

RESEARCH ARTICLE (ORIGINAL) 8

Epidemiological characteristics and spatial distribution of falls among older adults in pre-hospital care

Características epidemiológicas e distribuição espacial das quedas em idosos atendidos no serviço pré-hospitalar

Características epidemiológicas y distribución espacial de las caídas en ancianos atendidos en el servicio prehospitalario

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Abstract

Background: Falls are a common, serious, and growing public health problem among older adults.

Objectives: To analyze the epidemiological characteristics and spatial distribution of the care delivered to elderly victims of falls by the Mobile Emergency Care Service (in Brazil, SAMU - *Serviço de Atendimento Móvel de Urgência*) in a municipality in Brazil.

Methodology: Cross-sectional study based on data from the SAMU (2010-2017). The services were recorded in a database and georeferenced. Descriptive statistics were used, and Pearson's χ^2 test or Fisher's exact test ($\alpha < 5\%$) were applied to detect correlations. Kernel density estimation (KDE) was used to identify spatial clusters.

Results: There were 1,466 services, most of them with women, with a mean age of 79 years. The majority of patients fell at home, during the day, and from own height. Kernel density estimation identified a higher concentration of services in 7 residential areas.

Conclusion: The results may help to plan strategies to prevent fall-related injuries in older adults.

Keywords: aged; fall-related injuries; pre-hospital care; outpatient care; spatial analysis

Resumo

Enquadramento: Na população idosa, as quedas constituem um problema de saúde pública comum, grave e crescente.

Objetivos: Analisar as características epidemiológicas e a distribuição espacial dos atendimentos de idosos vítimas de quedas pelo Serviço de Atendimento Móvel de Urgência (SAMU) de um município do Brasil.

Metodologia: Estudo transversal, baseado em dados do SAMU (2010-2017). Os atendimentos foram registados num banco de dados e georreferenciados. Utilizou-se estatística descritiva e as associações foram verificadas com o teste de χ^2 de Pearson ou exato de Fisher ($\alpha < 5\%$). Para deteção de aglomerados espaciais aplicou-se o estimador de densidade Kernel.

Resultados: Houve 1466 atendimentos, a maioria do sexo feminino, com uma média de 79 anos. Prevalceu o domicílio como local das quedas, no horário diurno, maioritariamente da própria altura. O estimador de densidade Kernel identificou concentração de atendimentos em 7 áreas residenciais.

Conclusão: Os resultados poderão auxiliar o planeamento de estratégias de prevenção de acidentes por quedas na população idosa.

Palavras-chave: idosos; acidentes por quedas; assistência pré-hospitalar; assistência ambulatoria; análise espacial

Resumen

Marco contextual: En la población anciana, las caídas son un problema de salud pública común, grave y creciente.

Objetivos: Analizar las características epidemiológicas y la distribución espacial de la atención prestada a los ancianos víctimas de caídas por el Servicio de Atención Móvil de Urgencias (SAMU) de un municipio de Brasil.

Metodología: Estudio transversal, basado en datos del SAMU (2010-2017). Las asistencias se registraron en una base de datos y se georreferenciaron. Se utilizaron estadísticas descriptivas y las asociaciones se verificaron con la prueba χ^2 de Pearson o la prueba exacta de Fisher ($\alpha < 5\%$). Se aplicó el método de estimación de densidad Kernel para detectar los conglomerados espaciales

Resultados: Hubo 1466 asistencias, la mayoría de ellas del sexo femenino, con una edad media de 79 años. Hubo una prevalencia de caídas en el hogar, en horario diurno, principalmente desde la altura. El método de estimación de densidad Kernel identificó una concentración de cuidados en 7 zonas residenciales.

Conclusión: Los resultados pueden ayudar a planificar estrategias de prevención de accidentes por caídas en la población anciana.

Palabras clave: ancianos (adultos mayores); caídas; accidentes por caídas; servicio ambulatorio; servicio prehospitalario; análisis espacial



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Introduction

Falls are a common, serious, and growing public health problem among older adults (Florence et al., 2018). Approximately 30% of older adults aged 65 or more years fall every year, often resulting in severe injury, decreased mobility, and loss of independence (Vieira et al., 2018). Mobility and balance problems and loss of muscle strength increase the likelihood of falling (Hicks et al., 2020). In addition, people are living longer and with chronic diseases such as cardiovascular diseases, diabetes, and arthritis. About one-third of older people will fall at least once a year, and, of those, 5% will suffer fractures, leading to disability and even loss of independence (Kim, 2020).

It is necessary to know the epidemiological data about older adults and identify the places where falls occur more frequently to design strategies for preventing these accidents. This study aims to analyze the epidemiological characteristics and the spatial distribution of the care delivered to elderly victims of falls by the Mobile Emergency Care Service (*Serviço de Atendimento Móvel de Urgência - SAMU*) of a municipality in Brazil.

Background

Falls can result from intrinsic changes, such as sensory-motor changes inherent to the aging process (visual changes, paresthesia, paresis, decreased flexibility and mobility, and cognitive decline), and extrinsic changes associated with the environment (potholes, stairs, and uneven terrain; Christoforetti et al., 2006).

There are multiple risk factors for falls, including biological, behavioral, environmental, and socioeconomic factors (Hicks et al., 2020). Frailty is an important indicator of older people's health. With several definitions, it usually involves loss of physiological reserve and lower tolerance to stressful events. The most common definition requires the presence of three or more of five indicators: weight loss, exhaustion, weakness, slowness, and low physical activity (Albert, 2019).

According to international (European and American) societies, frailty is a medical syndrome with multiple causes and contributors, characterized by diminished strength, endurance, and physiological function, which increases vulnerability and propensity to develop dependency and/or death (Morley et al., 2013).

Frailty is a risk factor for many health problems in older adults, including falls, functional decline and disability, need for long-term care, and death (Albert, 2019). A meta-analysis study found that frail older people were more likely to experience recurrent falls than healthier older people (Cheng & Chang, 2017). Chronic diseases and many of the medications used to treat them can increase the risk of falling (Florence et al., 2018). An integrative literature review on the topic showed that institutionalized older women had a higher predisposition to falls in most of the studies (79%) than older men. The main risk factors for falls were the use of benzodi-

azepines and chronic diseases such as hypertension, diabetes, arthritis, and osteoporosis (Florence et al., 2018). Added to this are the external environment-related risk factors include household floor quality, lighting, and conditions of access to public transportation (Smith et al., 2017).

According to the Mortality Information System, between 1996 and 2012, 66,876 people died due to a fall in Brazil. There were 941,923 hospital admissions with a secondary diagnosis associated with falls. In the same period, both mortality and hospitalizations showed an increasing trend (Abreu et al., 2018).

Increased longevity is associated with an increased demand for emergency health services for elderly victims of falls. These services range from pre-hospital care to hospitalization and treatment of severe cases. Since 2003, the SAMU-192 delivers pre-hospital care in Brazil.

Research questions

What are the epidemiological characteristics of the elderly victims of falls assisted by SAMU?

What is the spatial distribution of the cases of elderly victims of falls assisted by SAMU?

Methodology

A cross-sectional, descriptive, and correlational study was conducted with a quantitative approach, based on secondary data from the SAMU of the municipality of Olinda, Pernambuco, Brazil. The municipality is located in the metropolitan region of Recife. It has a territorial extension of 41.681 km² (98% of urban area), 31 neighborhoods, and an estimated 390,771 inhabitants in 2017. This municipality's SAMU responds to approximately 600 services per month and has 87 trained professionals (doctors, nurses, nursing technicians, and ambulance drivers) and 10 ambulances.

The analysis included the cases of elderly victims of falls (60 years or older) assisted between 2010 and 2017.

The cases assisted by the SAMU units are registered in a database and georeferenced with a Global Positioning System (GPS) device. The ambulances are equipped with GPS, and the drivers are trained to use it. The SAMU database was the source of data for this study. The variables were collected directly from the database (gender, age, place of occurrence, day of the week, month, and year of occurrence, referral destination).

Initially, a descriptive analysis of the variables (gender, age group, time of occurrence, day of occurrence, referral to the health unit, type of fall) was performed using frequency distribution. Pearson's chi-square test or Fisher's exact test were applied when necessary. The significance level was set at 5%. Statistical analysis was performed using the Epi Info software, version 7.2.4.

The QGIS software, version 3.6.3, was used to map and identify spatial clusters with the Kernel density estima-

tor. This method is often used to identify spatial patterns by calculating the density of events around each point, scaled by the distance from the point to each event (Bonfim et al., 2018). The geolocated data were analyzed and compiled to generate a point cloud with information for each event. This result served as the basis for generating the point density maps. The Kernel density estimator draws a circular neighborhood around each sample point, corresponding to the radius of influence, and then a mathematical function is applied from 1, at the point position, to 0, at the neighborhood boundary. The value for the cell is the sum of the overlapping Kernel values divided by the area of each search radius. The Kernel classification was used to identify areas of event concentration. Low-density areas were represented in green, intermediate areas in yellow, and high-density areas in red.

The Ethics Committee of Hospital Universitário Oswaldo Cruz/Pronto Socorro Cardiológico de Pernambuco approved the study (CAAE 83723618.3.0000.5192).

Results

During the period under analysis, the SAMU assisted 1,954 older people. Of these, 1,466 (75%) were victims of falls. Most of them were women ($n = 891$; 60.7%), aged between 60 and 107 years, with a mean age of 79 years and a standard deviation of 9.6 years ($n = 891$; 60.7%; Table 1).

Most falls occurred from Monday to Thursday, at home ($n = 1178$; 80.3%), with a statistically significant difference ($p < 0.05$; Table 1).

Concerning the time, 32.9% ($n = 483$) of the falls occurred between 6:00 and 11:59, and 31.3% occurred between 12:00 and 17:59 ($n = 459$). Regarding the month of the year, the distribution was homogenous, and the highest frequencies were recorded in July ($n = 85$; 10.2%). Most of the victims were referred to Emergency Care Units (*Unidades de Pronto Atendimento*, UPA; $n = 603$; 41.4%), followed by those referred to public hospitals (24.2%; $n = 353$; Table 1).

Table 1

Characteristics of older people assisted by the SAMU, according to gender, age, type, place, day of the week, month, and year of occurrence

Variables	>60 years		p-value
	n	%	
Gender			
Male	574	39.2	<0.00001
Female	891	60.7	
Ignored	1	0.1	
Place of occurrence			
Home	1,178	80.3	<0.00001
Public Road	245	16.8	
Ignored	43	2.9	
Day			
Monday to Thursday	825	56.3	<0.00001
Friday to Sunday	641	43.7	
Time			
00:00 to 05:59	182	12.4	<0.00001
06:00 to 11:59	483	32.9	
12:00 to 17:59	459	31.3	
18:00 to 23:59	308	21.1	
Ignored	34	2.3	
Month			
January	139	9.5	0.08169
February	139	9.5	
March	118	8	
April	107	7.2	
May	114	7.8	
June	114	7.8	
July	140	9.6	
August	135	9.2	
September	132	9	
October	99	6.7	
November	114	7.8	
December	114	7.8	
Ignored	1	0.1	
Referral			
Emergency Care Unit	603	41.4	<0.000001
Private Network	241	16.5	
Polyclinic	10	0.7	
Public Hospital Network	353	24.2	
On-site care	8	0.5	
Others	243	16.7	

The most common reason for care-seeking was fall from own height (Figure 1). The most affected part of the

body was the head, followed by the lower limbs (Figure 2).

Figure 1

Older people assisted by the SAMU, according to type of fall and age group (2010-2017)

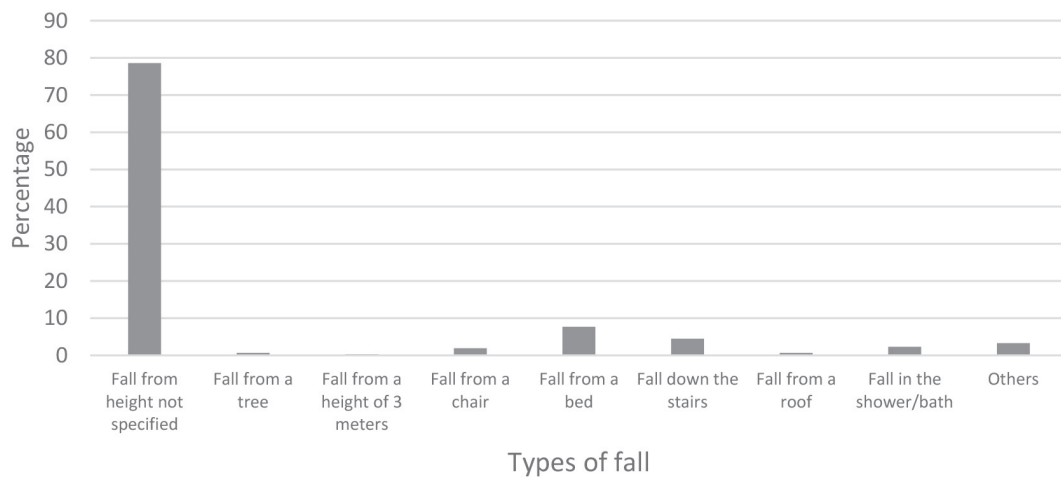
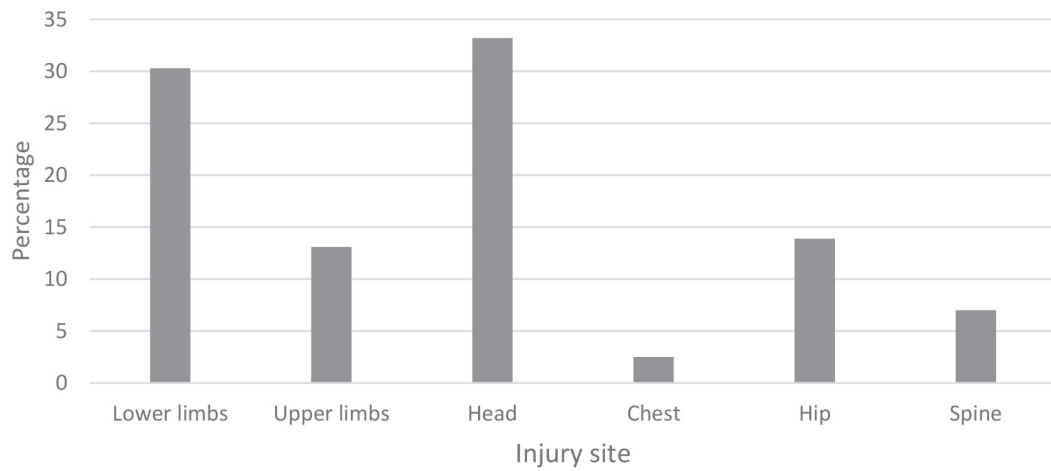


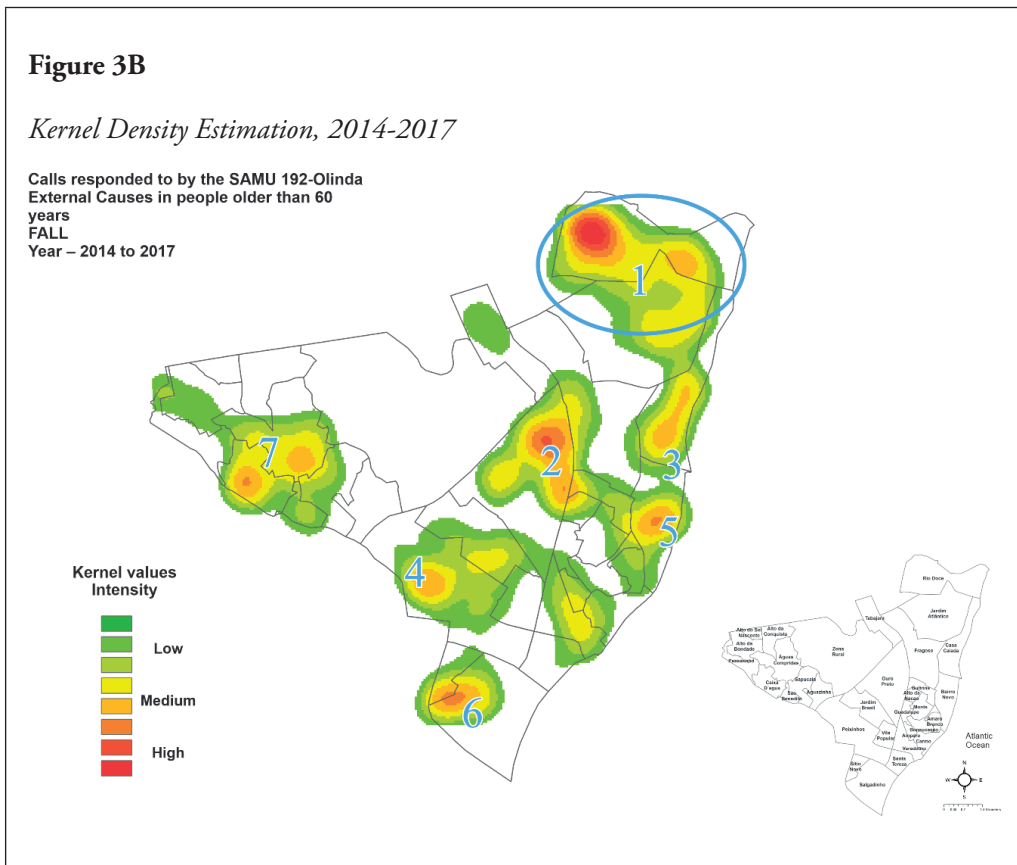
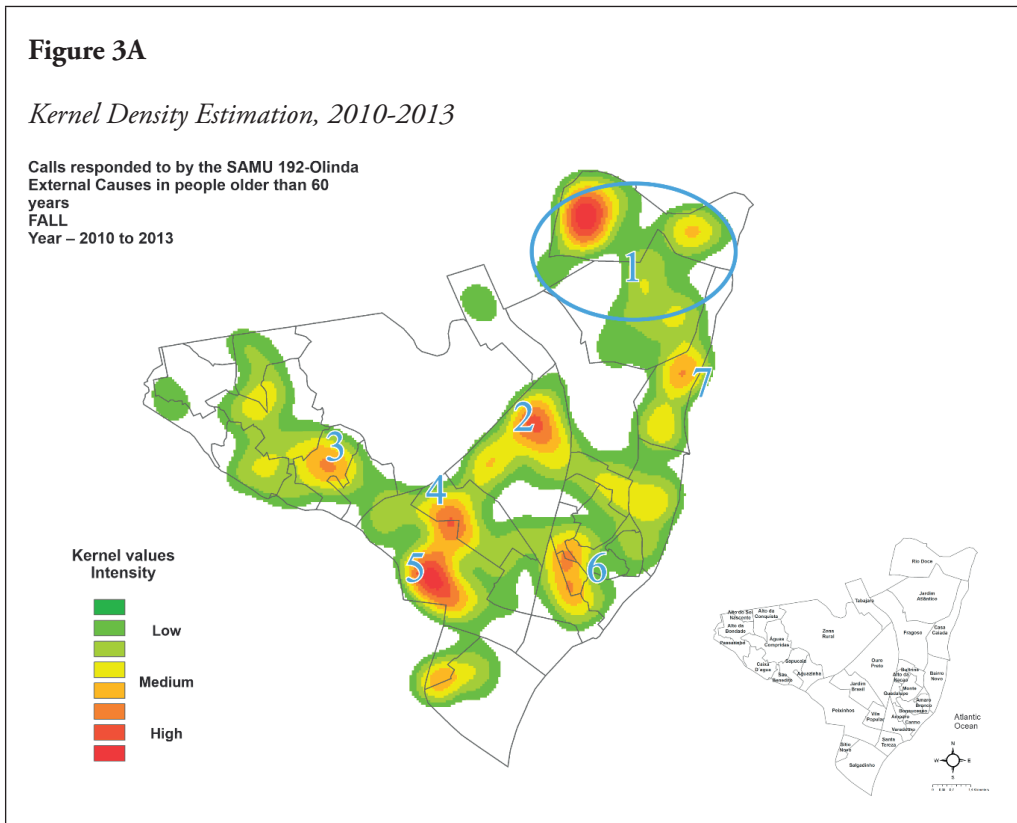
Figure 2

Older people assisted by the SAMU, according to injury site (2010-2017)



Figures 3A and 3B show the map with the Kernel density estimation based on the 1,446 visits of elderly victims of falls divided by two four-year periods (2010-2013

and 2014-2017). Seven areas of density were observed in both periods.



Discussion

The most prevalent demographic characteristics among elderly victims of falls were the female gender and advanced age. Falls can have a serious impact on older people's lives, and the injury may require prolonged treatment (Padrón-Monedero et al., 2017). Vieira et al. (2018) found a predominance of falls among women aged 60-79 years, while Oliveira et al. (2019) found that falls were predominant among men aged 80 or more years.

A study that characterized older adult victims of falls according to the differences between genders showed a higher proportion of falls in oldest-old women, at home, and from own height. In men, most falls occurred in youngest-old people, with the presence of ethyl breath, on public roads. These differences should be taken into account while planning prevention interventions (Meschial et al., 2014).

Regarding the day of the week and time of occurrence, most falls occurred between Monday and Thursday during the day, which may be associated with the performance of daily tasks. A review on the epidemiology of falls in older people in Brazil also found a higher frequency of falls during the day (Leitão et al., 2018). Concerning the days of the week, the study with older adults having experienced falls and receiving pre-hospital care also found a higher prevalence of falls during weekdays (Meschial et al., 2014).

In another study with elderly victims of falls treated in an emergency room, the authors found a higher frequency of contacts during the day, with homogeneous distribution across the days of the week (Tiensoli et al., 2019).

The most common reason for care was fall from own height. The most affected body part was the head, followed by the lower limbs, which is in line with the results found in another study (Carpenter et al., 2019). The most frequent mechanism of injury in adult trauma results from falls from a small height, particularly in older people, which can lead to more serious consequences, such as hip fracture, and be reflected in the complexity of care provided in hospitals and rehabilitation services (Christofoletti et al., 2006).

The association between age and mortality after hip fracture is an important aspect to be assessed in this population, considering specific indicators of frailty (performance of daily activities, healthy attitudes, and variables related to function, nutrition), and with the comorbidities. In light of this, public health programs should be implemented in community and healthcare settings to prevent or minimize frailty, especially in the age group of 75 or more years. These programs may include monitoring comorbidities, managing medication, healthy eating patterns, and moderate physical activity (Padrón-Monedero et al., 2017). The prioritization of these initiatives should not exclude other additional effective interventions for fall prevention in the age group of 75 or more years and also in younger age groups, especially in the case of men, with the main fall site being the home, which is similar to the results found by Leitão et al. (2018). It should be emphasized that external factors, such as loose carpets, slippery floors,

objects on the floor, the lack of support bars, light switch away from the bathroom door (Oliveira et al., 2019) are risk factors for falls at home. One study associated falls at home with increased mortality in older people aged 75 or more years due to less mobility and indicators of greater frailty (Bath & Morgan, 1999).

Therefore, health professionals play a key role in guiding interventions for fall risk reduction, encouraging physical activity to maintain postural stability and preventing possible functional impairment.

Using the Kernel density estimator, the spatial distribution showed that the areas with the highest density of falls in both 4-year periods were the most populated neighborhoods of the municipality, areas with active trade and heavy traffic, as well as fair venues, whose often-unplanned paving (alleys and lanes) impaired pedestrian circulation and increased the risk of falls. The spatial analysis identified areas with higher concentration of falls, enabling the development of preventive measures to reduce the risk of these accidents.

Similar to the results of this study, a study on the spatio-temporal dynamics of falls among older pedestrians showed that they occur in more densely populated areas and are associated with the specific characteristics of the built environment. A systematic maintenance service based on the local geography is suggested to ensure older people's safety (Ceccato & Willems, 2019).

A study using spatial analysis to investigate the geographic distribution of deaths of older adult victims of traffic accidents reports that this technique is an important tool to identify priority areas for public management actions aimed at accident prevention (Santos et al., 2016).

The study has some limitations. First, the data source does not cover the totality of occurrences, not including the care provided by the fire department rescue teams or the victims assisted by third parties and referred to the health services. Based on the records, it was not possible to analyze the severity indices of older adult falls or assess comorbidities because they were not included in the records of the database of the service being studied. It was also impossible to identify the outcome after pre-hospital care.

Conclusion

Most of the patients assisted by the SAMU were older women, with a mean age of 79 years, victims of falls at home, from own height, and with injuries to the lower limbs and head. The spatial analysis identified areas with a higher density of care contacts distributed in some neighborhoods of the municipality, indicating a pattern of occurrence in both periods.

The results contribute to expanding the knowledge about fall predictors among older people living in the municipality and reinforcing the need for health professionals to perform a more comprehensive initial assessment of patients that includes interdisciplinarity. This assessment should take into account not only the physical but also the cognitive and affective risks to prevent falls that can lead to hospitalization and death. Moreover, these results

can contribute to planning the reorganization of public spaces and revitalizing public roads, giving priority to pedestrians and, especially, older pedestrians.

Author contributions

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