An analysis of the risk factors for falls, recurrent falls, and fall-related injuries among the elderly in senior Chinese apartments: a cross-sectional study

Qingqing Su

Medical School of Chinese PLA

Mi Song

Medical School of Chinese PLA

Jie Zhang

Chinese PLA General Hospital

Yazhan Mao

Medical School of Chinese PLA

Jie Song

Medical School of Chinese PLA

Hongying Pi (✉ 879357401@qq.com)

Chinese PLA General Hospital

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Abstract

Objective

Falls, recurrent falls, and fall-related injuries among the elderly are severe problems that seriously threaten the quality of life and health in old age. However, there are few studies on fall risks among the elderly living in senior apartments in China. Our study aims to investigate the factors and differences in falls, recurrent falls, and fall-related injuries among these elderly residents, providing a reference for screening those with high fall risks.

Method

Face-to-face structured interviews were conducted on 331 older adults over 65 years of age living in four senior apartments. We performed comparative analyses on the results of fall events with two separate criteria (falls vs. no falls; number of falls ≤ 1 and without injury vs. fall-related injuries or number of falls ≥ 2). Several significant variables were involved in a logistic model for regression analysis.

Results

Falls, recurrent falls, and fall-related injuries among the elderly in senior apartments were independently associated with gender (female), urinary incontinence/frequency, and conscious unsteady gait. Furthermore, fall risks increased with age and the number of risk factors. The AUC, sensitivity, and specificity of the fall risk prediction model were 0.749, 82.4%, and 57.1%, respectively.

Conclusions

Falls among the elderly in senior apartments are affected by several factors. Female elderly with urinary incontinence/frequency and conscious unsteady gait should be prioritized for fall prevention interventions.

Introduction

With an increase in human life expectancy, the degeneration of physiological functions (e.g., body functions, balance, limb coordination [1]) and other factors (e.g., diseases, drugs, cognitive impairment) lead to a significantly enhanced probability of falls, recurrent falls, and fall-related injuries. Research has shown that about 32% of falls in the elderly lead to hip fractures, brain injuries, and other severe injuries, being the main causes of decreased activity, independence, quality of life, and thus increased mortality [2, 3]. Although falls in the elderly have received attention over time, they continue to be a global public health problem that needs to be addressed due to the aging population. Falls are the second leading cause of death from accidental injury worldwide and have become the leading cause of death from injury

among the elderly over 65 years of age in China [4, 5]. Due to the harmful effects of falls, people in China often refer to falls in the elderly as "the last fall in life". As the most populous nation in the world, the number of people aged 65 years and above has reached 190.64 million in China. Therefore, China faces more significant challenges in preventing and managing falls among the elderly compared to other nations.

Injuries caused by falls are often considered minor due to the low death rate from falls [6]. However, falls have a high incidence, with a third of the elderly experiencing falls each year [7, 8]. Moreover, injuries caused by falls have a significant impact on the daily life, independence, and mental health of the elderly [9]. It has been shown that even a fall without injury can be a psychological burden for the elderly [10]. Hence, fall prevention and intervention are vital. It has been proven that multi-factor interventions for risks among the elderly can reduce the incidence of falls and their adverse consequences [11]. Recently, researchers have focused on falls in the elderly, particularly on the fall-related factors of specific groups and fall interventions [12–14]. However, there are few reports or studies on falls among the elderly in senior housing. The research on the differences between the risk factors for isolated falls and recurrent falls/fall-related injuries is lacking. The above situation may result from the late emergence of supporting the elderly in senior housing in China.

In China, senior housing arrangements provide professional life and medical care services for the elderly with financial and self-care capabilities, typically in medium to high-end pension-based institutions [15]. Reducing and preventing falls in the elderly is one of the critical components of safety in pension-based institutions and is vital in reducing disputes, improving quality of service, and in the recognition of the benefits of institutional care [16]. Therefore, it is necessary to investigate falls in the elderly in senior apartments. Additionally, some researchers believe that the cause of an isolated fall is more uncertain than that of recurrent falls. Isolated falls are more likely to be affected by the environment or unexpected events, while recurrent falls are more likely to be affected by inherent factors. Consequently, risk interventions for recurrent falls are expected to get better outcomes [17].

This study aims to identify the primary factors and differences among these factors that affect falls, recurrent falls, and fall-related injuries among the elderly in senior apartments by investigating their fall status. The results provide a reference for identifying those at high risk for falls and help develop targeted interventions for fall prevention.

Materials And Methods

Subjects

A cross-sectional study was conducted from March to May 2019 on elderly persons at four senior apartments in Beijing who met the inclusion and exclusion criteria. The inclusion criteria were: age ≥ 65 years; able to walk independently or with assistance; has lived in the apartment for more than one year; subjects or their guardians provided informed consent to participate in the study. The elderly with mental

or acute physical illness were excluded. According to the requirement for multivariate analysis, the sample size was 5–10 times that of the number of study variables. In this study, 26 factors were investigated, and the minimum sample size was 130. Eventually, we investigated a total of 331 older people, which met the requirements of an adequate sample size. This study was approved by the medical ethics committee of Beijing PLA General Hospital (No.: S2018-048-01).

Data collection and variables

Two trained researchers engaged in geriatrics or geriatric nursing collected data by face-to-face interviews using a structured fall risk checklist. The interviewees were the elderly, their principal caregivers and family doctors (nurses). Written informed consent was obtained from the respondents before the investigation.

The survey items included gender, age, history of falls, diseases and symptoms, medications, difficulties with physical activity, psychological status, cognitive status, and abnormal behaviors of the elderly. Among them, diseases, symptoms, and medications were primarily obtained from medical and nursing records.

History of falls: The subjects were asked whether they had fallen within the past year. When the answer was "yes", they were further queried on whether they had been injured and if they had fallen ≥ 2 times. We defined a 'severe fall' by the occurrence of fall-related injuries or when the number of falls ≥ 2 times.

Diseases and symptoms: The subjects were asked whether they had ischemic heart disease, hypertension, stroke, diabetes, Parkinson's disease, urinary incontinence/frequent urination, orthostatic hypotension, dizziness while standing, and sensory disturbances. Sensory disturbances primarily included vision/hearing loss and numbness/pain in legs and feet.

Medications: The subjects were asked about their fall-risk related medications, including sedative hypnotics (ATC N05C), antipsychotics (ATC N05A), diuretics (ATC C03), and antihistamines (ATC R06). In addition, the elderly subjects were queried on whether they had a history of multiple-drug use involving more than four types of drugs.

Difficulties with physical activity: The subjects were asked whether they felt unstable while walking; whether hand support was necessary when getting up from a chair; whether crutches, walking aids, and other auxiliary equipment were needed for conducting daily activities.

Psychological status: The subjects were asked whether they suffered from insomnia/early awakening, depression, and the fear of falling.

Cognitive status: The subjects were asked whether they were able to communicate normally, and comprehend and follow the instructions of doctors and nurses. Based on the responses of "always", "sometimes", and "cannot", the cognitive status of the subjects was divided into "normal", "mild disorder", and "moderate/severe disorder".

Abnormal behaviors: The subjects were asked whether or not they followed necessary safety measures and whether they had been loitering.

Statistical analysis

SPSS24.0 statistical software was used for data analysis. The general information and main variables of the study were described by mean value, standard deviation, frequency, and percentage. A quantile-quantile plot (Q-Q plot) was performed to analyze the normality of variables. The chi-square test was used for univariate analysis. Following univariate analysis, a forward binary logistic regression analysis was performed to identify the independent risk factors of falls, recurrent falls, or fall-related injuries of the elderly. The Hosmer-Lemeshow statistics were used to test the goodness-of-fit of the model. Eventually, the ability of the model to identify fall risk in the elderly was quantified by the area under the receiver operating characteristic curve (AUC). $p < 0.05$ was considered statistically significant.

Results

General information and falls of the elderly

The age range of the 331 subjects was 65–104 years with an average age of 83.83 ± 6.37 years old. Among them, 60.4% were female, and 39.6% were male. In the past year, 142 subjects (42.9%) had experienced falls, and 102 subjects (30.8%) had serious falls.

Analysis of the factors causing falls/severe falls in the elderly living in senior apartments

The results of the univariate analysis for falls and severe falls are shown in Tables 1 and 2. The variables of statistical significance were included in a logistic regression model for multivariate analysis. The results showed that female gender (OR = 2.307), older age (OR = 4.724, 4.435, and 10.080 corresponded to 75–84, 85–94, and ≥ 95 years of age respectively), urinary incontinence/frequency (OR = 2.254), and unsteady gait (OR = 4.400) were independently associated with falls among the elderly (Table 3). In addition, female gender (OR = 2.289), urinary incontinence/frequency (OR = 2.004), and unsteady gait (OR = 3.612) were also closely related to severe falls in the elderly, including recurrent falls and fall-related injuries (Table 4).

Table 1
Univariate analysis of falls in the elderly (n = 331)

Risk factors	Overall n(%)	Falls n(%)	No falls n(%)	χ^2	<i>p</i>
Demographic data					
Gender					
Male	131(39.6)	47(14.2)	84(25.4)	4.365	0.037*
Female	200(60.4)	95(28.7)	105(31.7)		
Age					
65–74	27(8.2)	4(1.2)	23(6.9)	15.800	0.001**
75–84	136(41.1)	56(16.9)	80(24.2)		
85–94	155(46.8)	72(21.7)	83(25.1)		
≥ 95	13(3.9)	10(3.0)	3(0.9)		
Diseases and symptoms					
Ischemic heart disease	228(68.9)	100(30.2)	128(38.7)	0.275	0.600
Hypertension	172(52.0)	72(21.8)	100(30.2)	0.158	0.691
Diabetes	59(17.8)	28(8.4)	31(9.4)	0.609	0.435
Stroke	111(33.5)	53(16.0)	58(17.5)	1.602	0.206
Parkinson's disease	15(4.5)	9(2.7)	6(1.8)	1.875	0.171
Urinary incontinence / frequency	171(51.7)	91(27.5)	80(24.2)	15.369	< 0.001**
Orthostatic hypotension	17(5.1)	9(2.7)	8(2.4)	0.738	0.390
Dizziness while standing	101(30.5)	48(14.5)	53(16.0)	1.269	0.260
Vision/hearing loss	208(62.8)	94(28.4)	114(34.4)	1.200	0.273
Numbness/pain in legs and feet	91(27.5)	43(13.0)	48(14.5)	0.971	0.325
Drugs					
Sedative hypnotics	82(24.8)	38(11.5)	44(13.3)	0.527	0.468
Antipsychotics	92(27.8)	48(14.5)	44(13.3)	4.473	0.034*
Diuretics	24(7.3)	8(2.4)	16(4.8)	0.967	0.325

*Significant to the 0.05 level

**Significant to the 0.01 level

Risk factors	Overall n(%)	Falls n(%)	No falls n(%)	χ^2	<i>p</i>
Antihistamines	38(11.5)	21(6.3)	17(5.1)	2.678	0.102
Multiple-drug	201(60.7)	95(28.7)	106(32.0)	3.978	0.046*
Difficulties with physical activity					
Conscious unstable walking	209(63.1)	118(35.6)	91(27.5)	42.558	< 0.001**
Dysstasia	242(73.1)	121(36.6)	121(36.6)	18.520	< 0.001**
Walking aids	176(53.2)	100(30.2)	76(23.0)	29.721	< 0.001**
Psychological status					
Insomnia/early awakening	145(43.8)	66(19.9)	79(23.9)	0.721	0.396
Depression	124(37.5)	59(17.8)	65(19.6)	1.773	0.183
Fear of falling	229(69.2)	107(32.3)	122(36.8)	4.438	0.035*
Cognitive status					
Normal	156(47.1)	54(16.3)	102(30.8)	8.423	0.015*
Mild	98(29.6)	48(14.5)	50(15.1)		
Moderate/severe	77(23.3)	40(12.1)	37(11.2)		
Abnormal behaviors					
Lack of compliance with safety measures	128(38.7)	69(20.8)	59(17.8)	10.321	0.001**
Loitering behaviors	73(22.1)	38(11.5)	35(10.6)	3.204	0.073
*Significant to the 0.05 level					
**Significant to the 0.01 level					

Table 2
Univariate analysis of severe falls in the elderly (n = 331)

Risk factors	Fall-related injuries or falls ≥ 2 times n(%)	Falls ≤ 1 time and without injuries n(%)	χ^2	<i>p</i>
Demographic data				
Gender				
Male	30(9.1)	101(30.5)	6.371	0.012*
Female	72(21.8)	128(38.7)		
Age				
65–74	4(1.2)	23(6.9)	9.559	0.023*
75–84	45(13.6)	91(27.5)		
85–94	45(13.6)	110(33.2)		
≥ 95	8(2.4)	5(1.5)		
Diseases and symptoms				
Ischemic heart disease	73(22.0)	155(46.8)	0.496	0.481
Hypertension	51(15.4)	121(36.6)	0.228	0.633
Diabetes	24(7.2)	35(10.6)	3.276	0.070
Stroke	43(13.0)	68(20.5)	4.917	0.027*
Parkinson's disease	7(2.1)	8(2.4)	1.852	0.174
Urinary incontinence / frequency	66(20.0)	105(31.7)	10.045	0.002**
Orthostatic hypotension	8(2.4)	9(2.7)	2.218	0.136
Dizziness while standing	34(10.3)	67(20.2)	0.553	0.457
Vision/hearing loss	70(21.1)	138(41.7)	2.115	0.146
Numbness/pain in legs and feet	27(8.2)	64(19.3)	0.077	0.781
Drugs				

*Significant to the 0.05 level

**Significant to the 0.01 level

Risk factors	Fall-related injuries or falls ≥ 2 times n(%)	Falls ≤ 1 time and without injuries n(%)	χ^2	<i>p</i>
Sedative hypnotics	29(8.8)	53(16.0)	1.059	0.304
Antipsychotics	37(11.2)	55(16.6)	5.283	0.022*
Diuretics	8(2.4)	16(4.8)	0.077	0.782
Antihistamines	19(5.7)	19(5.7)	7.411	0.006**
Multiple-drug	68(20.5)	133(40.2)	2.182	0.140
Difficulties with physical activity				
Conscious unstable walking	84(25.4)	125(37.8)	23.380	< 0.001**
Dysstasia	90(27.2)	152(45.9)	17.153	< 0.001**
Walking aids	71(21.4)	105(31.7)	15.995	< 0.001**
Psychological status				
Insomnia/early awakening	46(13.9)	99(29.9)	0.100	0.752
Depression	47(14.2)	77(23.3)	4.672	0.031*
Fear of falling	78(25.6)	151(45.6)	3.671	0.055
Cognitive status				
Normal	36(10.9)	120(36.2)	8.706	0.013*
Mild	35(10.6)	63(19.0)		
Moderate/severe	31(9.4)	46(13.9)		
Abnormal behaviors				
Lack of compliance with safety measures	52(15.7)	76(23.0)	9.420	0.002**
Loitering behaviors	27(8.2)	46(13.9)	1.673	0.196
*Significant to the 0.05 level				
**Significant to the 0.01 level				

Table 3
Binary Logistic regression analysis of fall risks among the elderly

Risk factors	OR	<i>p</i>	95% CI for OR
Gender (Female)	2.307	0.001	1.378–3.864
Age			
75–84	4.724	0.012	1.403–15.903
85–94	4.435	0.015	1.330–14.787
≥ 95	10.080	0.010	1.742–58.322
Urinary incontinence / frequency	2.254	0.002	1.359–3.740
Unstable walking	4.400	< 0.001	2.523–7.673
Hosmer and Lemeshow Test, <i>p</i> = 0.993			

OR odds ratio, *CI* confidence interval

Table 4
Binary Logistic regression analysis of severe falls among the elderly

Risk factors	OR	<i>p</i>	95% CI for OR
Gender (Female)	2.289	0.002	1.344–3.896
Urinary incontinence / frequency	2.004	0.008	1.196–3.358
Unstable walking	3.612	< 0.01	2.005–6.507
Hosmer and Lemeshow Test, <i>p</i> = 0.954			

OR odds ratio, *CI* confidence interval

Predictive ability of the model on fall risks in the elderly

Four independent risk factors for falls were identified based on logistic regression analysis. The proportion of falls corresponding to different independent predictors among 331 older people are shown in Fig. 1. The incidence of falls increased from 0% for zero risk factors to 71.0% for four risk factors.

The ROC curve (Fig. 2) was obtained based on the fall risk prediction model, with an AUC of 0.749 (95% CI: 0.697–0.801, *p* < 0.001) and a cut-off value of 0.355. The corresponding sensitivity and specificity were 82.4% and 57.1%, respectively.

Discussion

Our study found that the incidence of falls in senior apartments in the past year was 42.9%. Moreover, 30.8% of the elderly had suffered recurrent falls or fall-related injuries. The incidence of falls was slightly

higher than that reported by the World Health Organization (28%-35%) [18]. The average age of the elderly in senior apartments is high, and their physical health condition is relatively poor in the present study. Therefore, they are more prone to falls than the elderly elsewhere. Research has shown that about 40% of the elderly who live in pension-based institutions do so in part due to falls[19]. It also reminds us that falls among the elderly living in senior apartments are worthy of attention and it is necessary to analyze the causes of falls and formulate targeted intervention strategies.

To classify different fall outcomes, we compared and analyzed the results of fall events in senior apartments using two separate criteria (falls vs. no falls; number of falls ≤ 1 time and without injury vs. fall-related injuries or number of falls ≥ 2), which is consistent with the literature [20]. It was found that gender, urinary incontinence/frequency, and unsteady gait were the primary factors predicting falls, recurrent falls, or fall-related injuries among the elderly in senior apartments. Furthermore, age was a critical predictor of falls in the elderly. Compared with the elderly in the age range of 65 to 74 years, the fall risk of the elderly over 75 years of age was 3 times higher, and that of the elderly over 95 years of age was 9 times higher, supporting the conjecture of the elderly in senior apartments having an increased incidence of falls due to their older age.

Marta *et al.* [21] performed a prospective cohort study on falls among the elderly in 37 pension-based institutions in Spain (average age = 82 years). Their results also confirmed that old age was a risk factor for falls, and those who fell were two years older than those who did not. However, we did not find an independent effect of age on recurrent falls or fall-related injuries in the elderly. This could be ascribed to the fact that the characteristics of people prone to recurrent falls and fall-related injuries were more stable and independent of age. Tinetti *et al.* [22] demonstrated that the risk factors were the same in the elderly with one fall and those with multiple falls, and the fall risk increased linearly with the number of risk factors, which is consistent with the conclusion of the current study.

The effect of gender on falls among the elderly in our study is consistent with other studies [23–25]. It was shown that older females were more likely to fall than older males and more than twice as likely to have recurrent falls and fall-related injuries (OR = 2.289, 95%CI: 1.344–3.896). This could be related to the decreased estrogen, osteoporosis, decreased muscle content, poor muscle strength, and a decline in lower limb strength in elderly females [26, 27]. Additionally, we found that the elderly with urinary incontinence or frequent urination were at high risk of falls, recurrent falls, and fall-related injuries. The risk was twice as high as the average elderly, consistent with a previous study [28]. The higher risk of falls in these cases was primarily due to the frequent use of toilets. Research has shown that the elderly are prone to falls when they rush to bathrooms which are the most common locations for falls [29, 30]. Unstable walking is the most direct manifestation of decreased physical functioning, balance, and limb coordination in the elderly. Our study showed that the elderly with conscious unsteady gait had a higher risk of falls and fall-related injuries. This result was indeed expected, given that the falls resulted from physical imbalance.

Fall risk has long been considered as being multifactorial. Our results showed that the incidence of falls increased significantly with increased risk factors and underscored the need for senior apartments to

develop targeted fall prevention intervention measures for the elderly. The formulation of measures should be conducted based on risk screening. Additionally, our study performed structured interviews to determine fall risk factors. The information was easy to obtain, and the sensitivity of the fall risk prediction model used was more than 80%, providing a reference for rapid and simple screening of the elderly with high fall risks in senior apartments. However, this study is a retrospective study. There may be recall bias in some of the information obtained, and most of the data are subjective indicators. Our study lacks quantitative tests of muscle strength, gait speed, and balance, with some exceptions. A prospective cohort study will be conducted in the future to demonstrate the predictive accuracy of the model.

Conclusions

Our study showed that the elderly who are female, have urinary incontinence/frequency, and have a conscious unsteady gait are more likely to have falls, recurrent falls, and fall-related injuries. Moreover, the overall risk of falls significantly increases with age and the number of risk factors. Hence, the risk factors mentioned above should be considered when formulating relevant fall prevention measures for the elderly. This study also provides a reliable method for rapid and simple screening of older people at a high risk of falls. However, this study is a retrospective study, and further research is necessary to verify the predictive accuracy of the model on falls in the elderly.

Declarations

Competing interest

The authors declare that they have no competing interest.

Author's contribution

SQQ, SM, and PHY conceived the study, contributed to study design, obtained the funding for the study, and were responsible to the conduct of the study. SQQ, ZJ, MYZ, and SJ contributed to data analysis. All authors contributed toward the writing of the manuscript and approved the final submitted version.

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Availability of data and materials

The data that support the findings of this study are available from the corresponding author upon request.

Ethics approval and consent to participate

The studies involving human participants were reviewed and approved by Chinese PLA General Hospital Medical Ethics Committee (No.: S2018-048-01). All procedures involving human participants were performed in accordance with the ethical standards of the Ethics Committee for Clinical Research of Chinese PLA General Hospital and with the Declaration of Helsinki and its later amendments. The participants provided their written informed consent to participate in this study.

Consent for publication

Not applicable.

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Figures

Figure 1

The proportion of falls corresponding to different independent predictors. Four independent risk factors for falls were identified by logistic regression analysis: female, older age, urinary incontinence/frequency, and unsteady gait

Figure 2
ROC curve for the fall risk prediction model of the elderly