09	-1.25x+8.14	Stationary	0.09	0.05
BA	1.73x+25.90	Crescent	<0.001	0.84	-0.77x+13.75	Stationary	0.58	0.09
CE	1.12x+24.70	Crescent	<0.001	0.63	-0.35x+6.99	Decrescent	0.002	0.34
DF	1.53x+31.30	Crescent	<0.001	0.47	-0.29x+8.64	Stationary	0.13	0.02
ES	2.10x+38.14	Crescent	0.001	0.41	-1.15x+18.17	Decrescent	0.003	0.32
GO	1.64x+26.93	Crescent	<0.001	0.76	-0.99x+17.70	Stationary	0.10	0.04
MA	0.59x+10.86	Crescent	0.001	0.39	-1.99x+22.13	Decrescent	0.003	0.33
MG	1.86x+45.36	Crescent	<0.001	0.98	-1.45x+16.30	Decrescent	0.004	0.31
MS	1.95x+30.87	Crescent	<0.001	0.76	-1.14x+15.80	Decrescent	0.004	0.30
MT	1.93x+30.13	Crescent	<0.001	0.68	-1.01x+12.07	Decrescent	0.01	0.19
PA	0.90x+14.88	Crescent	<0.001	0.72	-0.90x+8.60	Decrescent	0.01	0.20
PB	0.74x+23.33	Crescent	0.007	0.26	-0.32x+6.69	Stationary	0.18	0.005
PE	1.79x+28.45	Crescent	<0.001	0.73	0.31x+7.05	Stationary	0.40	0.06
PI	2.43x+27.40	Crescent	<0.001	0.78	-0.19x+19.94	Stationary	0.67	0.10
PR	2.29x+42.69	Crescent	<0.001	0.86	-1.81x+28.24	Decrescent	0.04	0.11
RJ	0.93x+37.65	Crescent	<0.001	0.58	-0.71x+14.70	Decrescent	0.04	0.11
RN	2.33x+29.58	Crescent	<0.001	0.63	-1.79x+23.89	Stationary	0.09	0.50
RO	1.80x+18.54	Crescent	<0.001	0.64	-1.51x+13.84	Decrescent	0.04	0.11
RR	0.70x+10.80	Crescent	0.001	0.38	0.17x++1.15	Crescent	0.001	0.40
RS	2.35x+59.96	Crescent	<0.001	0.84	-6.17x+63.01	Decrescent	0.04	0.12
SC	2.53x+52.62	Crescent	<0.001	0.88	-3.57x+41.69	Decrescent	0.01	0.22
SE	1.74x+25.65	Crescent	<0.001	0.48	-1.52x+10.07	Decrescent	0.02	0.15
SP	2.24x+49.73	Crescent	<0.001	0.97	-0.53x+12.09	Stationary	0.056	0.09
TO	0.46x+20.26	Crescent	0.01	0.19	-2.80x+19.87	Decrescent	0.04	0.11

FU: Federation unity; p - probability; R^2_{adjus}: Adjusted coefficient of determination; AC: Acre; AL: Alagoas; AM: Amazonas; AP: Amapá; BA: Bahia; CE: Ceará; DF: Distrito Federal; ES: Espirito Santo; GO: Goiás; MA: Maranhão; MG: Minas Gerais; MS: Mato Grosso do Sul; MT: Mato Grosso; PA: Pará; PB: Paraíba; PE: Pernambuco; PI: Piauí; PR: Paraná; RJ: Rio de Janeiro; RN: Rio Grande do Norte; RO: Rondônia; RR: Roraima; RS: Rio Grande do Sul; SC: Santa Catarina; SE: Sergipe; SP: São Paulo; TO: Tocantins.

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Table 3 – Adjusted model of the relationship between cases of AMI and stroke in the Brazilian population and public health programs for primary care

	B	Standard Error	95%CI of Wald		Hypothesis testing		
			Lower	Upper	Wald's x^2	df	p
Stroke							
Interception	1112.02	42.171	1029.36	1194.67	695.31	1	<0.001
Year	10.56	4.303	2.13	19.00	6.02	1	0.01
Mais Médicos							
After	-111.23	28.919	-167.91	-54.54	14.79	1	<0.001
Before	0						
Hiperdia							
After	-781.02	39.424	-858.29	-703.74	392.45	1	<0.0001
Before	0						
PMAQ							
After	-25.64	27.510	-79.56	28.27	0.86	1	0.35
Before	0						
AMI							
Interception	797.77	40.239	718.90	876.63	393.05	1	<0.001
Year	39.98	4.565	31.04	48.93	76.72	1	<0.001
Mais Médicos							
After	55.10	29.150	-2.02	112.24	3.57	1	0.059
Before	0						
Hiperdia							
After	-81.39	37.939	-155.75	-7.03	4.60	1	0.03
Before							
PMAQ							
After	19.50	25.369	-30.22	69.22	0.59	1	0.44
Before	0						

B: Model equation coefficient; CI: Confidence interval; x^2: chi-square; df: degrees of freedom; p: probability; AMI: Acute myocardial infarction.

in hospitalizations and 12.6% for in-hospital mortality.[16] It is important to highlight the limitations of this study regarding the absence of a trend analysis that controls the serial correlation of data and the effect of population size by using absolute data.

The intriguing opposition to the historic trend of stroke and AMI, even with similar risk factors, may have some explanations. One is that SAH is the most important risk factor for stroke,[17] whereas AMI is strongly associated with smoking, central obesity, dyslipidemia and diabetes. Drug approaches for SAH and diabetes have been widely disseminated in PHC services and with well-proven effectiveness; however, the unhealthy lifestyle is increasing the incidence and prevalence of diabetes and obesity in recent years in Brazil.[18] This, possibly, is contributing to raising rates of AMI while cerebrovascular diseases reflect greater effectiveness in controlling blood pressure.[19]

Another factor that helps the decline of stroke are the ten modifiable risk factors that make up about 90% of the population risk attributable to stroke worldwide.[17] The prevention of these risk factors is done with better pressure control, adequate nutrition, reduction in cholesterol levels and the use of tobacco and alcohol and reduced BMI justify being largely responsible for the drop in hospitalizations.[11,14,20]

The worsening of chronic conditions such as AMI and stroke is greatly influenced by social conditions such as income, education, ethnicity and access to health services, for example. In this perspective, the study by Krumholz, Normand and Wang recorded a decline in the rate of hospitalizations for AMI from 914 to 566 patients for every 10^5 people, a reduction of 38.1%. This study addressed an elderly population assisted by Medicare and financed in the form of a fee for service, which reveals possible factors that may influence access to hospitalizations such as having private health insurance, access to better working conditions and income, inherent social conditions quality of health.[21]

Even with similar risk factors, AMI and stroke are conditions that have different paths. However, it is possible to perceive that programs executed at the PHC level, such as Hiperdia and Mais Médicos, and those supported by national policies, such as tobacco control, based on media actions, price taxation, free program to support cessation of smoking, and food and nutrition that aim to improve the food, nutrition and health conditions of the Brazilian population by establishing national goals for reducing the sodium content of processed foods in Brazil.[22-24] These are key points in the decline in the prevalence of several chronic diseases in Brazil, which contrasts with the increase in use in other countries.[22,25]

PHC in Brazil is based on the Family Health Strategy (FHS), a robust approach aimed at defined populations, through comprehensive care to reduce hospitalizations and complications of chronic diseases[26] and improve well-being. Currently, the FHS has a coverage of approximately 137 million people (65.07% of the Brazilian population)[27] and runs national programs mentioned above.

A study pointed out that an investment of US$ 1 to 3 per person in strategies with a wide population reach can control several chronic non-communicable diseases.[20] The FHS allows the adoption of different lines of care, ensuring adequate therapy, bonding between patient and staff and continuity in attendance, with Hiperdia being added to it.[22,26] This program mitigates strong modifiable risk factors for AMI and stroke, such as hypertension and diabetes. These factors are diseases of slow evolution, asymptomatic or oligosymptomatic in most cases, usually noticeable when an acute cardiovascular event occurs.[28] Today, we know that it contributed to a reduction of more than 70% in hospitalizations due to stroke shortly after completion of the program, in 2002.[15,29] Other studies also revealed an effect of the FHS in the management of the conditions surveyed[30,31] associated with health promotion actions focusing on behavior and life habits such as the Academia em Saúde program.

The expansion of the FHS and the shortage of medical professionals in socially vulnerable regions with little supply, the Brazilian government responded with the Mais Médicos program for Brazil, importing 15,000 doctors from other countries.[26] The positive impact in reducing the number of hospitalizations due to stroke and limitation of AMI cases, despite the short time of implementation, reflect the effectiveness of expanding access to general medical care.[32] This greater access helps drug treatment to control blood pressure and dyslipidemia as a cost-effective way to control the CVD[33] and it is also available in a pharmaceutical assistance program,[33,34] with their dispensation in SUS health units.[22]

Despite making the distribution of doctors in Brazil more equitable, the Mais Médicos program, like all PHC, finds itself in a scenario of scarce funding and inefficient planning and management approaches, especially at local level.[35] Another feature of the program is its centrality in the medical professional, without the implementation of other health professionals, minimum FHS team, such as physiotherapists and psychologists, who work mainly in the management of chronic conditions, as well as health professionals for the management of services.[36]

In contrast, the improvements produced by the PMAQ still cannot be felt in the studied outcomes, probably because the organizational effects take longer to reveal impacts or such advances do not result in changes for AMI and CVA. The PMAQ has the characteristic of having the PHC teams adhere to participate and apply the improvement cycles, which also reduces the number of participating services.[37] In addition, the first PMAQ cycle presented a higher proportion of services below the average, which may have delayed the evolution of the quality of access and other dimensions of quality.[37] On the other hand, Hiperdia and Mais Médicos have the characteristic of being programs without bureaucratic and organizational counterparts.

In view of the interesting results, it is necessary to make some limitations explicit. The effect of PHC coverage or the family health strategy was not evaluated purely, but they maintain collinearity with the analyzed programs that interact with the effects of the analyzed programs. Finally, there is the problem of underreporting, which can lead to obtaining distorted information about the mortality profile as it is believed to happen in UF do Amapá.[38,39]

Conclusion

The present study evaluated the trend of hospitalizations for stroke and AMI during the years 1998 to 2018, and it is possible to infer that those resulting from stroke decreased significantly in this period, and that hospitalizations motivated by AMI grew. However, the Hiperdia and Mais Médicos programs considerably mitigated the acute events of these vascular conditions sensitive to primary care. It is also evident that there is a need for collective actions more focused on avoiding AMI.

Author contributions

Conception and design of the research: Lopes JM. Acquisition of data: Martinez ABR, Lopes JM Jesus E, Souza GRS. Analysis and interpretation of the data: Santos JM, Martinez ABR, Jesus E, Souza GRS, Lopes JM. Statistical analysis: Lopes JM. Obtaining financing: Lopes JM. Writing of the manuscript: Santos JM, Martinez ABR, Jesus E, Souza GRS. Critical revision of the manuscript for intellectual content: Santos JM, Lopes JM.

Potential Conflict of Interest

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

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Ethics approval and consent to participate

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

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