Mortality caused by accidental falls among the elderly: a time series analysis

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Abstract

Introduction: The worldwide increase in the elderly population has highlighted the importance of accidental falls and their consequences. *Objective:* To perform time-trend analysis of the mortality rate from accidental falls in (1) the city of Florianópolis (2) the state of Santa Catarina and (3) Brazil. *Method:* A time-series study of data from the Sistema de Informação sobre Mortalidade ("the Mortality Information System") was performed. The variation in mortality caused by accidental falls was estimated using the joinpoint regression method, based on the International Disease Classification (ICD-10), chapter XX, codes W00 to W15 and W17 to W19, from 1997 to 2010. *Results:* It was observed that in the most recent periods (2005/2008; 2002/2008; 2003/2008), there was a significant increase in mortality rates related to accidental falls in all three regions, and that these rates increased with advancing age. *Conclusion:* Strategies to prevent accidental falls among the elderly should be aimed, mainly, at those who are 80 and over, the age in which accidental falls result in higher death rates.

Key words: Accidental Falls; Elderly; Ecological Studies; Temporal Distribution; Mortality Rate; External Causes.

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INTRODUCTION

In the last century, the growth rate of the population older than 60 in Brazil has been significantly faster than in wealthier societies.[1] The country is growing progressively older at a faster and faster rate. Each year, 700,000 more elderly persons are incorporated into this segment of the age pyramid.[2] One result of this dynamic is the increased demand among the elderly for health services, resulting in more frequent hospitalizations, a greater bed occupancy time than other age groups, and a greater number of deaths among this group.[3]

The global increase in the elderly population has highlighted the importance of falls and their consequences, which are a frequent cause of loss of function, early admission to long term care facilities, and increased morbidity and mortality among the elderly.[4]

A fall is defined as an unintentional, unexpected change in position, which places the individual at a lower level than before, for example, on the furniture or the floor. This event is not the result of sudden paralysis, seizure or an external force.[5]

For these reasons, falls constitute a public health problem as, in addition to representing the sixth leading cause of death among the elderly,[6] they result in high morbidity and are among the leading causes of hospitalization among people aged 60 years or over.[7] Deaths caused by external causes represented, on average, 22.5% of deaths among the elderly in the state capitals of Brazil, between the period 1996 and 2005.[8]

In addition to causing fractures, falls have other consequences, such as a decreased quality of life, fear of walking and the loss of ability to perform tasks of daily life. About 5% of falls result in fractures and between 5% and 10% cause injuries which require medical care.[9,10]

The economic consequences of falls are also significant. Hospitalization or institutionalization results in increased costs for both health services and family members who must spend more on medication and care.[11]

In 2009 and 2010, a population-based study of 1,705 elderly persons in the city of Florianopolis, the capital of the state of Santa Catarina, found a prevalence of falls of 18.8%.[12] Considering the percentage found, and the relevance of the theme, the present study was undertaken in order to evaluate the trends in mortality from falls in Florianopolis, the state of Santa Catarina and Brazil.

METHOD

An ecological type study was performed using the Mortality Information System (MIS) database of DATASUS/Ministério da Saúde (the Ministry of Health).[13]

Information for people 60 years of age or older, of both genders, living in Brazil, in the state of Santa Catarina and in the city of Florianopolis was gathered. The state of Santa Catarina is located in the south of Brazil and in 2010 had 6,248,426 inhabitants, of whom 10.5% were aged 60 or more. Florianopolis is the capital of Santa Catarina, with a population of 421,240 inhabitants, of whom 11.5% are elderly.[14]

The collection of mortality data was based on the MIS database. Deaths arising from falls, whether identified as such in primary or secondary diagnosis, considered in the 10th revision of the International Classification of Diseases (CID-10) [15] codes W00 to W15 and W17 to W19 of Chapter XX – External causes of morbidity and mortality, were used.

Information on the number of elderly residents was obtained from the Instituto Brasileiro de Geografia e Estatística ("Brazilian Institute of Geography and Statistics") (IBGE). Data for the years 1997 to 1999 and 2001 to 2006 was calculated from preliminary estimates of population totals for inter-census years and stratified by age and gender by MS/SGEP/DATASUS. For the years 2007-2009, the figures refer to estimates prepared

as part of the UNFPA/IBGE Project (BRA/4/P31A) - Population and Development, Population Coordination and Social Indicators, while for the years 2000 and 2010, the values used were from the Demographic Census[16,17] of those years.

DATASUS data of both deaths and resident population was exported to *Microsoft Excel*® 2003, in which the annual mortality rates from falls, both crude and adjusted by age, were calculated to estimate trends in mortality.

Specific mortality rates from falls were calculated using the number of deaths from falls among the elderly in the area of interest in the given year, divided by the total population aged 60 or older in the same area and year, then multiplied by 100,000 (figure 1a).

The specific mortality rate from falls per 100,000 residents was calculated, as well as the specific mortality rate from falls for the age groups 60-69 years, 70-79 years and 80 years or older (figure 1b).

Next, the specific mortality rates from falls were standardized for age by the direct method, which uses the standard world population as a reference (60 years or older)[18] (figure 1c).

The age-adjusted rates calculated were used in the analysis of trends in mortality in the city of Florianopolis, the state of Santa Catarina and in Brazil, by estimating regression models. To smooth the time series, due to the oscillation of points caused by the small number of cases in certain strata, the moving average was calculated centered around five terms. In this process, the smoothed coefficient of year (i) (Y_{ai}) corresponds to the arithmetic average of the coefficients of the two previous years, of the same year (i) and of the following two years (Figure 1d). Thus, the historical series presented represented the years 1999-2008, despite using information from 1997 to 2010.

Mortality rate from falls:

$$= \frac{\textit{Number of deaths from falls}}{\textit{Reference population for this period}} \times 100.000 \qquad \text{a}$$

Specific mortality rate from falls:

$$= \frac{\textit{Number of deaths from falls by age group}}{\textit{Reference population for his period by age group}} \times 100.000 \qquad \text{b}$$

Rate adjusted by age:

$$= \frac{\sum (\textit{(Specific rate by age) x (standard global population per age group)})}{\sum \textit{Standard global population}} \qquad \text{c}$$

Average centered around five terms:

$$Y_{ia} = \frac{Y_{i-2} + Y_{i-1} + Y_i + Y_{i+1} + Y_{i+2}}{5} \qquad \text{d}$$

Figure 1. Formulas used for calculations. Florianopolis, SC, 2013.

The *Joinpoint* program, version 3.5.4 (*Statistical Research and Applications Branch, National Cancer Institute*, United States), was used to calculate the annual change in mortality from 1999 to 2008. The use of the *joinpoint* method allows the description of trends and identifies changes over time. The program performs segmented linear regression (*jointpont* regression) to estimate the annual percentage change and identify points where there is change in trends.[19]

From the estimated curve for each line segment the annual percentage change and its statistical significance is calculated, estimated by the least squares method for a generalized linear model. In this way, it was assumed that the rates followed a Poisson distribution, and that such variation is not constant over the period.[19]

RESULTS

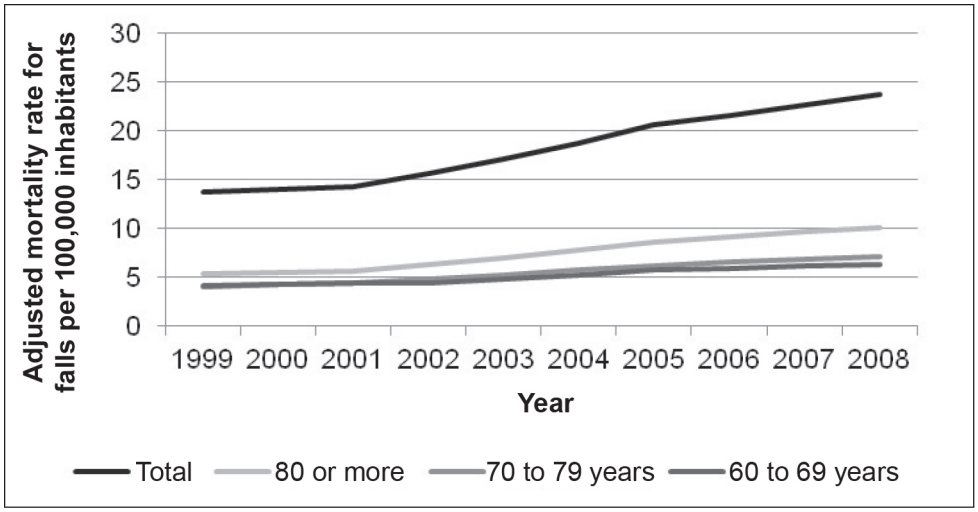
During the study period (1997-2010), of 8,142,342 deaths of people aged 60 and older in Brazil, 50,348 (0.61%) were due to falls (51.1% of such deaths involved men). A total of 916 (54.3% of which involved men) of those falls occurred in the state of Santa Catarina, and 93 (50.5% of which involved women) took place in Florianopolis (table 1). Of the 50,348 deaths, 50.6% occurred among the population aged 80 years or over. The crude and adjusted specific mortality rates from falls are shown in Table 1. These rates show variation between regions. In Brazil, the crude rate exceeded 30 deaths per 100,000 inhabitants, while in Santa Catarina, this rate fluctuated during the period, increasing in 2009 and 2010. There was also oscillation in Florianopolis, with a high of 62 deaths per 100,000 inhabitants in 2010. However, in analyzing the rates adjusted by age, it was found that in Brazil there was a progressive increase, while in Santa Catarina and Florianopolis there were variations over the period (Table 1).

Table 1. Specific Mortality Rates (MR) for falls among elderly persons* (per 100,000 residents) in Brazil, the state of Santa Catarina and the city of Florianopolis. Florianopolis, SC, 2013.

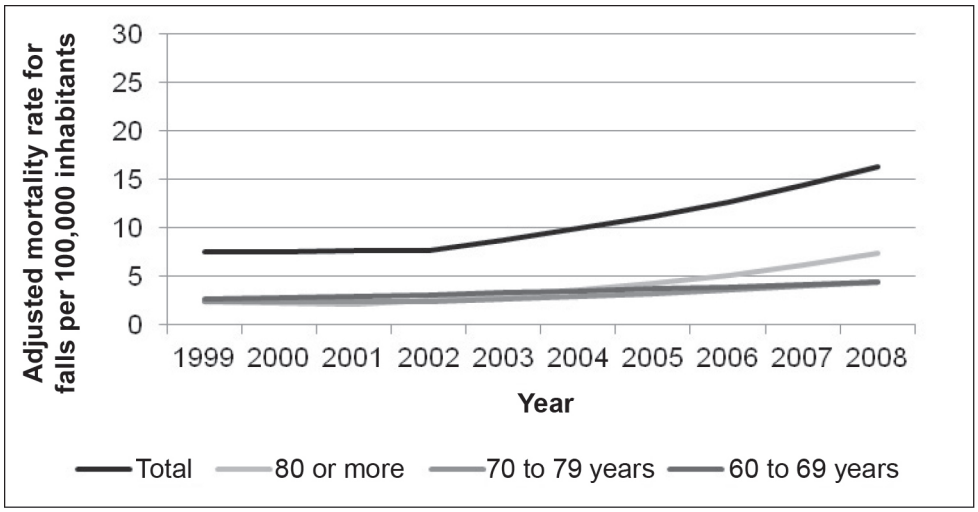
Year	Brazil			Santa Catarina			Florianópolis		
	Deaths	Gross rate	Adjusted rate	Deaths	Gross rate	Adjusted rate	Deaths	Gross rate	Adjusted rate
1997	1.721	13.7	12.4	26	7.1	6.8	4	18.3	19.1
1998	2.190	17.2	15.3	32	8.7	8.3	2	9.1	7.0
1999	2.040	15.9	14.3	44	11.7	11.2	6	26.8	23.4
2000	2.033	14.0	12.1	27	6.3	6.0	3	10.4	7.7
2001	2.507	17.0	14.7	27	6.2	5.7	3	10.1	8.4
2002	2.467	16.6	14.2	27	6.1	5.8	2	6.6	7.4
2003	3.022	20.1	17.2	45	10.0	9.3	-	-	-
2004	3.440	22.6	19.3	60	13.2	12.5	1	3.2	2.8
2005	3.664	23.5	20.1	47	10.1	9.2	3	9.0	7.4
2006	4.446	28.2	24.0	67	14.1	12.7	4	11.7	9.4
2007	4.957	27.2	22.1	105	18.1	15.7	12	28.6	26.0
2008	5.392	28.7	23.1	96	15.9	13.7	8	19.0	16.3
2009	5.668	29.2	23.3	132	20.8	17.3	15	33.7	26.6
2010	6.801	33.0	26.3	181	27.6	23.6	30	62.0	50.6

*The coefficients of the years represent the mean of the two previous years, the year itself, and the two subsequent years.

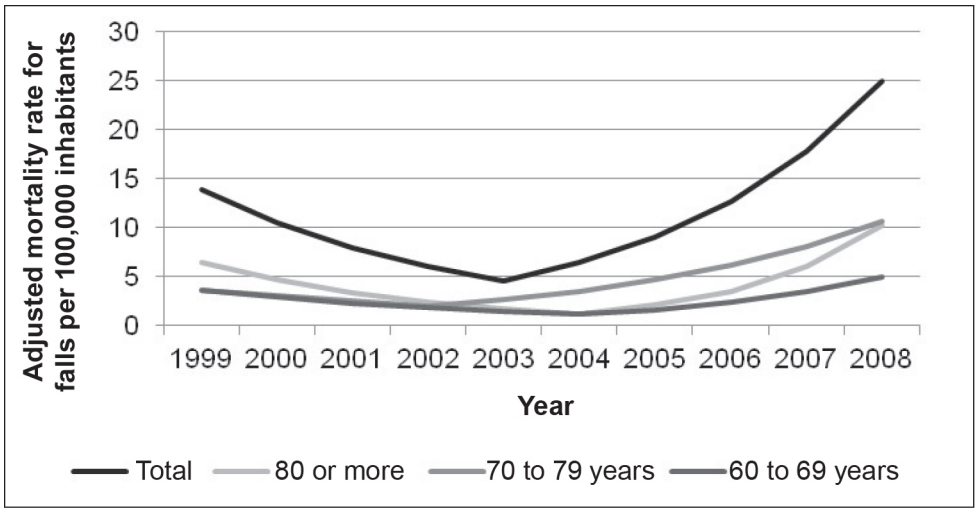
When analyzing the adjusted mortality rate per 100,000 residents for each age group, it appears that for all the areas surveyed, the death rate from falls increases with advancing age (Figure 2).



a. Brasil



b. Santa Catarina



c. Florianópolis

Figure 2. Analysis of trends in mortality from falls by age group in Brazil l (a), Santa Catarina (b) and Florianopolis (c), 1999-2008. Florianópolis, SC, 2013.

By analyzing the mean annual percentage change in mortality rate in the entire period between 1999 and 2008, there was a significant increase of 6.2% for Brazil, 9.1% for Santa Catarina and 6.7% for Florianopolis (Table 2).

Trends in the mortality rate from falls, without stratification by age group, oscillated between the periods. The trend for the city of Florianopolis, in which there were two periods of change, the first (1999-2003) with a significant reduction in mortality (24.2%) and the second (2003-2008) with a significant increase in mortality (40.4%), stands out. Although there were also two periods of change in Santa Catarina, this change was only significant in the period 2002-2008, with an increase of 13.3% per year. For Brazil, there were three variations in trend, with a significant increase in 2011 (Table 2).

Table 2. Distribution of annual percentage variation, both overall and by age group, in Brazil, the state of Santa Catarina, and the city of Florianopolis, 1999-2008. Florianópolis, SC, 2013.

	Brazil		Santa Catarina		Florianópolis	
	Period	Variation	Period	Variation	Period	Variation
Overall						
	1999-2008	6.2* (5.6;6.8)	1999-2008	9.1* (6.4;11.9)	1999-2008	6.7* (1.3;12.5)
	1999-2001	2.1 (-1.7;6.1)	1999-2002	1.2 (-7.3;10.4)	1999-2003	-24.2* (-33;-14.3)
	2001-2005	9.4* (7.6;11.4)	2002-2008	13.3* (10.6;16)	2003-2008	40.4* (30.3;51.2)
	2005-2008	4.8* (3.2;6.4)				
80 years or more						
	1999-2008	7.2* (6.1;8.4)	1999-2008	13.6* (9;18.4)	1999-2008	5.2 (-7.0;18.9)
	1999-2001	2.4 (-4.9;10.2)	1999-2001	-5.1 (-24.7;19.5)	1999-2004	-28.4* (-42.6;-10.6)
	2001-2005	11.1* (7.5;14.8)	2001-2008	19.6* (16.9;22.4)	2004-2008	70.0* (34.7;114.5)
	2005-2008	5.5* (2.6;8.5)				
70 to 79 years						
	1999-2008	6.5* (5.7;7.2)	1999-2008	7.0* (3.8;10.2)	1999-2008	12.5* (2.6;23.4)
	1999-2001	3.8 (-1;8.9)	1999-2002	-1.2 (-10.7;9.3)	1999-2002	-17.7 (-40.2;13.4)
	2001-2005	9.1* (6.8;11.5)	2002-2008	11.3* (8.1;14.6)	2002-2008	31.5* (20.6;43.5)
	2005-2008	4.8* (2.8;6.7)				
60 to 69 years						
	1999-2008	4.6* (4.1;5.2)	1999-2008	5.7* (4.2;7.3)	1999-2008	3.6 (-2.9;10.7)
	1999-2002	2.0* (0.3;3.7)	1999-2008	5.7* (4.2;7.3)	1999-2004	-20.8* (-28.9;-11.8)
	2002-2005	8.7* (5.5;12)			2004-2008	45.1* (26.4;66.6)
	2005-2008	3.4* (1.9;4.8)				

*Value of $p<0.05$.

When stratifying the study population by age group, it was found that, among elderly persons aged 80 or more, the annual percentage variation in the mortality rate was significant for Brazil and Santa Catarina for all the years analyzed, with increases of 7.2% and 13.6%, respectively.

For this same age group, three variations in mortality were found in Brazil and Santa Catarina and two in the city of Florianopolis. The increase of 70% from the year 2004 onwards in Florianopolis is worthy of note. For the 70-79 year age group, the annual percentage change in the mortality rate was 6.5% in Brazil, 7.0% for the state of Santa Catarina and 12.5% for Florianopolis.

In Brazil, for the age group 70-79 years, three trends in mortality were found, reaching 9.1% in the period from 2001 to 2005 and decreasing to 4.8% in the years 2005-2008. At state level, two trends in mortality were observed, most notably the increase of 11.3% from 2002 to 2008. At city level two periods (1999-2002; 2002-2008) were identiied, but without statistical significance.

Among those aged 60 to 69 years, the percentage of annual change in mortality rate was 4.6% at the national level and 5.7% within the state. Among the three periods with a significantly increasing trend in mortality in Brazil, the most significant was between the years 2001 and 2006, where growth reached 8.7%. For the two periods evaluated for the city of Florianópolis, the years 2004 to 2008, in which the mortality trend reached 45.1% per annum, are worthy of note.

DISCUSSION

Overall, an increasing trend in mortality from falls among the elderly was identified, and it was found that this indicator increased as age advances, irrespective of the location investigated. This increase was more accelerated in the 80 years or older age group. This result is consistent with the knowledge that aging results in a worsening of disabilities, affects the functionality of the elderly and results in a greater number of falls.[3,18] This increase, which grows with chronological age, is due to the cumulative effects of age-related disorders, diseases and an unsuitable environment.[20,21]

The annual growth in the mortality rate for falls observed in both Brazil and the state of Santa Catarina, shows that the outcome of death increased within the age group investigated, which makes the occurrence of falls of great significance.

Similar results were found in a study by Maciel et al.[8] By analyzing mortality from external causes among elderly persons in state capitals during the period 1996 and 2005, it was found that on average, falls resulted in 22.5% of these deaths. In this study, it was found that while deaths from falls fluctuated in both absolute numbers and rates, the weight of these deaths in relation to mortality caused by external causes has grown each year, with an increase of almost 6.7% between 1996 and 2005.[8]

The two trend periods identified for the city of Florianopolis also revealed fluctuation in the overall group, initially with a reduction in the mortality rate for falls (1999-2003), followed by an increase from the year 2003 onwards.

Other studies[8,22] have also observed an oscillation in mortality by falls. Such findings may be explained by the fact that the data provided by the MIS can be influenced by the quality of the information recorded on the Declaration of Death (DD). Deaths whose underlying cause was recorded as "other external causes" or "nature of accidents not specified" or even "other transport accidents", would today be better defined.

For the total group in Brazil and Santa Catarina, there were three trend variations, with the period 2001-2005 standing out in both regions. This period saw the most significant increase in the percentage variation in mortality rates from falls, with a smaller increase occurring in the period 2005-2008.

When analyzing the overall group, it should be noted that the high rates found are influenced

by the 80 and over age group, among which percentages were higher. This was confirmed by examining the annual percentage change in mortality rate in the 80 years or over age group, which presented significant values in all periods for Brazil and Santa Catarina. In Florianopolis the mortality trend reached a growth rate of 56.7% between 2003 and 2008.

These results reveal a change in the mortality profile in the 80 years or older age groups, with the occurrence of more deadly events following falls. Another possible explanation is that more attention is now paid to health, meaning it is more likely that the elderly person who suffered the trauma that led to death will be attended by medical services, and thus improving the accuracy of the information on the DD.

According to the World Health Organization,[23] the number of falls has grown as the number of elderly persons has increased in many countries of the world. Falls increase exponentially with the biological changes associated with aging, therefore, a greater number of people aged 80 years or over should trigger a substantial increase in falls and related injuries.[23]

For the 70-79 year age group, the trend of declining mortality did not present rectilinear behavior for any of the regions observed. However, the decrease observed for Brazil in the period between 2005 and 2008, which declined approximately 50%, stands out.

Among elderly persons aged 60-69 years, the annual percentage change in the mortality rate showed lower values than for the other age groups. Of the mortality trend periods observed for all the regions, the city of Florianópolis, where the trend in mortality increased approximately 70% in the period 2005-2008, is worthy of note. Such a result may be related to the major differences between regions and states in relation to social and economic characteristics and quality of life, which strongly influence the quality ofvital records,[24] which could in turn favor the city of Florianópolis, notable for its high sociodemographic conditions.

In addition to this increasing trend in mortality from falls, other studies have investigated the growing number of hospitalizations caused by injury. Mascarenhas et al.,[25] who, in a study of hospital admissions financed by the Sistema Único de Saúde ("the Unified Health System") in Brazil, found that the proportion of hospitalizations due to external causes showed a progressive increase (7.7% in 2000 to 10.4% in 2010), while hospitalizations for cardiovascular disease remained constant, and hospitalizations for respiratory diseases decreased, in the same period. During the same period (2000 to 2010), the risk of hospitalization because of falls remained the highest, exceeding 15 hospitalizations per every 10,000 residents each year.[25]

The results of the present study highlight the importance of considering the diversity of the elderly population, reflected in the differences between age groups. There is heterogeneity in mortality patterns between the age groups of elderly persons, and therefore the impact of age group on the epidemiological profile of the population must be taken into account, considering their different priorities when planning health actions and strategies.[26]

A fall is a multifactorial event, comprising biological, behavioral, environmental and socioeconomic factors.[27] Intervention projects that aim to reduce the occurrence of falls, therefore, should consider all these aspects. Data[28] exists indicating that more wide-ranging projects involving environmental modification and physical activity have better results than those focusing on only one of the factors involved. One limitation of the present study is its use of secondary database information, which may have suffered underreporting. Increased efficiency in declaration of death certificates may have contributed to the increased rates found.

CONCLUSION

Based on these results, there was an increasing trend in mortality from falls in the last period studied (2005/2008; 2002/2008; 2003/2008) in all the regions observed. Such growth, observed in Brazil and in the state of Santa Catarina, occurred mostly among elderly persons aged 80 years or older, the group for which more periods with a significant increase in mortality rates were identified, most notably for the state of Santa Catarina.

While institutions such as the World Health Organization and the Brazilian Ministry of Health are working more effectively at creating policies to prevent falls among the elderly, creating guides on how to prevent this danger, the results of the present study indicate that the number of deaths due to falls increases with advancing age, and therefore, actions aimed at preventing falls should especially focus on, among the elderly population, the 80 years and over age group, in which falls more often lead to death.

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