Original Article

Incidence and Associated Factors for Single and Recurrent Falls among the Elderly in an Urban Community of Beijing*

SHI Jing[1], ZHOU Bai Yu[2], TAO Yong Kang[3], YU Pu Lin[2,#], ZHANG Chuan Fang[4], QIN Zhao Hui[5], and SUN Zhen Qiu[1,#]

1. School of Public Health, Central South University, Changsha 410078, Hunan, China; 2. Beijing Institution of Geriatrics, Beijing Hospital Ministry of Health, Beijing 100730, China; 3. Department of Emergency Medicine, China-Japan Friendship Hospital, Beijing 100029, China; 4. Hunan Research Institute for Tuberculosis Control, Changsha 410013, Hunan, China; 5. Department of Public Health, Xuzhou Medical College, Nanjing 221002, Jiangsu, China

Abstract

Objective To investigate the incidence of falls and recurrent falls, and explore associated factors for single and recurrent falls among urban community-dwelling elderly in Beijing.

Methods A cross-sectional study was conducted in 472 elderly in the Longtan community of Dongcheng district, Beijing in 2009. Data regarding the incidence of fall and recurrent falls in the previous year, as well as associated factors were collected from the elderly through face-to-face interviews.

Results The incidence of falls and recurrent falls was 17.8% and 6.1%, respectively, and it increased with age ($\chi^2_{for\ trend}$=21.06, 19.20, *P*=0.001, 0.002). Binary logistic stepwise regression analysis showed that age (*OR*=2.20), living alone (*OR*=4.67) and gait disturbance (*OR*=1.27) were risk factors, while housing with elevators (*OR*=0.35), appropriate width/height of stair steps (*OR*=0.78), sufficient lighting for stairway (*OR*=0.45) and regular exercise (*OR*=0.12) could lower the risk for single fall; factors such as low monthly family income (*OR*=1.39), poor vision (*OR*=1.83), low physical ability (*OR*=4.47), abnormal static balance (*OR*=2.48), and fear of falls(*OR*=2.23) were risk factors, while appropriate width/height of stair steps (*OR*=0.49) and easiness of access to daily supplies (*OR*=0.41) were protective factors for recurrent falls.

Conclusion The incidence of falls in community-dwelling elderly people in Beijing is common, and falls and their related injuries have been associated with both intrinsic and extrinsic factors.

Key words: Falls; Incidence; Related factors; Prevention

Biomed Environ Sci, 2014; 27(12): 939-949 *doi: 10.3967/bes2014.134* *ISSN: 0895-3988*

www.besjournal.com (full text) *CN: 11-2816/Q*

INTRODUCTION

Falls are a common health problem that causes considerable morbidity and affects the quality of life of elderly people around the world. Data from studies on Western populations show that 18%-30% of the elderly experience falls[1-2]. One out of three community-dwelling adults aged 65 years or older suffers a fall each year[3], and the figure rises to 50%

*This research was supported by the National Health and Family Planning Commission of the People's Republic of China, No.W2013BJ02.

#Correspondence should be addressed to YU Pu Lin, Tel: 86-10-85111151, E-mail: pulin_yu@163.com; SUN Zhen Qiu, Tel: 86-731-84805771, E-mail: szq1942@126.com

Biographical note of the first author: SHI Jing, female, born in 1982, PhD candidate, majoring in geriatric epidemiology.

for those over the age of 80[4]. For over a decade, a considerable portion of injury and injury-related deaths has been attributed to falls, which also represent the single most common cause for trauma-related hospital visits by the elderly[5-6]. According to the Centers for Disease Control and Prevention, fall-related injuries were responsible for more than 19,700 deaths in 2008, and 2.2 million emergency department visits and more than 581,000 hospitalizations in 2009, for adults aged 65 years or older in the US[7]. Concerning the financial impact, the total direct cost on healthcare for the elderly with fall-related injuries is expected to increase as population aging continues[8]. In 2000, a total of $179 was spent as the direct medical cost on fatal fall injuries and $19 billion (equivalent to $28.2 billion in 2010 dollars) as the direct cost on care for nonfatal falls[8-9]. The annual direct and indirect costs are projected to reach $47 billion by 2020[10].

China represents one of the most rapidly aging societies and has the largest elderly population in the world. The number for people aged 60 and over in the country stood at 185 million at the end of 2011[11] and is expected to surge to make up 34% of the population in 2050, compared to about 12% in 2010[12]. Falls have now become a major health hazard among the aging population in China. In the community setting, the incidences of falls are 21%-23% and 43%-44%, respectively, for male and female residents aged 65 and over[13]. One study with a sample of 804 community residents aged 60 and over found that women (24.3%) are more likely than men (14.9%) to experience falls in the previous 12 months, and the incidence increases with age[14]. In another study on 507 retired teachers, the incidence of falls was found to be 16.57%, with 3.55% suffering two falls or more; the risk factors differentiating between recurrent falls and non-recurrent falls included the fall history and abnormalities in dynamic balance ability, while the risk factor separating recurrent falls from single falls could be ascribed to abnormalities in dynamic balance ability[15].

It has been demonstrated that falls occur as the result of a combination of biological, behavioral, and environmental factors, which can be managed with various intervention measures[16]. Consequently, specific public health policies should be formulated to allocate adequate resources to prevent and minimize falls among the elderly. To institute such intervention measures, it is essential to identify factors that contribute to falls and those that serve to prevent falls. Additionally, people with a fall history are at a greater risk of falling again, as shown by a study with 653 participants, which found that 6.0% of all participants and 41.1% of those with a fall history experienced recurrent falls and, of the participants who encountered recurrent falls, most had a fall history[17]. However, despite an abundance of literature on falls, most studies have treated fallers as a single group, instead of subdividing them into different categories based on criteria such as frequency and others. This study was conducted to estimate the incidence and locate related factors for single and recurrent falls among elderly residents in an urban Beijing community.

MATERIALS AND METHODS

Definition of A Fall and Recurrent Falls

In this study, a 'fall event' was defined as a sudden, unintentional change in position causing an individual to land at a lower level or on an object, the floor or other surface, other than as a consequence of a sudden onset of overwhelming external force[18]. The term 'recurrent falls' was defined as falling two or more times within the past 12 months, while 'single fall' was defined as falling one time.

Participants

This was a follow-up study to a baseline survey that had been conducted involving elderly residents of the Longtan community in Dongcheng District, Beijing. As described elsewhere[19], the baseline survey was performed with 1512 residents aged 60 years and over from four residential neighborhoods of the community in 2005 and established an 18.8% incidence for falls (272 cases).

The followed-up study was conducted in 2009. The research protocol was approved by the Ethics Committee of Beijing Hospital, Ministry of Health. The sample size was based on the incidence obtained from the 2005 baseline survey and its agreement with that of the general population. Of the 1512 participants from the 2005 baseline survey, individuals were randomly selected from each residential neighborhood of the community. A total of 514 elderly persons were selected, and the sample consisted of 75% people from the group who fell (272 cases) and 25% people from the group who did not fall (1240 cases) at baseline in 2005. Subjects who had resided in the community for at least one

year were enrolled in the study after signing an informed consent form. Of the 514 participants, 472 responded during the household visits, with a response rate of 91.83%. The economic level, health status and utilization of health care services of residents in this community were close to the average of urban residents in Beijing; and results from our sample might only have generalizability to elderly citizens living in urban communities of Beijing.

Measurements and Instruments

A structured questionnaire was used in this study. Prior to the survey, a pilot study was conducted with 30 elderly residents by interviewing each of them twice at a 20-day interval, to test the reliability of the questionnaire. The retest reliability coefficient was 0.78 and minor revisions based on pilot study results were made before the final structure of the questionnaire was concluded.

A face-to-face interview was carried out with each of the subjects at his or her home using the questionnaire. If the participants were not able to answer questions by themselves, their caregivers were asked to give answers. Collected data included seven categories: demographic variables (gender, age, educational level, nationality, marital status, and working status), environmental factors (type of housing, indoor illumination, height of the bed, easiness of access to daily supplies, outdoor illumination, and height and width of stair steps), socio-economic status (living expenses, monthly income, number of household members, number of family caregivers), utilization of health care services (type of health insurance, frequency of physical examination, and access to hospital), general health status (dependence on walking aids, vision, physical ability, health self-assessment, impact of health issues on daily life, evaluation of daily activity, mental state examination, and urinary/fecal incontinence), functional assessment (static balance, dynamic balance, and gait disturbance), behavioral and psychological factors (frequency of drinking, smoking, walking, riding, playing Tan Chi and doing physical exercises, frequency of emotional instability, being fear of falls, and reducing daily physical activities due to falls). For those who could not remember the situation of fall occurrence or the consequence, interviewers would check their medical records such as clinic medical records or discharge summaries. A physical functional assessment including dynamic and static balance was carried out during the interview.

Statistical Analysis

SPSS version 15.0 for Windows was used for data analysis. Descriptive analysis was performed for demographic characteristics and fall-related variables. Continuous variables were expressed as means and standard deviations. Categorical variables were analyzed by the chi-square test. Mantel-Haenszel's stratified analysis was used to control the confounding factors. As the sample size in this study was relatively small, logistic regression analysis was first performed parallelly within each category of collected information to identify related factors associated with fall-related injuries and falls (single and recurrent falls), and then built with all significant factors identified within each category to adjust the confounding effects among factors across categories. Statistically, multilevel model analysis is particularly appropriate for research designs where data for participants are organized at more than one level, and the units of analysis are usually individuals (at a lower level) who are nested within contextual/aggregate units at a higher level[20-21]. Thus, the relationship of falls with intrinsically and extrinsically related factors was estimated by using multilevel model analysis in the study. The statistical significance level was set as $P<0.05$ (2-tailed) and as $\alpha_{inclusion}=0.05$, $\alpha_{exclusion}=0.10$ for logistic regression.

RESULTS

General Characteristics & Incidence of Falls

Of the 472 participants, 289 (61.2%) were women and 183 (38.8%) were men. The mean age of the participants was 74.2±6.3 years. Information on education was collected in two categories, with 106 (22.5%) not having any education, 366 (77.5%) receiving at least elementary school education, and men receiving more education than women ($\chi^2=177.62$, $P<0.001$). Concerning marital status, 306 (64.8%) were married (49.3% of the men and 50.7% of the women in 306 samples) and 149 (31.6%) were widowed or divorced. Pension payments were the major source of income for 85.4% of the respondents and 5.7% were supported by their children. As for living arrangement, 30 (6.4%) lived alone, whereas 442 (93.6%) lived with family members or others. In terms of types of housing, 6.1%, 22.9%, and 71.0% of the community-dwelling elderly were living in bungalows, apartments with

elevators or apartments without elevators, respectively.

The incidence of falls and recurrent falls among the elderly is shown in Table 1. During the previous year, 121 falls occurred in 84 elderly persons, with a prevalence (the number of falls per 100 persons of 25.6% (121/472) and an incidence (the number of persons with at least one fall per 100 persons) of 17.8% (84/472). Of those who experienced falls in the previous year, their frequency was 1.44±0.67 per person, The incidence of falls was 16.6% (48/289) for women and 19.7% (36/183) for men; there was no statistical difference in the incidence of falls between men and women after adjustment for age with Mantel-Haenszel's stratified analysis (χ^2=0.72, P=0.400). Linear trend analysis showed that the occurrence of falls increased with age ($\chi^2_{for\ trend}$=21.06, P=0.001). Among those who fell, 55 (65.5%) had experienced single fall during the past year. A total of 29 respondents, including 17 women and 12 men, were recurrent fallers, constituting a prevalence of 34.5% among the fallers and an incidence of 6.1% among all participants. The incidence of recurrent falls between men and women also showed no statistical difference (χ^2=0.48, P=0.490) and it increased with age ($\chi^2_{for\ trend}$=19.20, P=0.002).

Fall-Related Injuries & Its Related Factors

Of the 84 elderly persons who had experienced falls in the previous year, 38 (45.2%) reported fall-related injuries. There were 16 single fallers and 22 recurrent fallers; and the ratio of injuried people among recurrent fallers was significantly higher than that among single fallers (22/29 *vs.* 16/55, χ^2=16.77, P<0.001). The 121 falls resulted in 48 (39.7%) injuries, including 18 injuries from single fallers and 30 injuries from recurrent fallers. The most common locations of injury were the lower limbs (22 times, 45.8%), followed by the upper limbs (13 times, 27.1%), the hip (7 times, 14.6%), the head (4 times, 8.3%), and the vertebral column (2 times, 4.2%). The types of injury, in order of frequency, included abrasions (27 times, 56.3%), fractures (7 times, 14.6%), soft-tissue bruises (7 times, 14.6%), lacerations (5 times, 10%), and cerebral concussions (2 times, 4.2%). As a result of falls, 22 elderly persons required hospitalization, which was due to hip fractures (7 cases), rib fractures (3 cases), lumbar vertebral fractures (4 cases), cerebral hemorrhages (4 cases), severe soft-tissue bruises (2 cases), or severe lacerations (2 cases).

Binary logistic regression was used to determine factors responsible for injuries related to single fall or recurrent falls. After adjustment for potential confounding factors across categories, logistic regression analysis found statistically significant variables associated with injuries ($\alpha_{inclusion}$=0.05, $\alpha_{exclusion}$=0.10), as listed in Table 2. Single fallers with age≥80 years had a higher risk for suffering injuries due to falls; and easiness of access to daily supplies and sufficient lighting for stairways could lower the risk of injuries related to single fall. Living alone, poor self-rated health and excessive drinking were risk factors, while having caregivers when being sick and having physical examination frequently appeared to be protective factors for fall-related injuries in single fallers. However, in recurrent fallers, age≥80 years, living alone, dependence on walking aids, poor self-rated health, abnormal dynamic balance and fear of falls could increase the risk of injuries, while having caregivers when being sick could protect elderly persons from fall-related injuries.

Table 1. Occurrence Rate of Falls in the Elderly by Stratified Age and Gender, *n* (%)

Age (yr)	Men			Women			Total		
	Participants	Fall	Recurrent Falls	Participants	Fall	Recurrent Falls	Participants	Fall	Recurrent Falls
60-	10	2 (20.0)	1 (10.0)	27	4 (14.8)	2 (7.4)	37	6 (16.2)	3 (8.1)
65-	32	9 (28.1)	1 (3.13)	74	7 (9.5)	3 (4.1)	106	16 (15.1)	4 (3.8)
70-	59	4 (6.8)	3 (5.1)	93	12 (12.9)	4 (4.3)	152	16 (10.5)	7 (4.6)
75-	57	13 (22.8)	2 (3.5)	48	9 (18.8)	1 (2.1)	105	22 (21.0)	3 (2.9)
80-	18	5 (27.8)	3 (16.7)	31	9 (29.0)	4 (12.9)	49	14 (28.6)	7 (14.3)
85-95	7	3 (42.9)	3 (42.9)	16	7 (43.8)	2 (12.5)	23	10 (43.5)	5 (21.7)
Total	183	36 (19.7)	13 (7.1)	289	48 (16.6)	16 (5.5)	472	84 (17.8)	29 (6.1)

Factors Associated with Single Fall and Recurrent Falls

Binary logistic stepwise regression procedure was performed for associations between variables across categories and single fall or recurrent falls ($\alpha_{inclusion}$=0.05, $\alpha_{exclusion}$=0.10), which are presented in Table 3. Results from Model 1, which examined non-fallers versus fallers (single fallers plus recurrent fallers), showed that age, living alone, gait disturbance, abnormal static balance, fear of falls and excessive drinking could increase the risk for falls, while appropriate width/height of stair steps, sufficient lighting for stairways and regular exercise had a protective effect on falls. Model 2, which examined non-fallers versus single fallers, displayed that age, living alone and gait disturbance were risk factors, while housing with elevators, appropriate width/height of stair steps in surrounding environment, sufficient lighting for stairway and regular exercise could lower the risk for single fall. Model 3, analyzing non-fallers/one-time fallers versus recurrent fallers through logistic regression analysis, found that factors such as low monthly family income, poor vision, low physical ability, abnormal static balance and fear of falls were risk factors, while appropriate width/height of stair steps in the surrounding environment and easiness of access to daily supplies were protective factors for recurrent falls.

Impact of Intrinsic & Extrinsic Factors on Falls

Multilevel model analysis was carried out to analyze the impact of intrinsic contributing factors (e.g. health status) and extrinsic contributing factors on falls. In this variance component model, individuals were set as level 1, while different residential neighborhoods of the community were set as level 2. Variances of models for the influence of intrinsic factors and extrinsic factors were both statistically significant (*P*=0.004, 0.007), which indicated that there was hierarchical clustering in level 2. Results showed that, when intrinsic factors such as health status were taken into consideration, location was the main contributing factor for falls. In other words, individuals with good health would have a higher risk for outdoor falls, while those with poor health were more likely to encounter falls indoors (Table 4). However, main extrinsic contributing factors for falls were season and time of the day, indicating that elderly persons were at a higher risk for falls at summertime or late night of the day (Table 5).

Table 2. Logistic Regression Analysis on Factors Responsible for Injuries Related to Single or Recurret Falls

Variables	Model 1 Single Fall			Model 2 Recurrent Falls		
	β-value	*P*-value	*OR* (95% CI)	*β-value*	*P*-value	*OR* (95% CI)
Demographic Variables						
Age≥80 years	0.675	0.012	1.96 (1.24-4.21)	0.827	0.006	2.29 (1.42-2.94)
Environmental Factors						
Easiness of Access to Daily Supplies	-0.895	0.008	0.41 (0.23-0.71)			
Sufficient Lighting for Stairways	-0.452	0.043	0.64 (0.32-0.94)			
Socio-economic Status						
Living Alone	0.539	0.036	1.71 (1.35-3.23)	0.735	0.054	2.09 (0.79-4.35)
Having Caregivers When Being Sick	-0.648	0.057	0.52 (0.21-2.64)			
Utilization of Health Care Services						
Having Physical Examination Frequently	-0.429	0.025	0.65 (0.37-3.97)	-0.227	0.063	0.80 (0.46-5.10)
General Health Status						
Dependence on Walking Aids				0.738	0.001	2.09 (1.37-5.03)
Poor Self-Rated Health	0.586	0.02	1.80 (1.10-2.95)	1.459	0.002	4.30 (1.72-8.76)
Functional Assessment						
Abnormal Dynamic Balance				0.667	0.003	1.95 (1.24-3.78)
Behavioral & Psychological Factors						
Excessive Drinking	1.13	0.005	3.10 (1.60-6.00)			
Fear of Falls				1.195	0	3.30 (2.15-5.08)

Table 3. Logistic Regression Analysis of Factors Associated with Single Fall or Recurrent Falls

Variables	Model 1 All Falls (Single Fallers & Recurrent Falls)			Model 2 Single Fall			Model 3 Recurrent Falls		
	β-value	*P*-value	*OR* (95% CI)	*β-value*	*P*-value	*OR* (95% CI)	*β-value*	*P*-value	*OR* (95% CI)
Demographic Variables									
Age	0.028	0.006	1.03 (1.01-1.05)	0.787	0.001	2.20 (1.37-3.53)			
Environmental Factors									
Housing with Elevators				-1.041	0.041	0.35 (0.13-0.96)			
Appropriate Width/Height of Stair Steps	-0.372	0	0.69 (0.56-0.85)	-0.255	0.03	0.78 (0.64-0.94)	-0.713	0.092	0.49 (0.21-1.12)
Easily Access to Daily Supplies							-0.89	0.093	0.41 (0.14-1.16)
Sufficient Lighting for Stairway	-0.485	0.009	0.62 (0.43-0.89)	-0.809	0.043	0.45 (0.21-0.96)			
Socio-economic Status									
Low Monthly Family Income							0.326	0.088	1.39 (0.67-2.16)
Living Alone	0.502	0.03	1.65 (1.05-2.59)	1.541	0.003	4.67 (1.66-13.10)			
General Health Status									
Poor Vision							0.604	0.018	1.83 (1.11-3.02)
Low Physical Ability							1.498	0.002	4.47 (1.70-5.75)
Functional Assessment									
Gait Disturbance	0.471	0.025	1.60 (1.06-2.42)	0.242	0.028	1.27 (1.03-1.58)			
Abnormal Static Balance	0.452	0.039	1.57 (1.02-2.41)				0.908	0.034	2.48 (1.84-4.05)
Behavioral & Psychological Factors									
Fear of Falls	0.621	0	1.86 (1.37-2.52)				0.8	0.047	2.23 (1.47-3.85)
Regular Exercise	-0.297	0.079	0.74 (0.53-1.03)	-2.133	0.089	0.12 (0.05-2.29)			
Excessive Drinking	0.324	0.002	1.38 (1.12-1.70)						

DICUSSION

Incidence of Falls & Recurrent Falls

This study showed that the incidence of falls during the previous year was 17.8% among the elderly aged 60 years or over living in an urban community of Beijing and was lower than the incidences presented by the WHO Global Report and a study on a community-dwelling population in Taiwan, which were 28%-35% and 22.7%, respectively[22-23]. Several earlier studies conducted in China reported incidences ranging from 14.7% to 34.0% for the elderly who experienced falls within a one-year period[24-26]. A population-based longitudinal study on falls among Taiwanese community-dwelling residents aged 60 years or over reported an incidence of 18.8%[27], which was close to what we found in this study. The inciedence of recurrent falls in this study was 6.1%, clearly lower than the incidence of 11.2% described by a study on community-dwelling older Koreans[28]. Such discrepancies in the incidence of falls could be partially explained by recall bias in the retrospective data collection approach and by different assessment tools adopted in these studies. However, since age is a major contributing factor for falls, differences in age brackets should be considered when results from different studies are compared. In

Table 4. Two-Level Variance Component Model for the Influence of Intrinsic Factors on Falls

Parameters		*b*	S_b	χ^2-Value	*P*-Value
Fixed Parts					
Intercept		-3.297	2.880	1.310	0.252
Gender		-0.299	1.352	0.049	0.848
Season	Summer	-2.288	1.503	2.317	0.128
	Autumn	2.476	1.960	1.595	0.207
	Winter	-0.934	1.226	0.544	0.461
Time of Day	Morning	1.777	1.599	1.235	0.266
	Noon	0.547	1.955	0.078	0.780
	Afternoon	0.059	1.692	0.001	0.975
	Night	0.280	1.698	0.027	0.869
	Late Night	1.641	3.292	0.248	0.619
Location		2.467	1.224	4.059	0.044
Random Parts					
Level 2		11.051	4.579	5.825	0.016
Level 1		1.000	0.000	-	-

Table 5. Two-Level Variance Component Model for the Influence of Extrinsic Factors on Falls

Parameters		*b*	S_b	χ^2-Value	*P*-Value
Fixed Parts					
Intercept		-2.743	2.452	1.251	0.263
Gender		0.428	1.039	0.170	0.680
Season	Summer	-2.691	1.272	4.477	0.034
	Autumn	-2.594	1.437	3.257	0.071
	Winter	-1.613	1.107	2.214	0.137
Time of Day	Morning	1.834	1.488	1.521	0.218
	Noon	1.955	1.920	1.080	0.299
	Afternoon	1.000	1.506	0.441	0.507
	Night	2.723	1.740	2.449	0.118
	Late Night	15.282	2.108	52.580	<0.001
Location		1.156	0.948	1.489	0.222
Random Parts					
Level 2		7.584	2.855	7.058	0.008
Level 1		1.000	0.000	-	-

most studies conducted in Western countries, subjects have consisted of people aged 65 years or older[29-30]. In contrast, all the participants in this study were 60 years old or over, with a mean age of 74.2 years. We also observed that the incidence of falls or recurrent falls in elderly people increased with age, a finding consistent with previously reported data[17,31]. Unlike results from other investigators, the present study was unable to detect a gender difference in the incidence of falls or recurrent falls[17,30,32].

Fall-Related Injuries

In our study, 45.2% of the falls were associated with injuries. Others have reported that 12% to 42% of falls had a fall-related injury[33-34] and 5%-10% of falls resulted in serious injuries such as fractures (6% to 8%)[25]. Falls and fall-related injuries can lead to functional decline, disability, and sometimes death in the elderly[35]. Data from the United States showed that a total of 15,802 persons aged 65 years or older died as a result of injuries from falls in 2005[36]. Existing studies have shown that common minor injuries, such as bruises, abrasions, lacerations, and sprains, account for a significant proportion (44%) of all injuries caused by falls, whereas more serious injuries, including hip and wrist fractures, occur much less frequently (approximately 4% to 5%)[37-38]. The current study recorded 121 falls, of which 48 resulted in injuries (39.7%), and most of the injuries are of the minor types, similar to others' observations. Moreover, we also noticed that older age, living alone, dependence on walking aids, poor health and abnormal dynamic balance placed the individual at a higher risk for suffering fall-related injuries. Generally, the elderly are increasingly susceptible to injury because of the higher prevalence of comorbidities, age-related physiological changes and delayed functional recovery, which in turn further exacerbate deconditioning, a common occurrence in physically inactive older people and characterized by reduced functional capabilities of multiple body systems, especially the musculoskeletal system[39]. As individuals age, their ability to coordinate movements, maintain steady gaits and control postures gradually declines. As such, they are less capable of making necessary reactions and adjustments in time to avoid an impending fall[33]. Meanwhile, this results in our study indicated that compared with injuries due to single fall, injuries related to recurrent falls had closer relationship with intrinsic factors such as age, poor health, mobility impairment, balance problem, and emotional problem. This result was consistent with existing study[40].

Fall-Related Factors

Since falls are complex events attributable to a host of factors, any effective prevention strategies should take a targeted, multidisciplinary approach[41]. This study identified age, type of housing, height, and width of stair steps, complexity to access to daily supplies, illumination, monthly income, number of household members, vision, physical status, gait and balance function, fear of falls, doing physical exercises, and frequency of drinking as the contributing factors, supporting the notion that falls are of multifactorial causes. Age is the most prominent risk factor for falls. Normal aging is accompanied with declines in several physiological systems, including those associated with critical cognitive and motor functions[42]. Environmental factors, including housing without elevators, inappropriate width/height of stair steps, difficultly of access to daily supplies, and poor lighting, are also important in contributing to falls. Interventions based on environment hazard assessment have proved to be beneficial in preventing falls[2]. Nevertheless, reducing environment hazards alone may be insufficient to significantly reduce the risk for falls[41].

The exact roles of the other factors have yet to be more clearly defined. We found that higher monthly income was related to fewer recurrent falls, yet, according to another study, although an increase in personal income seemed to have reduced the probability of falling, the actual effect was negligible[43]. Regarding living arrangement, our study recognized living alone as a contributing factor for falls, while other study either are in agreement with ours[44] or consider it inconsequential[45]. It needs to be pointed out that these observations have come from different cultural and ethnic groups. As many other studies[42,44,46], poor health status such as poor vision and low physical ability has been proved to contribute to a higher risk of falls in our study. Gait and balance disorders have been consistently identified as one of the strongest risk factors for falls[46]. The gait pattern in older people tends to be less coordinated and makes them more vulnerable to falls[47]. Many older adults who have experienced falls will develop a marked fear of falling and some of them try to restrict their

activities of daily living[48], thus setting up a vicious circle with debilitating consequences[49]. Similar to what we found in this study, a reduction in the incidence of falls after exercise has been reported[50]. Drinking has traditionally been linked to increased falls[51]. We noted that excessive drinking was associated with increased falls. However, others produced incongruous results, with one study reporting light alcohol intake contributing to a lower risk for falls[52] and another failing to reconcile cross-sectional and longitudinal data concerning the impact of heavy drinking on falls[53]. In our study, considering the number of falls, we analyzed associated factors for fall, single fall and recurrent falls, respectively. The results showed that while extrinsic factors such as environmental causes for falling had a commonsense appeal, it was likely that intrinsic factors such as health status, psychological factors and functional assessment became more important with recurrent falls, which also verified the hypothesis proposed by Nickens[54].

In order to identify intrinsic factors, we conducted multilevel model analysis and found that location had an influence on falls. Specifically, elderly persons in good health had a higher likelihood of encountering falls outdoors, whereas those in poor health were more likely to fall indoors. This finding was consistent with previously reported results[55]. Additionally, summertime and late night of the day were the times when elderly persons suffered fall more frequently. It is likely that increased numbers of activities scheduled for summertime was the underlying cause for the increased frequency of falls. As for late night, poor lighting or an altered mental state could be responsible for the higher risk.

Limitations

There are several limitations in this study. In particular, since self-reported data were used, the incidence of falls could have been underestimated because some participants might have been unable to recall all the falls. The validity of the findings could also be compromised by survival bias considering that only those who had survived falls were surveyed in this study. Meanwhile, the sample size 472 elderly for a cross-sectional study was relatively small, especially when testing a large number of potential associated factors. Moreover, even though we evaluated and adjusted many potential risk factors for falls in the elderly, some other risk factors such as medication use, bone mineral density and vitamin D intake, which are also important predictors of falls, were not included in this study. Therefore, future studies should take those factors into consideration.

Conclusions

In conclusion, with the population aging very rapidly in China, falls and their related injuries are becoming an important healthcare concern and economic burden. The occurrence of falls in community-dwelling elderly people in Beijing is common and increases with age. Both intrinsic and extrinsic factors are associated with falls and their related injuries. Some of these factors, like age or gender, cannot be altered. However, many other fall risk factors can be readily mitigated via intervention measures. Therefore, intervention protocols and outcome assessment methods need to be established to help those at an increased risk for falls and ultimately reduce the negative impact of falls in older adults.

AUTHOR CONTRIBUTIONS

SHI Jing performed the survey, collected and analyzed the data and wrote the paper. ZHOU Bai Yu performed the survey and collected the data. TAO Yong Kang performed the survey and collected the data. YU Pu Lin conceived and designed the survey. ZHANG Chuan Fang collected and analyzed the data. QIN Zhao Hui designed and performed the survey. SUN Zhen Qiu conceived and designed the survey.

Received: June 9, 2014;
Accepted: September 1, 2014

REFERENCES

1. Carpenter CR, Scheatzle MD, D'Antonio JA, et al. Identification of fall risk factors in older adult emergency department patients. Acad Emerg Med, 2009; 16, 211-9.
2. Gillespie LD, Gillespie WJ, Robertson MC, et al. Interventions for preventing falls in elderly people. Cochrane Database Syst Rev, 2003; 4, CD000340.
3. Gillespie LD, Robertson MC, Gillespie WJ, et al. Interventions for preventing falls in older people living in the community. Cochrane Database Syst Rev, 2012; 9, CD007146.
4. Soriano TA, DeCherrie LV, Thomas DC. Falls in the community-dwelling older adult: a review for primary-care providers. Clin Interv Aging, 2007; 2, 545-54.
5. Kannus P, Palvanen M, Niemi S, et al. Alarming rise in the number and incidence of fall-induced cervical spine injuries among older adults. J Gerontol A Biol Sci Med Sci, 2007; 62, 180-3.
6. Abdelhafiz AH, Austin CA. Visual factors should be assessed in older people presenting with falls or hip fracture. Age Ageing, 2003; 32, 26-30.
7. Centers for Disease Control and Prevention, National Center

for Injury Prevention and Control. Web-based Injury Statistics Query and Reporting System (WISQARS). Available from: http://www.cdc.gov/injury/wisqars; [2014-03-28].
8. Stevens JA, Corso PS, Finkelstein EA, et al. The costs of fatal and non-fatal falls among older adults. Inj Prev, 2006; 12, 290-5.
9. Lee A, Mills PD, Watts BV. Using root cause analysis to reduce falls with injury in the psychiatric unit. Gen Hosp Psychiatry, 2012; 34, 304-11.
10. Wu S, Keeler EB, Rubenstein LZ, et al. A cost-effectiveness analysis of a proposed national falls prevention program. Clin Geriatr Med, 2010; 26, 751-66.
11. The Central People's Government of the People's Republic od China. Available from: http://www.gov.cn/jrzg/2012-03/01/content_2080525.htm; [2014-03-28].
12. World Population Prospects, the 2010 Revision. Available from: http://esa.un.org/unpd/wpp/index.htm; [2014-03-28].
13. Lv J, Li LM. Review of injury in elderly population. J Dis Control Prev, 1999; 3, 300-3. (In Chinese)
14. Yan L, Li XH, Wu SC. Investigation of incidence of falls and its cognition in the elderly living in community. Chin J Mod Nurs, 2010; 16, 1399-402. (In Chinese)
15. Li LT, Wang SY, Jing CX. Investigation on risk factors of multi-falls in elderly people. Chin J Dis Control Prev, 2007; 11, 280-2. (In Chinese)
16. Goodwin VA, Abbott RA, Whear R, et al. Multiple component interventions for preventing falls and fall-related injuries among older people: systematic review and meta-analysis. BMC Geriatr, 2014; 14, 15.
17. Wu TY, Chie WC, Yang RS, et al. Risk factors for single and recurrent falls: a prospective study of falls in community dwelling seniors without cognitive impairment. Prev Med, 2013; 57, 511-7.
18. Tinetti ME, Baker DI, Dutcher J, et al. Reducing the risk of falls among older adults in the community. Berkeley, CA: Peaceable Kingdom Press, 1997.
19. Yu PL, Qin ZH, Shi J, et al. Prevalence and related factors of falls among the elderly in an urban community of Beijing. Biomed Environ Sci, 2009; 22, 179-87.
20. Fidell BG, Tabachnick LS. Using multivariate statistics (5th ed). Boston, Montreal: Pearson/A & B, 2007.
21. Luke DA. Multilevel modeling (3rd ed). Thousand Oaks, CA: Sage, 2004.
22. WHO Global Report on falls prevention in older age. Geneva: World Health Organization, 2007.
23. Lin CH, Liao KC, Pu SJ, et al. Associated factors for falls among the community-dwelling older people assessed by annual geriatric health examinations. PLoS One, 2011; 6, e18976.
24. Chu LW, Chi I, Chiu AY. Incidence and predictors of falls in the Chinese elderly. Ann Acad Med Singapore, 2005; 34, 60-72.
25. Kwan MM, Close JC, Wong AK, et al. Falls incidence, risk factors, and consequences in Chinese older people: a systematic review. J Am Geriatr Soc, 2011; 59, 536-43.
26. Lin CH, Liao KC, Pu SJ, et al. Associated factors for falls among the community-dwelling older people assessed by annual geriatric health examinations. Plos One, 2011; 6, e18976.
27. Chien MH, Guo HR. Nutritional status and falls in community-dwelling older people: a longitudinal study of a population-based random sample. PLoS One, 2014; 9, e91044.
28. Yoo IY. Recurrent falls among community-dwelling older Koreans: prevalence and multivariate risk factors. J Gerontol Nurs, 2011; 37, 28-40.
29. Sai AJ, Gallagher JC, Smith LM, et al. Fall predictors in the community dwelling elderly: a cross sectional and prospective cohort study. J Musculoskelet Neuronal Interact, 2010; 10, 142-50.
30. Ranaweera AD, Fonseka P, PattiyaArachchi A, et al. Incidence and risk factors of falls among the elderly in the district of Colombo. Ceylon Med J, 2013; 58, 100-6.
31. Fhon JR, Rosset I, Freitas CP, et al. Prevalence of falls among frail elderly adults. Rev Saude Publica, 2013; 47, 266-73.
32. Stenhagen M, Ekström H, Nordell E, et al. Falls in the general elderly population: a 3- and 6- year prospective study of risk factors using data from the longitudinal population study 'Good ageing in Skane'. BMC Geriatr, 2013; 13, 81.
33. Rubenstein LZ. Falls in older people: epidemiology, risk factors and strategies for prevention. Age Ageing, 2006; 35, ii37-ii41.
34. Stalenhoef PA, Crebolder H, Knottnerus JA, et al. Incidence, risk factors and consequences of falls among elderly subjects living in the community. Eur J Public Health, 1997; 7, 328-34.
35. Kannus P, Sievanen H, Palvanen M, et al. Prevention of falls and consequent injuries in elderly people. Lancet, 2005; 366, 1885-93.
36. Stevens JA, Mack KA, Paulozzi LJ, et al. Self-reported falls and fall-related injuries among persons aged>or = 65 years–United States, 2006. J Safety Res, 2008; 39, 345-9.
37. O'Loughlin JL, Robitaille Y, Boivin JF, et al. Incidence of and risk factors for falls and injurious falls among the community-dwelling elderly. Am J Epidemiol, 1993; 137, 342-54.
38. Close JC, Lord SL, Menz HB, et al. What is the role of falls? Best Pract Res Clin Rheumatol, 2005; 19, 913-5.
39. Rubenstein LZ, Josephson KR. The epidemiology of falls and syncope. Clin Geriatr Med, 2002; 18, 141-58.
40. Lee HS, Kim MJ. A study on fall accident. Taehan Kanho, 1997; 36, 45-62.
41. Panel on Prevention of Falls in Older Persons, American Geriatrics Society and British Geriatrics Society, Kenny RA, et al. Summary of the Updated American Geriatrics Society/British Geriatrics Society clinical practice guideline for prevention of falls in older persons. J Am Geriatr Soc, 2011; 59, 148-57.
42. Segev-Jacubovski O, Herman T, Yogev-Seligmann G, et al. The interplay between gait, falls and cognition: can cognitive therapy reduce fall risk? Expert Rev Neurother, 2011; 11, 1057-75.
43. Trujillo AJ, Puvanachandra P, Hyder AA. Individual income and falls among the elderly in Latin America. Geriatr Gerontol Int, 2011; 11, 180-90.
44. Kamel MH, Abdulmajeed AA, Ismail Sel-S. Risk factors of falls among elderly living in urban Suez-Egypt. Pan Afr Med J, 2013; 14, 26.
45. Ennis SK, Larson EB, Grothaus L, et al. Association of Living Alone and Hospitalization Among Community-Dwelling Elders With and Without Dementia. J Gen Intern Med, 2014; [Epub ahead of print].
46. Deandrea S, Lucenteforte E, Bravi F, et al. Risk factors for falls in community-dwelling older people: a systematic review and meta analysis. Epidemiology, 2010; 21, 658-68.
47. Jensen JL, Brown LA, Woollacott MH. Compensatory stepping: the biomechanics of a preferred response among older adults. Exp Aging Res, 2001; 27, 361-76.
48. Ambrose AF, Paul G, Hausdorff JM. Risk factors for falls among older adults: a review of the literature. Maturitas, 2013; 75, 51-61.
49. Zijlstra GA, van Haastregt JC, van Eijk JT, et al. Prevalence and correlates of fear of falling, and associated avoidance of activity in the general population of community-living older people. Age Ageing, 2007; 36, 304-9.

50.Cadore EL, Rodríguez-Mañas L, Sinclair A, et al. Effects of different exercise interventions on risk of falls, gait ability, and balance in physically frail older adults: a systematic review. Rejuvenation Res, 2013; 16, 105-14.
51.Kool B, Ameratunga S, Jackson R. The role of alcohol in unintentional falls among young and middle-aged adults: a systematic review of epidemiological studies. Inj Prev, 2009; 15, 341-7.
52.Cawthon PM, Harrison SL, Barrett-Connor E, et al. Alcohol intake and its relationship with bone mineral density, falls, and fracture risk in older men. J Am Geriatr Soc, 2006; 54, 1649-57.
53.Mukamal KJ, Mittleman MA, Longstreth WT Jr, et al. Self-reported alcohol consumption and falls in older adults: cross-sectional and longitudinal analyses of the cardiovascular health study. J Am Geriatr Soc, 2004; 52, 1174-9.
54.Nickens H. Intrinsic factors in falling among the elderly. Arch Intern Med, 1985; 145, 1089-93.
55.Kelsey JL, Procter-Gray E, Berry SD, et al. Reevaluating the implications of recurrent falls in older adults: location changes the inference. J Am Geriatr Soc, 2012; 60, 517-24.