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Influence of age and place of fall on the risk of hip fracture in older adults

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Hip fractures in older adults are a significant health issue, linked to high mortality, disability, and socioeconomic costs. This study examined the effects of age and place of injury on hip fractures from falls in older adults using data from the Emergency Department-based Injury In-Depth Surveillance (EDIIS) database in South Korea. Patients aged 65 years or older who visited 23 emergency departments from 2011 to 2020 were included. Among 170,095 older adults who visited the ED after a fall, the percentage diagnosed with a hip fracture increased with age, with the highest percentage observed in those aged 85 and older. Hip fractures were more common in women than in men across all age groups. Adjusted odds ratios (aOR) showed higher fracture risks with age: 2.45 (95% CI, 2.37–2.53) for ages 75 to 84 and 4.24 (95% CI, 4.09–4.40) for those aged 85 years and older. The odds of experiencing a hip fracture were highest in medical facilities (aOR 1.6, 95% CI, 1.51–1.70), followed by nursing homes (aOR 1.21, 95% CI, 1.11–1.30), compared to homes. Findings suggest the importance of prioritizing fall-prevention programs in settings such as nursing homes and medical facilities, where hip fractures were more commonly observed.

Keywords Hip fractures, Older adults, Nursing home falls, Hospital falls, Emergency department based injury in-depth surveillance, Korea disease control and prevention agency

Hip fracture is a major public health concern that disproportionately affects the aging population worldwide, with high mortality, long-term disability, and substantial socioeconomic burden[1–5]. Globally, an estimated 1.6 million hip fractures occurred in people aged 50 years and older in 2000, and this number is projected to increase to 2.6 million by 2025 and 4.5 million by 2050 due to population aging[1,2]. Hip fractures are also associated with significantly increased mortality. A systematic review found that hip fracture is associated with excess mortality during the first year after fracture, with estimates ranging from 8.4% to 36%, and the greatest risk of death occurring within the first six months[4]. In line with this, one study reported that the age-adjusted relative risk of death following a hip fracture was 6.68, highlighting the severe impact of hip fractures on survival[5]. The economic impact of hip fractures is substantial. In a UK population-based study of over 33,000 patients with hip fracture, the mean 1-year hospital cost per patient was £14,163, with total national hospital costs estimated at £1.1 billion annually[6]. Even among survivors, many fail to fully recover their pre-injury level of mobility, and long-term functional decline is frequently observed in gait, balance, daily living activities, cognitive performance, and social engagement[3,7].

Most hip fractures occur in aging populations. The incidence of hip fractures increases rapidly with age and is more common in women than in men in all age groups[8]. Falls are a leading cause of hip fractures in the older population, especially among women[9]. Vision, muscle strength, and cognitive abilities decline with age, and as a result, older people fall more easily than younger people[10]. Older adults tend to have lower bone mineral density due to osteoporosis, which increases their susceptibility to hip fractures following a fall[11].

Hip fractures can occur not only in healthy older adults who lead active lives, but also in those residing in nursing homes and receiving medical care in hospitals. When hip fractures occur in nursing homes or hospitals, they often lead to different outcomes compared to those occurring in community-dwelling older adults. Previous studies have indicated that environmental factors are the most common cause of falls in community elders, while nursing home residents are more likely to experience falls due to internal factors such as weakness, gait disturbance, and dizziness[12]. Additionally, it has been observed that nursing home residents and hospital patients tend to have poorer survival rates and functional outcomes following hip fractures[13,14].

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With the aging of society and increasing aging population, it is crucial to investigate injuries among older individuals and take measures to prevent them. Although many studies have explored the relationship between hip fractures and the place of fall, few have examined hip fracture diagnoses by specific place of injury among older adults who visited the emergency department after a fall, particularly using injury surveillance data[15,16]. Our hypothesis was that hip fractures resulting from falls in older adults become more prevalent with advancing age and that this trend is more apparent in nursing homes or hospitals where older adults may have reduced function. This study aimed to ascertain the impact of age and place of injury on hip fractures after falls in the older adults.

Methods

Study design and population

An analytical cross-sectional study was conducted. Patients aged ≥ 65 years who visited any of the 23 emergency departments (EDs) in South Korea between January 2011 and December 2020 were included in the study. The study included patients who had an unintentional fall resulting in injury, and hip fracture diagnosis was defined using the International Classification of Diseases (ICD)-10 codes S72.0, S72.1, and S72.2. To focus on hip fractures sustained by older adults residing in or receiving care at the reported place, we excluded patients whose activity at the time of injury was unrelated to daily living (e.g., visitors or workers in nursing homes) or medical care (e.g., visitors or staff in hospitals). We also excluded cases with missing data on place of injury or clinical outcomes, as well as those who were deceased upon arrival at the emergency department.

Data collection

The source of information was the Emergency Department-based Injury In-Depth Surveillance (EDIIS) database from South Korea. The EDIIS database was developed based on the International Classification of External Causes of Injuries proposed by the World Health Organization, and necessary injury prevention data for the database were collected by the Korea Disease Control and Prevention Agency. The EDIIS was initially established in five hospitals in 2006 and has since expanded to include 23 hospitals located in urban or metropolitan areas, primarily consisting of academic teaching hospitals and tertiary hospitals. In South Korea, emergency medical institutions are classified into regional emergency medical centers, local emergency medical centers, and local emergency medical institutions. The 23 hospitals that participated in the EDIIS survey were either regional or local emergency medical centers, ten of which were level 1 trauma centers. General physicians in each hospital collected data on all injuries reported in the EDs through patient interviews. To ensure data accuracy across participating hospitals, each site designated a trained research coordinator responsible for reviewing and validating collected information—such as place of injury—against electronic medical records and other clinical documentation. Once submitted to the national database, the data underwent a secondary quality-control process by the central surveillance team. This team applied predefined logic checks to identify inconsistencies or recordable entries and provided feedback to site coordinators for correction. Monthly quality-assurance (QA) meetings were held to monitor data integrity and maintain standardized procedures across hospitals.

Main outcomes

The primary outcome variable in this study was the percentage of fall patients diagnosed with hip fractures, which refers to the number of people diagnosed with hip fractures among those who fell. Additional clinical outcomes included whether the patient underwent emergency surgery, was admitted to the intensive care unit (ICU), or experienced in-hospital mortality. These outcomes were analyzed to evaluate the clinical severity and resource utilization associated with hip fractures.

Main independent variables

Age

The primary exposure variable in this study was age. Older people were divided into three groups: 65–74 years old as the young-old, 75–84 years as the middle-old, and 85 years old or older as the oldest-old.

Place of injury

The EDIIS gathers information about the place of injury; for the current study, specific places of injury were selected based on the variables provided by the EDIIS. These variables included the following specific places: home, residential institution, medical service areas, educational facilities, sports areas, roads, transport areas other than roads, industrial areas, farms, cultural facilities, commercial areas, nature (including mountains and seas), and others and unknown. Out of these fourteen variables, "other" and "unknown" variables were excluded, leaving twelve variables that were classified into four categories for analysis. Injuries occurring in homes were categorized as "homes", while those that occurred in residential institution were classified as "nursing homes." Similarly, injuries in medical service areas such as healthcare professionals' offices, outpatient clinics, healthcare centers, and hospitals were recorded as "medical facilities." Injuries that occurred in other areas were grouped and labeled as "other places."

Other independent variables

We categorized the seasons in which injuries occurred into four groups: spring (March-May), summer (June-August), autumn (September-November), and winter (December-February). We also classified the days on which the injury occurred into two categories: weekdays (Monday to Friday) and weekends (Saturday and Sunday). The time of injury occurrence was divided into two groups: daytime (6 AM–6 PM) and nighttime (6 PM–6 AM). Finally, the mechanism of fall was categorized into three groups based on predefined codes in the injury surveillance system: (1) slipping, which includes both slipping and tripping events on the same level;

(2) falling from a height, which includes falls from furniture or structures such as beds or ladders, categorized according to estimated height; and (3) falling on stairs, which includes slipping, tripping, jumping, or being pushed on stairs.

Statistical analysis

Patient characteristics and outcomes are presented as percentages. Categorical variables were analyzed using the chi-squared test. Outcomes were analyzed using a multivariable logistic regression model and are presented as odds ratios (ORs) and adjusted odds ratios (aORs) with corresponding 95% confidence intervals (95% CIs). All multivariable analyses were conducted using multivariable logistic regression adjusted for sex, time of injury, season of injury, and weekdays of injury. Age was included as an adjusted variable in the multivariate analysis of place. An interaction analysis was conducted to demonstrate the interaction between age and place of injury, adjusted for sex, time of injury, season of injury, and weekdays of injury. All statistical analyses were performed using SAS (version 9.4; SAS Institute Inc., Cary, NC, USA), and statistical significance was set at a two-sided p-value of less than 0.05.

Ethics statement

This study was conducted in accordance with relevant guidelines and regulations, including the Declaration of Helsinki. Ethical approval was obtained from the Institutional Review Board (IRB) of Seoul National University Bundang Hospital (IRB No: X-2304-825-902). The need for informed consent was waived by the IRB.

Results

From 2011 to 2020, the EDIIS database recorded 2,600,498 patients, of whom 178,872 were adults aged ≥ 65 years who presented to the ED following unintentional falls. We excluded 2,017 patients due to missing specific place of injury data or death on arrival (DOA). Additionally, 1,760 patients whose injuries occurred in nursing homes or medical facilities but whose activity data at the time of injury did not indicate that they were residents (daily living) or receiving care at those places (medical care) were excluded. This resulted in a final analysis sample of 175,095 patients (Fig. 1).

Table 1 shows the baseline characteristics and clinical outcomes of the study population according to the age group.

There were statistical differences in sex, time of injury, and acute alcohol consumption among the age groups, with slipping down being the most common injury mechanism in all age groups. Regarding the place of injury, the young-old group was most often injured other places, followed by homes, medical facilities, and nursing homes. Middle-old and oldest-old groups were most injured at home, followed by other places, medical facilities, and nursing homes. The percentage of patients receiving emergent operations and ICU care decreased with age, and in-hospital mortality of hip fractures increased with age.

Figure 2 illustrates how hip fractures were distributed across age groups and between sexes. The y-axis represents the percentage of fall-related ED patients within each age and sex group who were diagnosed with a hip fracture.

As age increased, more patients were diagnosed with hip fractures. Furthermore, in all age groups, hip fractures were more frequently diagnosed in women than in men.

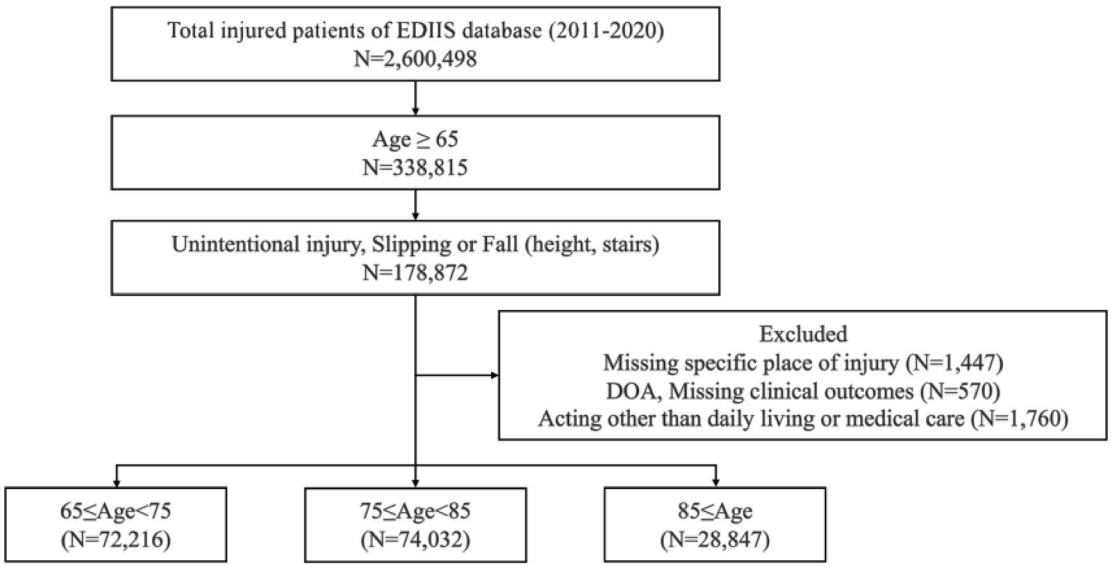

Fig. 1. Participant inclusion and exclusion flowchart. *EDIIS* Emergency Department Injury In-Depth Surveillance; *DOA* Dead on arrival.

	Young-old	Middle-old	Oldest-old	*P*-value
Total	72,216	74,032	28,847	
Sex				< 0.01
Female	38,531 (53.4)	47,554 (64.2)	20,650 (71.6)	
Season				< 0.01
Spring	16,956 (23.5)	17,268 (23.3)	6,751 (23.4)	
Summer	16,965 (23.5)	17,943 (24.2)	6,834 (23.7)	
Autumn	19,000 (26.3)	19,937 (26.9)	8,016 (27.8)	
Winter	19,295 (26.7)	18,884 (25.5)	7,246 (25.1)	
Weekend				< 0.01
Weekend	24,243 (33.6)	23,131 (31.2)	8,816 (30.6)	
Day-night				< 0.01
Day (6 AM-6 PM)	26,952 (37.3)	25,260 (34.1)	10,213 (35.4)	
Alcohol				< 0.01
Alcohol	8,182 (11.3)	2,874 (3.9)	294 (1.0)	
Mechanism				< 0.01
Slipping	54,111 (74.9)	59,515 (80.4)	23,955 (83.0)	
Falling from a height	10,975 (15.2)	8,629 (11.6)	3,338 (11.6)	
Falling from stairs	7,130 (9.9)	5,888 (8.0)	1,554 (5.4)	
Place of injury				< 0.01
Homes	32,406 (44.9)	44,146 (59.6)	19,927 (69.1)	
Nursing homes	808 (1.1)	1,487 (2.0)	1,258 (4.4)	
Medical facilities	1,618 (2.2)	2,709 (3.7)	1,519 (5.3)	
Other places	37,384 (51.8)	25,690 (34.7)	6,143 (21.3)	
Clinical outcomes				
Emergent operation	1,751 (2.4)	1,605 (2.2)	586 (2.0)	< 0.01
ICU admission	4,156 (5.8)	3,678 (5.0)	1,186 (4.1)	< 0.01
In-hospital mortality	995 (1.4)	1,236 (1.7)	685 (2.4)	< 0.01
Hip fractures	5,821 (8.1)	13,583 (18.4)	8,270 (28.7)	< 0.01

Table 1. Baseline characteristics and clinical outcomes according to age group. *ICU* Intensive care unit.

Figure 3 shows the distribution of hip fractures by place of injury and age group. The y-axis represents the percentage of fall-related ED patients within each age and injury place group who were diagnosed with a hip fracture.

The percentage of patients diagnosed with hip fracture was highest in medical facilities, followed by those in nursing homes, homes, and other places. In all injury places, the percentage of patients diagnosed with hip fractures increased with age.

Table 2 shows the results of the multivariate logistic regression analysis of the effects of age group and injury places on hip fracture occurrence.

Compared to the young-old group, the aOR for experiencing a hip fracture was 2.45 (95% CI, 2.37–2.53) in the middle-old group and 4.24 (95% CI, 4.09–4.40) in the oldest-old group. Compared to falls at home, the aOR for hip fracture was 0.46 (95% CI, 0.44–0.47) for other places, 1.21 (95% CI, 1.11–1.30) for nursing homes, and 1.60 (95% CI 1.51–1.70) for medical facilities.

Table 3 presents the results of the interaction analysis between age group and place on hip fracture occurrence.

Statistical analysis showed significant interactions between the oldest old group and specific places (medical facilities and other places).

Discussion

We conducted a cross-sectional study to examine the impact of age and place of injury on hip fractures resulting from falls in the aging population. Statistical analysis of EDIIS data revealed that hip fractures were more frequent in older age groups, with the highest rates in patients aged ≥ 85 years. Moreover, hip fracture occurrence varied by place of injury, being most common in medical facilities, followed by nursing homes, homes, and other places. This observed trend aligns with our initial hypothesis that hip fractures resulting from falls are more prevalent in older adults as they age, with a more notable increase in the prevalence observed in nursing homes or medical facilities where the older adults have reduced physical function.

A previous study conducted in Washington State compared the incidence of hip fractures between nursing home residents and non-nursing home residents aged ≥ 65 years. The study found that the rates of hip fractures by age and sex were approximately four times higher in nursing homes than in non-nursing homes[17], which is consistent with our study results. Our study compared hip fracture occurrence between community-dwelling

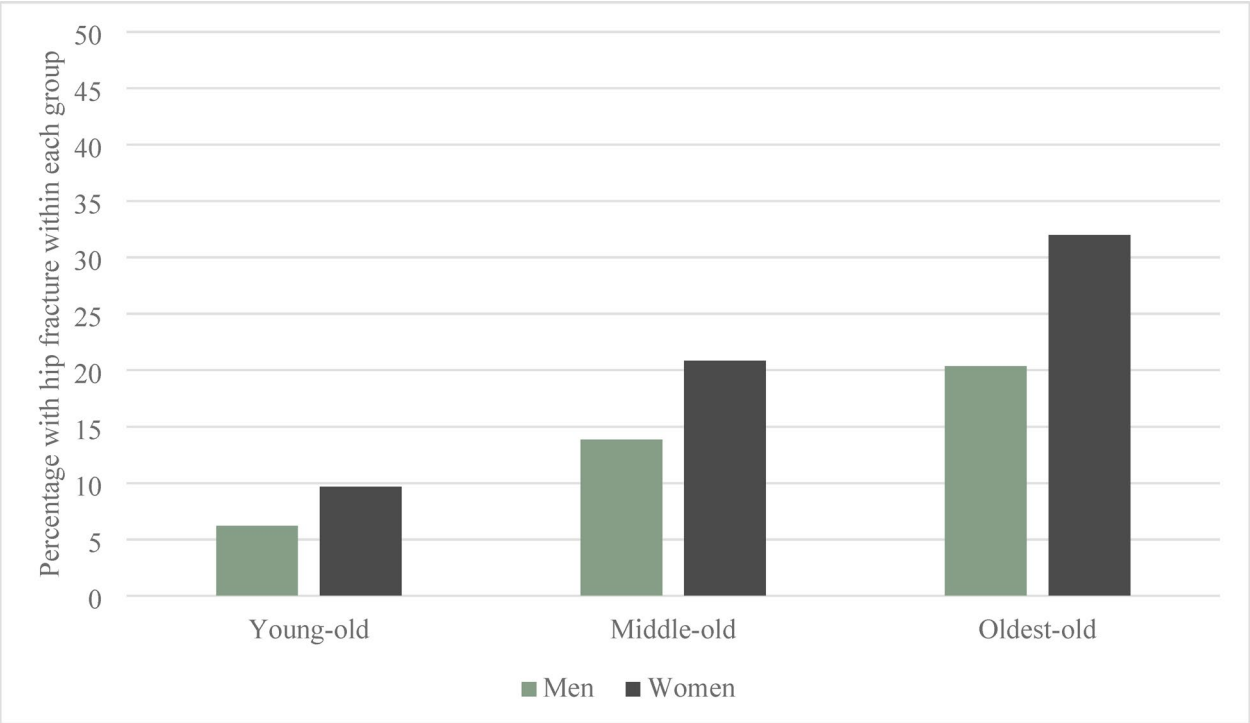

Fig. 2. Distribution of hip fractures by age group and sex among fall-related ED visits.

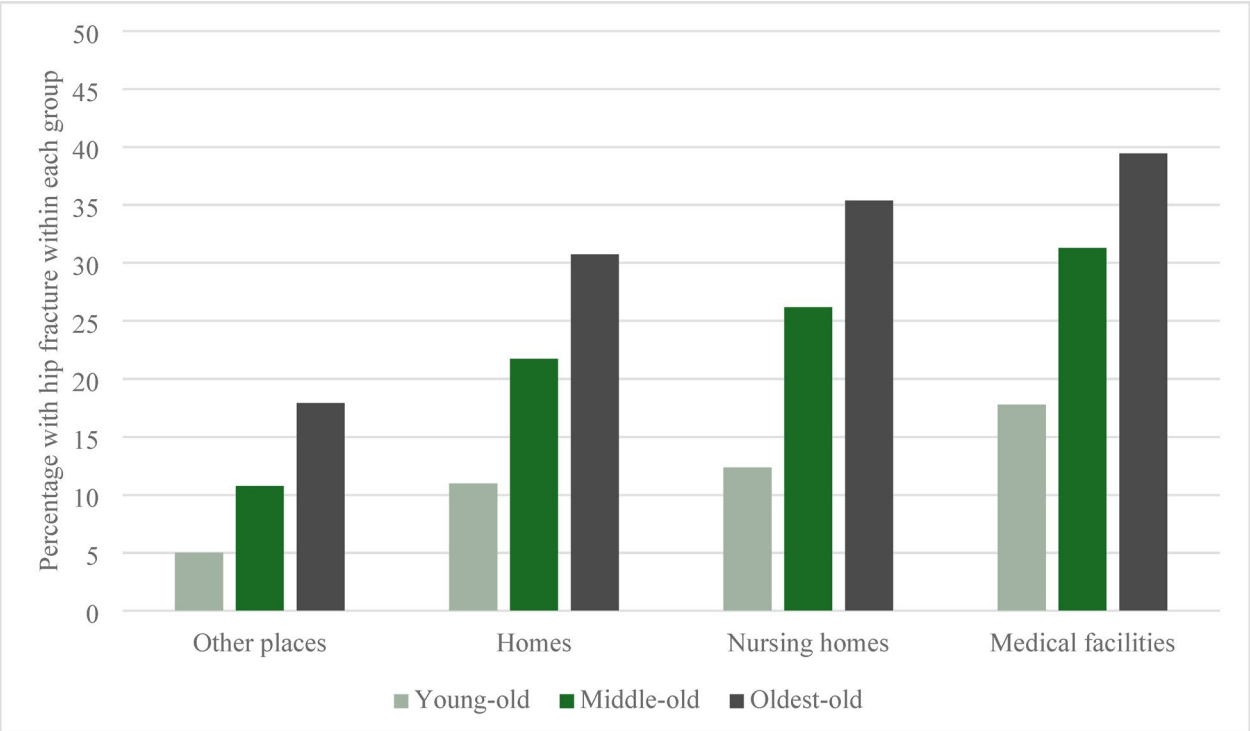

Fig. 3. Distribution of hip fractures by age group and sex among fall-related ED visits.

older adults and residents of nursing homes, and also evaluated fractures sustained outdoors and in medical facilities.

In over 90% of cases, hip fractures in older adults result from falls[18]. Older adults with reduced vision, cognitive function, and physical abilities due to aging may experience falls in environments with an increased risk

	Hip fracture Crude odds ratio	95% CI	Adjusted odds ratio*	95% CI
Age group				
Young-old (65–74)	1	-	1	-
Middle-old (75–84)	2.56	2.48–2.65	2.45	2.37–2.53
Oldest-old (85-)	4.58	4.42–4.76	4.24	4.09–4.40
Place of injury				
Other places	0.36	0.35–0.37	0.46	0.44–0.47
Homes	1		1	
Nursing homes	1.43	1.32–1.54	1.21	1.11–1.30
Medical facilities	1.69	1.59–1.79	1.6	1.51–1.70

Table 2. Multivariate logistic regression analysis. *CI* Confidence Intervals. * Adjusting variables: sex, time, season, weekday and age (for place of injury).

	Crude odds ratio	95% CI	Adjusted odds ratio*	95% CI
Other places				
Young-old (65–74)	1	-	1	-
Middle-old (75–84)	2.29	2.16–2.44	2.2	2.07–2.34
Oldest-old (85-)	4.15**	3.83–4.50	3.91**	3.61–4.24
Homes				
Young-old (65–74)	1	-	1	-
Middle-old (75–84)	2.24	2.15–2.34	2.18	2.09–2.27
Oldest-old (85-)	3.59	3.43–3.76	3.42	3.26–3.58
Nursing homes				
Young-old (65–74)	1	-	1	-
Middle-old (75–84)	2.51	1.98–3.19	2.38	1.88–3.03
Oldest-old (85-)	3.88	3.05–4.92	3.54	2.78–4.50
Medical facilities				
Young-old (65–74)	1		1	-
Middle-old (75–84)	2.1	1.81–2.44	2.02	1.74–2.35
Oldest-old (85-)	3.01**	2.55–3.54	2.83**	2.40–3.34

Table 3. Interaction analysis. *CI* Confidence Intervals. *Adjusting variables: sex, time, season, and weekday. **Interaction p-value < 0.05.

of falling, such as slippery floors. The physical force generated by a fall varies depending on the fall mechanism. When the proximal femur is unable to absorb the impact, a hip fracture—often involving the femoral neck or intertrochanteric region—may occur. A lower bone mineral density due to osteoporosis is associated with a higher risk of hip fracture after a fall[11]. Hip fracture incidence rates appear to vary across different settings—such as outdoor environments, private homes, nursing homes, and hospitals—which may support the consideration of more proactive fall prevention strategies in settings where fractures are more frequently observed[16,19].

Environmental factors are the primary cause of falls among older adults in the community, whereas those residing in nursing homes are more prone to falls due to internal factors, such as gait disturbance, weakness, and dizziness[12]. Various fall prevention strategies—such as environmental modifications, medication reviews, and exercise programs—have been suggested for older adults, particularly in settings where falls are more likely to occur, including nursing homes and community dwellings[20,21].

Hospitalized older adults are typically unable to perform their customary physical functions because of illness and are placed in an unfamiliar setting. The incidence of hip fractures resulting from inpatient falls is notably higher and is associated with increased mortality rates[22], which aligns with the findings of our study. Further research is warranted to examine the risk factors associated with hip fractures among older adults residing in nursing homes or hospitalized, and to devise customized fall prevention strategies that are specific to these risk factors.

Our interaction analysis revealed significant interactions between the oldest-old age group and certain places, specifically, medical facilities. This finding suggests that the effect of advanced age on hip fracture risk is particularly pronounced in these settings. For instance, in medical facilities, the oldest-old group had approximately three times higher odds of hip fracture than the young-old group, after adjusting for other factors. This interaction effect was not observed in homes or nursing homes, indicating that the relationship between age and hip fracture risk may be more complex in medical facilities and other places, possibly because of factors unique to these environments.

This study has several limitations. First, the 23 hospitals that participated in EDIIS were primarily located in large urban areas and were primarily academic teaching and tertiary hospitals. Cases of trauma that are difficult to treat in rural areas are typically transferred to urban hospitals. Therefore, the participants in this study may have predominantly consisted of patients with relatively severe injuries. Consequently, clinical outcomes such as in-hospital mortality may have been overestimated. This selection bias can be addressed by conducting research using a database representing the entire country.

Second, the percentage of hip fractures among fall-related ED visits may have been overestimated in nursing homes and medical facilities. In these settings, residents or patients with minor injuries may not have been transferred to the ED, whereas those with more severe injuries, such as suspected hip fractures, were more likely to be referred. This selective referral pattern could have led to a higher percentage of hip fracture diagnoses among those who visited the ED from these places.

Third, we categorized injuries occurring in residential facilities as "nursing home" injuries. To validate this classification and assess potential measurement bias, we conducted a detailed review of specific injury details for each patient. Upon examining the names of these residential facilities, we found that the vast majority were nursing homes. However, there is also the possibility of measurement bias in classifying other types of residential facilities as nursing homes.

Fourth, our study was limited by its examination of risk factors, such as underlying health conditions, bone mineral density, and the mechanisms of falls for older adults. Additional factors such as the use of psychotropic medications or sedatives, presence of comorbidities, functional status, and use of assistive devices—which could significantly affect fall risk and hip fracture occurrence—were not analyzed due to data limitations. Some hospitals participating in EDIIS are collecting more comprehensive data on these aspects, and including them in future analyses could enhance the robustness of findings.

Fifth, although the EDIIS registry is designed to collect injury data from all ED visits systematically, missing or incomplete data may occur due to unforeseen or unrecorded circumstances. Furthermore, structural variability between participating hospitals (e.g., differences in staffing, facility layout, or reporting practices) may affect the uniformity of data collection and could influence the generalizability of the findings.

Conclusions

This cross-sectional study investigated the impact of age and place of injury on hip fractures resulting from falls in the aging population. The percentage of fall patients diagnosed with hip fractures increased with age, with the highest percentage observed among individuals aged ≥ 85 years. Furthermore, the place of the injury plays a significant role, with the highest prevalence of hip fractures occurring in medical facilities, followed by nursing homes and homes. Hip fractures resulting from falls become more prevalent as older adults age, particularly in nursing homes or medical facilities, where physical function may be reduced. The higher incidence of hip fractures in nursing homes and medical facilities suggests that fall-prevention programs may need to be more actively implemented in these settings. These findings highlight the need to consider setting-specific strategies for fall prevention, particularly in nursing homes and hospitals where hip fractures were more frequently observed.

Data availability

The data that support the findings of this study are available from Korea Disease Control and Prevention Agency but restrictions apply to the availability of these data, which were used under license for the current study, and so are not publicly available. Data are, however, available from the corresponding author upon reasonable request and with permission from Korea Disease Control and Prevention Agency.

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Author contributions
Y.K.J and J.J contributed to the study concept and design. Y.J.K, D.K.K, and Y.C were responsible for data acquisition. Y.K.J, J.J, and Y.C performed the analysis and interpretation of data. Y.K.J. drafted the manuscript. All authors discussed the results and contributed to the final manuscript.

Declarations

Competing interests
The authors declare no competing interests.

Additional information
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