Original Article

Prevalence of Undiagnosed Vertebral Fractures Among Community-Dwelling Older Adults and Their Association With Chronic Back Pain and Clinical Characteristics: A Cross-Sectional Study in Egypt.

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ABSTRACT

Objective: Vertebral fractures are the most prevalent subtype of fragility fractures, and are associated with an elevated risk of subsequent fractures and mortality. Their risk varies by population, influenced by lifestyle, healthcare access, and ethnicity. So, this study aimed to determine the prevalence of undetected vertebral fractures and assess their association with chronic back pain and clinical characteristics among community-dwelling older adults.
Methods: A cross-sectional study was conducted on 140 individuals aged ≥60 years attending geriatric outpatient clinics in Ain shams University hospital. Participants underwent clinical assessment, laboratory testing, and lateral thoraco-lumbar spine X-ray (T4–L4). Vertebral fractures were identified based on a ≥20% reduction in vertebral body height. Sociodemographic, clinical, and functional data were collected. **Results:** The mean age of the participants was 71.51 ± 7.3 years (range: 60–93 years), 59.3% were females. Vertebral fractures were identified in 52.1% of participants, with the lumbar spine most frequently affected (50.7%). No significant associations were observed between VFs and age, gender, BMI, or most comorbidities. Use of calcium ($p = 0.039$) and vitamin D supplements ($p = 0.017$) was significantly lower among those with fractures. Chronic back pain and general spine tenderness were not predictive of VFs; however, thoracic spine tenderness showed a significant association ($p < 0.001$).
Conclusion: This study highlights the high prevalence and potential predictors of osteoporotic vertebral fractures among elderly patients in Egypt. The absence of significant associations with chronic back pain reinforces the silent and often overlooked nature of these fractures.
Keywords: elderly, osteoporosis, prevalence, vertebral fracture

INTRODUCTION

Osteoporosis is the most widespread bone disorder affecting humans and represents a significant public health issue. It is marked by a reduction in bone mass, degradation of bone tissue, and disruption of bone structure, all of which lead to diminished bone strength and a heightened risk of fractures [1]. Fractures caused by osteoporosis are linked to an increased likelihood of future fractures, reduced quality of life [2], and greater chances of hospitalization and death [3]. The spine, hip (particularly the proximal femur), and wrist (distal forearm) are among the most frequently affected fracture sites [4].

Vertebral fractures account for as much as 50% of all osteoporotic fractures, making them the most frequent type [5]. These fractures can occur during routine daily activities, often without any noticeable trauma or falls. They serve as strong indicators of future fracture risk—individuals with a vertebral fracture are approximately five times more likely to experience another vertebral fracture and two to three times more likely to sustain fractures at other skeletal sites [6].

Despite the fact that osteoporotic vertebral fractures are very common, only a third come to medical attention [7]. This may be attributed to the fact that many vertebral fractures (VFs) are asymptomatic or mildly painful [8]. Even in symptomatic patients with back pain, the severity of back pain is usually underreported due to the spontaneous character of fractures [9], the lack of awareness of patients about the existence and high incidence of spontaneous vertebral fractures, and the common occurrence of back pain in the older adults [10]. When a patient presents with back pain, the severity of symptoms is often attributed to degenerative spine disorders or nerve root compression (radiculopathy). As a result, treatment may focus solely on relieving symptoms, without a comprehensive diagnostic workup. This can lead to many vertebral fractures going unrecognized at the time they occur—or even remaining undiagnosed throughout the patient's life [11].

Vertebral fractures can be identified and assessed using a variety of methods, such as computed tomography (CT), magnetic resonance imaging (MRI), plain radiography, and vertebral fracture assessment (VFA) using dual-energy X-ray absorptiometry (DXA). While standard spinal radiographs are frequently used to identify VFs, they are less sensitive in detecting mild (Grade 1) fractures and expose patients to higher levels of radiation compared to DXA-based VFA [12]. CT and MRI provide high-resolution images but are generally less accessible, more costly, and may be less convenient for patients. Currently, there is no definitive gold standard for diagnosing osteoporotic vertebral fractures. VFA has emerged as a newer and more reliable technique, often employed using a semi-quantitative (SQ) approach. Despite its advantages, VFA with DXA has limitations—particularly in imaging the upper thoracic spine (above T7), where image quality may be insufficient in many cases [13]. Additionally, its effectiveness is reduced when detecting mild (Grade 1) fractures [14] and in individuals with moderate to severe disc space osteoarthritis [15]. The risks of VFs are population-specific based on lifestyles, medical care, and ethnicities [16]. Up to 30% of men and women in Western populations who are 50 years or older suffer from vertebral fractures [17], whereas in Asian populations within the same age group, the prevalence ranged between 12 and 25% [18]. Little information is known about prevalence of vertebral fractures in elderly in the middle east or Egypt.

Our study aimed to determine the prevalence of undetected vertebral fractures in elderly patients attending the geriatric outpatient clinics and to find its association with chronic back pain and clinical characteristics.

METHODS

Study design and participants:

This study was conducted as a cross-sectional investigation to assess the prevalence of undetected osteoporotic vertebral fractures among community-dwelling elderly individuals. The participants were recruited from the outpatient clinics of the Geriatric hospital at Ain Shams University hospitals, a tertiary care center providing comprehensive services to older adults in Egypt. The study was conducted over a period spanning from October 2023, following approval from the Research Ethics Committee, until the completion of the required sample size in June 2024.The target population included elderly patients aged 60 years and above, of both sexes, who attended the geriatric outpatient clinic and agreed to participate in the study and to provide informed consent . Exclusion Criteria included the following:

- Previous history of vertebral spine fracture.
- History of high-impact trauma.
- Diagnosed metastatic tumors, spinal tuberculosis, congenital spinal deformities, or scoliosis due to degeneration

Sampling Method:

A simple random stratified sampling technique was employed to recruit participants from those attending the geriatric clinic during the study period. The sample size was calculated based on findings from Gao et al. (2019), [19] which reported the prevalence of osteoporotic vertebral fractures to range between 3% and 18%, and considering an alpha error of 5% and a study power of 80%, the calculated sample size was 140 subjects. Sample size estimation was performed using STATA version 10.

Data collection:

All participants underwent a standardized assessment protocol as follows:

I. Medical assessment and anthropometric measurement.

II. Laboratory investigations.

III. Lateral view x -ray of the thoraco-lumbar spine (T4–L4).

I. Medical assessment and anthropometric measurement:

-Patients and their caregivers were interviewed to collect data on the following:

- Sociodemographic characteristics: age, gender, education level, marital status, smoking and alcohol intake history.
- Medical history: full history taking including history of previous fractures, parental history of hip fracture, mobility, presence of comorbidities (e.g., diabetes mellitus, liver disease, renal disease, hyperthyroidism, rheumatoid arthritis), current medication use and history of prolonged use of oral glucocorticoids (>3 months at ≥5 mg/day of prednisolone) and history of chronic back pain (persistent or fluctuating pain lasting for a period greater or equal to 12 weeks) [20].

  Participants were asked about the presence of back pain that limits their activity during the day, ie make it necessary to stop (even for a moment) regular household activities, and in which part of the spine the back pain is most severe.
- Physical Examination: which included measurement of height and weight and clinical examination of the spine for localized tenderness.
- Body mass index (BMI) was calculated as weight in kilograms divided by height in meters squared.
- Functional Assessment by using the following tool:

  Activities of Daily Living (ADL) scale.

II. Laboratory Investigations: which were recruited from patients' files included Complete Blood Count (CBC), renal function (mainly serum creatinine), Thyroid Stimulating Hormone (TSH), serum Alkaline Phosphatase, Calcium, Phosphorus, Serum albumin and total Proteins.

III. Lateral view x -ray of the thoraco-lumbar spine (T4–L5):

All participants underwent only one radiograph of the thoraco- lumbar spine to minimize radiation exposure. All the radiographs were analyzed by an experienced radiologist to identify and locate fractures within the vertebrae. Vertebral fractures were identified radiographically based on the criterion of a ≥20% reduction in the anterior, middle, or posterior vertebral body height. Vertebral height reduction of less than 20% was not classified as a fracture because of concern about unreliable assessment. We categorized spinal fractures into three anatomical regions: the thoracic area (T4 to T10), the thoracolumbar junction (T11 to L1), and the lumbar region (L2 to L5), creating corresponding variables for each fracture location.

Statistical analysis:

The collected data was revised, coded, tabulated and introduced to a PC using Statistical package for Social Science (SPSS 26). Data was presented and suitable analysis was done according to the type of data obtained for each parameter.

I. *Descriptive statistics*:

- Continuous variables were expressed as mean ± standard deviation (SD) and range for normally distributed data (e.g., age, BMI).
- Categorical variables were summarized as frequencies (N) and percentages (%) (e.g., gender, education, comorbidities).

II. *Analytical statistics*:

Comparative and inferential analyses were conducted to assess relationships between vertebral fracture status and various demographic and clinical variables:

1. **Chi-square test (χ^2)** was used for assessing associations between categorical variables, such as gender or smoking status, and vertebral fracture prevalence.
2. **Independent t-test** was used to compare means of continuous variables between participants with and without vertebral fractures (e.g., age, BMI).
3. Fisher's exact test was used to examine the relationship between two qualitative variables when the expected count is less than 5 in more than 20% of cells.

Level of Significance

- **P > 0.05**: Not statistically significant (NS)
- **P < 0.05**: Statistically significant (S)

***Ethical Considerations*:**

The study was approved by the Research Ethics Committee, Faculty of Medicine , Ain Shams University (FWA 000017585) approval number MS 408/2023. Informed consent was taken from all participants or their caregivers.

RESULTS

The general characteristics of the study population are presented in (Table 1). A total of 140 participants were enrolled in the study, with a mean age of 71.51 ± 7.3 years (range: 60–93 years). The majority (42.2%) were aged between 60–69 years, while 16.4% were aged 80 years or older. The mean Body Mass Index (BMI) was 27.64 ± 3.92 kg/m² (range: 15–36). Regarding gender distribution, females constituted 59.3% of the population, and males 40.7%. In terms of mobility, 50.7% were freely ambulant, while 3.6% were wheelchair-bound. Most participants (80.0%) were non-smokers. All participants were reported to be independent in performing activities of daily living (Table 1).

Diabetes mellitus was the most prevalent comorbidity, affecting 56.4% of participants, followed by hypertension (42.1%) and chronic kidney disease (27.1%). Regarding medication use, the most commonly reported were vitamin D supplements (38.6%) and calcium supplements (37.1%), followed by proton pump inhibitors (30.0%). (Table 2)

provides further details on participants' medical histories and medication use.

Vertebral fractures, as assessed by X-ray, were identified in 73 participants (52.1%). Among those, the most common sites were the lower lumbar spine (50.7%), followed by the mid-thoracic spine (43.8%), and thoraco-lumbar junction (5.5%). Vertebral fractures were more prevalent among females (63.0%) than males (36.9%) (Table 3).

Although vertebral fractures were more frequently observed in females (63.0%) than males (36.9%), this difference was not statistically significant (P=0.349). There were no statistically significant differences in age (p = 0.542), BMI (p = 0.81), marital status (p = 0.235), mobility (p = 0.534), or smoking status (p = 0.128) between participants with and without vertebral fractures. However, education level showed a statistically significant association with vertebral fracture presence (p = 0.025), with a higher proportion of illiterate individuals in the fracture group (Table 4).

Regarding comorbidities and vertebral Fractures (Table 5), no statistically significant associations were found between vertebral fractures and the presence of diabetes mellitus, chronic kidney disease, hyperthyroidism, coronary artery disease, or rheumatoid arthritis(P>0.05). However, significant associations were found with:

- Calcium supplement use (p = 0.039): Less frequent in the fracture group.
- Vitamin D supplement use (p = 0.017): Also lower in the fracture group

Table (6) presents the association between chronic back pain, spinal tenderness, and the presence of vertebral fractures in our study cohort. There was no statistically significant association between the presence of back pain and general spine tenderness and vertebral fracture status (P = 0.602), indicating that the general presence of pain and tenderness alone is not a reliable predictor of vertebral fracture. However, a significant association was found between the site of tenderness and the presence of vertebral fractures (P < 0.001). Specifically, individuals with thoracic spine tenderness were more likely to have fractures (76.67%) compared to those with lumbar (52.00%) or thoraco-lumbar tenderness (17.65%). These findings suggest that while general back pain with tenderness may not indicate fracture risk, thoracic spine tenderness could be a more specific clinical indicator of underlying vertebral fractures.

Discussion:

VFs are widely recognized as a key indicator of osteoporosis, given their prevalence as the commonest type of osteoporotic fracture [21]. However, the majority of these fractures go undiagnosed. People who experience vertebral fractures have a higher likelihood of sustaining additional fractures, both in the spine and in other parts of the skeleton [22], these fractures are also linked to increased rates of illness and death [23].

This study investigated the prevalence, demographics and clinical correlates of vertebral fractures among older adults, revealing a notably high prevalence of vertebral fractures (52.1%) among Egyptian community-dwelling elderly individuals aged 60 years, and above. This prevalence is at the higher end of the global spectrum, where rates in elderly populations generally range from 25% to 50% [24]. In the Middle East, studies conducted in Morocco reported a vertebral fracture prevalence of 40.3% in men with a mean age of 62.4 (±8.6) years, and 53.4% in women with a mean age of 58.8 (±8.2) years [25]. This contrasts with a study conducted in Lebanon, where the reported prevalence rate among the elderly was 19.9% [26].

Such findings underscore a potentially substantial but underrecognized burden of osteoporotic vertebral fractures in Egypt. The markedly higher prevalence in our Egyptian cohort may be attributed to several factors, including limited awareness

about osteoporosis, low rates of screening, inadequate calcium and vitamin D intake, and potential ethnic or genetic predispositions. Additionally, the reliance on symptom-based clinical evaluation may contribute to underdiagnosis in other settings, whereas the use of targeted thoraco-lumbar X-ray screening in our study may have facilitated the identification of previously undetected fractures.

Anatomically, our findings identified the lumbar region as the most common site of fracture (50.7%), followed by the thoracic spine (43.8%), and thoracolumbar fractures in 5.5% of cases. According to research by Bigdon et al. in Switzerland, the distribution of osteoporotic vertebral fractures was 43.2% in the thoracic spine and 49.0% in the lumbar spine. These findings are in line with our study [27].
However, a European cohort research conducted by O'Neill et al. found that the most frequent locations for vertebral abnormalities were the thoracolumbar junction and the mid-thoracic area (T5–T9)[28]. In East Asian countries such as China and Japan, research indicates not only a similar anatomical pattern but also a higher overall prevalence, potentially due to lower bone mineral density and smaller vertebral dimensions common in these populations [19]. Overall, these differences emphasize the importance of considering ethnicity, regional factors, and population-specific risk profiles when assessing vertebral fracture risk in the elderly.

In the present study, although vertebral fractures were more commonly observed in females (63.01%) than in males (36.99%), this gender difference did not reach statistical significance. A cohort study involving 415 participants conducted by Ikegami et al. supports our findings, indicating no significant difference in the prevalence of vertebral fractures between males and females [29]. Similarly, the Canadian Multicenter Osteoporosis Study (CaMos), which followed more than 9,000 individuals over a five-year period, reported comparable vertebral fracture prevalence between the sexes, with a male-to-female ratio of approximately 1:1[30]. In contrast, findings from the European Prospective Osteoporosis Study (EPOS, participants aged 75–79 years) revealed a higher incidence in men than women (29.3 vs 13.6 fractures per 100 person-years for men and women respectively)[31].

It is also notable that in our study, age and BMI—typically established risk factors—did not show a significant association with vertebral fractures.
Regarding the age, longitudinal studies in older adults have consistently shown that rates of bone loss accelerate with increasing age [24], which is associated with increased risk of fragility fractures. The lack of association in our study may be explained by the fact that most participants clustered around the early elderly age group (60–79 years), and there are other clinical risk factors for incident vertebral fractures status that may affect the risk and frequency of fractures (e.g falls).
Body mass index (BMI) is a well-established risk factor that has been extensively linked to fragility fractures [32]. Being underweight, in particular, has been identified as a significant risk factor for both vertebral and hip fractures. A cohort study conducted in Japan highlighted underweight status as a modifiable and preventable risk factor for hip fractures [33]. While obesity is often considered protective for bone health due to increased mechanical loading from higher body weight, some evidence suggests that excess adipose tissue may negatively impact bone metabolism [34]. Several studies have demonstrated that higher fat mass may be associated with reduced bone mass and compromised bone quality in the spine [35–37], potentially resulting in diminished vertebral bone strength. Despite these findings, the relationship between BMI and fracture risk remains complex and site-specific. For example, Johansson et al.

(2014) reported that the impact of BMI on fracture risk varies depending on the skeletal site affected [32], highlighting ongoing debate and complexity in understanding BMI's role in fracture susceptibility.

Education level and vertebral fracture status were found to be statistically significantly correlated in our study. The risk of vertebral fractures was higher among those with less education, particularly those who were illiterate. This finding may highlight inequalities in health literacy, access to healthcare services, awareness of prevention strategies, and general health-related behaviors.

In our study, most participants were non-smokers (80%), and no statistically significant association was found between smoking status and the prevalence of vertebral fractures. Although smoking is a well-established lifestyle factor linked to osteoporosis, with numerous studies demonstrating its association with reduced bone mineral density (BMD) [38-40], BMD alone does not fully explain fracture occurrence. Fracture risk is influenced by a complex interplay of multiple factors. Consequently, several studies have attempted to elucidate the association between smoking and fracture risk [41,42], with some reporting no significant association between smoking and fracture incidence [43,44].

Comorbid conditions such as diabetes mellitus, hypertension, chronic kidney disease, coronary heart disease, hyperthyroidism, and rheumatoid arthritis were not significantly associated with vertebral fractures in our study population. Although previous studies have proposed links between these conditions and bone fragility [45-47], our findings suggest that their roles may be more complex or mediated through other factors such as medication use, disease duration, or control.

Regarding calcium and vitamin D supplementation. Both supplements were used less frequently in the fracture group, with statistically significant differences for calcium and vitamin D. These results support existing evidence on the protective role of adequate calcium and vitamin D intake in supporting bone strength and preventing fractures [48]. Although causation cannot be established due to the study's cross-sectional design, the association suggests potential benefits of regular supplementation, especially in high-risk groups.

In the current study, we did not observe a statistically significant association between the presence of chronic back pain and vertebral fracture status. This suggests that the general presence of pain and tenderness alone is not a reliable indicator of vertebral fractures. These findings go in line with Manji et al. who observed that, in patients with osteoporotic vertebral fractures, factors such as the number, severity, and location of fractures did not explain much of the variation in self-reported pain, even after adjusting for age and the use of pain medication [49].

Chronic pain is a common consequence of osteoporotic vertebral fractures. While some improvement in pain may occur within the first three months post-fracture, further reduction in pain intensity often does not continue throughout the first year [50]. Studies have shown that women with osteoporotic vertebral fractures tend to report greater pain than men, with this difference persisting for up to five years following the fracture [51]. However, the occurrence and severity of fracture-related pain vary considerably, with some women reporting no pain at all [50]. This variability in self-reported pain underscores the complexity of chronic low back pain etiology, where multiple factors, including but not limited to osteoporotic fractures, may play a role.

Several limitations might be considered when interpreting our results. First, the cross-sectional design limits the ability to establish causal relationships between risk factors and vertebral fractures. Second, the study relied on conventional X-ray

imaging, which, while useful, may underestimate the true prevalence of subclinical fractures compared to more advanced imaging modalities such as MRI or CT. Third, certain variables such as duration and control of comorbid conditions, history of falls, or physical activity levels were not captured, which may influence fracture risk. Fourth, bone mineral density measurements were not included, which could have provided further insights into fracture risk. Nevertheless, to our knowledge, it is the first study evaluating the prevalence of osteoporotic vertebral fractures in community-dwelling Egyptian elderly, providing a foundation for future research aimed at improving early detection and preventive strategies in this population.

In conclusion, our study demonstrates a strikingly high prevalence (52.1%) of previously undiagnosed vertebral fractures among community-dwelling elderly individuals attending geriatric outpatient clinics in Egypt. The absence of significant associations with chronic back pain reinforces the silent and often overlooked nature of these fractures. While vertebral fractures were more frequent in females and in those with lower educational levels, no significant correlations were observed with age, BMI, or most comorbid conditions. Importantly, lower use of calcium and vitamin D supplements among affected individuals suggests a potential avenue for preventive intervention. These findings highlight the critical need for routine screening and public health strategies aimed at early detection and osteoporosis management in older adults. Further research incorporating bone mineral density assessments and longitudinal follow-up is essential to better understand prevalence, risk trajectories and improve fracture prevention efforts in this population.

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REFERENCES

1. NIH Consensus Development Panel on Osteoporosis Prevention, Diagnosis, and Therapy. Osteoporosis prevention, diagnosis, and therapy. JAMA. 2001 Feb 14;285(6):785-95. doi: 10.1001/jama.285.6.785. PMID: 11176917.
2. Melton III LJ, Atkinson EJ, Cooper C, O'fallon WM, Riggs BL. Vertebral fractures predict subsequent fractures. Osteoporos Int. 1999 Sep;10:214-21. doi: 10.1007/s001980050218.
3. Cummings SR, Melton LJ. Epidemiology and outcomes of osteoporotic fractures. Lancet. 2002 May 18;359(9319):1761-7. doi: 10.1016/S0140-6736(02)08657-9.
4. Mackey DC, Lui LY, Cawthon PM, Bauer DC, Nevitt MC, Cauley JA, Hillier TA, Lewis CE, Barrett-Connor E, Cummings SR, Study of Osteoporotic Fractures (SOF). High-trauma fractures and low bone mineral density in older women and men. JAMA. 2007 Nov 28;298(20):2381-8. doi: 10.1001/jama.298.20.2381.
5. Schousboe JT. Epidemiology of vertebral fractures. J Clin Densitom. 2016 Jan 1;19(1):8-22. doi: 10.1016/j.jocd.2015.08.004.
6. Ensrud KE, Ewing SK, Taylor BC, Fink HA, Stone KL, Cauley JA, Tracy JK, Hochberg MC, Rodondi N, Cawthon PM. Frailty and risk of falls, fracture, and mortality in older women: the Study of Osteoporotic Fractures. J Gerontol A Biol Sci Med Sci. 2007 Jul 1;62(7):744-51. doi: 10.1093/gerona/62.7.744.
7. Cooper C. Epidemiology and public health impact of osteoporosis. Baillieres Clin Rheumatol. 1993 Oct 1;7(3):459-77. doi: 10.1016/S0950-3579(05)80073-1.
8. Delmas PD, van de Langerijt L, Watts NB, Eastell R, Genant H, Grauer A, Cahall DL. Underdiagnosis of vertebral fractures is a worldwide problem: the IMPACT study. J Bone Miner Res. 2005 Apr 1;20(4):557-63. doi: 10.1359/JBMR.041214.
9. Parfitt M, Qiu S, Palnitkar S, Rao DS. Abnormal bone remodeling in patients with spontaneous painful vertebral fracture. J Bone Miner Res. 2011 Mar 1;26(3):475-85. doi: 10.1002/jbmr.239.
10. Makris UE, Higashi RT, Marks EG, Fraenkel L, Gill TM, Friedly JL, Reid MC. Physical, emotional, and social impacts of restricting back pain in older adults: a qualitative study. Pain Med. 2017 Jul 1;18(7):1225-35. doi: 10.1093/pm/pnw196.
11. Lenchik L, Rogers LF, Delmas PD, Genant HK. Diagnosis of osteoporotic vertebral fractures: importance of recognition and description by radiologists. Am J Roentgenol. 2004 Oct;183(4):949-58. doi: 10.2214/ajr.183.4.1830949.
12. Ferrar L, Jiang G, Adams J, Eastell R. Identification of vertebral fractures: an update. Osteoporos Int. 2005 Jul;16:717-28. doi: 10.1007/s00198-005-1880-x.
13. Grigoryan M, Guermazi A, Roemer FW, Delmas PD, Genant HK. Recognizing and reporting osteoporotic vertebral fractures. Aging Spine. 2005:22-30. doi: 10.1007/s00586-003-0613-0.
14. Binkley N, Krueger D, Gangnon R, Genant HK, Drezner MK. Lateral vertebral assessment: a valuable technique to detect clinically significant vertebral fractures. Osteoporos Int. 2005 Dec;16:1513-8. doi: 10.1007/s00198-005-1891-7.
15. Osman AA, Bassiouni H, Koutri R, Nijs J, Geusens P, Dequeker J. Aging of the thoracic spine: distinction between wedging in osteoarthritis and fracture in osteoporosis—a cross-sectional and longitudinal study. Bone. 1994 Jul 1;15(4):437-42. doi: 10.1016/8756-3282(94)90822-2.
16. Barrett-Connor E, Siris ES, Wehren LE, Miller PD, Abbott TA, Berger ML, Santora AC, Sherwood LM. Osteoporosis and fracture risk in women of different ethnic groups. J Bone Miner Res. 2005 Feb 1;20(2):185-94. doi: 10.1359/JBMR.041007.
17. Clark P, Cons-Molina F, Deleze M, Ragi S, Haddock L, Zanchetta JR, Jaller JJ, Palermo L, Talavera JO, Messina DO, Morales-Torres J. The prevalence of radiographic vertebral

fractures in Latin American countries: the Latin American Vertebral Osteoporosis Study (LAVOS). Osteoporos Int. 2009 Feb;20:275-82. doi: 10.1007/s00198-008-0657-4.
18. Ho-Pham LT, Mai LD, Pham HN, Nguyen ND, Nguyen TV. Reference ranges for vertebral heights and prevalence of asymptomatic (undiagnosed) vertebral fracture in Vietnamese men and women. Arch Osteoporos. 2012 Dec;7:257-66. doi: 10.1007/s11657-012-0106-z.
19. Gao C, Xu Y, Li L, Gu WQ, Yi CT, Zhu Q, Gu HA, Chen BH, Wang QQ, Tang F, Xu JL. Prevalence of osteoporotic vertebral fracture among community-dwelling elderly in Shanghai. Chin Med J (Engl). 2019 Jul 20;132(14):1749-51. doi: 10.1097/CM9.0000000000000332.
20. Koes BW, Van Tulder M, Lin CW, Macedo LG, McAuley J, Maher C. An updated overview of clinical guidelines for the management of non-specific low back pain in primary care. Eur Spine J. 2010 Dec;19:2075-94. doi: 10.1007/s00586-010-1502-y.
21. Ballane G, Cauley JA, Luckey MM, El-Hajj Fuleihan G. Worldwide prevalence and incidence of osteoporotic vertebral fractures. Osteoporos Int. 2017 May;28:1531-42. doi: 10.1007/s00198-017-3909-3.
22. Kanis JA, Johnell O, De Laet CE, Johansson H, Odén A, Delmas P, Eisman J, Fujiwara S, Garnero P, Kroger H, McCloskey EV. A meta-analysis of previous fracture and subsequent fracture risk. Bone. 2004 Aug 1;35(2):375-82. doi: 10.1016/j.bone.2004.03.024.
23. Pongchaiyakul C, Nguyen ND, Jones G, Center JR, Eisman JA, Nguyen TV. Asymptomatic vertebral deformity as a major risk factor for subsequent fractures and mortality: a long-term prospective study. J Bone Miner Res. 2005 Aug;20(8):1349-55. doi: 10.1359/JBMR.050317.
24. Melton LJ, Lane AW, Cooper C, Eastell R, O'fallon WM, Riggs BL. Prevalence and incidence of vertebral deformities. Osteoporos Int. 1993 May;3:113-9. doi: 10.1007/BF01623271.
25. El Maghraoui A, Mounach A, Rezqi A, Achemlal L, Bezza A, Ghozlani I. Vertebral fracture assessment in asymptomatic men and its impact on management. Bone. 2012;50(4):853-857. doi: 10.1016/j.bone.2011.12.018.
26. Arabi A, Baddoura R, Awada H, Khoury N, Haddad S, Ayoub G, Fuleihan GEH. Discriminative ability of dual-energy X-ray absorptiometry site selection in identifying patients with osteoporotic fractures. Bone. 2007;40(4):1060-1065. doi:10.1016/j.bone.2006.11.017
27. Bigdon SF, Saldarriaga Y, Oswald KA, Müller M, Deml MC, Benneker LM, Ecker T, Albers CE. Epidemiologic analysis of 8000 acute vertebral fractures: evolution of treatment and complications at 10-year follow-up. J Orthop Surg Res. 2022 May 14;17(1):270. doi: 10.1186/s13018-022-03147-9.
28. O'Neill TW, Felsenberg D, Varlow J, Cooper C, Kanis JA, Silman AJ, European Vertebral Osteoporosis Study Group. The prevalence of vertebral deformity in European men and women: the European Vertebral Osteoporosis Study. J Bone Miner Res. 1996 Jul 1;11(7):1010-8. doi: 10.1002/jbmr.5650110719.
29. Ikegami S, Uehara M, Tokida R, Nishimura H, Sakai N, Horiuchi H, Kato H, Takahashi J. Male–female disparity in clinical features and significance of mild vertebral fractures in community-dwelling residents aged 50 and over. Sci Rep. 2024 Mar 7;14(1):5602. doi: 10.1038/s41598-024-56379-6.
30. Jackson SA, Tenenhouse A, Robertson L, CaMos Study Group. Vertebral fracture definition from population-based data: preliminary results from the Canadian Multicenter Osteoporosis Study (CaMos). Osteoporos Int. 2000 Sep;11:680-7. doi: 10.1007/s001980070066.

31. Felsenberg D, Silman AJ, Lunt M, Armbrecht G, Ismail AA, Finn JD, et al. Incidence of vertebral fracture in Europe: results from the European Prospective Osteoporosis Study (EPOS). J Bone Miner Res. 2002;17(4):716-24. doi: 10.1359/jbmr.2002.17.4.716.
32. Johansson H, Kanis JA, Odén A, McCloskey E, Chapurlat RD, Christiansen C, Cummings SR, Diez-Perez A, Eisman JA, Fujiwara S, Glüer CC. A meta-analysis of the association of fracture risk and body mass index in women. J Bone Miner Res. 2014 Jan 1;29(1):223-33. doi: 10.1002/jbmr.2017.
33. Fujiwara S, Kasagi F, Yamada M, Kodama K. Risk factors for hip fracture in a Japanese cohort. J Bone Miner Res. 1997 Jul 1;12(7):998-1004. doi: 10.1359/jbmr.1997.12.7.998.
34. Shapses SA, Pop LC, Wang Y. Obesity is a concern for bone health with aging. Nutr Res. 2017 Mar 1;39:1-3. doi: 10.1016/j.nutres.2016.12.010.
35. Bredella MA, Torriani M, Ghomi RH, Thomas BJ, Brick DJ, Gerweck AV, Harrington LM, Breggia A, Rosen CJ, Miller KK. Determinants of bone mineral density in obese premenopausal women. Bone. 2011 Apr 1;48(4):748-54. doi: 10.1016/j.bone.2010.12.011.
36. Zhang W, Ma X, Xue P, Gao Y, Wu X, Zhao J, Wang Y, Li S. Associations between fat distribution and volumetric bone mineral density in Chinese adults. Endocrine. 2014 Dec;47:862-8. doi: 10.1007/s12020-014-0252-8.
37. Ruosi C, Liccardo S, Rossi D, Colella G, Di Somma C, Colao A. Importance of spinal deformity index in risk evaluation of VCF (vertebral compression fractures) in obese subjects: prospective study. Eur Spine J. 2013 Nov;22:945-9. doi: 10.1007/s00586-013-3009-9.
38. Kanis JA, Johnell O, Odén A, Johansson H, De Laet C, Eisman JA, Fujiwara S, Kroger H, McCloskey EV, Mellstrom D, Melton LJ. Smoking and fracture risk: a meta-analysis. Osteoporos Int. 2005 Feb;16:155-62. doi: 10.1007/s00198-004-1640-3.
39. Taes Y, Lapauw B, Vanbillemont G, Bogaert V, De Bacquer D, Goemaere S, Zmierczak H, Kaufman JM. Early smoking is associated with peak bone mass and prevalent fractures in young, healthy men. J Bone Miner Res. 2010 Feb 1;25(2):379-87. doi: 10.1359/jbmr.090809.
40. Yoon V, Maalouf NM, Sakhaee K. The effects of smoking on bone metabolism. Osteoporos Int. 2012 Aug;23:2081-92. doi: 10.1007/s00198-012-1940-y.
41. Aloia JF, Cohn SH, Vaswani A, Yeh JK, Yuen K, Ellis K. Risk factors for postmenopausal osteoporosis. Am J Med. 1985 Jan 1;78(1):95-100. doi: 10.1016/0002-9343(85)90468-1.
42. Høidrup S, Prescott E, Sørensen TI, Gottschau A, Lauritzen JB, Schroll M, Grønbæk M. Tobacco smoking and risk of hip fracture in men and women. Int J Epidemiol. 2000 Apr 1;29(2):253-9. doi: 10.1093/ije/29.2.253.
43. Cornuz J, Feskanich D, Willett WC, Colditz GA. Smoking, smoking cessation, and risk of hip fracture in women. Am J Med. 1999 Mar 1;106(3):311-4. doi: 10.1016/S0002-9343(99)00022-4.
44. Meyer HE, Tverdal A, Falch JA. Risk factors for hip fracture in middle-aged Norwegian women and men. Am J Epidemiol. 1993 Jun 1;137(11):1203-11. doi: 10.1093/oxfordjournals.aje.a116622.
45. Gifre L, Massó E, Fusaro M, Haarhaus M, Ureña P, Cozzolino M, Mazzaferro S, Calabia J, Peris P, Bover J. Vertebral fractures in patients with CKD and the general population: a call for diagnosis and action. Clin Kidney J. 2024 Aug;17(8):sfae191. doi: 10.1093/ckj/sfae191.
46. Syu DK, Hsu SH, Yeh PC, Kuo YF, Huang YC, Jiang CC, Chen M. The association between coronary artery disease and osteoporosis: a population-based longitudinal study in Taiwan. Arch Osteoporos. 2022 Dec;17(1):91. doi: 10.1007/s11657-022-01128-3.

47. Guañabens N, Olmos JM, Hernández JL, Cerdà D, Hidalgo Calleja C, Martinez López JA, Arboleya L, Aguilar del Rey FJ, Martinez Pardo S, Ros Vilamajo I, Suris Armangué X. Vertebral fractures are increased in rheumatoid arthritis despite recent therapeutic advances: a case-control study. Osteoporos Int. 2021 Jul;32:1333-42. doi: 10.1007/s00198-021-05824-7.
48. Prentice RL, Pettinger MB, Jackson RD, Wactawski-Wende J, Lacroix AZ, Anderson GL, Chlebowski RT, Manson JE, Van Horn L, Vitolins MZ, Datta M. Health risks and benefits from calcium and vitamin D supplementation: Women's Health Initiative clinical trial and cohort study. Osteoporos Int. 2013 Feb;24:567-80. doi: 10.1007/s00198-012-2224-2.
49. Manji R, Ponzano M, Ashe MC, Wark JD, Kendler D, Papaioannou A, Cheung AM, Adachi JD, Thabane L, Scherer SC, Ziebart C. Exploring the association between pain and fracture characteristics in women with osteoporotic vertebral fractures. Phys Ther Can. 2022 May 1;74(2):165-72. doi: 10.3138/ptc-2020-0067.
50. Suzuki N, Ogikubo O, Hansson T. The course of the acute vertebral body fragility fracture: its effect on pain, disability and quality of life during 12 months. Eur Spine J. 2008 Oct;17:1380-90. doi: 10.1007/s00586-008-0753-3.
51. Papaioannou A, Kennedy CC, Freitag A, O'Neill J, Pui M, Ioannidis G, Webber C, Pathak A, Hansen S, Hennessey R, Adachi JD. Longitudinal analysis of vertebral fracture and BMD in a Canadian cohort of adult cystic fibrosis patients. BMC Musculoskelet Disord. 2008 Dec;9:1-8. doi: 10.1007/s00198-008-0743-7.

Tables

Table 1. General Characteristics of the Study Population (N = 140)

Variable	Mean ± SD / N (%)	Range
Age (years)	71.51 ± 7.3	60 – 93
Age groups		
• 60–69 years	59 (42.2%)	
• 70–79 years	58 (41.4%)	
• ≥80 years	23 (16.4%)	
BMI (kg/m²)	27.64 ± 3.92	15 – 36
Gender		
• Male	57 (40.7%)	
• Female	83 (59.3%)	
Marital Status		
• Single	9 (6.4%)	
• Married	68 (48.6%)	
• Widow	58 (41.4%)	
• Divorced	5 (3.6%)	
Education Level		
• Illiterate	68 (48.6%)	
• Primary School	47 (33.6%)	
• Secondary School	20 (14.3%)	
• Higher Education	5 (3.6%)	
Mobility		
• Freely ambulant	71 (50.7%)	
• Assisted by device	64 (45.7%)	
• Wheelchair-bound	5 (3.6%)	
Smoking Status		
• Smoker	28 (20.0%)	
• Non-smoker	112 (80.0%)	
Activities of daily lining		
• Independent	140 (100.0%)	
Alcohol intake	0	

Table 2. Medical History and Medications in the Study Population (N = 140)

Variable	N (%)
Comorbidities	
• Diabetes mellitus	79 (56.4%)
• Chronic kidney disease	38 (27.1%)
• Hypertension	59 (42.1%)
• Hyperthyroidism	4 (2.9%)
• Hypothyroidism	8 (5.7%)
• Rheumatoid arthritis	28 (20.0%)
• Coronary heart disease	17 (12.1%)
• History of parental hip fracture	0 (0.0%)
Medication Use	
• Thyroid hormone	8 (5.7%)
• Proton pump inhibitors	42 (30.0%)
• History of oral steroid intake	18 (12.9%)
• Calcium supplements	52 (37.1%)
• Vitamin D supplements	54 (38.6%)
Anti-epileptics	2 (1.4%)
History of Previous Non-Vertebral Fractures	
• Yes	32 (22.9%)
• No	108 (77.1%)
Site of Non-Vertebral Fractures (n = 32)	
• Femur	20 (62.5%)
• Forearm	9 (28.1%)
• Humerus	3 (9.4%)
Chronic back pain	
• Yes	97 (69.3%)
• No	43 (30.7%)
Site of back pain and spinal tenderness (n = 91)	
• Thoracic	30 (31.9%)
• Lumbar	50 (51.5%)
• Thoraco- lumbar	17(12.1%)

Table 3. Prevalence of Vertebral Fracture by X-ray in the Studied Population (N = 140)

Variable	N (%)
Presence of Vertebral Fracture	
• Yes	73 (52.1%)
• No	67 (47.9%)
Site of Vertebral Fracture (n = 73)	
• thoracic (T4 to T10)	32 (43.8%)
• Lumbar (L2-L5)	37 (50.7%)
• Thoraco-lumbar junction (T11-L1)	4 (5.5%)
Presence of Vertebral Fracture by Gender	
• Male	27 (36.99%)
• Female	46 (63.01%)
Number of vertebral fractures:	73
Single	73
Multiple	0

Table 4. General Characteristics of the Studied Population by Prevalent Vertebral Fracture (N = 140)

Variable	Vertebral Fracture (n = 73)	No Fracture (n = 67)	Test	p-value	Significance
Age (years)	71.88 ± 6.87	71.12 ± 7.78	$t = 0.61$	0.542	NS
BMI (kg/m²)	27.71 ± 3.55	27.55 ± 4.31	$t = 0.24$	0.81	NS
Gender			$\chi^2 = 0.88$	0.349	NS
• Male	27 (36.99%)	30 (44.78%)			
• Female	46 (63.01%)	37 (55.22%)			
Marital Status			Fisher's exact	0.235	NS
• Single	5 (6.85%)	4 (5.97%)			
• Married	30 (41.10%)	38 (56.72%)			
• Widow	34 (46.58%)	24 (35.82%)			
• Divorced	4 (5.48%)	1 (1.49%)			
Education Level			Fisher's exact	0.025	**S**
• Illiterate	38 (52.05%)	30 (44.78%)			
• Primary school	18 (24.66%)	29 (43.28%)			
• Secondary school	12 (16.44%)	8 (11.94%)			
• Higher education	5 (6.85%)	0 (0.0%)			
Mobility			Fisher's exact	0.534	NS
• Freely ambulant	36 (49.32%)	35 (52.24%)			
• Assisted by device	33 (45.21%)	31 (46.27%)			
• Wheelchair bound	4 (5.48%)	1 (1.49%)			
Smoking Status			$\chi^2 = 2.32$	0.128	NS
• Smoker	11 (15.07%)	17 (25.37%)			
• Non-smoker	62 (84.93%)	50 (74.63%)			

Note: *S = significant, NS = not significant.*

t**: Independent t-test**

χ^2:Chi-square test

Table 5. Medical History in the Study Population by Prevalent Vertebral Fracture (N = 140)

Category	With vertebral Fracture (n = 73)	Without vertebral Fracture (n = 67)	Test of Significance	p-value	Significance
Medical Conditions					
Diabetes Mellitus			$\chi^2 = 0.92$	0.338	NS
• Yes	44 (60.27%)	35 (52.24%)			
• No	29 (39.73%)	32 (47.76%)			
Hyperthyroidism			Fisher's exact	0.349	NS
• Yes	1 (1.37%)	3 (4.48%)			
• No	72 (98.63%)	64 (95.52%)			
Chronic Kidney Disease			$\chi^2 = 1.47$	0.226	NS
• Yes	23 (31.51%)	15 (22.39%)			
• No	50 (68.49%)	52 (77.61%)			
Hypertension			$\chi^2 = 2.67$	0.103	NS
• Yes	26 (35.62%)	33 (49.25%)			
• No	47 (64.38%)	34 (50.75%)			
Coronary Heart Disease			$\chi^2 = 0.20$	0.654	NS
• Yes	8 (10.96%)	9 (13.43%)			
• No	65 (89.04%)	58 (86.57%)			
Rheumatoid Arthritis			$\chi^2 = 0.35$	0.554	NS
• Yes	16 (21.92%)	12 (17.91%)			
• No	57 (78.08%)	55 (82.09%)			
Medications / Supplements					
Thyroid Hormone			Fisher's exact	0.278	NS
• Yes	6 (8.22%)	2 (2.99%)			
• No	67 (91.78%)	65 (97.01%)			
Steroid Intake			$\chi^2 = 0.67$	0.415	NS
• Yes	11 (15.07%)	7 (10.45%)			
• No	62 (84.93%)	60 (89.55%)			
PPI (Proton Pump Inhibitors)			$\chi^2 = 1.31$	0.252	NS
• Yes	25 (34.25%)	17 (25.37%)			
• No	48 (65.75%)	50 (74.63%)			
Calcium Supplement			$\chi^2 = 4.25$	0.039	**S**
Yes	19 (28.36%)	33 (45.21%)			
• No	48 (71.64%)	40 (54.79%)			
Vitamin D Supplement			$\chi^2 = 5.66$	0.017	**S**
• Yes	19 (28.36%)	35 (47.95%)			
• No	48 (71.64%)	38 (52.05%)			

Table 6. Association between chronic back pain, spine tenderness, and the presence of vertebral fracture (N = 140)

Variable	With Fracture (n = 73)	Without Fracture (n = 67)	Chi-square	p-value	Significance
Back pain			$\chi^2 = 0.27$	0.602	NS
• Yes	52 (53.61%)	45 (46.39%)			
• No	21 (48.84%)	22 (51.16%)			
Site of spine tenderness			$\chi^2 = 15.31$	< 0.001	**S**
• Thoracic	23 (76.67%)	7 (23.33%)			
• Lumbar	26 (52.00%)	24 (48.00%)			
• Thoraco-lumbar	3 (17.65%)	14 (82.35%)			