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Hospitalizations related to complications of diabetes mellitus

Internações relacionadas às complicações do diabetes mellitus

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ABSTRACT

This work aims to analyze the temporal pattern of hospitalization for complications related to Diabetes mellitus in Brazil. We use an ecological study, which analyzed the temporal trend of hospitalizations due to diabetes, using data from the Hospital Morbidity System. A regression analysis was carried out by inflection points, transforming the values into logarithms, analyzing the mean annual percentage variation and the significance of the change in trend, with a confidence interval of 95%. A total of 250,134 hospitalizations were recorded in Brazil, with an average rate decline of 1.3% (range -2.0–-0.5) and a greater reduction in the Midwest region, 12.5% (range -16.9; -7.8). There was an increase for males in the North (range: 3.5; 95%CI: 0.6-6.4) and Northeast (range: 1.9; 0.4 - 3.4) regions, and a significant reduction in the rate between people aged 60 to 79 3.2% (range: -4.1–-2.4) nationwide. Among the Brazilian capitals, Fortaleza fell by 3.7% (range: -4.9–-2.5) and Goiânia by 18.4% per year (range: -28.7–3.7), but Vitória increased by 9% over the period (range: 5.7–12.5). The temporal pattern of hospitalization for complications related to Diabetes mellitus showed a significant stationary trend, with declines in some extracts.

Keywords: Diabetes mellitus. Complications of diabetes. Hospital internment. Time series studies. Epidemiology.

RESUMO

Este trabalho objetiva analisar o padrão temporal de hospitalização por complicações relacionadas ao Diabetes mellitus no Brasil. Este é um estudo ecológico, que analisou a tendência temporal de internações por diabetes, utilizando dados do Sistema de Morbidade Hospitalar. Fez-se análise de regressão por pontos de inflexão, transformando os valores em logaritmos, analisando a variação percentual anual média e a significância da mudança de tendência, com intervalo de confiança de 95%. Foram registradas 250.134 internações no Brasil, com declínio médio da taxa de 1,3% (intervalo -2,0 – -0,5) e maior redução na região Centro Oeste 12.5% (intervalo -16.9; -7.8). Houve aumento para o sexo masculino nas regiões Norte (intervalo: 3,5; IC95%: 0,6 – 6,4) e Nordeste (intervalo: 1,9; 0,4 – 3,4) e redução importante da taxa entre pessoas de 60 a 79 anos 3,2% (intervalo: -4,1 – -2,4) em todo o país. Entre as capitais brasileiras, Fortaleza apresentou queda de 3,7 % (intervalo: -4,9 – -2,5) e Goiânia de 18,4% ao ano (intervalo: -28,7 – 3,7), mas Vitória aumentou em 9% no período (intervalo: 5,7 – 12,5). O padrão temporal de internação por complicações relacionadas ao Diabetes mellitus mostrou expressiva tendência estacionária, com declínios em alguns extratos.

Palavras-chave: Diabetes mellitus. Complicações do diabetes. Internação hospitalar. Estudos de séries temporais. Epidemiologia.

Introduction

Diabetes mellitus (DM) represents a prevalent global metabolic disorder of increasing concern. In 2015, the diagnosis of diabetes affected 415 million adults, constituting 8.8% of individuals aged 20 to 79 (Santos *et al*., 2020). Projections indicate that by 2040, this figure will rise to 642 million adults, or one in ten (Santos *et al*., 2019). Brazil ranks fourth globally in the prevalence of DM, with 14.3 million cases, following China, India, and the United States (Borges; Lacerda, 2018).

DM significantly contributes to morbidity and mortality rates. Individuals with diabetes face elevated risks of hospitalization and readmission due to inherent disease complications. Global health expenditures related to DM and its complications reached an estimated US$637 billion in 2015, representing a substantial proportion of healthcare costs, varying from 2.5% to 15% across countries depending on the availability and accessibility of medical services (Rosa *et al*., 2018).

The rise in DM incidence and prevalence worldwide can be attributed primarily to demographic, epidemiological, and nutritional transitions, urbanization, and economic and social growth (Flor; Campos, 2017). Consequently, continual and comprehensive monitoring of DM morbidity and mortality trends is imperative. Epidemiological studies play a crucial role in this regard, enabling the monitoring and analysis of hospitalizations for DM to provide insights into disease behavior and assess the effectiveness of interventions in Primary Health Care (PHC), given that DM is a Sensitive Condition for Primary Care (CSAP). Furthermore, investigating hospitalizations for acute and chronic DM complications is essential for understanding the impact of interventions aimed at disease control.

No national studies with comparable data analysis scope to this research have been conducted on this topic. Given Brazil's vast geographic expanse, it was imperative to explore how this pattern manifests across its regions and capitals, disaggregated by gender and age group. This study represents the first comprehensive analysis spanning the entire available period in secondary data from various sources, enhancing the validity of the findings. Consequently, the objective of this research was to analyze the temporal trends of hospitalizations for complications associated with DM in Brazil.

1 Method

An ecological time series study was conducted to analyze the temporal pattern of hospitalizations for complications related to DM in Brazil from 2000 to 2018. The data sources included the Ministry of Health's Hospital Morbidity Information System of the Unified Health System (SIH/SUS) and annual population projections from the Brazilian Institute of Geography and Statistics (IBGE).

Data was collected in December 2019 through the SUS IT Department's (DATASUS) electronic portal using the TabNet application. Hospitalization counts were filtered by criteria such as “General Brazil,” “Brazilian capitals,” “region,” “gender,” and “age group.” Diagnoses of DM-related complications were selected using the “International Classification of Diseases (ICD-10)” filter. Population data were retrieved from the demographic and sociodemographic information tab, with population projections tailored to the specific extract required for each year of the study period.

The data were organized into tables in Microsoft Excel® and imported into Joinpoint Regression Program® software version 4.6.0.0 for segmented linear analysis (using inflection points or joinpoints), with logarithmic transformation of the values.

We tested the null hypothesis that a single straight-line segment could explain variations over the years, against the alternative hypothesis that inflection points in the period would alter the slope of the line segments. The program calculated the annual percentage change (APC) with a 95% confidence interval (CI). A positive APC indicates an increasing trend, while a negative APC indicates a decreasing trend. Additionally, the average annual percentage change (AAPC) was calculated for the entire period, with interpretation similar to APC but focused on the overall trend (Sousa *et al.*, 2019).

The study tested the null hypothesis that a simple linear trend could express the variation in hospitalizations for complications related to DM in Brazil, and considered the alternative hypothesis that inflection points should be included in the model to account for changes in trend segments. A significance level of 5% was used to test the APC and AAPC hypotheses, with significance indicated by a p-value <0.05 or a 95% CI that was entirely positive or negative.

The year of hospitalization was the independent variable, and the percentage of hospitalizations each year was the dependent variable. These percentages were calculated and standardized according to logarithmization criteria. The numerators included the number of hospitalizations for DM, and the denominators included the total number of hospitalizations in the same period, all expressed as percentages. The presence of missing data was the only exclusion criterion, but this criterion did not need to be applied.

According to resolution No. 466/12 of the National Health Council, research involving open and public domain data does not require prior authorization from the Research Ethics Committee.

2 Results

A temporal trend analysis over 19 years revealed a total of 250,134 hospitalizations for complications related to DM in Brazil, with 52.5% (n=131,913) of these hospitalizations attributed to females. The AAPC was used to analyze the trend of hospitalizations at the end of the series.

In the country, 74% of the capitals (n=20/27) did not show a significant change in the average annual rate of hospitalizations for DM. However, 22% (n=6/27) experienced a decline in hospitalizations, while 4% (n=1/27) saw an increase.

When evaluating the general hospitalization rate in Brazil over the same period, an average decline of 1.3% (95% CI: -2.0 to -0.5) was observed across the entire national territory. The Southeast and South regions showed declines of 2.3% (95% CI: -3.1 to -1.4) and 2.1% (95% CI: -3.1 to -1.1), respectively.

The most prominent reduction was in the Central-West region, with a drop of 12.5% (95% CI: -16.9 to -7.8). In contrast, the North and Northeast regions did not show significant changes during the years analyzed (Table 1).

Table 1. Hospitalization rates related to DM complications* in Brazil and its regions, 2000 to 2018. Fortaleza-Ceará-Brazil, 2020.

Country Regions	APC1† (95%CI)††	IP‡	APC2§ (95%CI)††	IP‡	APC3|| (95%CI)††	IP ‡	APC4¶ (95%CI)††	AAPC** (95%CI)††
Brazil	-2.9‡‡ (-4.0; -1.8)	2006	5.4‡‡ (2.0; 8.8)	2010	-3.2‡‡ (-3.9; -2.6)			-1.3‡‡ (-2.0; -0.5)
North	4.7 (-11.3; 2.4)	2004	9.7‡‡ (6.2; 13.2)	2011	-1.5 (-3.5; 0.6)			2.0 (-0.0; 4.0)
Northeast	- 4.3‡‡ (-7.1; -1.5)	2005	9.4‡‡ (6.6; 12.3)	2011	-2.8‡‡ (-4.2; -1.4)			0.7 (-0.5; 1.9)
Southeast	-4.5‡‡ (-5.4; -3.7)	2006	0.9 (-1.8; 3.7)	2010	-3.3‡‡ (-4.5; -2.1)	2016	1.8 (-3.7; 7.6)	-2.3‡‡ (-3.1; -1.4)
Midwest	-0.7 (-3.2; 1.7)	2015	-53.3‡‡ (-66.0; -35.9)					-12.5‡‡ (-16.9; -7.8)
South	-4.2‡‡ (-7.0; -1.3)	2004	3.1‡‡ (0.1; 6.1)	2009	-4.0‡‡ (-4.8; -3.2)			-2.1 ‡‡ (-3.1; -1.1)

*DM – Diabetes Mellitus; †APC1 – Annual Percentage Change 1; ‡IP – Inflection Point (year in which the line segment changes); §APC2 – Annual Percentage Change 2; ||APC3 – Annual Percentage Change 3; ¶APC4 – Annual Percentage Change 4; **AAPC – Average Annual Percentage Change; ††95%CI – 95% Confidence Interval; ‡‡ p<0.05.
Source: SIH/SUS, IBGE, 2000-2018

When evaluating the hospitalization rate by sex in the regions, a significant increase in male hospitalizations was identified in the North (AAPC: 3.5; 95% CI: 0.6 to 6.4) and Northeast (AAPC: 1.9; 95% CI: 0.4 to 3.4) regions, with no change for females. Conversely, there was a reduction in the annual average of hospitalizations for females in the Southeast (AAPC: -3.6; 95% CI: -4.4 to -2.2) and South (AAPC: -3.3; 95% CI: -4.4 to -2.2) regions, without significant changes for males. The Central-West region was the only one that showed a significant drop in the annual hospitalization rate for both females (AAPC: -3.1; 95% CI: -4.3 to -1.8) and males (AAPC: -1.1; 95% CI: -1.7 to 0.5) (Table 2).

Table 2. Hospitalization rates related to DM complications* in Brazilian regions according to sex, 2000 to 2018. Fortaleza-Ceará-Brazil, 2020.

Region	APC1† (95%CI)††	IP‡	APC2§ (95%CI)††	IP‡	APC3|| (95%CI)††	IP‡	APC4¶ (95%CI)††	AAPC** (95%CI)††
North								
Female	-1.9 (- 6.9; 3.3)	2005	10.5‡‡ (5.9; 15.4)	2011	-3.5‡‡ (-5.7; -1.4)			1.4 (-0.6; 3.4)
Male	-0.6 (-3.9; 2.8)	2006	19.0‡‡ (0.1; 41.4)	2009	1.5‡‡ (0.2; 2.8)			3.5‡‡ (0.6; 6.4)
North East								
Female	-3.9‡‡ (-7.5; -0.2)	2005	8.9‡‡ (5.3; 12.6)	2011	-4.3‡‡ (-6.1; -2.4)			0.0 (-1.5; 1.6)
Male	-2.7‡‡ (-5.0; -0.4)	2006	14.7‡‡ (7.8; 22.1)	2010	-0.6 (-1.7; 0.6)			1.9‡‡ (0.4; 3.4)
Southeast								
Female	-4.0‡‡ (-4.6; -3.3)	2007	-1.1 (-6.6; -4.8)	2010	-4.1‡‡ (-4.8; -3.5)			-3.6‡‡ (-4.4; -2.7)
Male	-3.2‡‡ (-4.2; -2.3)	2007	4.6 (-3.0; 12.8)	2010	-2.7 (-9.6; 4.8)	2013	0.2 (-1.4; 1.9)	-0.9 (-2.5; 0.7)
Midwest								
Female	3.1‡‡ (1.1; 5.1)	2006	-1.4 (-6.4; 3.9)	2010	-8.2‡‡ (-9.4; -7.0)			-3.1‡‡ (-4.3; -1.8)
Male	2.7‡‡ (1.9; 3.5)	2010	-5.7‡‡ (-6.6; -4.7)					-1.1‡‡ (-1.7; -0.5)
South								
Female	-4.5‡‡ (-7.6; -1.3)	2004	1.8 (-1.5; 5.1)	2009	-5.4‡‡ (-6.4; -4.5)			-3.3‡‡ (-4.4; 2.2)
Male	-1.9 (-4.4; 0.7)	2004	4.2‡‡ (1.7; 6.8)	2009	-2.2‡‡ (-2.8; -1.5)			-0.4 (-1.2; 0.5)

*DM – Diabetes Mellitus; †APC1 – Annual Percentage Change 1; ‡IP – Inflection Point (year in which the line segment changes); §APC2 – Annual Percentage Change 2; ||APC3 – Annual Percentage Change 3; ¶APC4 – Annual Percentage Change 4; **AAPC – Average Annual Percentage Change; ††95%CI – 95% Confidence Interval; ‡‡ p<0.05.
Source: research data.

By analyzing hospitalization rates by age groups across the country, we identified a significant drop in the annual average of hospitalizations for complications related to DM in individuals up to 59 years old (AAPC: -1.4; 95% CI: -2.2 to -0.6), from 60 to 79 years old (AAPC: -3.2; 95% CI: -4.1 to -2.4), and in those over 80 years old (AAPC: -2.4; 95% CI: -3.5 to -1.3) (Table 3).

Table 3. Hospitalization rates related to DM complications* by age group, 2000 to 2018. Fortaleza-Ceará-Brazil, 2020.

Range Age	APC1† (95%CI)**	IP‡	APC2§ (95%CI)**	IP‡	APC3‖ (95%CI)**	AAPC¶ (95%CI)**
0 -59 years	-2.8†† (-3.9; -1.7)	2006	3.3 (-0.1; 6.7)	2010	-2.6†† (-3.3; -1.9)	-1.4†† (-2.2; -0.6)
Older adults aged 60 - 79	-4.0†† (-5.1; -2.8)	2006	3.6 (-0.0; 7.3)	2010	-6.0†† (-6.7; -5.2)	-3.2†† (-4.1; -2.4)
80 years and over (long-lived)	-3.0 (-6.9; 0.9)	2004	3.1†† (1.2; 5.0)	2011	-7.4†† (-8.7; -6.1)	-2.4†† (-3.5; -1.3)

*DM – Diabetes Mellitus; †APC1 – Annual Percentage Change 1; ‡IP – Inflection Point (year in which the line segment changes); §APC2 – Annual Percentage Change 2; ||APC3 – Annual Percentage Change 3; ¶AAPC – Average Annual Percentage Change; **95%CI – 95% Confidence Interval; ††p<0.05.
Source: research data.

Evaluating the rates in Brazilian metropolitan areas by region (Table 4), among the capitals in the North region, only Rio Branco showed a significant decrease of 4.3%/year (95% CI: -5.5 - -0.9). Of the nine capitals in the Northeast region, Fortaleza was the only one with a significant decrease (AAPC: -3.7; 95% CI; -4.9 - -2.5).

Table 4. Hospitalization rates related to DM complications* in Brazilian women living in capitals of the North and Northeast regions, 2000 to 2018. Fortaleza-Ceará-Brazil, 2020.

Capitals	APC1† (95%CI)††	IP‡	APC2§ (95%CI)††	IP‡	APC3|| (95%CI)††	IP‡	APC4¶ (95%CI)††	AAPC** (95%CI)††
North region								
Porto Velho	-19.3‡‡ (-27.8; -9.7)	2005	39.8‡‡ (8.5; 80.2)	2009	-10.9‡‡ (-14.3; -7.3)			-4.2 (-9.7; 1.8)
Rio Branco	-4.3‡‡ (-5.5; -3.1)							-4.3‡‡ (-5.5; -3.1)
Manaus	-22.4 (-44.0; 7.5)	2003	6.9‡‡ (4.5; 9.4)					1.4 (-3.8; 6.8)
Boa vista	21.7 (-2.3; 51.6)							21.7 (-2.3; 51.6)
Belém	-3.3 (-7.5; 1.2)	2006	21.2 (-4.8; 54.3)	2009	-1.4 (-3.3; 0.5)			1.4 (-2.5; 5.5)
Macapá	-6.7 (-16.4; 4.2)	2006	19.4 (-0.2; 42.8)	2011	-15.2‡‡ (-20.8; -9.2)			-3.7 (-9.3; 2.2)
Palmas	9.0‡‡ (5.5; 12.6)	2014	-13.3 (-26.3; 2.0)					3.6 (-0.5; 7.8)
Northeast Region								
São Luís	-8.4‡‡ (-14.9; -1.5)	2007	24.3 (-28.9; 117.4)	2010	-1.7 (-6.5; 3.3)			-0.6 (-9.0; 8.7)
Teresina	-5.0 (-15.4; 6.7)	2004	15.0‡‡ (7.5; 23.1)	2010	-12.0‡‡ (-15.2; -8.7)			-2.1 (-5.4; 1.2)
Fortaleza	-3.7‡‡ (-4.9; -2.5)							-3.7‡‡ (-4.9; -2.5)
Natal	-6.8 (-25.4; 16.2)	2006	52.1 (-11.4;161.0)	2010	2.0 (-4.0; 8.4)			8.2 (-4.8 ;22.9)
João Pessoa	-2.8 (-14.0; 10.0)	2006	60.9 (-6.2; 176.2)	2009	-4.4‡‡ (-7.6; -1.0)			4.9 (-4.1; 14.7)
Recife	-4.4 (-10.3; 2.0)	2006	24.7 (-14.0; 80.9)	2009	-4.2‡‡ (-6.9; -1.4)			0.1 (-5.7; 6.2)
Maceió	-7.7‡‡ (-11.6; -3.6)	2008	32.7‡‡ (12.8; 56.1)	2012	-9.0‡‡ (-13.4; -4.5)			-0.4 (-4.3; 3.6)
Aracaju	1.3 (-0.6; 3.3)							1.3 (-0.6; 3.3)
Salvador	-15.0‡‡ (-17.5;-12.5)	2006	24.9‡‡ (3.2; 51.1)	2009	14.0‡‡ (9.1; 19.0)	2014	-4.6‡‡ (-8.2; 0.9)	0.8 (-2.2; 4.0)

*DM – Diabetes Mellitus; †APC1 – Annual Percentage Change 1; ‡IP – Inflection Point (year in which the line segment changes); §APC2 – Annual Percentage Change 2; ||APC3 – Annual Percentage Change 3; ¶APC4 – Annual Percentage Change 4; **AAPC – Average Annual Percentage Change; ††95%CI – 95% Confidence Interval; ‡‡ p<0.05.
Source: research data.

In the Southeast region, Vitória showed a significant increase in the average hospitalization for DM of 9% per year (95% CI: 5.7 - 12.5), being the only capital city in the country to show an increase. In the South region, only Curitiba showed a decrease of 5.8% per year (95% CI: -7.8 - -3.7). In the mid-west of the country, Goiânia showed a decrease of 18.4% per year (95%CI: -28.7 - 3.7), which was the most significant decrease in the whole country (Table 5).

Table 5. Hospitalization rates related to DM complications* in the Brazilian capitals of the Southeast, South and Midwest regions, 2000 to 2018. Fortaleza-Ceará-Brazil, 2020.

Capitals	APC1† (95%CI)††	IP‡	APC2§ (95%CI)††	IP‡	APC3‖ (95%CI)††	IP‡	APC4¶ (95%CI)††	AAPC** (95%CI)††
Southeast								
Belo Horizonte	-3.8‡‡ (-7.2; -0.2)	2006	15.6 (-5.7; 41.8)	2009	-2.7 (-8.1; 3.1)	2014	9.6‡‡ (3.9; 15.6)	2.4 (-1.1; 6.1)
Vitória	9.0‡‡ (5.7; 12.5)							9.0‡‡ (5.7; 12.5)
Rio de Janeiro	-10.2 (-21.1; 2.1)	2003	-1.9‡‡ (-3.1; -0.7)					-3.3‡‡ (-5.4; -1.2)
São Paulo	-2.7‡‡ (-4.7 -0.7)	2006	4.0‡‡ (0.2; 8.0)	2011	-5.6 (-11.1;0.1)	2015	3.2 (-2.8; 9.5)	-0.6 (-2.3; 1.2)
South								
Curitiba	-20.7‡‡ (-25.9; -15.2)	2005	0.7 (-1.4; 2.9)					-5.8‡‡ (-7.8; -3.7)
Florianópolis	-0.2 (-2.0; 1.6)							-0.2 (-2.0; 1.6)
Porto Alegre	-2.6 (-5.5; 0.3)	2006	15.8 (-1.8; 36.5)	2009	-2.4‡‡ (-3.8;-1.0)			0.3 (-2.3; 3.1)
Midwest								
Campo Grande	-10.9‡‡ (-14.5; -7.2)	2007	14.8 (-18.0;60.6)	2010	-5.2 (-18.5;10.3)	2014	12.0‡‡ (2.6; 22.2)	-0.9 (-6.6; 5.2)
Cuiabá	10.0‡‡ (6.5; 13.7)	2011	-12.2‡‡ (-17.8; 6.3)					0.8 (-2.2; 3.8)
Goiânia	5.0‡‡ (3.5; 6.5)	2007	-81.8‡‡ (-92.4;56.4)	2010	15.0‡‡ (4.7; 26.3)			-18.4‡‡ (-28.7;-6.6)
Brasília	1.5 (-1.6; 4.7)	2008	-5.0‡‡ (-7.1; -2.9)					-2.2‡‡ (-3.8; -0.5)

*DM – Diabetes Mellitus; †APC1 – Annual Percentage Change 1; ‡IP – Inflection Point (year in which the line segment changes); §APC2 – Annual Percentage Change 2; ||APC3 – Annual Percentage Change 3; ¶APC4 – Annual Percentage Change 4; **AAPC – Average Annual Percentage Change; ††95%CI – 95% Confidence Interval; ‡‡ p<0.05.
Source: research data.

3 Discussion

The number of hospitalizations due to complications from DM in the Brazilian health system is significantly influenced by the rapid demographic transition, which impacts the epidemiological landscape, imposes a high care burden, and necessitates the planning of actions to control the progression of this chronic condition and its complications, with care models tailored to its specificities (Salci; Meirelles; Silva, 2017).

This study found a reduction in hospitalization rates due to DM across Brazil. This trend indicates that Brazil has been aligning with international best practices by eliminating barriers and expanding access to primary health services (Pedraza *et al*., 2017; Borges; Lacerda, 2018). Additionally, research describes an increase in the coverage of the Family Health Strategy (FHS) and investments in regions that showed a decline in hospitalization trends in this study (Rosa *et al*., 2018; Neves *et al*., 2018).

Recent studies point to a strong correlation between hospitalization rates and FHS coverage (Arruda; Schmidt; Marcon, 2018; Moreschi *et al*., 2018). PHC population coverage increased by 108% between 1998 and 2010. Considering Brazil's vast territorial and administrative divisions, this increase in coverage represents a reorientation of Primary Health Care (PHC) and a progressive overcoming of barriers to accessing health services (Borges; Lacerda, 2018).

The inclusion of DM in the Ambulatory Care Sensitive Conditions (ACSC) group promotes effective action by Primary Health Care (PHC) professionals and managers, leading to a reduction in hospitalizations and deaths associated with DM, primarily by preventing its micro and macrovascular complications (Arruda; Schmidt; Marcon, 2018). Identifying weaknesses in the care provided to people with diabetes in PHC and ensuring continuous and sustained care are crucial for the success of public health policies and care for individuals with this disease.

In this context, nurses play a vital role in strengthening health promotion and care actions and are prominent in the execution and implementation of programmatic care within the Family Health Strategy (FHS). The actions of primary care health teams significantly reduce episodes of hypo- or hyperglycemia, which can lead to common complications in people with DM (Ferreira; Périco; Dias, 2018). Notably, stratifying this rate revealed different patterns.

The hospitalization rate by sex showed heterogeneous characteristics across regional extracts. Sex has been identified as a factor influencing the behavior and attitude of individuals who need to adopt healthy habits. Studies on people with DM have shown that women tend to have worse outcomes related to glycemic and lipid control, while men demonstrate poorer behaviors related to foot care (Rossaneis *et al*., 2016; Eid *et al*., 2018). However, there is insufficient evidence linking the occurrence of these DM complications exclusively to sex.

The hospitalization rates by age group found in this study differ from those in research conducted with older adults in Paraná (Gerhardt *et al*., 2016) and Maranhão (Soeiro *et al*., 2019), which showed that as individuals age, the annual increase in hospitalizations is greater. This trend is generally attributed to physiological changes associated with aging or may reflect complications arising from the duration of the disease (Nunes *et al*., 2019). However, it is important to note that the literature indicates that legal provisions have been strengthening healthy aging (Minayo; Firmo, 2019) and improving the health care model for older adults (Veras; Oliveira, 2018).

Among the metropolises in the North region, only Rio Branco showed a reduction in hospitalization rates. Literature indicates that the capitals in this region have the poorest rates of health service utilization in the country, with a low availability of doctors (1.0 doctor per 1,000 inhabitants), which is seven times lower than the rate in the capitals of the South region (7.0 doctors per 1,000 inhabitants). Analysis of health regions in capital cities reveals a low Human Development Index (HDI) in 46% of them, highlighting the need for more institutionalized policies to eliminate barriers to accessing primary services (Garnelo *et al*., 2018).

In the Northeast region, Fortaleza showed a downward trend in hospitalization rates, consistent with a study conducted over a shorter period (Santos *et al*., 2014). Fortaleza experienced cycles of increasing FHS coverage between 2006 and 2008, although this trend did not continue in subsequent years. In 2014, Fortaleza had the lowest percentage of coverage by family health teams (42%), corresponding to 1,072,950 inhabitants. This low coverage percentage led to the establishment of the Fortaleza Municipal Health Plan, which aimed to expand the number of complete FHS teams. This expansion likely contributed to the reduction in hospitalizations for DM-related complications in later years (Alves *et al*., 2018).

In the Southeast region, Vitória showed significant growth in the hospitalization rate for complications related to diabetes, despite having the highest number of doctors per inhabitant in Brazil (almost 12 doctors per 1,000 inhabitants) (Oliveira *et al.*, 2017). This data suggests that merely increasing the number of doctors is insufficient to reduce disease rates in the population; instead, the involvement of the entire multidisciplinary team is crucial.

In the South region, Curitiba was the capital with the greatest reduction in the hospitalization rate, strongly correlated with the expansion of the FHS (Arruda; Schmidt; Marcon, 2018). This increase in coverage reflects the progress of the PHC reorientation process and the capital's commitment to decentralizing health care as an organizational model. Through regionalization, access and efficiency of health care networks are enhanced (Facchini; Tomasi; Dilélio, 2018).

Goiânia had the most significant drop in hospitalizations among all Brazilian capitals. The data show that the metropolis achieved over 75% FHS coverage in the dependent population (Neves *et al.*, 2018), despite notable inequalities between health districts and weaknesses in its care model (Magalhães; Morais Neto, 2017). Nonetheless, FHS coverage data confirms a positive impact on reducing hospitalization rates related to DM complications.

Among the limitations of this study, the use of secondary data (SIH/SUS), which covers 75% of the population with DM in Brazil, should be noted. However, this data source is effective in terms of ease of access, enabling continuous assessment of the population's health indicators. indicators.

Conclusion

In conclusion, Brazil experienced a reduction in hospitalization rates, with particular emphasis on the Central-West region, which exhibited the most significant decrease. Analysis of hospitalizations by region according to sex revealed relative variability, with females showing higher reduction rates. Moreover, there were notable reductions observed in the older adult group, particularly among the oldest-old individuals. Among the capitals, a significant stationary trend was observed, with a noteworthy increase observed in Vitória and a more substantial reduction in Goiânia.

The findings of this research hold significant potential to inform the planning and implementation of preventive actions targeting complications related to diabetes. Given that diabetes is highly sensitive to primary health care (PHC) interventions, and its hospitalization rate is intricately linked to the effectiveness of primary health services, these results underscore the importance of prioritizing preventive measures within PHC settings. By leveraging these insights, healthcare policymakers and practitioners can develop targeted strategies aimed at reducing the burden of diabetes-related complications and improving overall health outcomes for affected individuals.

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