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RESEARCH

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How prevalent is osteoporosis in a high-risk subgroup? A multicenter study of postmenopausal women hospitalized for fractures in China

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Abstract

Introduction Osteoporosis is the principal underlying cause of fractures in postmenopausal women. Despite consensus on the importance of secondary prevention, a profound treatment gap exists, partly due to the lack of precise data on disease burden in the highest-risk population. This study aimed to determine the prevalence of osteoporosis and its associated factors specifically among postmenopausal women hospitalized for fractures, a critical evidence gap in orthopedic practice.

Methods We conducted a multicenter cross-sectional study across eight tertiary hospitals in China between March and May 2024. Eligible participants were postmenopausal women hospitalized for fractures who met predefined inclusion and exclusion criteria. All participating surgeons completed standardized protocol training for data collection, and each study site contributed up to 160 cases.

Results The study included 822 postmenopausal women (mean age: 68.9 ± 10.7 years), with an overall osteoporosis prevalence of 76.9% (95% CI: 73.8%–79.7%). The prevalence was significantly higher among those with longer menopause duration (per year: adjusted odds ratio [aOR] = 1.08, 95% CI: 1.04-1.13, $P < 0.001$), vertebral fractures (vs patellar, tibiofibular, or ankle fractures: aOR = 3.16, 95% CI: 1.84-5.45, $P < 0.001$), and a history of fractures (aOR = 8.53, 95% CI: 2.56-52.94, $P < 0.001$).

Conclusions This study reveals an alarmingly high prevalence (76.9%) of osteoporosis among postmenopausal women hospitalized for fractures in China, identifying prolonged menopause, vertebral fractures, and recent fracture history as key risk profiles. The findings mandate a shift in inpatient fracture care. They provide compelling evidence for implementing universal bone health assessment, specifically through in-hospital systems like Fracture Liaison Services (FLS), as a standard of care for this high-risk population to mitigate subsequent fracture risk.

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Summary
For orthopedic surgeons managing fracture care, this study delivers a pivotal finding: osteoporosis is the underlying condition in over three-quarters (76.9%) of postmenopausal women hospitalized for fractures. The prevalence escalates to over 88% in patients with vertebral fractures or a recent fracture history. This quantifies the immense missed opportunity for secondary fracture prevention at the point of care. The data provide irrefutable evidence for implementing in-hospital systems like Fracture Liaison Services (FLS) and routine DXA screening, moving beyond fracture repair to definitive management of the root cause during the critical inpatient episode.

Keywords Prevalence, Risk factors, Osteoporosis, Postmenopausal women, Fractures, A cross-sectional study

Introduction

Osteoporotic fractures are highly prevalent among older women, with osteoporosis being a leading underlying etiology. Consequently, the timely diagnosis and management of osteoporosis following an initial fracture is widely recognized as a critical strategy for preventing subsequent fractures [1, 2].

Despite this consensus, a significant care gap persists, as evidenced by the suboptimal rates of osteoporosis diagnosis and treatment in postmenopausal women. Global evidence consistently reveals profound osteoporosis treatment gaps. A 2004 study found treatment rates of only 39.6% and 4.1% in women and men following fractures, respectively [3]. Subsequent multinational [4] and Asian [5] studies confirmed this trend, with post-fracture treatment rates remaining below 43%. Recent data confirm that underdiagnosis and undertreatment remain pervasive without structured Fracture Liaison Services (FLS) [6–10].

This gap is exacerbated by a fundamental evidence shortfall: although both menopause and prior fracture are well-established risk factors for osteoporosis [1, 2], the precise prevalence of the condition specifically among postmenopausal women hospitalized for fractures, who is arguably the highest risk group encountered in orthopedic practice, remains unquantified at a global level.

Therefore, there is an urgent need to accurately determine the prevalence of osteoporosis in this targeted population. Our study aims to fill this critical evidence gap, providing essential data to support the implementation of widespread bone health screening and secondary fracture prevention strategies.

Methods

Study design and eligibility

This is a multicenter cross-sectional study conducted between March and May 2024. Eligible women were enrolled from eight Chinese hospitals spanning four regions: Northern (Shandong, Henan), Eastern (Shanghai, Jiangxi), Southern (Guangdong x2), and Western (Sichuan, Guizhou). These hospitals are located in major urban centers, and thus the study primarily references an urban population.

Based on published osteoporosis prevalence ranging from 32.1% to 52.8% in elderly or postmenopausal patient groups [11–13], we adopted a conservative estimate of 35% for sample size calculation (n = 400* Q/P), yielding 743 subjects. To accommodate missing data and ensure robustness across eight hospitals, the total sample size was increased to 1280 (160 per hospital). Eligible participants were postmenopausal women (≥ 12 months amenorrhea) aged ≥ 50 years hospitalized with imaging-confirmed fractures. Exclusion criteria included: (1) male sex, (2) age < 50 years, (3) inability to complete laboratory testing, (4) communication barriers preventing reliable medical history collection, or (5) inability to provide informed consent. Approval was obtained from Fudan University School of Public Health (IRB#2023-12-1094) and all local IRBs. Written informed consent was mandatory.

Data collection and variable definitions

A secure electronic database recorded demographic/clinical variables, imaging-confirmed fracture sites, DXA results and medical history. Trained staff entered data after standardized training, with 10% random audits for quality control. To prevent selection bias, all eligible fracture patients were enrolled consecutively, without subspecialty selection.

The primary outcome was osteoporosis diagnosis in postmenopausal women hospitalized for fractures, defined by any of the following criteria [1, 2]: (1) DXA confirmed osteoporosis (T-score ≤ -2.5), (2) documented prior clinical diagnosis in medical records, or (3) attending surgeons' confirmation of fragility fractures (low-trauma fractures from falls at standing height or less). All fragility fracture diagnoses were confirmed by two orthopedic surgeons blinded to patient history, with discordant cases resolved by a third experienced orthopedic surgeon.

The execution of DXA examinations in this study adhered strictly to the 2020 American Association of Clinical Endocrinologists (AACE) and 2022 Chinese Society of Osteoporosis and Mineral Bone Disease (CSBMR) guidelines, with measurements performed at the lumbar spine, proximal femur, or one-third distal radius of the non-dominant forearm as the standard protocol across all centers. To ensure measurement validity, a general quality control principle was followed: DXA scans were not performed on skeletal sites where acute fracture-related changes (e.g., edema) were likely to compromise accuracy. In such cases, an alternative site was scanned or the examination was postponed. All participating hospitals are nationally accredited clinical research bases, and their DXA devices underwent mandatory regular quality control inspections by local governmental Medical Equipment Quality Control Centers to ensure accuracy and consistency throughout the study.

We collected demographic data, laboratory data and osteoporosis related medical history. Table 1 specifies all exposure variables and their definitions.

Statistical analysis

Cases with missing data for any variable in the multivariate model were excluded from the primary complete-case analysis. This approach was chosen to provide unbiased estimates under the assumption that data were missing completely at random (MCAR) and to avoid the additional assumptions required for imputation methods. Demographic characteristics were analyzed descriptively by osteoporosis status. Continuous variables were expressed as mean ± standard deviation (SD) and compared using independent samples t-tests (normal distribution) or Mann-Whitney U tests (non-normal distribution). Categorical variables were expressed as frequency (n, %) and compared using Pearson's χ^2 tests or Fisher's exact tests (expected cell counts < 5). Univariate logistic regression models were used to assess individual risk factors for osteoporosis, with results reported as odds ratios (ORs) with 95% confidence intervals (CIs). All variables demonstrating significant associations ($P < 0.05$) in univariate analyses were included in the multiple logistic regression models. To assess the robustness of the primary results against potential bias introduced by missing data, a pre-specified sensitivity analysis was conducted using multiple imputation by chained equations (MICE, m = 5 iterations) for all missing variables. The results from this sensitivity analysis are presented alongside the primary findings. All analyses were conducted using R software (version 4.3.3; R Foundation for Statistical Computing). A two-sided $P < 0.05$ defined statistical significance.

Results

Characteristics of subjects

Our primary analysis included 822 postmenopausal women (mean age 68.9 ± 10.7 years) hospitalized for fractures, following the exclusion of 316 patients due to incomplete data, most commonly missing serum creatinine for GFR estimation. Among these, 632 patients (76.9%) were diagnosed with osteoporosis. Specifically, 451 osteoporotic patients (71.36%) met the densitometric criterion (BMD T-score ≤ -2.5). Of the remaining 181 patients with T-score > -2.5, 18 (2.85%) had a documented prior diagnosis, and 163 (25.79%) were classified based on an adjudicated fragility fracture.

Table 1 Definition and classification of collected variables

Variables	Operational Definition	Data type
Age (years)	Recorded in years	Continuous
The duration of menopause (years)	Time since last menstrual period (≥ 12 months amenorrhea) [14].	Continuous
Premature menopause	The spontaneous onset of menopause before the age of 40 years old [14].	Binary (Yes /No)
Site of current fracture	Hip fracture (including femur, femoral neck and pelvis) Vertebral fracture Upper limb fractures (including hand, radius and ulna, humerus, scapula and clavicle) Patella, tibiofibular and ankle fractures Other fractures.	Nominal (categorical)
Low body weight (Yes or No)	Body mass index (BMI) BMI < 18.5 kg/m^2 [15].	Binary (Yes /No)
Anemia (Yes or No)	Hemoglobin (Hb) < 120 g/L [16].	Binary (Yes /No)
Glomerular filtration rate (GFR)[a]	Normal GFR: ≥90 mL/min/1.73 m^2, indicating normal renal function. Mild decrease: 60–89 mL/min/1.73 m^2, indicating a mild decrease in renal function. Moderate decrease: 30–59 mL/min/1.73 m^2, indicating a moderate decrease in renal function. Severe decrease: 15–29 mL/min/1.73 m^2, indicating a severe decrease in renal function. Renal failure: < 15 mL/min/1.73 m^2, usually requiring dialysis or renal [17].	Ordinal
Long-course oral glucocorticoid	Oral glucocorticoids ≥ 3 months [18].	Binary (Yes /No)
Smoking	No: no smoking. Yes: smoking regularly.	Binary (Yes /No)
Alcohol consumption	No: no or little alcohol consumption. Yes: take alcohol every day.	Binary (Yes /No)

[a]The GFR values were determined using the CKD-EPI Formula based on the serum creatinine levels

Table 2 shows that patients with osteoporosis were significantly older (70.8 ± 10.4 vs. 62.8 ± 9.0 years, $p < 0.001$) and had longer menopause duration (21.3 ± 10.5 vs. 13.4 ± 8.9 years, $p < 0.001$) compared with those without osteoporosis. The osteoporosis group demonstrated significantly higher prevalence of vertebral fractures (47.3% vs. 21.1%, $p < 0.001$) and recent fractures within the past 2 years (10.4% vs. 1.1%, $p < 0.001$) compared to the non-osteoporosis group.

The prevalence of osteoporosis

Among 822 postmenopausal women hospitalized for fractures, the overall prevalence of osteoporosis was 76.9% (95% CI: 73.8%-79.7%). The prevalence varied significantly across demographic and clinical subgroups (Table 3), showing a significant increase with age ($P < 0.001$) and significant fracture site-specific variations ($P < 0.001$). Patients with vertebral fractures had the highest prevalence (88.2%; 95% CI: 84.3%–91.4%), followed by those with hip fractures (75.1%; 95% CI: 68.8%–80.7%), upper limb fractures (68.1%; 95% CI: 59.7%–75.7%), and patella/tibiofibular/ankle fractures (56.5%; 95% CI: 46.6%–66.0%). Osteoporosis prevalence varied significantly with renal function ($P < 0.001$). A history of fractures in the past 2 years was associated with markedly higher osteoporosis prevalence (97.1%; 95% CI: 89.8%–99.6%) compared to those without such history (75.1%; 95% CI: 71.8%–78.1%, $P < 0.001$). Patients with a history of long-course oral glucocorticoid use had a significantly higher prevalence (96.8%; 95% CI: 83.3%–99.9%) than those without such a history (76.1%; 95% CI: 73.0%–79.0%, $P = 0.007$).

Risk factors for osteoporosis: univariate and multivariate analyses

Table 4 illustrates the results of both univariate and multivariate analyses on factors associated with osteoporosis. After adjusting for covariates, three factors demonstrated particularly strong associations: menopausal duration (adjusted odds ratio [aOR] = 1.08, 95% CI: 1.04–1.13, $P < 0.001$), vertebral fractures (aOR = 3.16 vs. patella/tibiofibular/ankle fractures, 95% CI: 1.84–5.45, $P < 0.001$), and history of fractures in the past 2 years (aOR = 8.53, 95% CI: 2.56–52.94, $P < 0.001$).

While age showed substantial univariate associations (cOR range: 1.85–12.05), they attenuated after adjustment (aOR range: 0.68–1.24). Long-course of oral glucocorticoid showed borderline significance (aOR = 7.31, 95% CI: 1.45–133.58).

Sensitivity analysis

Following multiple imputation (m = 5 iterations) for the 316 excluded cases with missing data (total $n = 1$ 138), our primary findings remained consistent with the complete-case analysis for primary risk factors such as menopause duration, vertebral fractures, and recent fracture history. However, the association for long-course glucocorticoid use became non-significant after imputation (aOR = 6.24, 95% CI: 0.82–47.80 vs. original aOR = 7.31, 95% CI: 1.45–133.58), potentially due to increased heterogeneity or differential risk patterns among missing cases. Nevertheless, the stability of other key associations supports the overall reliability of our conclusions (*Supplemental Table 1*).

Discussion

This novel investigation provides the first comprehensive assessment of osteoporosis prevalence in postmenopausal women hospitalized for fractures. Our findings demonstrate a 76.9% prevalence of osteoporosis in this high-risk population, defined by the confluence of postmenopausal status and a recent fracture, with particularly strong associations for vertebral fractures (aOR = 3.16) and recent fracture history (aOR = 8.53). These results highlight the urgent need for standardized bone health assessments and support the development of targeted secondary prevention strategies for this population.

In our study, the prevalence of osteoporosis(76.9%, 95% CI 73.8%- 79.7%) among Chinese postmenopausal women hospitalized due to fracture is significantly higher compared to general Chinese postmenopausal women (32.1%, 95%CI, 30.1%-34.1%) [13], This prevalence was also higher when compared to elderly women undergoing spine surgery (52.8%) [11] and elderly women undergoing total joint arthroplasty (TJA) (38.3%) [12]. The higher prevalence of osteoporosis among postmenopausal women hospitalized for fractures compared to the general postmenopausal population is expected because that fracture hospitalization inherently selects for a high-risk subgroup in which osteoporosis is the primary underlying etiology. The explanation for the higher prevalence of osteoporosis among postmenopausal women hospitalized for fractures compared to elderly women undergoing spine surgery or TJA is understandable: Surgical cohorts (spine/TJA) exclude frail patients unable to tolerate procedures, artificially lowering prevalence. Certainly, not all postmenopausal women with fractures would seek medical treatment (such as vertebral fractures), nor do all elderly women with fractures require hospitalization. Therefore, the results of this study cannot be extrapolated to all postmenopausal women with fractures.

Among fracture patients, we observed a strong positive association between longer menopause duration and osteoporosis diagnosis. This aligns with existing literature on postmenopausal bone loss [1, 2, 13, 19–21]. The attenuation of age effects after adjusting for menopause duration suggests that chronological aging may less influential on osteoporosis risk than the prolonged estrogen

Table 2 Demographic characteristics and clinical data of the postmenopausal women hospitalized due to fractures with and without osteoporosis ($n=822$)

Parameters	Total ($n=822$, %)	Non-osteoporosis ($n=190$)	Osteoporosis ($n=632$)	*P* value
Age, years				
Means ± SD	68.9 ± 10.7	62.8 ± 9.0	70.8 ± 10.4	< 0.001
50–59 (n, %)	188 (22.9)	76 (40.0)	112 (17.7)	
60–69 (n, %)	250 (30.4)	67 (35.3)	183 (29.0)	
70–79 (n, %)	234 (28.5)	39 (20.5)	195 (30.9)	
≥80 (n, %)	150 (18.2)	8 (4.2)	142 (22.5)	
Marital status (n, %)				0.43
Married	737 (89.7)	174 (91.6)	563 (89.1)	
Widowed	77 (9.4)	13 (6.8)	64 (10.1)	
Single	3 (0.4)	1 (0.5)	2 (0.3)	
Separated	5 (0.6)	2 (1.1)	3 (0.5)	
Duration of menopause (years)	19.5 ± 10.7	13.4 ± 8.9	21.3 ± 10.5	< 0.001
Premature menopause (n, %)				1
No	811 (98.7)	187 (98.4)	624 (98.7)	
Yes	11 (1.3)	3 (1.6)	8 (1.3)	
Site of current fracture (n, %)				< 0.001
Hip fractures	217 (26.4)	54 (28.4)	163 (25.8)	
Vertebral fractures	339 (41.2)	40 (21.1)	299 (47.3)	
Upper limb fractures	141 (17.2)	45 (23.7)	96 (15.2)	
Patella, tibiofibular and ankle fractures	108 (13.1)	47 (24.7)	61 (9.7)	
Other fractures	17 (2.1)	4 (2.1)	13 (2.1)	
Low body weight (n, %)				0.11
No	769 (93.6)	183 (96.3)	586 (92.7)	
Yes	53 (6.4)	7 (3.7)	46 (7.3)	
Anemia (n, %)				0.652
No	423 (51.5)	101 (53.2)	322 (50.9)	
Yes	399 (48.5)	89 (46.8)	310 (49.1)	
Glomerular filtration rate (GFR, n, %)				< 0.001
Normal GFR	408 (49.6)	136 (71.6)	272 (43.0)	
Mild decrease	329 (40.0)	43 (22.6)	286 (45.3)	
Moderate decrease	36 (4.4)	3 (1.6)	33 (5.2)	
Severe decrease	10 (1.2)	1 (0.5)	9 (1.4)	
Renal failure	39 (4.7)	7 (3.7)	32 (5.1)	
History of fractures in the past 2 years (n, %)				< 0.001
No	754 (91.7)	188 (98.9)	566 (89.6)	
Yes	68 (8.3)	2 (1.1)	66 (10.4)	
Diabetes (n, %)				1
No	764 (92.9)	177 (93.2)	587 (92.9)	
Yes	58 (7.1)	13 (6.8)	45 (7.1)	
Long-course of oral glucocorticoid (n, %)				0.014
No	791 (96.2)	189 (99.5)	602 (95.3)	
Yes	31 (3.8)	1 (0.5)	30 (4.7)	
Smoking (n, %)				1
No	804 (97.8)	186 (97.9)	618 (97.8)	
Yes	18 (2.2)	4 (2.1)	14 (2.2)	
Alcohol consumption (n, %)				0.158
No	799 (97.2)	188 (98.9)	611 (96.7)	
Yes	23 (2.8)	2 (1.1)	21 (3.3)	

Table 3 Prevalence of osteoporosis according to potential risk factors in postmenopausal women hospitalized due to fractures in China ($n = 822$)

	Cases of osteoporosis	Prevalence of osteoporosis (95% CI)	*P* value
Overall	632	76.9 (73.8–79.7)	
Age, years			< 0.001
50–59	112	59.6 (52.2–66.7)	
60–69	183	73.2 (67.3–78.6)	
70–79	195	83.3 (77.9–87.9)	
≥80	142	94.7 (89.8–97.7)	
Premature menopause			0.742
No	624	76.9 (73.9–79.8)	
Yes	8	72.7 (39.0–94.0)	
Site of current fracture			< 0.001
Hip fractures	163	75.1 (68.8–80.7)	
Vertebral fractures	299	88.2 (84.3–91.4)	
Upper limb fractures	96	68.1 (59.7–75.7)	
Patella, tibiofibular and ankle fractures	61	56.5 (46.6–66.0)	
Other fractures	13	76.5 (50.1–93.2)	
Low body weight			0.077
No	586	76.2 (73.0-79.2)	
Yes	46	86.8 (74.7–94.5)	
Anemia			0.593
No	322	76.1 (71.8–80.1)	
Yes	310	77.7 (73.3–81.7)	
Glomerular filtration rate (GFR)			< 0.001
Normal GFR	272	66.7 (61.9–71.2)	
Mild decrease	286	86.9 (82.8–90.4)	
Moderate decrease	33	91.7 (77.5–98.2)	
Severe decrease	9	90.0 (55.5–99.7)	
Renal failure	32	82.1 (66.5–92.5)	
History of fractures in the past 2 years			< 0.001
No	566	75.1 (71.8–78.1)	
Yes	66	97.1 (89.8–99.6)	
Diabetes			0.896
No	587	76.8 (73.7–79.8)	
Yes	45	77.6 (64.7–87.5)	
Long-course of oral glucocorticoid			0.007
No	602	76.1 (73.0–79.0)	
Yes	30	96.8 (83.3–99.9)	
Smoking			0.928
No	618	76.9 (73.8–79.7)	
Yes	14	77.8 (52.4–93.6)	
Alcohol consumption			0.096
No	611	76.5 (73.4–79.4)	
Yes	21	91.3 (72.0-98.9)	

deficiency associated with extended postmenopausal status [22]. Many studies revealed that women experience accelerated bone-loss during the menopausal transition, significantly increasing skeletal fragility [21, 23–25]. Recent advances in biomarker research like anti-Mullerian hormone (AMH) show promise for identifying high-risk women during premenopausal stages, enabling early intervention before fracture occurrence [26].

Our study found a significantly higher prevalence of osteoporosis in postmenopausal women with vertebral fractures (88.2%, 95% CI: 84.3%-91.4%) compared to other types of fractures (ranging from 56.5% to 76.5%). This can be attributed to the fact that vertebral fractures are the most common type of fracture among patients with osteoporosis [1, 14, 20]. This result indicated that for postmenopausal women, a vertebral fracture should trigger automatic osteoporosis evaluation, regardless of age

Table 4 Univariate analysis and multivariate analyses of factors associated with osteoporosis ($n=822$)

Variable	No.	Cases of osteoporosis (%)	cOR (95% CI)	aOR (95% CI)
Age, years				
50–59	188	112 (59.6)	Ref.	
60–69	250	183 (73.2)	1.85 (1.24–2.78) **	0.67 (0.38–1.20)
70–79	234	195 (83.3)	3.39 (2.17–5.36) **	0.68 (0.28–1.61)
≥80	150	142 (94.7)	12.05 (5.90-28.03) **	1.24 (0.32–5.01)
The duration of menopause (years, mean ± SD)	19.5 ± 10.7	21.3 ± 10.5	1.08 (1.06–1.10) **	1.08 (1.04–1.13) **
Premature menopause				
No	811	624 (76.9)		
Yes	11	8 (72.7)	0.80 (0.23–3.68)	
Site of current fracture				
Patella, tibiofibular and ankle fractures	108	61 (56.5)	Ref.	
Hip fractures	217	163 (75.1)	2.33 (1.43–3.80) **	1.00 (0.57–1.73)
Vertebral fractures	339	299 (88.2)	5.76 (3.49–9.58) **	3.16 (1.84–5.45) **
Upper limb fractures	141	96 (68.1)	1.64 (0.98–2.77)	1.32 (0.76–2.29)
Other fractures	17	13 (76.5)	2.50 (0.82–9.34)	2.26 (0.69–8.84)
Low body weight				
No	769	586 (76.2)	Ref.	
Yes	53	46 (86.8)	2.05 (0.97–5.05)	
Anemia				
No	423	322 (76.1)	Ref.	
Yes	399	310 (77.7)	1.09 (0.79–1.51)	
Glomerular filtration rate (GFR)				
Normal GFR	408	272 (66.7)	Ref.	
Mild decrease	329	286 (86.9)	3.33 (2.29–4.91) **	1.27 (0.79–2.05)
Moderate decrease	36	33 (91.7)	5.50 (1.93–23.15) *	1.36 (0.41–6.20)
Severe decrease	10	9 (90.0)	4.50 (0.83–83.41)	0.81 (0.11–16.89)
Renal failure	39	32 (82.1)	2.28 (1.04–5.76) *	1.15 (0.48–3.12)
History of fractures in the past 2 years				
No	754	566 (75.1)	Ref.	
Yes	68	66 (97.1)	10.96 (3.39–67.16) **	8.53 (2.56–52.94) **
Diabetes				
No	764	587 (76.8)	Ref.	
Yes	58	45 (77.6)	1.04 (0.57–2.06)	
Long-course of oral glucocorticoid				
No	791	602 (76.1)	Ref.	
Yes	31	30 (96.8)	9.42 (2.00-168.30) *	7.31 (1.45-133.58) *
Smoking				
No	804	618 (76.9)	Ref.	
Yes	18	14 (77.8)	1.05 (0.37–3.75)	
Alcohol consumption				
No	799	611 (76.5)	Ref.	
Yes	23	21 (91.3)	3.23 (0.94–20.32)	

cOR Crude odds ratio, *aOR* Adjusted odds ratio, *Ref* Reference category

*$P<0.05$, ** $P<0.001$

or BMD results. Additionally, the lack of direct comparison studies highlights a gap in the literature regarding fracture type-specific rates of osteoporosis. Essentially, the 3.16-fold higher adjusted odds (95% CI: 1.84–5.45) of osteoporosis in vertebral fracture patients versus lower limb fractures underscores the need for distinct clinical pathways. We recommend implementing "vertebral fracture alerts" in electronic health record (EHR) systems to prevent missed diagnoses.

A history of fractures within the past 2 years was confirmed as a significant risk factor for osteoporosis (aOR = 8.53; 95% CI: 2.56–52.94), aligning with prior studies [27, 28]. This magnified risk reflects the established "fracture cascade" phenomenon, where an initial fracture increases 1-year subsequent fracture risk by 5.3-fold (95% CI:

4.0–6.6) [29]. The 8.53-fold adjusted odds of fracture history in the past 2 years underscores necessity to initiate mandatory osteoporosis treatment after any fracture in this population and to structure follow-up for more than 2 years to monitor secondary fracture prevention.

While our study suggests a strong association between long-term glucocorticoid use and osteoporosis (aOR = 7.31), the imprecise estimate (95% CI spanning 1.45 to 133.58) warrants caution in interpretation. The extreme upper bound may indicate unmeasured confounding or outlier influence. Clinically, these findings reinforce existing guideline recommending bone density monitoring in glucocorticoid-treated patients [18].

In univariate analysis of our study, glomerular filtration rate (GFR) showed an association with osteoporosis, consistent with well-established evidence and current clinical guidelines [17]. However, due to limited statistical power, we were unable to confirm other well-established risk factors including early menopause, low body weight, anemia, diabetes, smoking, and alcohol consumption [30–38].

Although this multicenter study provides important insights into osteoporosis prevalence in high-risk fracture patients, several limitations must be acknowledged. First, despite exceeding the minimum required sample size, the effective sample for analysis was reduced by missing data, primarily serum creatinine levels required for GFR calculation. This, along with sparse data in certain age-by-fracture site subgroups, limited our power for detailed stratified analyses and may have affected our ability to confirm some established risk factors. Second, while the participating hospitals were geographically diverse, their exclusive tertiary-center status may limit the generalizability of our findings to patients managed in community hospital settings. Furthermore, this setting may have influenced the observed distribution of fracture types (e.g., toward a higher proportion of vertebral fractures manageable with specialized care) compared to a national inpatient profile. However, this does not diminish the validity of the core finding of a critically high osteoporosis prevalence in this population. Third, although all sites followed ISCD protocols, the lack of cross-calibration between hospital DXA scanners could have introduced systematic variability in T-score measurements. Finally, our study relied in part on patients' retrospective self-reporting of medical history and prior fractures, which may be subject to recall bias. The number of patients with premature menopause in our study was very small ($n = 11$, 1.3%), which precludes any robust statistical conclusions regarding this specific risk factor. Furthermore, due to the constraints mentioned above, we were unable to confirm other well-established risk factors such as early menopause and lifestyle factors in our multivariate model.

Conclusion

In conclusion, this study quantifies a critical opportunity for secondary fracture prevention within the hospitalized setting in China: over three-quarters of postmenopausal women admitted for fractures have underlying osteoporosis. While our findings pertain specifically to inpatients, they reveal an actionable high-risk profile characterized by prolonged menopause, a vertebral fracture (which should trigger mandatory assessment), or a recent fracture history. These data provide compelling evidence for standardizing in-hospital bone health evaluation. To translate this evidence into practice, the systematic implementation of Fracture Liaison Services (FLS) within Chinese hospitals is a necessary and feasible strategy. Specifically for the high-burden vertebral fracture subgroup, integrating FLS with routine vertebral fracture identification protocols could substantially close the current pervasive care gap. Moving beyond fracture repair to definitive management of the root cause during the inpatient episode should become a new standard of care.

Supplementary Information

The online version contains supplementary material available at https://doi.org/10.1186/s12891-026-09517-2.

Supplementary Material 1. Supplemental Table 1. Sensitivity Analysis: Univariate Analysis and Multivariate Analysis Including the Additional 316 Cases after Multiple Imputation (n=1138)

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Authors' contributions

**Jun Jiang: ** Writing – original draft, Formal analysis, Data curation, Investigation, Methodology, Conceptualization. **Yuyang Zhou: ** Formal analysis, Data curation. **Yue Chen: ** Writing – review & editing, Formal analysis. **Cong Xiao: ** Writing – review & editing, Data curation, Investigation. **Shaoyun Zhang: ** Writing – review & editing, Data curation, Investigation. **Xianzhong Ma: ** Writing – review & editing, Data curation, Investigation. **Jinglei Xu: ** Writing – review & editing, Data curation, Investigation. **Ming Chen: ** Writing – review & editing, Data curation, Investigation. **Qixin Liu: ** Writing – review & editing, Data curation, Investigation. **Xiaosheng Ma: ** Writing – review & editing, Data curation, Investigation. **Zhaoyang Gong: ** Writing – review & editing, Data curation, Investigation. **Peng Zhang: ** Writing – review & editing, Data curation, Investigation. **Jianjun Zhou: ** Writing – review & editing, Data curation, Investigation. **Huan Xiao: ** Writing – review & editing, Data curation, Investigation. **Bailing Chen: ** Writing – review & editing, Data curation, Investigation. **Sujun Qiu: ** Writing – review & editing, Data curation, Investigation. **Yibiao Zhou: ** Writing – review & editing, Supervision, Methodology, Conceptualization, Funding acquisition.

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Data availability

The individual participant data that support the findings of this study are subject to data protection regulations and are owned by the 8 hospitals which attended the research. These data cannot be made publicly available to protect patient privacy. De-identified data may be made available to qualified researchers upon reasonable request, following review and approval of a research proposal by the institutional review board (IRB) of the 8 hospitals and the execution of a data use/transfer agreement. Requests should be directed to the corresponding author.

Declarations

Ethics approval and consent to participate
This study was conducted in accordance with the principles of the Declaration of Helsinki. Approval was obtained from the Institutional Review Board of Fudan University School of Public Health (IRB#2023-12-1094) as well as the ethics committees of all eight participating hospitals. All patients were informed about the study's details and their rights, and provided written informed consent prior to participation.

Consent for publication
Not applicable.

Competing interests
The authors declare no competing interests.

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