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Epidemiology and Clinical Outcomes of Vertebral Fractures in Older Adults: A Three-Year Study from Northwestern Iran

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ABSTRACT

Objective: This study aimed to determine the epidemiological characteristics of elderly patients hospitalized for spinal fractures at Mousavi Referral Hospital in Zanjan, Iran, from 2021 to 2023.
Methods: In this cross-sectional study, medical records of 261 elderly patients hospitalized with vertebral fractures were reviewed. Data on demographic characteristics, injury mechanisms, vertebral involvement, associated injuries, spinal cord damage, and patient outcomes were extracted and analyzed.
Results: Of the 261 patients, 138 (52.9%) were men and 123 (47.1%) were women. The mean age was 70.4±8.37 (range: 60-95). Women were significantly older than men (70±11 vs. 67±11, p=0.03). Male patients sustained a significantly higher number of fractured vertebrae than females (p=0.02). The incidence of fractures varied significantly across seasons (p=0.001). The most common fracture site was the thoracolumbar junction (56.2%), and the main cause was falling (58.6%). Spinal cord injuries occurred in 7.3% of patients. The most frequent associated fractures were pelvic (25.9%). The length of hospital stay increased significantly with the presence of associated fractures (p=0.001), spinal cord injuries (p=0.02), and a greater number of fractured vertebrae (p=0.04).
Conclusion: Elderly spinal fracture patients, particularly men and those with multiple vertebral fractures, are at an increased risk of spinal cord injury, associated fractures, prolonged hospitalization, and mortality. Falls remain the most frequent cause, and the thoracolumbar junction the most common site. These findings highlighted the need for targeted prevention strategies, cautious clinical management, and early identification of high-risk patients to improve outcomes.

Keywords: Epidemiology; Vertebral fracture; Injury mechanism; Aged, Iran.

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Introduction

Aging, typically beginning around 60 to 65 years of age, is a gradual and irreversible process characterized by a decline in physical and functional abilities. As elderly individuals represent one of the most vulnerable groups in society, safeguarding their health is a critical responsibility [1]. A necessary step toward this goal is understanding the factors that influence their health and modify their risk profiles.

Meanwhile, increased life expectancy has led to rapid growth of the elderly population worldwide [2-4]. The World Health Organization projects that the global aged over 60 years will reach approximately 2.1 billion by 2050 [5]. A similar demographic trend has been observed in Iran, which suggests that population aging will pose a significant public health challenge in the coming years [1, 6]. In Iran, injuries account for 28% of the total disease burden [7], and the risk of severe injury appears significantly higher among the geriatric population than the younger adults [8]. Accidents and falls are prevalent and serious in older adults, with falls recognized as their primary cause [1, 3].

Globally, Oceania and the Americas report the highest and second-highest prevalence of geriatric falls, respectively [4]. In Iran in 2021, the incidence rate of falls among individuals aged 60 years and older was 1,674 falls per 100,000 population [9]. Similarly, the pooled prevalence of falls among the Chinese elderly (aged ≥60 years) between 2000 and 2021 was 19.3% [10].

Fractures are a serious consequence of falls [11, 12]. Fall-related fractures occur frequently in the elderly and have become a major public health concern [1, 2, 13]. Vertebral fractures are among the injuries that can result from trauma [2, 12]. In 2021, an estimated 5.37 million people worldwide experienced vertebral fractures, a number projected to rise to around 8.01 million by 2050 [14]. The highest prevalence of these fractures is reported in Europe, North America, and Australia, typically high-income regions, while rates are lower in Latin America and parts of Asia [14-16].

Vertebral fractures are the most common osteoporosis-related fractures in the elderly, with falls and traffic accidents being major causative factors in this age group [14, 16-20]. Although men generally have a higher incidence rate, women surpass men after 65 years of age [14, 16]. Overall, the incidence of vertebral fractures increases with advancing age [15, 21].

Initial symptoms of a vertebral fracture may be subtle, with back pain and loss of height being the only indicators [22]. In moderate to severe cases, these fractures can cause depression, reduced quality of life, early satiety, spinal deformity, pulmonary dysfunction, and weight loss. Functional impairment often results in a loss of independence. Vertebral fractures are also associated with an increased risk of future fractures, higher mortality, and greater healthcare costs [18, 22-25]. As the population ages, the burden of vertebral fractures and corresponding healthcare expenditures is expected to rise substantially [14, 16, 26]. Despite this, comprehensive epidemiological studies on fractures among older Iranians are lacking.

Although vertebral fractures are a common and serious problem in older adults, many aspects of their presentation and outcomes in Iran remain unclear. Clinicians often face challenges in anticipating which patients are at higher risk for complications such as spinal cord injury, prolonged hospitalization, or mortality. A better understanding of these patterns could inform timely clinical decisions and improve patient care. Therefore, the present study was designed to describe the epidemiological and clinical characteristics of elderly patients with vertebral fractures and to identify the factors influencing their outcomes. Our findings aimed to provide practical insights to support the early recognition of high-risk cases and guide more effective management strategies.

Materials and Methods

This cross-sectional descriptive study was conducted on elderly patients aged 60 years and older, who were hospitalized with a diagnosis of vertebral fracture at Mousavi Hospital in Zanjan, Iran, between March 2021 and March 2023. The study was approved by the Ethics Committee of Zanjan University of Medical Sciences (Ethics code: IR.ZUMS.REC.1403.099). Mousavi Hospital serves as the provincial referral center for trauma and orthopedic injuries.

The medical records of all patients aged 60 or older hospitalized with a vertebral fracture (including cervical, thoracic, lumbar, or multiple spinal regions) during the study period were assessed. Patients with isolated sacral fractures or those whose records lacked relevant demographic or clinical data were excluded. Using the census approach, we reviewed all eligible patients' records.

Data were extracted on the following variables: age, sex, marital status, comorbid conditions, duration of hospital stay, season of admission, mechanisms of injury (categorized as fall, traffic accident, or chronic pain/unknown), number of fractured vertebrae, associated fractures, spinal cord injury, and patient outcomes.

The data were analyzed using SPSS software version 26 and RStudio 4.4.1. Qualitative variables were described as frequencies and percentages. Quantitative variables were summarized as mean±standard deviation (SD) if normally distributed (assessed via the one-sample Kolmogorov-Smirnov test, P-value>0.05); otherwise, the median and interquartile range (IQR) were reported.

Associations between qualitative variables were assessed using the Chi-square test or Fisher's exact test. For comparisons of non-normally distributed quantitative variables between two groups, the

Mann-Whitney *U* test was used, and for comparisons across more than two groups, the Kruskal-Wallis test was applied. Normally distributed quantitative variables were compared between two groups using the independent samples *t*-test and across more than two groups using one-way ANOVA.

To examine factors influencing clinical outcomes and predictors of spinal cord injury, a Firth penalized logistic regression model was employed. Factors affecting the length of hospital stay were assessed using a nominal regression model. A *p*-value of <0.05 was considered statistically significant.

Results

A total of 261 elderly patients (aged ≥60 years) with vertebral fractures were admitted to Mousavi Hospital in Zanjan, between 2021 and 2023. As shown in Table 1, the number of admissions in 2021 (n=59) was significantly lower than in subsequent years (p<0.001). The mean age of patients did not change significantly from 2021 to 2023 (p=0.11). Besides, the sex distribution of patients showed no statistically significant difference over 3 years (p=0.28).

Patient age ranged from 60 to 95 years, with a mean age of 70.4±8.37 years. Female patients were significantly older than males (71.54±8.31 vs. 69.33±8.32, p=0.03), as shown in Figure 1.

Figure 2 shows the comorbidity status of the patients. Hypertension was the most common comorbidity, followed by diabetes mellitus and ischemic heart disease. Other conditions, including osteoporosis, osteoarthritis, and hypothyroidism, were less prevalent in this population.

Table 2 presents the distribution of fractures by sex, season, mechanism of injury, clinical outcome, and spinal cord injury status. There was no statistically significant difference in the number of male and female patients (p=0.35). However, male patients had a significantly higher number of fractured vertebrae than females (p=0.02). The distribution of fracture regions also differed significantly between sexes (p=0.04), with thoracolumbar junction (TLJ) fractures more common in women and cervical fractures more frequent in men. Other vertebral regions were similarly affected. The incidence of fractures varied significantly by season (p=0.001), with the highest number occurring in summer (n=90) and the lowest in spring (n=46). The median number of fractured vertebrae per patient was 1 (IQR=1-2) across all seasons except spring, which also had a median of 1 (IQR=1-2) (p=0.03). The fracture location showed no difference by season (p=0.46). The distribution of injury mechanism was statistically significant (p<0.001), with falls being the most common.

Table 1. Demographic characteristics of elderly patients with vertebral fractures between 2021 and 2023

Variables / Year		2021	2022	2023	*P*-value
Number		59	90	112	<0.001[a]
Age (mean±SD)		70.80±8.18	68.91±8.53	71.32±8.25	0.11[b]
Sex	Male (%)	26(44.1)	47(52.2)	65(58)	0.28[c]
	Female (%)	33(55.9)	43(47.8)	47(42)	
Marital status	Single (%)	45(76.3)	62(68.9)	83(74.1)	0.56[c]
	Married (%)	14(23.7)	28(31.1)	29(25.9)	

[a] One-sample Chi-Square test, [b]One-way ANOVA, [c]Chi-Square

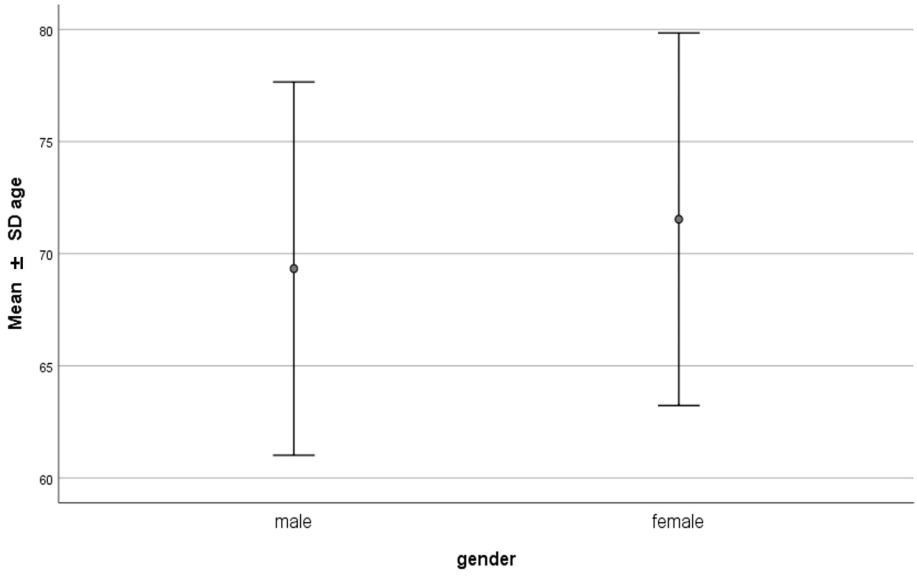

Fig. 1. Age distribution by sex in patients with vertebral fractures between 2021 and 2023

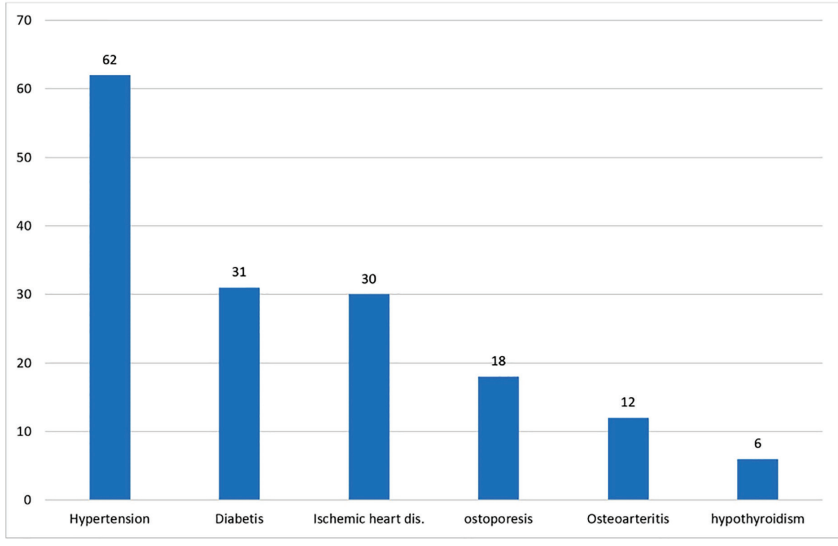

Fig. 2. Comorbidity frequency in elderly patients with vertebral fracture between 2021 and 2023

Table 2. Comparison of vertebral fracture number and fracture site by gender, season, and mechanism of injury, in elderly patients with vertebral fracture between 2021 and 2023

Variable		N (%)	Number of fractured vertebrae (Median / IQR)	Spine region				
				Cervical n (%)	Thoracic n (%)	Lumbar n (%)	Thoraco lumbar junction n (%)	Cervical+ thoracic+ lumbar n (%)
Gender	Male	138(53)	2(1-3)	30(21.7%)	5 (3.6%)	13(9.4%)	65(47.1%)	19(13.8%)
	Female	123(47)	1 (1-3)	13(10.6%)	6 (4.9%)	13(10.6%)	76(61.8%)	11(8.9%)
P-value		0.35 [b]	0.02 [a]	0.04 [b]				
Season	Spring	46(18)	1(1-1)	7(16.7%)	3(7.1%)	3(7.1%)	27(64.3%)	2(4.8%)
	Summer	90(34)	1(1-2)	15(16.9%)	5(5.6%)	12(13.5%)	45(50.6%)	12(13.5%)
	Fall	59(23)	1(1-2)	13(23.2%)	2(3.6%)	7(12.5%)	28(50%)	6(10.7%)
	Winter	66(25)	1(1-2)	8(12.5%)	1(1.6%)	4(6.3%)	41(64.1%)	10(15.6%)
P-value		0.001 [b]	0.03 [c]	0.46 [d]				
Mechanism	Falling	153(58.6)	1(1-2)	18(11.9%)	3(2%)	11(7.3%)	102(67.5%)	17(11.3%)
	Terrific accident	88(33.7)	1(1-2)	25(31.3%)	6(7.5%)	12(15%)	25(31.5%)	12(15%)
	Unknown/chronic pain	20(7.7)	1(1-1)	0(0%)	2(10%)	3(15%)	14(70%)	1(5%)
P-value		<0.001 [b]	0.04 [c]	<0.001 [d]				
Clinical outcome	Ceased	7(2.7)	3(1-5)	4(57.1%)	1(14.3%)	0(0%)	2(28.6%)	0(0%)
	Routine discharge	219(83.9)	1(1-2)	31(14.6%)	8(3.8%)	20(9.4%)	125(58.7%)	29(13.6%)
	Discharge against medical advice	32(12.3)	1(1-2)	7(25%)	2(7.1%)	6(21.4%)	12(42.9%)	1(3.6%)
	Refer to the other hospital	3(1.1)	1(1-1)	1(33.3%)	0(0%)	0(0%)	2(66.7%)	0(0%)
P-value		<0.001 [b]	0.09 [c]	0.03 [d]				
Spinal cord injury	Yes	19(7.3)	2(1-3)	6(31.6%)	0(0%)	3(15.8%)	6(31.6%)	4(21.1%)
	No	242(92.7)	1(1-2)	37(15.9%)	11(4.7%)	23(9.9%)	135(58.2%)	26(11.2%)
p-value		<0.001 [b]	0.01 [a]	0.07 [d]				

[a] Mann-Whitney U, [b] Chi-square, [c] Kruskal-Wallis, [d] Fisher's Exact

The distribution of fractured vertebrae per patient is presented in Figure 3. The median number of fractured vertebrae per patient differed by mechanism (p=0.04), as did the fractured spinal region (p=0.001). For instance, falls primarily affected the TLJ, while traffic accidents most often involved the cervical vertebrae; other regions were similarly affected across mechanisms.

Regarding clinical outcome, 219 patients (83.9%) were discharged after recovery, and 7 (2.7%) patients died. A significant association was found between clinical outcome and fracture site (p=0.03). Cervical vertebral fractures were more frequent among deceased patients than survivors (57.1% vs 14.5%), whereas TLJ fractures were less common in deceased patients (28.6% vs. 58.7%).

Spinal cord injury occurred in 7.3% of patients. The number of fractured vertebrae was significantly higher in patients with spinal cord injury than those without (2 [1–3] vs. 1 [1-2], p=0.01). No significant relationship was found between spinal cord injury and fracture site (p=0.07). To investigate predictors of spinal cord injury, a Firth penalized logistic regression model was used (Wald test=103.17, df=2,

p<0.001). Age, presence of associated fractures, and fracture mechanism were not included in the model. The number of fractured vertebrae was identified as a risk factor for spinal cord injury (p=0.04; Table 3). Fracture site distribution is shown in Figure 4. TLJ was the most common fractured site (56.2%), while the thoracic vertebra was the least common (4.4%). A total of 68 (26.1%) patients had associated fractures. As shown in Figure 5, the most common site of associated fractures was the pelvis (25.9%).

As presented in Table 4, the frequency of other fractures was higher in men than in women (p=0.03). Spinal cord injury occurred more frequently in men than in women (p=0.04), whereas the mechanism of injury did not differ significantly between sexes (p=0.17).

After excluding referred patients and those discharged against medical advice or due to personal consent issues, the median hospital stay was 5 days (IQR=3-8).

Table 3. Firth penalized logistic regression model to identify the predictors of spinal cord injury in elderly patients with vertebral fracture between 2021 and 2023.

Model	B	SE	df	Odds ratio	95% Confidence Interval	*P*-value
Sex (male=0)	-1.05	0.55	1	0.347	0.117-1.024	0.04
Number of fractured vertebrae	0.23	0.10	1	1.270	1.031-1.563	0.04

Wald test=103.1755, df=2, p<0.001

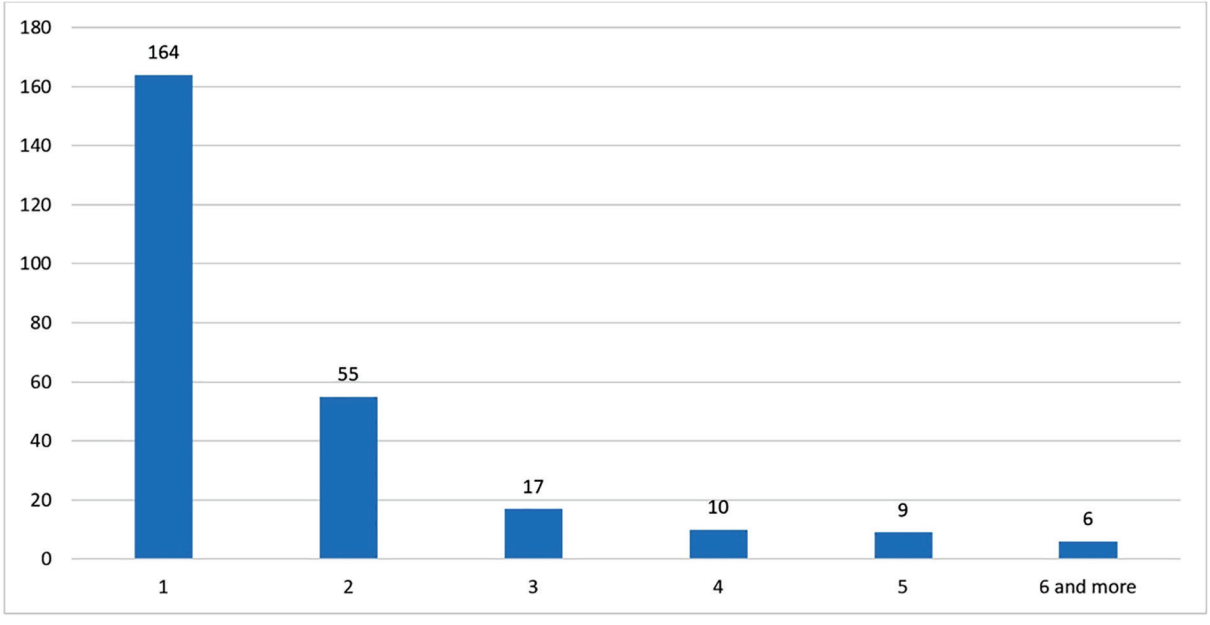

Fig. 3. The distribution of the number of fractured vertebrae per patient in elderly patients with vertebral fractures between 2021 and 2023

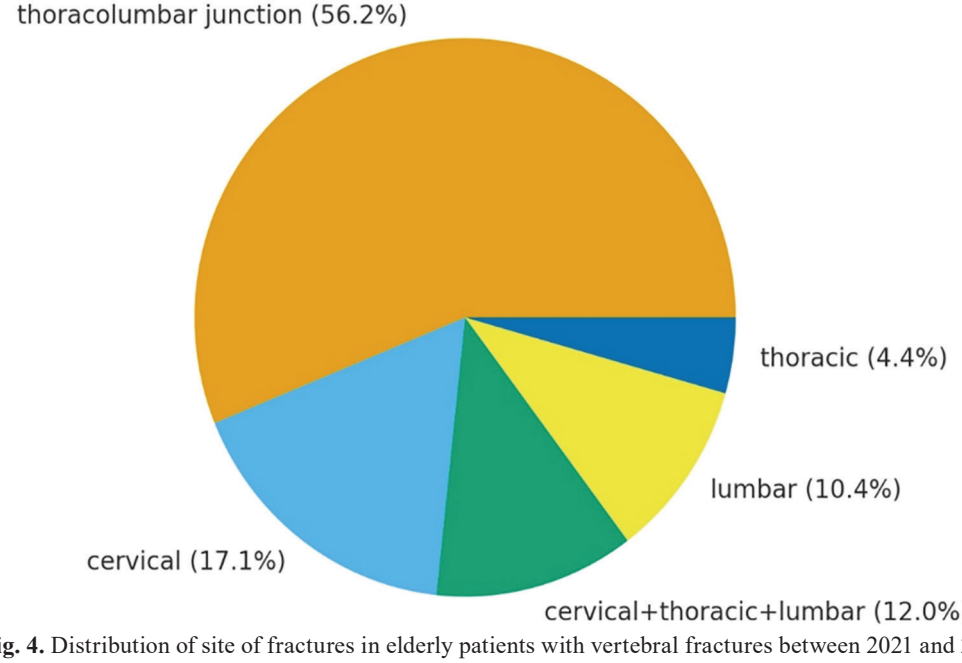

Fig. 4. Distribution of site of fractures in elderly patients with vertebral fractures between 2021 and 2023

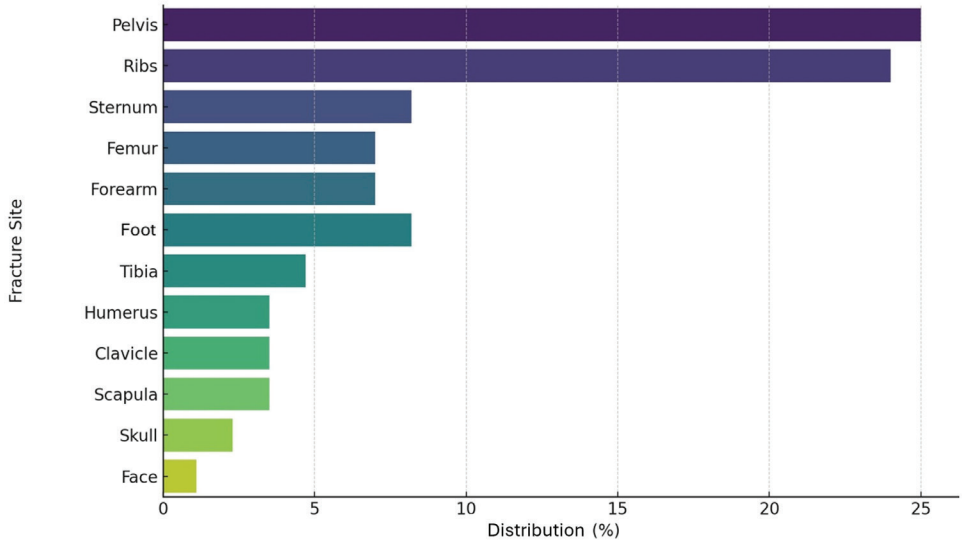

Fig. 5. Distribution (%) of associated fractures in elderly patients with vertebral fractures between 2021 and 2023

Table 4. Distribution of other fractures and Spinal cord injury and mechanism of injury by gender in elderly patients with vertebral fracture between 2021 and 2023.

Variable		Total	Male n (%)	Female n (%)	*P*-value
Other fractures	Yes	55(100)	36(65.5)	19(34.5)	0.03 [b]
	No	171(100)	84(49.1)	87(50.9)	
Spinal cord injury	Yes	17(100)	13(76.5)	4(23.5)	0.04 [b]
	No	209(100)	107(51.2)	109(48.8)	
Mechanism of injury	Falling	153(100)	80(52.3)	73(47.7)	0.17 [b]
	Traffic	88(100)	51(58)	37(42)	
	Chronic pain	20(100)	7(35)	13(65)	

[b]Chi-square test

Table 5. Linear Regression analysis to identify the predictors of hospital stay duration in elderly patients with vertebral fractures between 2021 and 2023

Model	B	SE	t	*P*-value
Accompanied fracture	3.86	0.87	4.428	0.0001
Spinal cord injury	3.1	1.37	2.258	0.02
Number of fractured vertebrae	0.50	0.25	1.979	0.04

Table 6. Firth penalized logistic regression model to identify the predictors of clinical outcome in elderly patients with vertebral fracture between 2021 and 2023

Model	B	SE	df	Odds ratio	95% Confidence Interval	*P*-value
Mechanism (falling)	-0.86	1.59	1	0.42	0.01-9.54	0.63
Mechanism (traffic accident)	0.83	1.49	1	2.29	0.12-42.53	0.54
Spinal cord injury	1.92	0.80	1	6.82	1.42-32.72	0.03
Number of fractured vertebrae	0.31	0.14	1	1.36	1.03-1.79	0.06

Wald test=64.19, df=4, $p<0.001$

To determine which variables affected the length of hospital stay, a linear regression model was used. Patient age and sex, mechanism of injury, and fracture site were excluded due to collinearity. Variables predicting hospital stay duration are presented in Table 5. The presence of other fractures ($p<0.001$) and spinal cord injury ($p=0.02$), and a higher number of fractured vertebrae ($p=0.04$) were associated with prolonged hospital stay.

After excluding patients who were referred elsewhere, discharged against medical advice, or discharged due to personal consent issues, the remaining patients were divided into two groups: those discharged after clinical improvement and those who died. Factors influencing mortality were examined using a Firth penalized logistic regression model (Wald test=64.19, df=4, $p<0.001$). Spinal cord injury was associated with an increased risk of death ($p=0.03$; Table 6).

Discussion

The present study found an approximately equal distribution of vertebral fractures between elderly men and women. However, the number of fractured vertebrae per patient was higher in men. In both sexes, the most common fracture site was TLJ. Female patients were significantly older than their male counterparts, while cervical fractures were more frequent in men. The highest number of fractures occurred in summer, while the lowest was in spring. Falls were the predominant injury mechanism, and different mechanisms were associated with distinct fracture patterns. Over 80% of patients were discharged after improvement, with a small mortality rate. Spinal cord injury occurred in approximately 7% of patients and was associated with a higher number of fractured vertebrae. A greater number of fractured vertebrae was also associated with an increased likelihood of associated fractures, most commonly pelvic and rib fractures. The length of hospital stay increased with the presence of associated fractures, spinal cord injury, and a greater number of fractured vertebrae. Furthermore, spinal cord injury was associated with an increased risk of mortality. Despite the known elevated fracture risk in older, postmenopausal women, men in this study experienced more severe injury patterns, including a higher number of fractured vertebrae, more associated injuries, and a greater frequency of spinal cord injury, likely attributable to the higher incidence of cervical injury in men.

The predominance of falls as the injury mechanism was consistent with previous studies from Iran. Similar to our findings, Saadat *et al.,* [3] and Gilasi *et al*., [12] reported that falls are the most common cause of vertebral and other fractures among the elderly in Iran, resulting from the interaction of age-related balance impairment and environmental hazards. Likewise, Mohammadi *et al.,* [1] examined data from Ilam and found that most spinal cord injuries in older adults were trauma-related and occurred more frequently in men. This finding aligned with our observation of more severe injury patterns—including more spinal cord injury, a higher number of fractured vertebrae, and more associated injuries— in male patients.

The seasonal peak in summer might be explained by increased outdoor activity and potentially reduced caution during warmer months [27, 28]. Regarding the anatomical site, our finding that the majority of fractures occurred at the TLJ was consistent with studies by Yousefzadeh-Chabok *et al.,* [29], Andalib *et al.,* [30], and Moradi-Lakeh *et al*., [31], who identified the TLJ as the most vulnerable transition zone due to the rigidity of the thoracic spine and flexibility of the lumbar region.

Our findings regarding sex and mechanism differences contrast with those of Gonnelli *et al.,* [32] and Papaioannou *et al.,* [17], who reported a higher incidence of vertebral fractures in women, often linked to osteoporosis and future fracture risk. In our study, men sustained a higher number of fractured vertebrae and more associated fractures than women, despite no significant difference in the overall injury mechanism. This discrepancy might be explained by differing activity patterns: elderly women, who often have a homemaker lifestyle, typically sustain vertebral fractures from low-energy, ground-level falls. In contrast, men may more frequently engage in activities such as driving or working at heights, increasing their exposure to high-energy trauma and resulting in more severe injury patterns [33, 34].

Furthermore, the observed summer peak in fracture incidence in our study was consistent with the findings of Williams *et al.,* [35] and Wilson *et al.,* [36], who suggested trauma rates increase during warm months due to greater outdoor activity and environmental exposure. Overall, the present study supported these established observations while providing specific regional data from northwestern Iran.

This study had several limitations, including its retrospective design, reliance on archived data, and restriction to a single tertiary center. Although the hospital serves as a provincial referral center, outpatient vertebral fracture cases were not captured. Therefore, the findings could not be generalized to the broader population. Nevertheless, the large sample size and comprehensive analysis provide valuable insights into regional fracture epidemiology and associated risk factors.

In conclusion, elderly spinal fracture patients with vertebral fractures, particularly men and those with multiple vertebral fractures, are at an increased risk of spinal cord injury, associated fractures, prolonged hospitalization, and mortality. Falls remain the most frequent cause, and the TLJ remains the most common site. These observations underscored the need for targeted prevention strategies, cautious clinical management, and early identification of high-risk patients to improve outcomes.

Declaration

Ethics Approval and Consent to Participate: This study was approved by the Research Ethics Committee of Zanjan University of Medical Sciences (Approval Code: IR.ZUMS.REC.1403.099) and was conducted in accordance with the ethical standards of the 1964 Helsinki Declaration and its later amendments. Written informed consent was obtained from all individual participants included in the study.

Consent for Publication: Written informed consent for publication of the research data and related materials was obtained from all participants, where applicable.

Availability of data and material: The datasets

used and/or analyzed during the present study are available from the corresponding author upon reasonable request.

Conflict of Interests: The authors declare that there is no conflict of interest regarding the publication of this paper.

Declaration of Generative AI in Scientific Writing: During the preparation of this work, ChatGPT (OpenAI, GPT-4.1) was used to improve the fluency of the scientific text. The authors subsequently reviewed, edited, and verified all content as required and assume full responsibility for the content of the publication.

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Authors' Contributions: SAS: Conception, design, data analysis, and manuscript revision for the study; RK: Data collection, manuscript drafting, and correspondence with the journal as the corresponding author. Both authors read and approved the final manuscript.

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