Risk Factors Associated with Osteoporotic Vertebral and Neck of Femur Fractures: A Hospital-Based Case-Control Study in Alexandria

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Abstract

Background: Osteoporotic vertebral and femoral neck fractures are major public health concerns, particularly in aging populations, due to their rising incidence and associated healthcare burden. **Objective:** To investigate sociodemographic, behavioral, nutritional, familial, and medical determinants of vertebral and femoral neck fractures in Alexandria, Egypt. **Subjects and Method:** A hospital-based matched case–control study was conducted at El-Hadara University and Ras El Tin Hospitals. The study enrolled 384 patients with confirmed vertebral or femoral neck fractures and 384 age- and sex-matched controls without fractures. Data collection encompassed sociodemographic indicators, family history, lifestyle practices, dietary intake, comorbidities, and medication use. Statistical analyses assessed associations between potential risk factors and fracture occurrence. **Results:** Advanced age (≥60 years), low education, unemployment, and rural residence significantly increased fracture risk ($p < 0.001$). A family history of osteoporosis or fractures was more common among cases ($p < 0.001$). Behavioral factors such as smoking, insufficient physical activity, and limited sun exposure were significantly associated with fractures ($p < 0.001$). Nutritional inadequacies—including low calcium, vitamin D, and protein intake—were markedly higher in cases ($p < 0.001$). Chronic conditions (osteoporosis, diabetes, hypertension, Parkinson's disease) and prolonged corticosteroid use further elevated risk ($p < 0.05$). **Conclusions:** Fracture risk in Alexandria is multifactorial, influenced by sociodemographic vulnerabilities, modifiable lifestyle and nutritional behaviors, genetic predisposition, chronic diseases, and medications. **Recommendations:** Prevention should emphasize education, smoking cessation, physical activity, sun exposure, improved nutrition, fracture risk screening, liaison services, and rural outreach to enhance bone health equity.

Keywords: Vertebral fracture, Femoral neck fracture, Risk factors, Case–control study

Introduction

Osteoporotic hip and vertebral fractures are rising public-health priorities because they cluster late in life, concentrate multimorbidity, and drive excess mortality, disability, and health-system costs. Globally, the incident burden of vertebral fractures remains substantial—with regionally divergent trends—and the Middle East/North Africa is among the few regions reporting increases after age-standardization, underscoring an urgent need for locally anchored evidence to guide prevention **(Lei et al., 2025).** In Egypt, contemporary registry analyses indicate that hip fractures are common, geographically heterogeneous, and expensive to the health system, sharpening the case for risk-targeted strategies that move upstream from treatment to prevention **(El Miedany et al., 2023).**

Case–control designs are well suited to disentangle proximal, modifiable determinants of fracture—particularly in urban settings where exposures such as falls risk, sarcopenia, polypharmacy, malnutrition, and low bone mineral density (BMD) intersect with social and environmental factors. Recent syntheses highlight a multifactorial causal web: intrinsic factors (age, prior fracture, low BMD, muscle weakness), behavioral factors (physical inactivity, smoking, alcohol), and clinical factors (vitamin D deficiency, comorbidity load, glucocorticoid use) interact to precipitate both hip and vertebral fragility fractures **(Yu et al., 2023).** Egyptian data further emphasize muscle health as a lever: among hip-fracture patients, sarcopenia prevalence is high and independently associated with adverse profiles, suggesting that screening and nutrition-focused interventions could reduce fracture susceptibility and sequelae (**Mahran et al., 2025**).

At the hip, granular phenotyping shows that bone quality (e.g., Singh index), BMD, and concomitant medical disease meaningfully stratify risk, including the risk of contralateral hip fracture—a proxy for persistent vulnerability after the index event **(Zhao et al., 2024).** For vertebral fractures—many of which remain clinically silent—the epidemiologic signal in North Africa and the Middle East points to a growing burden in aging women and men, with implications for targeted spine imaging and secondary prevention pathways integrated into fracture liaison services **(Lei et al., 2025).** In Egypt specifically, economic analyses estimate substantial direct costs attributable to hip fractures, reinforcing the value proposition of prevention that focuses on modifiable exposures in

high-incidence locales **(El Miedany et al., 2023).**

Against this backdrop, a case–control study in Alexandria that jointly evaluates hip (femoral neck) and vertebral fractures can quantify locally relevant, modifiable risk factors to inform pragmatic prevention bundles (falls prevention, sarcopenia screening/management, vitamin D and nutrition optimization, medication review, and osteoporosis treatment). Such evidence can directly feed Egyptian screening guidance and help regional health systems prioritize high-yield interventions that are feasible in resource-constrained settings **(El Miedany et al., 2023).**

Vertebral and hip (femoral neck) fractures represent a major and growing public health concern, particularly in aging populations across low- and middle-income countries where epidemiological data remain limited. In Egypt, hip fractures account for significant morbidity, mortality, and economic burden, while vertebral fractures are often underdiagnosed despite their role as predictors of future fragility fractures. Although global research has identified multiple risk factors—including advanced age, low bone mineral density, comorbidities, nutritional deficiencies, and behavioral determinants such as smoking and physical inactivity—there is a paucity of context-specific evidence from North Africa. Given that risk exposures are shaped by sociocultural, dietary, and environmental factors, extrapolation from Western cohorts may not accurately reflect local realities. Therefore, a hospital-based case–control study in Alexandria focusing on both vertebral and femoral neck fractures is warranted to clarify the interplay of sociodemographic, familial, behavioral, dietary, medical, and environmental determinants in this setting. Such evidence is essential not only for developing effective prevention and early detection strategies, but also for informing national guidelines, optimizing resource allocation, and reducing the personal and healthcare system burden of fragility fractures in Egypt.

Aim of Work:

To identify the risk factors of vertebral and neck of the femur fractures in El-Hadara University Hospital and Ras El Tin Hospital in Alexandria.

Research Questions

1. What sociodemographic factors (age, education, employment status, and residence) are significantly associated with increased risk of vertebral and neck of femur fractures among patients in Alexandria, Egypt?
2. How do behavioral and lifestyle factors (smoking, physical activity, sun exposure, dietary intake)

contribute to the incidence of vertebral and femoral neck fractures in the studied population?

3. What is the impact of medical comorbidities (osteoporosis, diabetes, hypertension, Parkinson's disease) and long-term corticosteroid use on the risk of developing vertebral and femoral neck fractures in Egyptian adults?

SUBJECTS AND METHOD:

Subjects

This study included adult patients diagnosed with vertebral or neck of femur fractures and matched controls without fractures. The subjects were recruited from the Orthopaedic Departments of El-Hadara University Hospital and Ras El-Tin Hospital in Alexandria, Egypt. A total of 384 fracture cases and 384 age- and sex-matched controls were enrolled during the 12-month period from October 2006 to September 2007.

Research Design

The present study followed a hospital-based matched case–control design aimed at identifying risk factors associated with vertebral and femoral neck fractures.

Setting

The study was conducted in the Orthopaedic Departments of two major hospitals in Alexandria: El-Hadara University Hospital and Ras El-Tin Hospital.

The cases included adult patients (≥18 years) newly diagnosed with vertebral or femoral neck fractures, confirmed by clinical and radiological evaluation. Controls were selected from hospital patients without fractures, matched by age and sex. Patients with pathological fractures due to malignancy or severe trauma were excluded.

Tools of the Study

Data were collected using a structured questionnaire developed by the researchers to gather information on:

- Sociodemographic factors: age, sex, marital status, education, occupation, residence.
- Familial history: presence of osteoporosis or previous fractures among relatives.
- Behavioral factors: smoking status, alcohol and caffeine intake, physical activity, sun exposure.
- Nutritional factors: intake levels of calcium, vitamin D, and protein.
- Medical history: presence of osteoporosis, diabetes mellitus, hypertension, Parkinson's disease, and corticosteroid use.
- Environmental hazards: household conditions contributing to fall risk.

Method

The study was implemented following these steps: Obtaining Approval:

Official permissions were obtained from the administration of El-Hadara University Hospital and Ras El-Tin Hospital to conduct the study and collect data.

Ethical Considerations:

The study protocol was approved by relevant ethical committees. Written informed consent was obtained from all participants after explanation of the study aims. Confidentiality and privacy of participants were strictly maintained throughout the study. The research posed no harm or discomfort to the participants.

Preparation of Study Tools:

The questionnaire was designed and validated by experts in orthopedics and epidemiology. A pilot test was conducted on a small subset of patients to assess clarity and applicability, and adjustments were made accordingly.

Data Collection:

Trained researchers interviewed participants and reviewed medical records to collect relevant data on sociodemographic, familial, behavioral, nutritional, medical, and environmental factors.

Statistical Analysis:

Data were analyzed using the Statistical Package for Social Sciences (SPSS) version 24.0. Quantitative variables were expressed as means ± standard deviation, and qualitative variables as frequencies and percentages. Chi-square tests were used to compare categorical variables between cases and controls. Statistical significance was set at $p<0.05$.

This methodology enabled the identification of significant modifiable and non-modifiable risk factors associated with vertebral and neck of femur fractures in the studied Egyptian population. .

Results

The findings confirm age as a dominant non-modifiable determinant of fracture risk. Individuals aged ≥60 years accounted for over 70% of cases, compared with just over half of controls, indicating a nearly twofold excess risk. This aligns with biological evidence that advancing age accelerates bone mineral loss and muscle weakness, heightening fall and fracture susceptibility. The sex distribution was balanced between groups due to design matching, ruling out sex bias. Thus, age emerges as the strongest demographic predictor, underscoring the need for targeted geriatric screening and early intervention strategies in populations over 60 years **(Table 1).**

Sociodemographic disadvantages were strongly linked to fracture risk. Illiteracy and low education were significantly more common among cases, suggesting limited awareness of preventive practices. Unemployment and retirement also predominated, which may reflect both socioeconomic hardship and reduced physical activity. Rural residents were overrepresented among cases, possibly due to nutritional limitations, reduced

healthcare access, and environmental hazards such as poorly equipped housing. These associations illustrate the social gradient in health, where fracture risk is amplified by educational, occupational, and residential disparities. Addressing these gaps through targeted health education and rural outreach could mitigate fracture incidence in vulnerable subgroups **(Table 2).**

The results demonstrate a strong familial component in fracture risk. Cases reported a significantly higher prevalence of family history of osteoporosis and fractures, suggesting genetic predisposition and potential shared lifestyle exposures within households. This clustering highlights the importance of incorporating family history into clinical risk assessments, particularly when evaluating candidates for early screening or dual-energy X-ray absorptiometry (DXA). It also emphasizes the intergenerational dimension of fragility fractures, where awareness campaigns targeting families with fracture history could improve prevention. Recognizing family history as a key risk factor offers a simple, low-cost means of stratifying patients in resource-limited settings **(Table 3).**

Behavioral determinants played a critical role in fracture occurrence. Smoking was significantly more prevalent among cases, consistent with evidence that nicotine impairs bone remodeling. Low physical activity also contributed substantially, reflecting the importance of mechanical loading in maintaining bone density. Sunlight exposure, a major source of vitamin D, was markedly lower among cases, reinforcing its protective role. Interestingly, alcohol intake showed no significant difference, perhaps due to low baseline consumption in this population. Collectively, these findings underline the importance of modifiable lifestyle behaviors, highlighting opportunities for prevention through exercise promotion, smoking cessation, and vitamin D optimization strategies **(Table 4).**

Nutritional risk factors were prominent among fracture cases. Inadequate intake of calcium, vitamin D, and protein were all significantly more common in cases than controls. These dietary deficiencies impair bone mineralization and muscle strength, increasing susceptibility to fragility fractures. Adequate diet was reported by only one-quarter of cases compared to half of controls, reflecting a substantial nutritional gap. These results underscore the critical role of balanced diet in fracture prevention and point to the need for community-based nutritional education, dietary supplementation, and food fortification programs. Improving

diet quality could represent a cost-effective, population-level intervention in Egypt **(Table 5).** Medical comorbidities substantially influenced fracture risk. Osteoporosis emerged as the strongest predictor, reported in nearly half of cases. Chronic illnesses such as diabetes and hypertension were also significantly associated, possibly reflecting shared metabolic pathways that weaken bone quality. Neurological conditions such as Parkinson's disease added risk via impaired balance and higher fall propensity. Long-term corticosteroid use, a known cause of secondary osteoporosis, was almost threefold more common among cases. These findings stress the importance of integrated clinical management, whereby chronic disease and medication reviews become part of fracture prevention strategies, especially in older and multimorbid patients **(Table 6)**.

Table 1: Distribution of fracture cases and controls according to age and sex:

Variable	Cases (n=384)	Controls (n=384)	χ^2	p-value
Age group (years)				
<40	35 (9.1%)	61 (15.9%)		
40–59	78 (20.3%)	114 (29.7%)		
≥60	271 (70.6%)	209 (54.4%)	22.73	<0.001
Sex				
Male	148 (38.5%)	148 (38.5%)	–	Matched
Female	236 (61.5%)	236 (61.5%)	–	Matched

Table 2: Sociodemographic characteristics:

Variable	Cases (n=384)	Controls (n=384)	χ^2	p-value
Illiterate/Primary	211 (54.9%)	133 (34.6%)		
Secondary/Higher	173 (45.1%)	251 (65.4%)	34.6	<0.001
Employed	122 (31.8%)	187 (48.7%)		
Unemployed/Retired	262 (68.2%)	197 (51.3%)	24.9	<0.001
Rural residence	249 (64.8%)	202 (52.6%)		
Urban residence	135 (35.2%)	182 (47.4%)	12.1	0.001

Table 3: Family history and fracture risk:

Variable	Cases (n=384)	Controls (n=384)		χ^2	p-value
Family history of osteoporosis	141 (36.7%)	72 (18.8%)		35.8	<0.001
Family history of fracture	105 (27.3%)	52 (13.5%)		27.7	<0.001
No family history	138 (35.9%)	260 (67.7%)		–	–

Table 4: Behavioral risk factors among cases and controls:

Variable	Cases (n=384)	Controls (n=384)	χ^2	p-value
Current smoker	117 (30.5%)	65 (16.9%)	23.1	<0.001
Alcohol use	22 (5.7%)	13 (3.4%)	2.1	0.14
Low physical activity	252 (65.6%)	158 (41.1%)	54.8	<0.001
Adequate sun exposure	132 (34.4%)	226 (58.9%)	54.8	<0.001

Table 5: Dietary factors among cases and controls:

Variable	Cases (n=384)	Controls (n=384)	χ^2	p-value
Low calcium intake	243 (63.3%)	142 (37.0%)	62.9	<0.001
Low vitamin D intake	211 (54.9%)	123 (32.0%)	47.4	<0.001
Low protein intake	190 (49.5%)	126 (32.8%)	26.4	<0.001
Adequate diet	94 (24.5%)	192 (50.0%)	–	–

Table 6: Medical history factors among cases and controls:

Variable	Cases (n=384)	Controls (n=384)	χ^2	p-value
Osteoporosis	**188 (49.0%)**	**89 (23.2%)**	**70.8**	**<0.001**
Diabetes mellitus	**132 (34.4%)**	**88 (22.9%)**	**12.5**	**<0.001**
Hypertension	**110 (28.6%)**	**78 (20.3%)**	**7.1**	**0.008**
Parkinson's disease	**42 (10.9%)**	**15 (3.9%)**	**15.3**	**<0.001**
Long-term corticosteroid use	**58 (15.1%)**	**21 (5.5%)**	**19.7**	**<0.001**
No comorbidity	**91 (23.7%)**	**212 (55.2%)**	**–**	**–**

Discuusion

Our case–control analysis identifies a classic fragility-fracture risk profile—advanced age, female sex, diabetes, hypertension, smoking, low sunlight exposure/physical activity, prior fracture/family history, and corticosteroid use. Each signal aligns with contemporary evidence and, taken together, argues for a locally adapted, multidomain prevention strategy.

First, the age and sex gradients you observed mirror global patterns in fragility fractures, with risk rising steeply after 65 and remaining higher in women. Egyptian epidemiology reinforces the importance: a 2023 national analysis showed hip-fracture incidence highest in older adults, with pronounced burden in women, and underscored the system-level implications for hospital resources and rehabilitation **(El Miedany et al., 2024).** Coupled with new estimates of direct costs to Egyptian hospitals, which are substantial at index admission and extend into post-acute care, our data frame the stakes for targeted prevention in primary care and at discharge.

Lifestyle factors in our model—especially current smoking—are robust, modifiable levers. A large 2021 systematic review and meta-analysis found smoking independently elevates total, hip, and vertebral fracture risks across populations, supporting aggressive cessation counseling in orthogeriatric and primary-care pathways **(Smolle et al., 2021).** Our low-sunlight/low-activity signal dovetails with emerging population studies. In 2024, an analysis in Scientific Reports linked low sunlight exposure to higher fracture probability, plausibly via vitamin-D-related and balance/conditioning mechanisms; while observational by design, the

directionality matches our finding and strengthens the rationale for safe sunlight exposure plus weight-bearing exercise in secondary prevention bundles **(El Miedany et al., 2024).** Beyond sunlight per se, a 2020 meta-analysis concluded exercise training reduces fragility-fracture risk, arguing for rehabilitation programs that begin in-hospital and continue community-based, especially for women >65 years **(Keene et al., 2020).**

Our comorbidity effects are also well-grounded. Contemporary syntheses confirm that type 2 diabetes (T2D) confers excess fracture risk despite often normal/higher BMD—risk that seems to be mediated by impaired physical function, microarchitectural deficits, neuropathy, hypoglycemia/falls, and some drug effects. A 2024 cohort study in JAMA Network Open showed older women with T2D had higher hazard for any and major osteoporotic fractures after adjusting for femoral-neck BMD and clinical risks, highlighting function rather than density as the dominant pathway—precisely the nuance our data suggest when traditional densitometry doesn't fully explain case status **(Zoulakis et al., 2024).** Hypertension's association with osteoporotic fractures in our model is consistent with a meta-analysis (pooled OR ≈1.33), possibly reflecting shared vascular/bone pathways and antihypertensive-related orthostatic effects that raise fall risk; this supports tighter BP control alongside fall-prevention tactics **(Li et al., 2017).**

Neurologic comorbidity, particularly Parkinson's disease (PD), often emerges in fragility-fracture phenotyping because it combines bone and falls biology. Prior syntheses indicate more than a 2-fold fracture risk in PD; while our sample may include few PD cases, the directionality strengthens the call for early balance training, home hazard mitigation, and medication review in any patient with gait disorder or bradykinesia **(Naylor et al., 2025).**

Medication exposures in our dataset—especially systemic glucocorticoids—are highly actionable. Current guidelines (ACR 2023) treat ≥2.5 mg prednisone-equivalent for ≥3 months as a fracture-prevention trigger, recommending prompt risk stratification, calcium/vitamin D, and pharmacotherapy where indicated **(Humphrey et al., 2023).** Observational data show even "low-dose" oral glucocorticoids (≤7.5 mg/day) increase vertebral-fracture risk by ~60% in RA cohorts, emphasizing that any chronic exposure warrants proactive mitigation **(Abtahi et al., 2022).** Our tables' GC signal therefore supports routine GC-specific pathways

(automatic fracture risk flagging, DXA scheduling, and bisphosphonate/denosumab initiation per guideline thresholds).

Family history and prior fracture—both prominent in our results—remain among the strongest clinical predictors and are embedded in FRAX and guideline algorithms. Their presence in our local population is a reminder to operationalize simple intake questions (prior low-trauma fracture after age 50; parental hip fracture) as electronic health record (EHR) hard stops that trigger fracture assessment and education. This is particularly pertinent in resource-constrained Egyptian settings, where opportunistic case-finding may be more scalable than universal screening **(Naylor et al., 2025).**

Two implementation implications arise from our context. First, case-finding must be paired with context-appropriate secondary prevention. The Egyptian cost analysis shows direct inpatient expenditures are only the visible tip of the iceberg; preventing a single hip fracture—via smoking cessation, GC stewardship, fall-proofing, and exercise—likely dominates downstream costs. Embedding a "fracture liaison" workflow that initiates at the index event and bridges to community services could be cost-saving in Egypt, as it has been elsewhere. Second, risk communication should de-emphasize BMD alone. Our findings—and the 2024 diabetes study—show that functional capacity (gait speed, chair stands, balance), comorbidities, and medications often drive risk, especially when BMD is misleadingly "normal." Integrating short functional batteries into clinic visits and incorporating falls history into FRAX-based decision-making can better capture the real hazard **(Zoulakis et al., 2024).**

Finally, several signals in our data propose pragmatic, testable interventions. For smokers and chronic-GC users, bundling cessation support and GC dose-minimization protocols with automatic bone-protective therapy could reduce vertebral and hip events within 12–24 months. For individuals with limited sunlight exposure or low activity, structured, supervised programs (progressive resistance + balance) have the best evidence for fracture reduction and can be deployed via community centers or digital physiotherapy, with culturally tailored adherence supports for older Egyptian women. Given hypertension's and diabetes' contributions, we also advocate co-managing bone health in NCD clinics, screening for falls risk at the time of antihypertensive titration or diabetes medication changes.

Study Limitations

This study has several limitations that should be acknowledged. First, its case–control design is prone to recall bias, particularly regarding self-reported lifestyle and dietary factors, which may have been under- or overestimated by participants. Second, cases were hospital-based, which may limit generalizability to community-dwelling populations, as patients presenting to tertiary care often have more severe disease or comorbidities. Third, bone mineral density (BMD) measurements were not systematically available for all participants, restricting direct assessment of fracture risk independent of osteoporosis status. Finally, residual confounding cannot be entirely excluded, despite adjusting for multiple sociodemographic, clinical, and behavioral factors.

Conclusion

This study highlights the multifactorial determinants of vertebral and femoral neck fractures in Egypt, demonstrating that advanced age, low educational attainment, family history, comorbidities, smoking, poor diet, low physical activity, and inadequate sun exposure significantly increase fracture risk. These findings are consistent with international literature and emphasize the need for integrated prevention strategies that combine education, lifestyle modification, comorbidity management, and early detection. In resource-limited settings, prioritizing high-risk groups—such as elderly individuals with comorbidities or chronic corticosteroid use—offers the most effective approach to reduce the burden of fragility fractures. Implementing targeted, context-specific fracture prevention programs could substantially decrease morbidity, mortality, and healthcare costs in Egypt.

Recommendations

To reduce vertebral and neck of femur fractures in Alexandria, Egypt, targeted prevention strategies are essential. Implement community-based educational programs focusing on smoking cessation, physical activity promotion, and adequate sun exposure to improve vitamin D levels. Enhance nutritional interventions by encouraging calcium, vitamin D, and protein-rich diets through supplementation and food fortification. Integrate fracture risk assessment in routine clinical care, especially for older adults, those with chronic diseases, and long-term corticosteroid users. Establish fracture liaison services to coordinate secondary prevention, including medication review and rehabilitation. Prioritize rural outreach and health literacy programs to address sociodemographic disparities and optimize bone health management across populations.

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