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Research Paper

# Incidence and risk factors of falls in older adults after discharge: A prospective study

Siyu Long [a], Liangzhu Hu [b], Yetao Luo [c], Yaling Li [d], Fu Ding [d,*]

[a] Department of Nephrology, South China Hospital of Shenzhen University, Shenzhen, China
[b] Department of Vascular Surgery, South China Hospital of Shenzhen University, Shenzhen, China
[c] Department of Infectious Diseases, Second Affiliated Hospital of Army Medical University, Chongqing, China
[d] Department of Nursing, The First Affiliated Hospital of Chongqing Medical University, Chongqing, China

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ABSTRACT

*Objectives:* This study aimed to determine the incidence of falls and risk factors associated with falling in discharged older adults.
*Methods:* A prospective study was conducted on older adults who had been issued a discharge order in a Class A tertiary hospital in Chongqing, China, from May 2019 to August 2020. The risk of falling, depression, frailty, and daily activities were evaluated at discharge using the mandarin version of the fall risk self-assessment scale, Patient Health Questionnaire-9 (PHQ-9), FRAIL scale, and Barthel Index, respectively. The cumulative incidence function estimated the cumulative incidence of falls in older adults after discharge. And the risk factors of falls were explored using the sub-distribution hazard function in the competing risk model.
*Results:* In a total of 1,077 participants, the total cumulative incidence of falls at 1, 6 and 12 months after discharge was 4.45%, 9.03%, and 10.80%, respectively. The cumulative incidence of falls in older adults with depression (26.19%, 49.93%, and 58.53%, respectively) and those with physical frailty (21.59%, 41.67%, and 48.73%, respectively) was much higher than that in those without depression and physical frailty ($P < 0.05$). Depression, physical frailty, Barthel Index, length of hospital stay, re-hospitalization, being cared for by others, and the self-assessed risk of falling were directly associated with falls.
*Conclusions:* The incidence of falls among older adults discharged from the hospital has a cumulative effect with the lengthening of the discharge time. It is affected by several factors, especially depression and frailty. We should develop targeted intervention strategies to reduce falls for this group.


**What is known?**

- An aging society incurs tremendous losses due to fall-related injuries and mortalities.
- In China, falling is the first cause of injury-related deaths in older adults aged 65 years or over.
- Few studies have examined the incidence and risk factors of falls among older adults after discharge.

**What is new?**

- The incidence of falls among older adults discharged from the hospital has a cumulative effect with the lengthening of the discharge time.
- The cumulative incidence of falls in older adults with depression was higher than in those with other fall risk factors.
- Depression, physical frailty, Barthel Index, length of hospital stay, re-hospitalization, being cared for by others, and the self-assessed risk of falling were directly associated with falls in discharged older adults.

## 1. Introduction

A fall is an event, including a slip or a trip, where the person

* Corresponding author.
*E-mail address:* 734403117@qq.com (F. Ding).
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loses balance and inadvertently lands on the ground, floor, or other lower level. An estimated 646,000 fatal falls occur each year, making it the second leading cause of unintentional injury death. Over 80% of fall-related fatalities occur in low- and middle-income countries, with regions of the Western Pacific and Southeast Asia accounting for 60% of these deaths [1]. In China, the 25 million falls suffered annually by the estimated 20 million elder population exact direct medical costs of about 5 billion yuan and social costs of 60–80 billion yuan [2]. The prevention of falls and fall-related injuries are major subjects in China. However, recent studies focused on falls among the community and hospitalized older adults, while the discharged older adults still present with features such as decreased function and frailty [3,4]. These directly or indirectly affect the independent living ability and have long-term adverse effects on the functional status of older adults after treatment in the acute phase of the disease. Studies have revealed that about 25%–41.2% of hospitalized older adults cannot recover their original function of daily living following discharge [5,6]. Furthermore, 72% of older patients could not independently complete daily living activities one month after discharge from a non-surgical hospital [7]. Moreover, one-third of patients could not return to their preability activities after discharge six months later [8]. The period of the return home of older adults from the hospital is a high-risk period for falls, and the fall rate one month after discharge is two times higher than that of the non-hospitalized populations [9]. Studies have revealed that six months after discharge, the incidence of falls in older adults ranged from 31% to 40.2% [10,11].

Identifying the risk factors of falls is very important for preventing falls in discharged older adults. Previous studies have examined the risk factors for falls in discharged older adults in other countries, including dependency on activities of daily living (ADL) [10], fall history, the use of auxiliary devices [9,10], depression [12,13], and physical frailty [14,15]. However, in China, few studies have examined the incidence and risk factors of falls in older adults after discharge. Yet several lines of evidence suggest that this may be a high-risk period [16]. Furthermore, fall prevention strategies adopted during hospitalization are not fully applicable to fall prevention outside the hospital. This is often due to the lack of adequate supervision and recognition of one's own fall risk; hence, falls outside the hospital often occur. Therefore, there is a need to identify the influencing factors and preventive interventions for falls in the discharged older adults. This study aimed to determine the incidence of falls and the associated risk factors of falls among the Chinese older adults.

## 2. Methods

### 2.1. Design setting and participants

A prospective study was conducted at a Class A tertiary hospital in Chongqing, China, between May 2019 and August 2020. This study report follows the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) statement.

The sample size for this study was determined using a single population proportions formula. According to the prevalence of falls within 12 months of 24%–58% [16,17], the required sample size was 573–764. The margin of error is 5%, and the confidence interval is 95%. Considering a 10% non-response rate, the final sample size was 630–841. The basic information (department, name, age, and hospital number) of older adults >65 years who had been issued a discharge order was extracted from the hospital medical record system, and then study participants were randomly selected using a computer-generated sequence.

A total of 1,077 patients who met the following eligibility criteria were enrolled in this study:1) aged ≥65 years; 2) acutely admitted and hospitalized for at least 48 h; 3) clear consciousness; 4) willing to participate in the research, and 5) Barthel Index (BI) score >61. Patients with other conditions such as cognitive impairment or physical disabilities who could not walk were excluded.

### 2.2. Variables and measures

#### 2.2.1. Socio-demographics and clinical characteristics

Relevant socio-demographic details were self-reported, including age, sex, education level, self-care, and living status (situation regarding co-residents). Clinical data, including hospitalization days, diseases, and medication were recorded at discharge.

#### 2.2.2. Fall risk measurement

The risk of falls was screened by the fall risk self-assessment instrument [18], which includes 12 variables covering several physiological and psychological domains. The instrument domains included a history of falls, medication, gait, balance, accessory equipment, and emotional psychology. The total score ranged from 0–14. According to the Stopping Elderly Accidents, Deaths & Injuries Tool Kit (STEADI) 2019 fall risk criteria, a score ≥4 implied that the patient was at risk and not at risk if < 4. The score was derived by asking if the patient fell in the past year (if yes, the patient is considered at risk) [20]. The Mandarin version of the fall risk measurement had good reliability and validity (Cronbach's $\alpha = 0.716$) [19].

#### 2.2.3. Depression measurements

Depression was assessed by using the Patient Health Questionnaire-9 (PHQ-9), which includes nine variables (interest, depression, sleep disorder, having little energy, poor appetite or overeating, and feeling bad about yourself, among others) [22]. The PHQ-9 is a self-administered survey that consists of nine questions, each based on a criterion from the *Diagnostic and Statistical Manual of Mental Disorders*, *fourth edition*, used to establish a major depressive episode. Each question asked for the frequency of a particular depressive symptom experienced by a patient in the past two weeks ("not at all" = 0, "several days" = 1, "more than half the days" = 2, and "nearly every day" = 3). The total score range is 0–27. A score of 0–4, 5–9, 10–14, 15–19, and 20–27, indicates no depression, mild, moderate, moderately severe, and severe depression, respectively [23]. The PHQ-9 has an established clinical cut-off of 15, meaning that patients scoring ≥15 demonstrated significant signs of depression and may benefit from referral to a mental health professional. The Mandarin version of the PHQ-9 had good reliability and validity (Cronbach's $\alpha = 0.879$) [24].

#### 2.2.4. Physical frailty measurements

Physical frailty was screened by the FRAIL scale developed by the International Nutrition, Health, and Aging Working Group in 2008 [25]. It considers five attributes: the presence of fatigue, ability to climb stairs, difficulty with ambulation, comorbidities (>5), and unexpected weight loss (>5% in 12 months). For each item, "yes" was scored as "1" while "no" was scored as "0." The total score ranged from 0 to 5. The FRAIL scale assessment criteria indicated 0, 1 to 2, and ≥3 as no frailty, pre-frailty, and frailty, respectively [25]. The Mandarin version of the FRAIL scale had good reliability and validity (Cronbach's $\alpha = 0.826$) [26].

#### 2.2.5. Activities of daily living measurements

Activities of daily living (ADL) was measured by the BI, which was developed to assess disability in patients with neuromuscular and musculoskeletal conditions receiving inpatient rehabilitation in 1965 [27]. BI is a 10-item scale, which includes the following parts: feeding, bathing, grooming, dressing, controlling bowels and

bladder, toilet use, transfers, mobility, and climbing stairs. The score ranges from 0 (total dependence) to 100 (complete independence) [27]. Each item can be scored with 0, 5, 10, and 15 points. The Mandarin version of the BI had good reliability and validity (Cronbach's $\alpha = 0.916$) [28].

### 2.3. Data collection

Random sampling was used to complete the data collection. Before the start of the investigation, participants were introduced to the purpose and significance of the study. After informed consent was obtained, four trained personnel collected the face-to-face data. The patients completed the fall risk self-assessment scale and PHQ-9. For participants who had reading or comprehension difficulties, the researcher read the content of the questionnaire verbatim and helped the participants to complete the questionnaire. Patients were assessed within 24 h after the discharge order was issued. To ensure data quality, the researchers were trained on research methods, operations, content, and follow-up etiquette until they were proficient in using all the assessment scale applications to conduct the surveys. Our research group also established a strict quality control team and a communication platform based on a WeChat app to guarantee timely feedback.

A telephone follow-up was performed at 1, 6, and 12 months after the patient's discharge for the history of falls by a follow-up plan. The follow-up records included whether the discharged elderly experienced falls and the time from discharge to the fall; whether the discharged elderly died and the time from discharge to death; or whether data were censored and the time from discharge to the end of follow-up. To prevent loss of follow-up, we obtained at least two phone numbers of relatives and provided disease-related consultations.

### 2.4. Statistical analysis

Statistical analysis was performed using SAS 9.4 software. Categorical variables were described by frequency and percentage, and differences between groups were conducted by Chi-square test. The cumulative incidence of falls was estimated using the cumulative incidence function. Gray's test was used for the comparison between groups, and the Bonferroni method was used to calibrate the *P*-values for pairwise comparisons between multiple groups (the corrected *P*-value was equal to the original *P*-value multiplied by the number of comparisons between groups). Correlations between variables were analyzed using the sub-distribution hazard function in the competing risk model. The level of statistical significance was set at $P < 0.05$.

### 2.5. Ethical considerations

This study was approved by the Ethics Committee of Chongqing Medical University (2019−179). Consent to participate was obtained from patients who met the inclusion criteria.

## 3. Results

### 3.1. Demographic characteristics of the participants

A total of 1,384 hospitalized patients aged ≥65 years from the Departments of Nephrology, Geriatrics, Gastroenterology, Hepatobiliary Surgery, and Gastrointestinal Surgery, among others, were invited to participate in this study; and 230 (17.27%) refused. After enrolling the 1,154 individuals, 52 died, and 25 withdrew consent for personal reasons. The final sample consisted of 1,077 discharged patients. During the follow-up, 107 patients experienced falls after discharge, accounting for 9.94%. Fifty-two patients died from other causes and did not fall. The total number of diseases ranged from 1 to 27, with a mean of 6.72. The number of drugs used ranged from 0 to 14, with a mean of 4.5 (Table 1).

### 3.2. Univariate analysis of falls among older adults after discharge

The rates of depression, physical frailty, re-hospitalization, living alone, middle school and above, cared by others, and fall risk among the elderly with falls, were higher than those without falls ($P < 0.05$). The number of hospitalization days among the elderly with falls was longer than that of those without falls ($P < 0.05$), while their BI score was lower at discharge for the first time in comparison ($P < 0.05$). There were no significant differences in age, gender, comorbidities, or polypharmacy ($P > 0.05$) (Table 1).

### 3.3. Long-term trend of falls in discharged older adults

In total, the cumulative incidence of falls at 1, 6, and 12 months after discharge for the 1,077 elderly patients was 4.45%, 9.03%, and 10.80%, respectively. Falls mainly occurred within six months after discharge, with a rapid increase within one month after discharge. The cumulative incidence among discharged elderly with depression, frailty, BI of 61−80 points, living alone and re-hospitalization after discharge, middle school and above, cared by others, fall risk, and hospitalization days ≥20 was higher than in those with non-depressed,non-frail, BI > 81 points, living with others, not admitted to the hospital within the follow-up time, low level of education, self-care, no falls risk, and hospitalization days <20, respectively ($P < 0.05$) (Table 2).

### 3.4. Influencing factors of falls among older adults after discharge

The variables with $P < 0.05$ in the univariate competing risk model results, namely depression, physical frailty, length of hospital stay, BI, re-hospitalization, education, living alone, cared by others, and fall risk, were included in the multivariate analysis. Depression, physical frailty, Barthel index, length of hospital stay, readmission, being cared for by others, and the risk of falling were directly associated with falls, $P < 0.05$. (Table 3).

## 4. Discussion

### 4.1. The current situation of falls among the discharged older adults

Studies assessing falls in discharged elderly populations based on a long-term follow-up are lacking. Here, we examined differences in rates of falls over a 1-year study period. We found that the cumulative incidence of falls in 1,077 elderly patients at 1, 6, and 12 months after discharge was 4.45%, 9.03%, and 10.80%, respectively. These results were lower than those of other countries. In the United States, the incidence of falls within one month in the elderly after discharge was 14.8% [9]. Australian studies showed an incidence at 6 and 12 months after discharge of 40.2% [10] and 58% [16], respectively. Differences in sample sizes (241 and 343 vs. 1,077 in our study) and inclusion criteria of the participants between studies may be the reasons for these differences. In addition, from the Nelson-Aalen cumulative risk curve, we observed that falls mainly concentrated within six months after discharge. However, the incidence was highest within one month but tended to stabilize after six months; this is similar to the results of other studies [9]. Scholars revealed that all the elderly with reduced functions could gradually improve their functions after 180 days of discharge from the hospital [29]. We recommended that the critical intervention time for falls in the elderly should be within one month after

**Table 1**
Demographic characteristics of falls and non-falls in the discharged older adults ($n$ = 1,077).

| Variables | Total | Non-falls ($n$ = 970) | Falls ($n$ = 107) | $\chi^2$ | $P$ |
|---|---|---|---|---|---|
| Depression | | | | | |
| No | 955 (88.67) | 917 (94.54) | 38 (35.51) | 334.223 | <0.001 |
| Yes | 122 (11.33) | 53 (5.46) | 69 (64.49) | | |
| Length of hospital stay (days) | | | | | |
| <10 | 511 (47.45) | 469 (48.35) | 42 (39.25) | 21.831 | <0.001 |
| 10–19 | 435 (40.39) | 398 (41.03) | 37 (34.58) | | |
| ≥20 | 131 (12.16) | 103 (10.62) | 28 (26.17) | | |
| BI score | | | | | |
| >90 | 200 (18.57) | 188 (19.38) | 12 (11.21) | 57.711 | <0.001 |
| 81–90 | 753 (69.92) | 694 (71.55) | 59 (55.14) | | |
| 61–80 | 124 (11.51) | 88 (9.07) | 36 (33.64) | | |
| Re-hospitalization | | | | | |
| No | 788 (73.17) | 731 (75.36) | 57 (53.27) | 23.951 | <0.001 |
| Yes | 289 (26.83) | 239 (24.64) | 50 (46.73) | | |
| Sex | | | | | |
| Male | 565 (52.46) | 508 (52.37) | 57 (53.27) | 0.031 | 0.860 |
| Female | 512 (47.54) | 462 (47.63) | 50 (46.73) | | |
| Age (years) | | | | | |
| 65–69 | 357 (33.15) | 327 (33.71) | 30 (28.04) | 3.004 | 0.223 |
| 70–79 | 493 (45.78) | 445 (45.88) | 48 (44.86) | | |
| ≥80 | 227 (21.08) | 198 (20.41) | 29 (27.10) | | |
| Education | | | | | |
| Illiterate and primary school | 485 (45.03) | 452 (46.60) | 33 (30.84) | 9.666 | 0.002 |
| Middle school and above | 592 (54.97) | 518 (53.40) | 74 (69.16) | | |
| Living arrangement | | | | | |
| Alone | 559 (51.90) | 485 (50.00) | 74 (69.16) | 14.17 | <0.001 |
| With others | 518 (48.10) | 485 (50.00) | 33 (30.84) | | |
| Living care | | | | | |
| Cared by others | 1029 (95.54) | 933 (96.19) | 96 (89.72) | 9.462 | 0.002 |
| Self-care | 48 (4.46) | 37 (3.81) | 11 (10.28) | | |
| Fall risk | | | | | |
| No | 611 (56.73) | 580 (59.79) | 31 (28.97) | 37.296 | <0.001 |
| Yes | 466 (43.27) | 390 (40.21) | 76 (71.03) | | |
| Frailty | | | | | |
| Robust | 189 (17.55) | 181 (18.66) | 8 (7.48) | 248.977 | <0.001 |
| Pre-frail | 748 (69.45) | 715 (73.71) | 33 (30.84) | | |
| Frail | 140 (13.00) | 74 (7.63) | 66 (61.68) | | |
| Number of discharge medications | | | | | |
| 1–3 | 431 (40.02) | 383 (39.48) | 48 (44.86) | 1.951 | 0.377 |
| 4–6 | 506 (46.98) | 457 (47.11) | 49 (45.79) | | |
| >6 | 140 (13.00) | 130 (13.40) | 10 (9.35) | | |
| Number of discharge disease | | | | | |
| 1–5 | 462 (42.90) | 422 (43.51) | 40 (37.38) | 2.143 | 0.343 |
| 6–10 | 294 (27.30) | 265 (27.32) | 29 (27.10) | | |
| >10 | 321 (29.81) | 283 (29.18) | 38 (35.51) | | |

*Note*: Data were $n$ (%). BI = Barthel Index.

discharge, and the focus of intervention should extend to at least six months later.

### 4.2. Depression is an essential factor in falls in discharged older adults

Depression is the most common psychological problem in the elderly. Although severe depression decreases with age, the incidence of mild depression increases with age [30]. In America, depression is the single predictor of adverse events due to falls in the elderly at home after controlling for other factors [12]. Depressive symptoms and antidepressants independently predicted fall longer than 12 months in Australia [13]. This study also found that depression was the primary cause of falls among discharged elderly in China. The cumulative incidence of falls in the elderly with depression at discharge was much higher than that in the non-depressed elderly, and the risk was 9.03 times higher than that in the non-depressed elderly. Although depression plays a vital role in falls in the elderly, Chinese medical institutions rarely include it in the comprehensive assessment of fall risk factors. Depression is a desirable target for primary care prevention interventions [31], and routine clinical inspection can find patients' depressive symptoms [12]. Through adequate intervention, elder patients with depression can recover well [29].

In China, most of the elderly go home directly after discharge. The house's comfortable environment and the family's companionship and care are conducive to the physiological, safety, and social needs of the elderly. A 6-month follow-up survey of 311 elderly discharged from the hospital showed that falls are positively associated with depressive symptoms [32]. For the elderly who are assessed with depressive symptoms when discharged from the hospital, a psychiatrist is recommended for further evaluation to determine whether the depressive symptoms are temporary or natural. Under the care of specialists, extensive use of medications (psychiatric drugs/antidepressants), psychotherapy, cognitive behavioral therapy or interpersonal therapy [33], and physical exercise [34], can alleviate depression in the elderly and reduce the incidence of falls. The use of antidepressants to address depressive symptoms is associated with an increased risk of falls in a recent review [35]. Therefore, we recommend thoroughly

**Table 2**
The cumulative incidence of falls in the 1, 6, and 12 months after discharge.

| Factors | | Cumulative incidence of falls (95% CI), % | | | $\chi^2$ | *P* |
|---|---|---|---|---|---|---|
| | | 1 month | 6 month | 12 month | | |
| Total falls | | 4.45 (3.41, 5.81) | 9.03 (7.38, 11.06) | 10.80 (9.01, 12.94) | | |
| Depression | No | 1.55 (1.00, 2.40) | 3.49 (2.42, 5.04) | 4.42 (3.17, 6.18) | 209.007 | <0.001 |
| | Yes | 26.19 (21.07, 32.56) | 49.93 (42.52, 58.62) | 58.53 (50.53, 67.79) | | |
| Length of hospital stay (days) | <10[a] | 3.72 (2.69, 5.15) | 7.62 (5.68, 10.22) | 9.10 (7.07, 11.72) | 19.691 | <0.001(a, b < c) |
| | 10–19[b] | 3.74 (2.59, 5.40) | 7.65 (5.56, 10.51) | 9.14 (6.54, 12.76) | | |
| | ≥20[c] | 9.63 (6.57, 14.13) | 19.06 (12.90, 28.16) | 22.49 (16.37, 30.90) | | |
| BI score | >90[a] | 2.72 (1.53, 4.84) | 5.60 (3.23, 9.73) | 6.71 (3.77, 11.93) | 50.002 | <0.001(a, b < c) |
| | 81–90[b] | 3.47 (2.53, 4.74) | 7.12 (5.72, 8.86) | 8.51 (6.85, 10.57) | | |
| | 61–80[c] | 13.26 (9.24, 19.02) | 25.76 (20.11, 33.00) | 30.14 (23.47, 38.70) | | |
| Re-hospitalization | No | 3.22 (2.40, 4.32) | 6.60 (5.07, 8.58) | 7.92 (6.18, 10.14) | 21.880 | <0.001 |
| | Yes | 7.78 (5.68, 10.65) | 15.54 (12.29, 19.64) | 18.46 (14.23, 23.94) | | |
| Sex | Male | 4.53 (3.27, 6.26) | 9.19 (6.99, 12.06) | 10.98 (8.74, 13.79) | 0.036 | 0.849 |
| | Female | 4.37 (3.20, 5.95) | 8.87 (6.53, 12.06) | 10.61 (8.27, 13.61) | | |
| Age(years) | 65–69 | 3.74 (2.60, 5.40) | 7.63 (5.34, 10.90) | 9.14 (6.16, 13.54) | 2.879 | 0.237 |
| | 70–79 | 4.38 (3.10, 6.20) | 8.90 (6.78, 11.70) | 10.65 (8.09, 14.00) | | |
| | ≥80 | 5.71 (3.77, 8.65) | 11.51 (8.34, 15.88) | 13.72 (9.49, 19.85) | | |
| Education | Illiterate and primary school | 3.04 (2.01, 4.61) | 6.23 (4.47, 8.68) | 7.47 (5.70, 9.79) | 8.889 | 0.003 |
| | Middle school and above | 5.60 (4.12,7.60) | 11.30 (8.89,14.37) | 13.48 (10.85,16.75) | | |
| Living care | Alone | 6.03 (4.65, 7.83) | 12.23 (9.85, 15.19) | 14.68 (11.96, 18.02) | 14.567 | <0.001 |
| | With others | 2.73 (1.83, 4.08) | 5.64 (3.99,7.96) | 6.82 (4.95, 9.40) | | |
| Living arrangement | Self-care | 4.17 (3.19, 5.45) | 8.49 (6.85, 10.53) | 10.17 (8.71, 11.88) | 9.326 | 0.002 |
| | Cared by others | 10.27 (6.17, 17.10) | 20.22 (11.90, 34.38) | 23.90 (15.34, 37.25) | | |
| Fall risk | No | 2.32 (1.50, 3.57) | 4.74 (3.26, 6.89) | 5.66 (4.00, 8.00) | 30.246 | <0.001 |
| | Yes | 7.25 (5.47, 9.62) | 14.45 (11.77, 17.73) | 17.06 (13.77, 21.13) | | |
| Frail | Robust[a] | 1.65 (0.83, 3.31) | 3.62 (1.78, 7.40) | 4.47 (2.30, 8.69) | 169.907 | <0.001(a, b < c) |
| | Pre-frail[b] | 1.82 (1.18, 2.82)[b] | 4.00 (2.87, 5.57) | 4.93 (3.55, 6.84) | | |
| | Frail[c] | 21.59 (17.15, 27.17) | 41.67 (34.19, 50.79) | 48.73 (40.40, 58.77) | | |
| Number of discharge medications | 1–3 | 4.93 (3.41,7.12) | 9.97 (7.40,13.44) | 11.90 (9.48,14.95) | 1.663 | 0.435 |
| | 4–6 | 4.39 (3.09, 6.24) | 8.92 (6.61, 12.03) | 10.66 (8.24, 13.77) | | |
| | >6 | 3.20 (1.64, 6.23) | 6.54 (3.44, 12.42) | 7.83 (4.27, 14.38) | | |
| Number of discharge diseases | 1–5 | 3.70 (2.45, 5.57) | 7.57 (5.50, 10.41) | 9.09 (6.97, 11.86) | 3.177 | 0.204 |
| | 6–10 | 4.50 (3.07, 6.60) | 9.17 (6.53, 12.87) | 11.00 (7.67, 15.76) | | |
| | >10 | 5.48 (3.79, 7.93) | 11.11 (7.92, 15.57) | 13.30 (10.18, 17.37) | | |

*Note*: [a, b, c] Cumulative incidence of falls with the different letter are significantly different, and adjusted *P* value by the Bonferroni method in Gray's test. CI = confidence interval.

**Table 3**
Influencing factors of falls in discharged older adults.

| Factors | Univariate | | | Multivariable | | |
|---|---|---|---|---|---|---|
| | *β* | SHR (95% CI) | *P* | *β* | SHR (95% CI) | *P* |
| Depression (yes) | 2.968 | 19.449 (13.007, 29.083) | <0.001 | 2.201 | 9.030 (4.794, 17.008) | <0.001 |
| Length of hospital stay (days) (ref. <10) | | | | | | |
| 10–19 | 0.982 | 0.375 (0.232, 0.605) | <0.001 | −0.170 | 0.840 (0.549, 1.288) | 0.425 |
| ≥20 | 0.978 | 0.376 (0.230, 0.615) | <0.001 | 0.504 | 1.656 (1.066, 2.571) | 0.025 |
| BI score (>90) | | | | | | |
| 81–90 | 1.642 | 0.194 (0.101, 0.372) | <0.001 | −0.19 | 0.831 (0.474, 1.458) | 0.520 |
| 61–80 | 1.394 | 0.248 (0.164, 0.375) | <0.001 | 0.799 | 2.224 (1.193, 4.143) | 0.012 |
| Re-hospitalization (yes) | 0.906 | 2.473 (1.692, 3.614) | <0.001 | 0.655 | 1.926 (1.339, 2.769) | <0.001 |
| Sex (female) | 0.037 | 0.964 (0.660, 1.408) | 0.850 | | | |
| Age (ref. 65–69 years) | | | | | | |
| 70–79 | 0.161 | 1.175 (0.745, 1.853) | 0.488 | | | |
| ≥80 | 0.432 | 1.541 (0.929, 2.555) | 0.094 | | | |
| Education (low) | 0.623 | 1.864 (1.238, 2.807) | 0.003 | −0.010 | 0.987 (0.668, 1.457) | 0.947 |
| Living care (cared by others) | 0.810 | 2.249 (1.483, 3.409) | <0.001 | 0.483 | 1.621 (1.068, 2.462) | 0.023 |
| Live arrangement (alone) | 0.935 | 2.547 (1.398, 4.641) | 0.002 | 0.508 | 1.662 (0.917, 3.011) | 0.094 |
| Self-assessed fall risk (yes) | 1.167 | 3.213 (2.120, 4.871) | <0.001 | 0.596 | 1.815 (1.098, 2.999) | 0.020 |
| Frailty (ref. robust) | | | | | | |
| Pre-frail | 0.100 | 1.105 (0.507, 2.410) | 0.801 | 0.246 | 1.279 (0.590, 2.775) | 0.533 |
| Frail | 2.681 | 14.600 (6.933, 30.749) | <0.001 | 1.260 | 3.525 (1.480, 8.398) | <0.001 |
| Number of medications at discharge (ref. 1–3) | | | | | | |
| 4–6 | 0.118 | 0.889 (0.597, 1.323) | 0.562 | | | |
| >6 | 0.441 | 0.644 (0.326, 1.269) | 0.203 | | | |
| Number of diseases at discharge (ref. 1–5) | | | | | | |
| 6–10 | 0.200 | 1.222 (0.760, 1.965) | 0.409 | | | |
| >10 | 0.403 | 1.497 (0.961, 2.331) | 0.075 | | | |

*Note*: *β*: partial regression coefficient; SHR = sub-distribution hazard ratio; CI = confidence interval.

evaluating the clinical benefits before deciding whether the elderly should use antidepressant drugs. Once the antidepressants are administered, fall prevention should be carefully ensured during the use of antidepressants.

### 4.3. Frailty is another crucial factor in the occurrence of falls in discharged older adults

In this study, older people with physical frailty had 3.525 times higher risk of falls than those without physical frailty. Other studies have confirmed that falls in physical frailty in older adults are 1.16 times [14] to 3.6 times [15] higher than those without physical frailty. During hospitalization, the use of medications in the elderly increases and unnecessary activities decrease; along with the influence of diseases, the incidence of physical frailty is as high as 40% [36]. Physical frailty is a dynamic process that can switch between different states. For example, active exercise can reverse the development of physical frailty—at least partially [37]. Management of frailty can free the elderly from debilitating conditions. Comprehensive interventions for multiple causes of physical frailty, such as those addressing the use of various medications, improving muscle mass through exercise and nutritional intake, and actively treating diseases that can cause weight loss (such as depression, anemia, and vitamin $B_{12}$ deficiency), should be provided [38]. A study has shown that home-based proprioception programs may be an alternative to complex multi-component exercise programs and become an effective way to intervene in the physical frailty of the elderly when resources are limited [39]. The aging of China's population has the characteristics of number, a noticeable trend of oldest aging, and several with disability. In this context, research on home-based proprioception programs may provide a reference as an intervention for physical frailty and falls in the elderly in China.

### 4.4. Other factors influencing the occurrence of falls after discharge

Studies have confirmed that functional decline within three months after discharge is related to the length of hospital stay [40]. Hospitalization for >20 days is a risk factor for falls in discharged elderly in China. Admission itself is a cause of deterioration in elderly functions, especially if the patient stays in bed for a long-time during admission or cannot eat by mouth [41]. This is because the loss of independence and limited activity during hospitalization negatively impact recovery after discharge [42].In turn, these increase the risk of falling. This study found that the BI score of 61–80 and the elderly cared for by others correlated positively with fall risk, consistent with the results of a similar study [10]. Hospitalized patients commonly become deconditioned and often have impaired stamina, coordination, and strength, which places them at greater risk for falls. More than 30% of patients aged ≥65 experienced hospitalization-related disabilities, defined as loss of one or more ADL compared with their experience two weeks before being hospitalized, resulting in increased dependence on discharged older people [6]. After discharge, elderly patients may need more support from family caregivers or community service agencies to resume their daily life. In addition, this study also found that the fall risk was 1.926 times higher in the elderly who were re-admitted compared with those who were not re-admission of the elderly may lead to another admission syndrome, which further increases depression, debilitating status, and life dependency, increasing their risk of falls. A study has pointed out that the risk factors of falls in the elderly after discharge are unique to this population [10]. Therefore, it is urgent to propose effective intervention strategies for this population's impressive fall risk to ensure their safety and improve their quality of life.

### 4.5. Limitations

There were some limitations in this study. First, the patients enrolled in our study were selected from only one hospital and some of its departments. The study results may not fully represent the experience of falls in elderly discharged patients from tertiary hospitals in China. Second, participants reported the falls retrospectively, which may result in biased results. Third, the screening of various factors such as falls and depression were performed after the elderly were discharged, and no further evaluations were made during the follow-up period. Therefore, it was impossible to determine when the incidence of falls stabilized six months after discharge from the hospital, and whether the risk factors such as depression and physical frailty were also reduced at the same time. In addition, with only five sample sizes using antidepressants in this study, we can not confirm that it is a fall risk factor.

## 5. Conclusion

In China, the incidence of falls among the elderly discharged from the hospital has a cumulative effect with the lengthening of the discharge time. In addition, the factors that led to falls in Chinese discharged elderly are complex and diverse. However, the crucial factors remain depression and frailty accompanying discharge. In previous studies, exercise [43], health education [43–45], and psychological intervention [46] have all been proven to be effective in reducing the incidence of falls in hospitalized older people after discharge.

If fall prevention strategies are designed to intervene in depression and frailty in discharged older people, while considering other factors, these may result in better outcomes. Therefore, a chair rise exercise which the STEADI program recommended as a daily exercise, health education, psychological intervention, and home-based proprioception programs, may be used to reduce the incidence of falls. More importantly, it is necessary to increase the elderly's active participation in these fall prevention measures to reduce the incidence of falls.

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## Data availability statement

The datasets used and analyzed during the current study are available from the corresponding author on reasonable request.

## Declaration of competing interest

The authors have declared no conflict of interest.

## CRediT authorship contribution statement

**Siyu Long:** Conceptualization, Investigation, Data curation, Writing - original draft. **Liangzhu Hu:** Data curation, Writing - original draft. **Yetao Luo:** Data curation, Validation. **Yaling Li:** Data curation, Validation. **Fu Ding:** Conceptualization, Supervision, Editing.

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## Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.ijnss.2022.12.010.

## References


[1] WHO.Falls. 2018. http://www.who.int/zh/news-room/fact-sheets/detail/falls. [Accessed 1 March 2021].

[2] Wang J, Chen Z, Song Y. Falls in aged people of the Chinese mainland:epidemiology, risk factors and clinical strategies. Ageing Res Rev 2010;(9 Suppl 1). https://doi.org/10.1016/j.arr.2010.07.002. S13-7.

[3] Palese A, Gonella S, Moreale R, Guarnier A, Barelli P, Zambiasi P, et al. Hospital-acquired functional decline in older patients cared for in acute medical wards and predictors: findings from a multicentre longitudinal study. Geriatr Nurs 2016;37(3):192–9. https://doi.org/10.1016/j.gerinurse.2016.01.001.

[4] van Seben R, Reichardt LA, Essink DR, van Munster BC, Bosch JA, Buurman BM. I feel worn out, as if I neglected myself": older patients' perspectives on post-hospital symptoms after acute hospitalization. Gerontol 2019;59(2):315–26. https://doi.org/10.1093/geront/gnx192.

[5] Mahoney J, Sager M, Dunham NC, Johnson J. Risk of falls after hospital discharge. J Am GeriatrSo 1994;42(3):269–74. https://doi.org/10.1111/j.1532-5415.1994.tb01750.x.

[6] Zisberg A, Shadmi E, Gur-Yaish N, Tonkikh O, Sinoff G. Hospital-associated functional decline: the role of hospitalization processes beyond individual risk factors. J Am Geriatr Soc 2015;63(1):55–62. https://doi.org/10.1111/jgs.13193.

[7] Zisberg A, Shadmi E, Sinoff G, Gur-Yaish N, Srulovici E, Admi H. Low mobility during hospitalization and functional decline in older adults. J Am Geriatr Soc 2011;59(2):266–73. https://doi.org/10.1111/j.1532-5415.2010.03276.x.

[8] Loyd C, Beasley TM, Miltner RS, Clark D, King B, Brown CJ. Trajectories of community mobility recovery after hospitalization in older adults. J Am Geriatr Soc 2018;66(7):1399–403. https://doi.org/10.1111/jgs.15397.

[9] Mahoney JE, Palta M, Johnson J, Jalaluddin M, Gray S, Park S, et al. Temporal association between hospitalization and rate of Falls after discharge. Arch Intern Med 2000;160(18):2788–95. https://doi.org/10.1001/archinte.160.18.2788.

[10] Hill AM, Hoffmann T, McPhail S, Beer C, Hill KD, Oliver D, et al. Evaluation of the sustained effect of inpatient falls prevention education and predictors of falls after hospital discharge–follow-up to a randomized controlled trial. J Gerontol A Biol Sci Med Sci 2011;66(9):1001–12. https://doi.org/10.1093/gerona/glr085.

[11] Tiedemann A, Sherrington C, Orr T, Hallen J, Lewis D, Kelly A, et al. Identifying older people at high risk of future Falls: development and validation of a screening tool for use in emergency departments. Emerg Med J 2013;30(11):918–22. https://doi.org/10.1136/emermed-2012-201783.

[12] Byers AL, Sheeran T, Mlodzianowski AE, Meyers BS, Nassisi P, Bruce ML. Depression and risk for adverse Falls in older home health care patients. Res Gerontol Nurs 2008;1(4):245–51. https://doi.org/10.3928/19404921-20081001-03.

[13] Kvelde T, Lord SR, Close JCT, Reppermund S, Kochan NA, Sachdev P, et al. Depressive symptoms increase fall risk in older people, independent of antidepressant use, and reduced executive and physical functioning. Arch Gerontol Geriatr 2015;60(1):190–5. https://doi.org/10.1016/j.archger.2014.09.003.

[14] Fried LP, Tangen CM, Walston J, Newman AB, Hirsch C, Gottdiener J, et al. Frailty in older adults: evidence for a phenotype. J Gerontol A Biol Sci Med Sci 2001;56(3):M146–57. https://doi.org/10.1093/gerona/56.3.M146.

[15] Nelson JM, Dufraux K, Cook PF. The relationship between glycemic control and falls in older adults. J Am Geriatr Soc 2007;55(12):2041–4. https://doi.org/10.1111/j.1532-5415.2007.01430.x.

[16] Fairhall N, Sherrington C, Lord SR, Kurrle SE, Langron C, Lockwood K, et al. Effect of a multifactorial, interdisciplinary intervention on risk factors for Falls and fall rate in frail older people: a randomised controlled trial. Age Ageing 2014;43(5):616–22. https://doi.org/10.1093/ageing/aft204.

[17] Chin LF, Wang JY, Ong CH, Lee WK, Kong KH. Factors affecting falls in community-dwelling individuals with stroke in Singapore after hospital discharge. Singap Med J 2013;54(10):569–75. https://doi.org/10.11622/smedj.2013202.

[18] Centers for Disease Control and Prevention. Resource algorithm for fall risk screening, assessment, and intervention. 2019. https://www.cdc.gov/steadi/materials.html. [Accessed 1 May 2021].

[19] Li YL, Ding F. Translation of a fall risk self-assessment tool of the STEADI Toolkit:testing reliability and validity in the elderly. Journal of Nursing Science 2020;35(3):8–12. https://doi.org/10.3870/j.issn.1001-4152.2020.03.008 [in Chinese].

[20] Centers for Disease Control and Prevention. Resource algorithm for fall risk screening, assessment, and intervention. 2019. https://www.cdc.gov/steadi/pdf/STEADI-Algorithm-508.pdf. [Accessed 1 February 2021].

[22] Kroenke K, Spitzer RL. The PHQ-9:A new depression diagnostic and severity measure. Psychiatr Ann 2002;32(9):509–15. https://doi.org/10.3928/0048-5713-20020901-06.

[23] Fu H. Clinical preventive medicine[M]. Shanghai: Fudan University Press; 2014. p. 234 [in Chinese].

[24] Wang C, Qian W, Liu CT, Sheng XC, Fu H, Dai JM. Comparison of the reliability and validity between PHQ-9 and GDS-15 in screening depression for middle aged and elderly in some community of Shanghai. Fudan Univ Med Sci 2014;41(2):168–73. https://doi.org/10.3969/j.issn.1672-8467.2014.02.005 [in Chinese].

[25] Abellan van Kan G, Rolland Y, Bergman H, Morley JE, Kritchevsky SB, Vellas B. The I.A.N.A Task Force on frailty assessment of older people in clinical practice. J Nutr Health Aging 2008;12(1):29–37. https://doi.org/10.1007/BF02982161.

[26] Wei Y, Cao YP, Yang XL, Xu Y. Reliability and validity of the Chinese version of fatigue, resistance, ambulation, illness, and loss for elder inpatients. Chin J Prac Nurs 2018;34(20):1526–30. https://doi.org/10.3760/cma.j.issn.1672-7088.2018.20.002 [in Chinese].

[27] Mahoney FI, Barthel DW. Functional evaluation: the barthel index. Md State Med J 1965;14:61–5.

[28] Hou DZ, Zhang Y, Wu JL, Li Y, An ZP. Study on reliability and validity of Chinese version of Barthel Index. Clinical Focus 2012;127(3):219–21. https://doi.org/10.3760/cma.j.issn.0254-1424.2012.05.013 [in Chinese].

[29] Weng CF, Lin KP, Lu FP, Chen JH, Wen CJ, Peng JH, et al. Effects of depression, dementia and delirium on activities of daily living in elderly patients after discharge. BMC Geriatr 2019;19(1):261. https://doi.org/10.1186/s12877-019-1294-9.

[30] Eliopoulos Charlotte. Gerontological nursing. eighth ed. New York: Lippincott Williams &Wilkins; 2014.

[31] Bruce ML, McAvay GJ, Raue PJ, Brown EL, Meyers BS, Keohane DJ, et al. Major depression in elderly home health care patients. Am J Psychiatr 2002;159(8):1367–74. https://doi.org/10.1176/appi.ajp.159.8.1367.

[32] Lee DA, Lalor AF, Russell G, Stolwyk R, Brown T, McDermott F, et al. Understanding temporal relationships between depression, falls, and physical activity in a cohort of post-hospitalized older adults a breakthrough or a conundrum? Int Psychogeriatr 2017;29(10):1681–92. https://doi.org/10.1017/S104161021700103X.

[33] National Institute for Health and Clinical Excellence (NICE). Depression. 2012. https://www.ncbi.nlm.nih.gov/books/NBK552056/#!po=5.10204.

[34] Schuch FB, Vancampfort D, Firth J, Rosenbaum S, Ward PB, Silva ES, et al. Physical activity and incident depression: a *Meta*-analysis of prospective cohort studies. Am J Psychiatr 2018;175(7):631–48. https://doi.org/10.1176/appi.ajp.2018.17111194.

[35] Park H, Satoh H, Miki A, Urushihara H, Sawada Y. Medications associated with falls in older people: systematic review of publications from a recent 5-year period. Eur J Clin Pharmacol 2015;71(12):1429–40. https://doi.org/10.1007/s00228-015-1955-3.

[36] Joosten E, Demuynck M, Detroyer E, Milisen K. Prevalence of frailty and its ability to predict in hospital delirium, falls, and 6-month mortality in hospitalized older patients. BMC Geriatr 2014;14:1–9. https://doi.org/10.1186/1471-2318-14-1.

[37] Gill TM, Gahbauer EA, Han L, Allore HG. The relationship between intervening hospitalizations and transitions between frailty states. J Gerontol A Biol Sci Med Sci 2011;66(11):1238–43. https://doi.org/10.1093/gerona/glr142.

[38] Gosselink R. Appraisal of clinical practice guideline: physical frailty: ICFSR international clinical practice guidelines for identification and management. J Physiother 2022;68(1):75. https://10.1016/j.jphys.2021.11.004.

[39] Pérez-Ros P, Vila-Candel R, Martínez-Arnau FM. A home-based exercise program focused on proprioception to reduce Falls in frail and pre-frail community-dwelling older adults. Geriatr Nurs 2020;41(4):436–44. https://doi.org/10.1016/j.gerinurse.2020.01.017.

[40] Yoo HW, Kim MG, Oh DN, Hwang JH, Lee KS. Factors associated with functional decline in older adults after discharge from an acute-care hospital. Asian Nurs Res 2019;13(3):192–9. https://doi.org/10.1016/j.anr.2019.05.001.

[41] Krumholz HM. Post-hospital syndrome: an acquired, transient condition of generalized risk. N Engl J Med 2013;368(2):100–2. https://doi.org/10.1056/NEJMp1212324.

[42] Gill TM, Allore HG, Holford TR, Guo ZC. Hospitalization, restricted activity, and the development of disability among older persons. JAMA 2004;292(17):2115–24. https://doi.org/10.1001/jama.292.17.2115.

[43] Naseri C, Haines TP, Etherton-Beer C, McPhail S, Morris ME, Flicker L, et al. Reducing Falls in older adults recently discharged from hospital: a systematic review and meta-analysis. Age Ageing 2018;47(4):512–9. https://doi.org/10.1093/ageing/afy043.

[44] Hill AM, McPhail S, Hoffmann T, Hill K, Oliver D, Beer C, et al. A randomized trial comparing digital video disc with written delivery of falls prevention education for older patients in hospital. J Am Geriatr Soc 2009;57(8):1458–63. https://doi.org/10.1111/j.1532-5415.2009.02346.x.

[45] Haines TP, Hill AM, Hill KD, McPhail S, Oliver D, Brauer S, et al. Patient education to prevent Falls among older hospital inpatients: a randomized controlled trial. Arch Intern Med 2011;171(6):516–24. https://doi.org/10.1001/archinternmed.2010.444.

[46] Agmon M, Zisberg A, Tonkikh O, Sinoff G, Shadmi E. Anxiety symptoms during hospitalization of elderly are associated with increased risk of post-discharge falls. Int Psychogeriatr 2016;28(6):951–8. https://doi.org/10.1017/S1041610215002306.