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Fall accidents in older people: a time trend analysis of the period 2000-2020 and the estimated economic burden on the Brazilian health system in 2025

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Abstract *Longitudinal monitoring of indicators of accidental falls can facilitate the planning of effective care and prevention actions. This article aims to analyze temporal trends in variables related to falls among older persons in Brazil and in the state of São Paulo during the period 2000-2020 and estimate the projected economic burden on the health system in 2025. We conducted a quantitative retrospective observational study using data from the Health Information System. The Joinpoint Regression Program version 4.7.0 and SPSS version 20.0 were used to perform linear regression and calculate the Average Annual Percent Change (AAPC), adopting a 95% confidence interval. There was an increase in mean and total admissions costs due to falls at national level in both intervals of the study period. There was an increase in total admissions costs and the total number of admissions due to falls in the state of São Paulo (AAPC of 8.5% and 4.3%, respectively). Projections for the year 2025 suggest that the total number of admissions due to falls in Brazil will be around 150,000, resulting in costs of approximately R$ 260 million. There was an increase in the variables analyzed by this study, revealing the importance of fall prevention programs associated with national public policies.*
Key words *Falls accidents, Health costs, Elderly health*

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Introduction

Falls in older people are a major public health problem because they can result in a decline in functional capacity and impaired mobility. These problems can be exacerbated if the fall results in fractures, hospital admission, the need for surgical interventions, and pulmonary complications[1]. Declining functional capacity in older people can hamper independence and autonomy, demanding greater care from family members, formal caregivers, and the state, and often resulting in institutionalization or even death[1-3].

The prevalence of falls is considered a key indicator for monitoring healthy aging in different countries[4,5]. In the United States there were 24,190 fatal falls and 3.2 million fall injuries in 2012. Direct medical costs totaled $616.5 million for fatal falls and $30.3 billion for non-fatal injuries, rising to $637.5 million and $31.3 billion, respectively, in 2015[5]. These figures reveal the economic impact of falls and the consequences for the health system.

A descriptive study of temporal trends in deaths due to falls in the Federal District between 1996 and 2017 showed that there were 2,828 deaths, 54.2% of which were among females and 45.8% males. The findings also show that the number of deaths due to falls increased, being more frequent in hospital settings and individuals aged 80 years and over[6].

The Brazilian Longitudinal Study of Aging (ELSI-Brasil) found that 25.1% of 4,533 older persons suffered a fall between 2015 and 2016, with 1.8% of falls resulting in a hip or femur fractures, 31.8% of which required surgery for prosthesis placement[7]. Based on the study findings, assuming an urban population of older persons of 25 million, the authors estimated that approximately 6.2 million older people in Brazil had fallen in the last year[7]. This generates a burden on the health system due to hospital admissions, hospital stays, and the need for long-term care for older fallers. Brazil's public health system, the *Sistema* Único *de Saúde* (SUS) or Unified Health System, spent more than R$1 billion on admissions of older persons for femur fractures between 2002 and 2016[8], revealing the need for integrated fall prevention actions at local, state, and federal level.

Data by region show that the prevalence of falls is highest in the Southeast (Minas Gerais, Rio de Janeiro, and São Paulo). Fall prevalence in this region by age group is as follows: 60-69 years (26.1%), 70-79 years (32.4%), and 80 years and over (38.1%), compared to a national overall rate of 27.6%[9]. Another study showed that the rate of admissions due to falls in São Paulo (51.83%) was higher than in other cities. The findings also showed an increase in both admissions and deaths due to a fall, reinforcing the need to investigate the particularities of the state[10].

It is therefore important to investigate the epidemiology of fall accidents among the older population and its relationship with data indicating the economic burden of this problem to the health system (admissions due to falls, admissions for femur fractures, length of hospital stay, number of falls, etc.) in order to produce indicators to measure the effectiveness of fall prevention actions developed under the National Health Care Policy for Older Persons[11].

The aim of this study was to analyze temporal trends in admissions and deaths due to falls among the older population in Brazil and the state of São Paulo, calculate the costs of admissions during the period 2000-2020, and estimate the projected economic burden for the SUS in 2025.

Methods

We conducted a retrospective quantitative observational study using data collected in November 2021 from the national health information system. The study did not require ethical approval as it was conducted using exclusively secondary data available in the public domain.

We used data from the SUS's Department of Informatics (DATASUS), more specifically, the Hospital Information System (SIH/SUS). The data were collected for the periods 1998-2007 and 2008-2020 due to changes to the platform brought about by the implementation of the Table of Procedures, Medications, Orthotics and Prostheses, and Special Materials of the Unified Health System in accordance with Ministerial Order 321 issued in 2007[12]. The two different trajectories were: Health information (TABNET) > Epidemiological and Morbidity > External causes by place of admission - 1998-2007 > Brazil by Region and State; Health information (TABNET) > Epidemiological and Morbidity > External causes by place of admission - from 2008 > Brazil by Region and State (*Ministério da Saúde*)[13].

The study period was January 2000 to December 2020, during which several key health policies were created, including the National Policy for Older Persons, which emphasizes the im-

portance of monitoring health indicators among this population. The Policy divides older persons into the following age groups: 60-69 years, 70-79 years, and 80 years and over.

Data on admissions in the code range for Slipping, tripping, stumbling and falls (International Classification of Diseases - ICD-10, W00-W19) were derived from general data on admissions of adults aged 60 years and over. The following information was extracted: Admissions (inpatient hospital authorizations, or IHAs, approved during the period); Total admissions costs during the period; mean length of hospital stay; deaths due to falls; and mean cost per admission (Table 1).

IHAs contain key data on the patient, procedures and tests performed, justification for hospitalization, initial diagnosis, ICD-10 code, requested procedures, among other factors. Total admissions costs were inflation-adjusted based on the National Consumer Price Index (IPCA). Admissions costs did not include budget resources or equipment costs.

Data analysis

Statistical analysis was performed using SPSS version 20.0, adopting a significance level of 0.05. A descriptive statistical analysis was performed to determine the prevalence of admissions and deaths from fall accidents during the study period. Mean admissions costs were calculated by dividing total admissions costs by the total number of admissions.

An annual temporal analysis was performed of the number of admissions and deaths over the period 2000-2020. Regression analysis was carried out using the Joinpoint Regression Program version 4.7.0 to calculate the annual percentage rate change, adopting a 95% confidence interval. Average Annual Percent Change (AAPC) was calculated based on the cumulative geometric mean of annual percentage change (APC) using equal weighting for the length of each segment during the fixed interval. Level of significance was measured using the Monte Carlo permutation test and based on the calculation of the annual percentage change of the ratio using the logarithm of the ratio[14,15].

Linear regression was performed for each variable to observe growth in the number of falls over the years and estimated future rates. The economic burden of admissions for the SUS in 2025 was estimated based on the slope coefficient of the linear regression of length of stay and cost de admissions multiplied by the period of time (five years).

Results

Table 1 shows the epidemiological data on falls accidents collected from DATASUS (*Ministério da Saúde*)[13]. The results of the linear regression show a significant increase in the number of admissions due to falls and associated health costs over the period in Brazil and the state of São Paulo (Table 2). Scatter plots of the number of admissions and total and mean admissions costs reveal a linear distribution (Figure 1).

Based on the study findings, it is estimated that the total number of admissions due to falls in the country in 2025 will be around 150,000 and that total admissions costs will amount to R$260 million. It is also important to highlight that, while average hospital stay remained stable over the study period (between 6 and 7 days), mean admissions costs more than doubled. The data for the state of São Paulo followed the same pattern.

Temporal analysis (Brazil)

Table 3 shows temporal trends in the distribution of the epidemiological data, revealing a significant increase in admissions due to falls in the two periods analyzed by this study (2000-2008 and 2008-2020). The findings show an increase in total admissions costs across all segments. Mean admissions costs showed a significant increase in both periods (p-value≤0.001). The AAPC over the period 2000-2020 was 4.4%. There was a significant increase in the number of deaths over the period 2000-2020 (AAPC 5.5%, p≤0.001).

Temporal analysis (state of São Paulo)

There was a significant increase in admissions due to falls in the State of São Paulo over the period 2000-2020, with an AAPC of 4.3% (Table 4). There was a significant increase in AAPC for total and mean admissions costs over the period (8.5% and 4.3%, respectively). Finally, the number of deaths also showed a significant AAPC of 5.5% over the study period.

Table 1. Epidemiological data on fall accidents among older persons presented in five-year periods.

Local	Variable	2000	2005	2010	2015	2020
Brazil	Admissions (IHAs)	51,193	61,368	79,524	102,102	128,013
	Total costs (R$ IHA)	37,253,897	65,287,236	102,959,288	151,039,368	212,356,306
	Mean length of hospital stay (days)	6.4	6.5	6.4	6.8	5.9
	P-value/admission (R$ mean)	728	1,064	1,295	1,479	1,787
	Total number of deaths	2,156	2,666	3,838	5,198	6,385
São	Admissions (IHAs)	16,864	20,045	26,612	29,481	34,830
Paulo	Total costs (R$ IHA)	13,315,068	21,164,910	33,629,293	45,316,799	62,253,437
	Mean length of hospital stay (days)	5.8	5.7	5.9	6.4	5.5
	P-value/admission (R$ mean)	790	1,056	1,264	1,537	1,658
	Total number of deaths	874	1,013	1,456	1,792	2,317

Notes: *IHA = Inpatient Hospital Authorization.

Source: Hospital Information System (SIH/SUS).

Table 2. Summary of liner regression.

	Variable	R^2	Annual percentage change	P-value
Brazil	Admissions (IHAs)	0.941	4,199	<0.001
	Total number of deaths	0.954	240	<0.001
	Total costs (R$ IHA)	0.961	9,122,195.44	<0.001
	P-value/admission (R$ mean)	0.990	49.20	<0.001
São Paulo	Admissions (IHAs)	0.972	1,043	<0.001
	Total number of deaths	0.955	86	<0.001
	Total costs (R$ IHA)	0.980	2,595,418.42	<0.001
	P-value/admission (R$ mean)	0.979	45.62	<0.001

Notes: *IHA = Inpatient Hospital Authorization.

Source: Hospital Information System (SIH/SUS).

Discussion

The findings reveal a significant increase in the number of falls and deaths and costs during the period 2000-2020, together with a projected increase up to 2025 if effective prevention policies and interventions are not implemented. The number of admissions due to falls increased by 5.1% per year. This increase has also been observed in other countries, reinforcing that in the absence of preventive measures numbers are set to escalate alarmingly in the coming years.

Advances in technology and medicine have contributed to a fall in fertility rates and an increase in life expectancy, resulting in the phenomenon of population aging[16]. Today it is estimated that there are around 1 billion older persons worldwide and 28 million in Brazil[17]. While this is a global phenomenon, as a developing country Brazil does not have the capacity to meet the demands of a growing 60-and-over population, resulting in individual changes that lead to health problems, including fall accidents[18]. The data show a relationship between population aging and an increase in falls[16].

It is important to note that cost increases and inflation contributed to the overall increase in total and mean admissions costs. When the mean admission cost in 2000 is inflation-adjusted using the consumer price index the amount is R$ 3,101.72. This amount is almost twice that in 2019, suggesting a reduction in investment in senior care and fall prevention. Nevertheless, there was an increase of 9.6% per year in the overall cost of admissions due to falls in Brazil[19].

The temporal analysis also reveals a number of trends across different periods. It is important to highlight that costs of falls may be underesti-

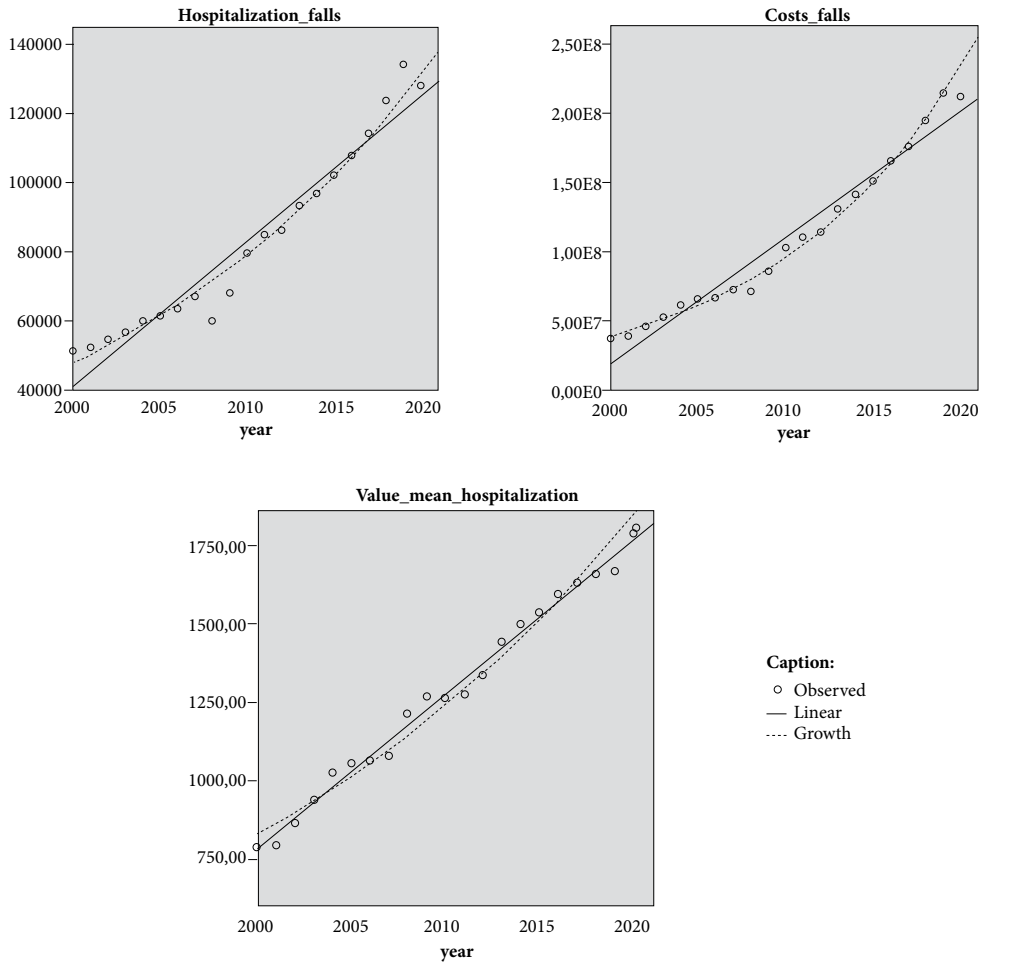

Figure 1. Scatter plot of the number of admissions and total and mean admissions costs.

Source: Authors.

mated because not all falls result in hospitalization. In this respect, studies show that the prevalence of falls varies between 25% and 30% and that falls can involve unreported costs associated with out-of-hospital treatment[20].

The admissions rate per 100,000 population in Brazil is similar to that in other developing countries such as China, Kuwait, and Thailand[21-23]. However, rates are almost half those in developed countries such as the Netherlands and Poland[24,25]. This may be explained by the difference in the proportion of the population aged over 60 between countries, as older age is a risk factor for falls and admissions due to falls[26].

The number of deaths due to falls rose constantly throughout the study period, with an APC of 6.4%. This rate was 5.5% in the state of São Paulo, which is consistent with the findings of recent studies. The findings of a study conducted by Abreu *et al.*[10] of the period 1996-2012 show that there were 941,923 admissions and 66,876 deaths due to falls among people aged 60 years and over in Brazil, with 32.3% of deaths and 21.2% of admissions occurring in state capitals. The results also point to a growing trend in rates of admissions and deaths due to falls in state capitals, with a 200% increase in mortality (from 1.25 to 3.75 per 10,000 population), and a sharp rise in admission rates, from 2.58 to 41.37 per 10,000 population[10]. These findings point to a need for changes to health services in the country, given that falls can have serious consequences, such as

Table 3. Temporal trends in the distribution of total and mean admission costs, number of admissions and deaths, and mean length of hospital stay in days due to falls in Brazil during the period 2000-2020.

	Seg.	First year	Final year	AAPC
Number of admissions	1	2000	2008	5.1*
	2	2008	2020	
Total admission costs	1	2000	2004	9.6*
	2	2004	2008	
	3	2008	2011	
	4	2011	2020	
Mean admissions costs	1	2000	2004	4.4*
	2	2004	2020	
Mean length of hospital stay	1	2000	2003	-0.3
	2	2003	2009	
	3	2009	2017	
	4	2017	2020	
Number of deaths	1	2000	2020	6.4*

Notes: Seg.: Segment; First year: first year of the segment; Final year: final year of the segment; AAPC: Average Annual Percent Change. *Statistically significant (5% significance level).

Source: Authors.

Table 4. Temporal trends in the distribution of total and mean admissions costs, number of admissions and deaths, and mean length of hospital stay in days due to falls in the state of São Paulo during the period 2000-2020.

	Seg.	First year	Final year	AAPC
Number of admissions	1	2000	2020	4.3*
Total admissions costs	1	2000	2010	8.5*
	2	2010	2020	
Mean admissions costs	1	2000	2004	4.3*
	2	2004	2014	
	3	2014	2020	
Mean length of hospital stay	1	2000	2011	-0.2
	2	2011	2016	
	3	2016	2020	
Number of deaths	1	2000	2002	5.5*
	2	2002	2020	

Notes: Seg.: Segment; First year: first year of the segment; Final year: final year of the segment; AAPC: Average Annual Percent Change. *Statistically significant (5% significance level).

Source: Authors.

femur fractures. One measure adopted by health professionals is early mobilization to stimulate mobility after a surgical intervention. The adoption of this approach has been associated with a reduction in mortality within 6 to 12 months after sustaining the fracture, with lower mortality rates in individuals who walk within 10 days after surgery[27].

Another important finding reported by Abreu *et al.*[10] is that São Paulo had one of the highest rates of admissions (51.83%). This may be related to the fact that the number of falls and associated costs are highest in the South and Southeast. This may explain the small difference in the rate of increase across the variables. At national level, the number of deaths due to falls increased by 3.7%, compared to 3.6% in São Paulo. These results reinforce the need for further research in this area[10,27].

One of the indicators used to assess the safety and quality of health care for older persons in Australia is the number of falls in long-term care facilities or hospitals divided by the number of total admissions[28]. Efforts are therefore made to monitor accidental falls among older persons to ensure high-quality care.

As mentioned above, trends in falls and costs of admissions in São Paulo were similar to national trends over the study period, showing the urgent need to implement low-cost fall prevention programs in primary care services, train health professionals to assess risk factors for falls, and promote fall education for older persons, family members, and caregivers. In this respect, Winser *et al.*[29] found that physical activity-based interventions have the best benefit-to-cost ratio for fall prevention in older persons. This is due to the low cost of implementing these programs, as, interventions can be implemented independently at home using simple low-cost equipment after training and the familiarization of older persons[29]. Furthermore, in a systematic review of studies involving individuals aged 80 years and over, Davis *et al.*[30] showed that home-based strength and balance interventions were the most cost effective form of fall prevention.

In general, multifactorial programs combining physical exercise, medication adjustment, education, home adaptations, and other interventions are less cost effective due to the high cost and relatively low real impact on fall reduction[31]. However, individualized multifactorial programs are essential for fall prevention, especially for frail fallers. It is important to highlight that the SUS already has multiprofessional health care teams, meaning that additional spending on human resources would not be necessary to implement these types of programs. New research to

monitor the long-term costs of these monitoring programs for elderly fallers is urgent to promote fall prevention in Brazil. Primary care services play an important role in fall prevention and in the management and implementation of these interventions for both frail and stronger fallers, reducing adverse fall outcomes such as admissions, fractures, and deaths.

When implementing fall prevention actions, it is important to consider key information on the socioeconomic status of older persons. Recent studies show that fallers are mostly retired women, due to the feminization of old age, with a low level of education (between 1 and 4 years of schooling). Other important factors include age, with chances of suffering a fall increasing with age, and comorbidities, with the likelihood of falling increasing with increasing number of conditions. This pattern can also be seen in relation to fragility, with each point on the frailty scale increasing the chances of falling[26]. In addition, older persons with low incomes tend to have poorer access to health services[32].

The factors mentioned above require an alternative approach to health care for older persons, focusing on prevention and health promotion. Fall accidents have an extremely negative impact on older persons and the health system, including high care costs, various social problems, and overburdening of health services. These factors underscore the need to establish groups, gain a comprehensive understanding of falls, and take an interdisciplinary approach to prevention, considering that these accidents are influenced by multiple factors[33].

Fall prevention interventions should be evidence-based to ensure the efficient use of public resources and promote a real impact on the health of older persons. It is therefore important to develop studies in Brazil of fall prevention programs and their impact on costs. Furthermore, there is a need to develop indicators that demonstrate the real situation and enable this type of analysis. Finally, prevention and monitoring programs should also analyze modifiable fall risk factors that go beyond balance and muscle strength. Some of these factors, such as fear of falling and vitamin D deficiency, can result in an increase in the utilization of health services, hospitalization, and the development of new problems, including depression, anxiety, and frailty syndrome.

To this end, greater attention needs to be given to DATASUS and data feeding, which requires the commitment of professionals across all spheres of health to ensure the generation of reliable data[34,35].

In a study published in 1994, Veras et al. reported a low level of reliability of data on certain variables, including the primary diagnosis and auxiliary diagnostic and therapeutic services[36]. In a study conducted in 2000, contrary to expectations, Mendes *et al.*[37] concluded that the SIH was a high quality disease surveillance platform with great potential for improvement, provided certain modifications were made and professionals used it on a constant basis. Similarly, as study[38] undertaken in 2016 confirmed that, while the completion rate for the fields "procedure performed", "primary diagnosis", and "secondary diagnosis" was inadequate, the completion of basic hospital registration information fields was comprehensive and consistent. In addition, the SIH has exceeded 100% admissions coverage[38].

However, a study by Piccolo[39] found only seven studies on the quality data such as infant mortality, live births, and vital statistics made available on the DATASUS platform, suggesting improvements in records over time and a limited number of studies that effectively evaluate the quality of available data[39].

One of the limitations of this study is therefore the use of data from the SIH-SUS and the fact that we only examined relationships between variables and time. Furthermore, there are few records of accidents that do not result in hospitalization or more serious consequences, meaning it was not possible to investigate these events. Future research should seek to gain a more in-depth understanding of the relationship between falls and other variables of interest and potentially modifiable risk factors.

Conclusion

The number of admissions due to falls and total admissions costs increased over the period 2000-2020 at both national level and in the state of São Paulo. The results of the temporal trend analysis showed a significant increase across all areas assessed over the study period except length of hospital stay. Our findings reveal the need for increased investment in low-cost interventions in primary health care services and greater attention to fall prevention on the part of local and state health care managers. Without any change to patterns of growth, it is estimated that costs will amount to R$260 million in 2025. Finally, additional research is needed in Brazil to evaluate the

cost effectiveness of prevention interventions and programs using accurate data collected across the various spheres of health care.

Collaborations

ADC Novaes: contributing to article design, data collection, writing methodology and editing files for submission. OAFM Bianco: contributing to the article's design, data analysis, writing the methodology and editing the files for submission. DB Silva: contributing to article design, data analysis and article review. JH Ansai: contributing to the article's conception, writing the methodology and reviewing the article and other files for submission. LC Silva: contributing with the writing of the methodology and review of the article and other files for submission. EA Dotta: contributing with the writing of the methodology and review of the article and other files for submission. LRC Tavares: contributing to the article's design, writing the methodology and reviewing the article and other files for submission. K Gramani-Say: contributing to article design, methodology writing, analysis and review of the article and other files for submission. Each of the authors read and agreed with the content of the manuscript.

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