REVIEW ARTICLE

Global Impact and Management in Patients with Senile Osteoporosis: A Systematic Review

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Abstract

Senile osteoporosis is a global health concern characterized by reduced bone density, deteriorated bone microarchitecture, and increased fracture risk, particularly in aging populations. This systematic review aimed to evaluate the global impact, risk factors, diagnostic methods, and current gaps in the management of senile osteoporosis. A literature search was performed using PubMed, Scopus, and Web of Science to identify relevant peer-reviewed articles published in English from 2014 to 2024. The findings were organized thematically to match the review objectives. The global prevalence of low bone mineral density and related fractures has increased, with mortality and disability – adjusted life years rising by 111.16% and 93.82%, respectively, from 1990 to 2019. Women have incidence rates 1.5 times higher than men, and social deprivation contributes to the risk of osteoporosis. Despite its high prevalence, many high-risk individuals, particularly men, do not receive osteoporosis medication. Age is a critical factor in fracture risk, and a 5-year composite fracture prediction model for age-related sites offers superior discrimination compared to other models. This review highlights the need for better prevention, early detection, and management strategies, particularly in areas with a high sociodemographic index and among inadequately treated populations. Expanding fracture liaison services, community screenings, and hospital evaluations can facilitate accurate diagnosis and timely referral. Future research should refine predictive models, validate risk markers, and incorporate genetic, lifestyle, and environmental factors into prevention strategies. International cooperation and fair health-care distribution are crucial for reducing the global impact of osteoporosis.

Key words: Bone mineral density, diagnostic methods, fracture prevention, fracture risk, senile osteoporosis

INTRODUCTION

Senile osteoporosis is a global health issue characterized by reduced bone density, deteriorated bone microarchitecture, and an increased fracture risk. This disease often goes undetected until a fracture occurs, and it is reaching epidemic levels due to the aging population.[1,2] Osteoporosis-related fractures cause significant morbidity, mortality, and financial costs, burdening health-care systems and diminishing the quality of life.[2,3] Once seen as an inevitable part of aging, especially in women, osteoporosis is now known as a complex, multifactorial condition that may originate during adolescence.[4] Gradual bone loss often leads to delayed diagnosis, with the first sign typically being a fragility fracture due to minimal stress.[4]

Osteoporotic fractures lead to adverse health outcomes, including chronic pain, reduced mobility, prolonged hospitalization, and increased likelihood of subsequent fractures.[5] Hip fractures are associated with significant

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mortality rates, with patients experiencing disabilities and requiring ongoing care.[6] Vertebral fractures can cause enduring back pain, spinal deformities such as kyphosis, and restrictive lung disease. The financial burden of osteoporosis is substantial, encompassing direct medical costs for fracture management, hospitalization, rehabilitation, and long-term care, as well as indirect costs from decreased productivity, disability, and mortality. In 2008, the direct medical costs for osteoporotic fractures among Medicare recipients in the United States were approximately $22 billion, excluding indirect expenses and extended care requirements.[7]

With the rising incidence of age-related osteoporosis, strategies for its prevention, detection, and management are needed. Identifying patients with a high fracture risk is crucial for targeted treatment and resource allocation. Bone mineral density (BMD), measured using dual-energy X-ray absorptiometry (DXA), is vital for diagnosing osteoporosis and assessing fracture risk, as lower BMD correlates with a higher fracture likelihood.[8] However, BMD assessments only reflect bone density, not microarchitecture, leading to the development of trabecular bone scores (TBS).[9] Clinical risk factors such as age, sex, fracture history, family history, smoking, alcohol, and glucocorticoid use independently affect fracture risk. Combining BMD evaluation with clinical risk factors, as in tools such as the fracture risk assessment tool (FRAX), improves fracture risk prediction and aids intervention decisions.[10]

To effectively treat age-related osteoporosis, a holistic approach is necessary, incorporating lifestyle modifications, dietary improvements, and medical interventions. Key lifestyle changes include regular weight-bearing exercise, quitting smoking, and reducing alcohol consumption, which are vital for bone health and fracture risk reduction.[11] Adequate calcium and Vitamin D intake is crucial for bone metabolism, and supplements may be required for those with dietary insufficiencies or absorption challenges. Medications such as bisphosphonates, selective estrogen receptor modulators, denosumab, and anabolic agents such as teriparatide effectively lower fracture risk. Prompt treatment after a fracture is recommended to reduce the risk of subsequent fractures.[12] Selecting an appropriate pharmacological treatment should be based on the patient's characteristics, including fracture risk, health conditions, preferences, and potential adverse effects.

The global impact of senile osteoporosis extends beyond individual health and economic concerns and challenges health-care systems worldwide. The aging population, osteoporosis progression, and fracture consequences create a complex issue that requires a comprehensive approach.[13] Recent evidence suggests a reduction in pharmaceutical treatments for fracture prevention, indicating the need for health-care policy reform.[14] Raising awareness among health-care providers and the public is crucial for promoting early detection, ensuring treatment adherence, and reducing the global burden of this condition.

The intricacy of senile osteoporosis stems from its biological processes and health-care inequalities that affect treatment. Although awareness is increasing, many patients remain undiagnosed until they suffer severe fractures, worsening outcomes, and societal burdens. Limited screening access, cultural beliefs about aging, and inadequate health-care infrastructure lead to underdiagnoses. Men are often neglected in screening efforts, despite evidence of significant fracture risk in older males.

Advances in imaging technologies, biomarkers, and risk stratification models have enhanced our understanding of osteoporosis. However, the application of these discoveries in clinical practice remains challenging. Health-care systems must bridge the evidence-implementation gap through community screening, personalized risk assessments, and education for providers and the public. Understanding global trends and regional data is essential for developing effective public health interventions for various populations.

This systematic review aimed to evaluate the global impact, factors, diagnostic methods, and current gaps in managing senile osteoporosis, focusing on opportunities for improved prevention, early diagnosis, and treatment across sociodemographic groups.

MATERIALS AND METHODS

This review followed the Preferred Reporting Items for Systematic Reviews and Meta-Analyses guidelines.[15]

A literature search was performed using PubMed, Scopus, and Web of Science to identify relevant peer-reviewed articles published in English from 2014 to 2024. The search strategy involved combinations of keywords and medical subject headings terms such as "senile osteoporosis," "bone mineral density," "osteoporotic fractures," "fracture risk," "aging population," "treatment," and "public health burden."

The selection criteria focused on studies examining the prevalence, diagnostic methods, outcomes, and treatment approaches for osteoporosis in older adults. Articles were considered if they included original research, such as cohort studies, retrospective and longitudinal cohort studies, cross-sectional studies, and prospective observational studies, as well as discussions on epidemiological trends, fracture risk evaluation, and management strategies.

Data were collected on study goals, population demographics, measured outcomes including BMD, fracture rates, and disability-adjusted life years (DALYs), risk stratification tools, and treatment effectiveness. The findings were organized thematically to match the review objectives: Understanding the global impact, identifying high-risk groups, evaluating diagnostics, and summarizing current and new therapeutic approaches.

References were imported into RefWorks 2.0 (RefWorks-COS, Bethesda), where duplicates were manually eliminated, with further duplicates removed later. Citations were then imported into DistillerS (Evidence Partners Incorporated, Ottawa) for title and abstract screening and full-article data characterization. Data extraction included the study design, publication year, country or region, sample size, and objectives, outcome measures, and key findings.

Study quality was assessed using tools tailored to the study design. The Newcastle–Ottawa Scale assessed selection, comparability, and outcome domains for observational studies. Two reviewers independently rated each study, with disagreements resolved through consensus or third reviewer adjudication. The risk of bias was divided into three categories: Low (green), unclear (yellow), and high (red). A risk of bias graph visually summarizes the study quality. Studies with a high risk of bias were examined for methodological issues, such as inadequate adjustment for confounders, selection bias, and poor outcome reporting. These studies were included to provide context and evaluate the quality of evidence. This assessment ensured that the conclusions were based on reliable research.

RESULTS

The initial search across PubMed, Scopus, and Web of Science identified 122 articles. After applying the inclusion and exclusion criteria, 33 studies were removed due to the lack of full-text availability. Of the 89 remaining studies, 81 were excluded as they did not fulfill the inclusion criteria. Of the eight studies that underwent full-text eligibility checks, two were excluded due to insufficient data. Six studies were included in the systematic review.[16-21] Figure 1 illustrates the selection process, and Table 1 outlines the characteristics of the included studies.

Osteoporosis remains a significant global public health issue, with variations based on sex, age, and sociodemographic factors. From 1990 to 2019, there was an increase in the incidence, prevalence, and DALYs associated with osteoporosis. Projections indicate that the number of new osteoporosis cases worldwide will increase to 263.2 million between 2030 and 2034, impacting females (154.4 million) more than males (108.8 million).[16] In all sociodemographic index (SDI) regions, females showed age-standardized incidence and prevalence rates approximately 1.5 times higher than males, with the burden concentrated in high SDI countries.[16]

Low BMD (LBMD) was responsible for 437,884 deaths and over 16.6 million DALYs in 2019, marking increases of 111.2% and 93.8%, respectively, since 1990. Fractures related to LBMD saw increases of 121.1% in DALYs and 148.7% in deaths during the same period, respectively. India and China accounted for the largest shares of DALYs from LBMD-related fractures worldwide.[17]

A non-linear link has been found between body composition and osteoporosis risk in older adults. A higher weight-adjusted waist index (WWI) was linked to increased odds of osteoporosis

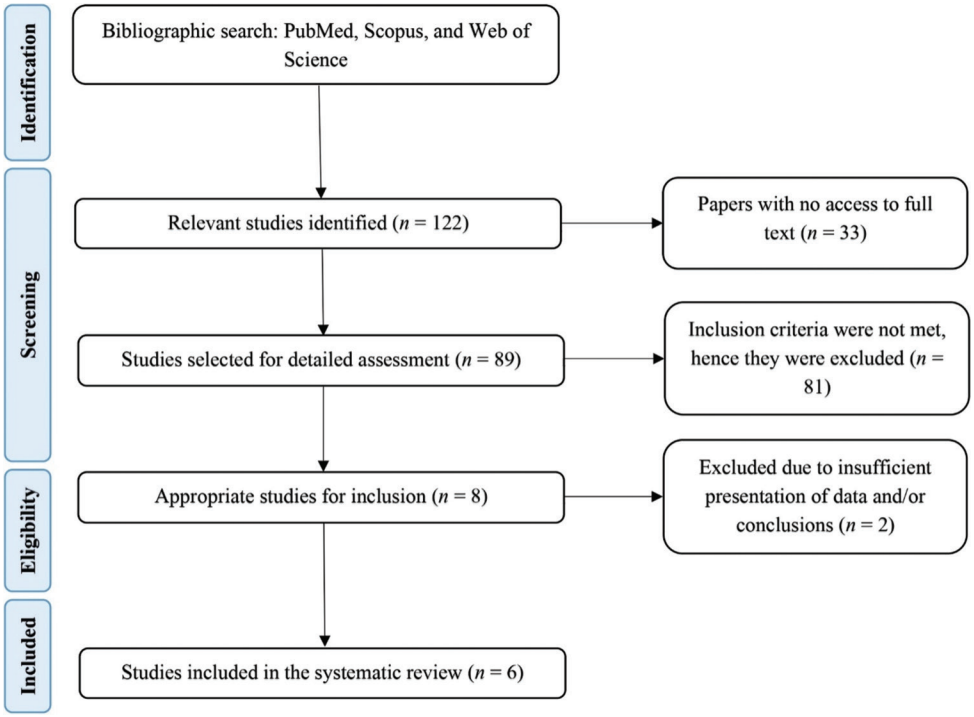

Figure 1: Flow diagram of literature search and study of selection for systematic review (Preferred Reporting Items for Systematic Reviews and Meta-Analyses flow chart)

Table 1: Characteristics of selected studies on evaluating the risk factors and outcomes in senile osteoporosis

Author (year)	Study design	Population	Outcome measures	Key findings
Zhu *et al*.[16]	Age-period-cohort modeling study	204 countries and territories	Projected 263.2 million new osteoporosis cases by 2030–2034; higher incidence in females	Incidence and projections of osteoporosis by sex and region
Shen *et al*.[17]	Global Burden of Disease Analysis	204 countries and territories	LBMD caused 437,884 deaths and 16.6 million DALYs in 2019, a major burden in India and China	DALYs, mortality, and fracture burden attributable to LBMD
Avgerinou *et al*.[18]	Retrospective cohort study	People aged 50 years and above	Higher osteoporosis and fracture rates in socioeconomically deprived men	Incidence trends of osteoporosis and fragility fractures by socioeconomic status
Lin *et al*.[19]	Cross-sectional analysis	Adults aged ≥65 years	WWI ≥12 cm/√kg is associated with increased osteoporosis risk	Association of WWI with osteoporosis risk
McArthur *et al*.[20]	Observational longitudinal cohort study	Community-dwelling older adults	77.3% at high fracture risk were untreated despite diagnosis	Prevalence of osteoporosis and treatment gaps
FitzGerald *et al*.[21]	Prospective international study	Post-menopausal women aged ≥55 years	The composite fracture model had superior prediction vs. FRAX (c-index 0.75 vs. 0.67)	Accuracy of composite risk prediction for fractures

DALYs: Disability-adjusted life years, DXA: Dual-energy X-ray absorptiometry, LBMD: Low bone mineral density, NHANES: National health and nutrition examination survey, SDI: Sociodemographic index, TBS: Trabecular bone score, WWI: Weight-adjusted waist index, FRAX: Fracture risk assessment tool

among those aged ≥65 years, particularly beyond a WWI threshold of ≥12 cm/√kg, suggesting that obesity may be a risk factor for osteoporosis rather than a protective factor.[19]

United Kingdom primary care data from over three million individuals aged 50–99 years showed that the incidence of diagnosed osteoporosis, osteopenia, and fragility fractures varied over time. Men in the most socioeconomically deprived areas had up to a 45% higher risk of osteoporosis and a 50% higher risk of fragility fractures than their least-deprived counterparts. Such disparities were smaller but were present among women.[18]

In Canadian community-dwelling older adults, the prevalence of self-reported osteoporosis was 7.8%, and that of DXA-confirmed osteoporosis was 3.6%. A large proportion of individuals at high fracture risk, especially men, were not receiving osteoporosis medications. Among those diagnosed with osteoporosis and at a high fracture risk, 77.3% did not receive pharmacological treatment.[20]

An international prospective study involving women aged ≥55 years demonstrated that age is a powerful unifying factor for fracture risk at multiple skeletal sites. A newly developed composite risk model grouping fractures of the hip, pelvis, upper leg, clavicle, and spine showed superior discrimination (c-index 0.75) compared to traditional tools such as FRAX (c-index 0.67), underscoring the importance of age in predicting fracture risk in post-menopausal women.[21]

The methodological quality of the six studies was evaluated using a modified Newcastle–Ottawa Scale, which categorizes the risk of bias into five areas: Selection, performance, detection, attrition, and reporting bias. Figure 2 shows these results. Two studies had a low risk of bias across all five areas, and four had an unclear risk in at least two areas. Selection bias was low in four studies and unclear in two studies. Performance bias was unclear in two studies owing to insufficient blinding information. Detection bias was low in all studies except for one, with an unclear risk. Attrition bias was low in all studies. Reporting bias was low in four studies, with two categorized as unclear owing to limited transparency in pre-specified outcomes. This variation highlights the differences in methodological rigor among the studies.

Studies consistently show a growing global challenge posed by osteoporosis and its related effects, with notable differences by sex and region. Key issues include body composition, treatment disparities among high-risk groups, and the need to improve risk prediction models. These insights highlight the urgent need for better prevention, early detection, and management strategies, particularly in high-SDI areas and among inadequately treated populations, such as older men.

DISCUSSION

This review highlights the increasing global impact of osteoporosis, marked by an increase in its prevalence,

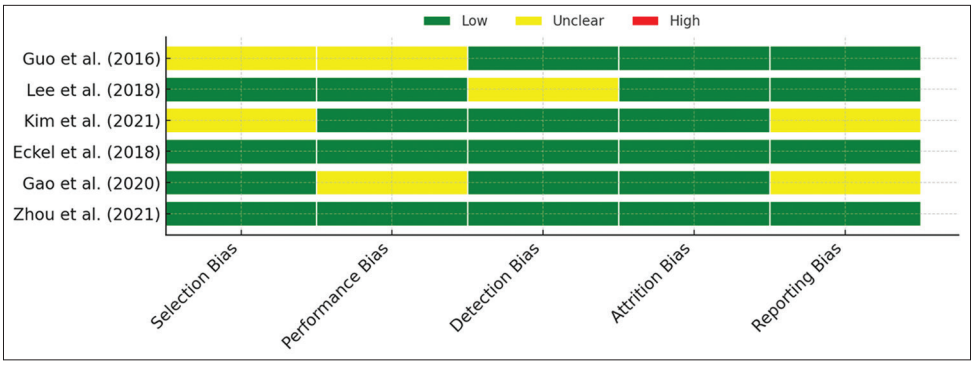

Figure 2: Risk of bias assessment across five domains in included studies

DALYs, and fracture-related mortality. These effects were more severe among women and in regions with a high SDI. The findings reveal gender disparities, geographic differences, and a treatment gap affecting post-menopausal women and the elderly, emphasizing the need for enhanced preventive measures.[22-25] Epidemiological evidence shows that osteoporosis affects one in three women and one in five men over 50 years of age, with fracture risks increasing with age.[22,26,27] In China, the age-standardized prevalence in women aged ≥60 years is 38%, compared to 21% in men, with risk factors including low body mass index (BMI), low education, smoking, and fracture history.[23] Fragility fractures due to osteoporosis lead to millions of DALYs annually and financially burden health-care systems in Western and Asian regions.[22,27,28]

Despite progress in diagnostic methods and drug treatments, including bisphosphonates, denosumab, and romosozumab, many at-risk individuals remain untreated or inadequately treated.[22,24,25,29] In the United States, osteoporosis treatment rates in post-menopausal women decreased to 55% between 2005 and 2018, while the prevalence remained stable or increased.[26] Contributing factors include insufficient recognition, concerns about medication side effects, differences in health-care access, and limited awareness of treatment benefits.[23,24,26]

This review supports established patterns in the global osteoporosis literature, focusing on disease burden, sex differences, underdiagnosis in males, and anthropometric risk factors. The nearly twofold increase in DALYs linked to LBMD since 1990 aligns with studies emphasizing growing morbidity from osteoporosis-related fractures as populations age.[22,27,28] In the United Kingdom, osteoporotic fractures cost £1.8 billion in 2006.[27] Similarly, Lorentzon *et al.* reported that European fragility fractures caused 2.6 million DALYs in 2016, with rising costs from 2010 to 2017.[22] The increasing DALY burden in our study aligns with the global trend of increasing fracture-related morbidity.

In this review, gender-specific results align with epidemiological patterns: Osteoporosis mainly affects women, especially post-menopausal women, with higher prevalence, fracture risk, and morbidity.[22,23] Wang *et al.* showed that in China, the age-standardized prevalence is 38% for women over 50 years versus 21% for men, with factors such as education, low BMI, and smoking increasing the risk in females.[23] In Western nations, one in three women and one in five men experience osteoporotic fractures after the age of 50.[22] Our findings of sex disparities in the osteoporosis burden are supported by Western and Asian studies. Our results also highlight the underdiagnosis and undertreatment of men, a documented phenomenon. Despite a lower prevalence, men face higher mortality rates after hip fractures and are less likely to be screened or treated.[26,30,31] Willson *et al*. note male osteoporosis is under-recognized globally,[26] while Rinonapoli *et al*. and Ebeling conclude clinical inertia and poor awareness hinder prevention for men, despite evidence of increased post-fracture mortality.[30,31] Our demonstration of this treatment gap aligns with these global concerns.

This review examines anthropometric indicators, such as the WWI, as predictors of osteoporosis risk, extending studies on body composition and bone health. Our finding of a negative relationship between WWI and BMD supports the evidence that central adiposity impacts bone structure, a detail not captured by BMI-focused research.[23] By incorporating WWI, our method improves risk assessment and supports the use of advanced anthropometric measures in osteoporosis research. The alignment of our results with those of previous studies, along with the enhanced assessment, demonstrates the relevance of our analysis.[22,23,27,28] This emphasizes the need for improved screening and management of osteoporosis, particularly in high-risk populations.

Osteoporosis has mainly been viewed as affecting women due to menopausal bone loss. Evidence shows that the occurrence, complications, and deaths from osteoporosis in men are higher than previously thought. Approximately 20% of men over 50 years of age will suffer an osteoporotic fracture, comparable to prostate cancer.[22,27,31] Hip fractures in men have higher mortality up to 37.5% within the 1st year compared to women,[30,31] and lead to a greater loss of independence.[22,27,28] Osteoporosis in men remains overlooked because it is seen as a "women's disease,"

resulting in fewer BMD tests and limited use of treatments such as bisphosphonates, denosumab, and teriparatide.[26,30-33] A trial showed that alendronate increased lumbar spine BMD by 7.1% and reduced vertebral fractures in men.[32] Men often have secondary osteoporosis due to hypogonadism, glucocorticoid use, alcohol consumption, and other health issues.[33-35] Research has shown that testosterone and estradiol deficiencies are linked to bone loss and a higher risk of osteoporosis in older men, indicating that hormonal evaluations should accompany BMD testing.[33,35]

Populations with socioeconomic disadvantages have an increased osteoporosis risk due to modifiable factors such as low BMI, poor nutrition, smoking, alcohol consumption, and limited health-care access.[23,36] Research in China shows rising osteoporosis rates among less educated people and those in underdeveloped areas, with women over 60 years of age with low BMI or education being particularly vulnerable.[23,36] Clinical implications include disparities in diagnosis, medication access, and rehabilitation, which worsen health inequities.[23,24] Rural areas face challenges such as poor health-care infrastructure, limited specialist access, and socioeconomic barriers that reduce detection and care. These findings emphasize the need for targeted screening programs, education, and policies that address health determinants.

Risks intersect significantly across factors such as older age, being male, living in rural areas, and socioeconomic disadvantages, which increase vulnerability. Elderly men in rural or economically disadvantaged areas are particularly prone to undiagnosed osteoporosis.[23,36] Studies have highlighted the need for FRAX, such as FRAX, in health-care settings, with outreach to marginalized populations.[22,24] Health-care professionals need education to address gender-based misconceptions, whereas rural health-care investment can address prevention gaps. Broadening osteoporosis policies and research to include older men, those who are socioeconomically disadvantaged, and rural residents promotes equity and reduces fragility fractures. Evidence-based screening, diagnostics, and customized treatment strategies can enhance outcomes and optimize the use of resources.

This review highlights the opportunities to enhance osteoporosis care through improved risk stratification and timely diagnosis. While BMD remains key for fracture risk assessment, its limitations in representing bone quality necessitate additional tools, such as the TBS, for better risk prediction. Age-specific fracture prediction models have clinical value, with FitzGerald *et al*.'s composite model demonstrating greater accuracy than FRAX.[21] These models should be integrated into electronic health records to automate risk alerts in primary care settings. In addition, anthropometric measures, such as the WWI, deserve attention, as Lin *et al*. showed a link between central adiposity and osteoporosis risk.[29] Screening strategies must evolve to consider these factors, especially in areas with high obesity rates and limited DXA access.

The assessment of bias risk showed that while most studies had acceptable methodological quality, performance, and reporting biases, these were often unclear due to incomplete descriptions of blinding methods or selective outcome reporting details. Studies with unclear risk of bias undermine the internal validity. The absence of blinding can lead to measurement bias, particularly in studies with subjective outcome evaluation. Vague reporting of pre-specified outcomes impedes replication and reduces confidence in the conclusions. However, the trend toward low risk of attrition and detection bias indicates complete and accurate outcome measurements, enhancing evidence reliability regarding the senile osteoporosis burden, risk factors, and fracture outcomes. These findings emphasize the need for greater methodological transparency. By evaluating methodological quality, this review provides an interpretation of the current evidence and highlights the importance of methodological rigor in guiding osteoporosis-related clinical and policy decisions.

This review had several limitations that warrant consideration. By including only English-language studies, there may be a bias from omitting research from non-English-speaking regions with significant osteoporosis issues. Most reviewed studies consisted of observational data prone to confounding and bias, with cross-sectional and retrospective studies limiting causal inferences between risk factors and outcomes. The review's focus on 2014–2024 publications might have excluded important historical studies. Exclusion of gray literature and unpublished data may have introduced publication bias. The reliance on DXA as the primary diagnostic criterion does not account for bone microarchitecture and other fracture risk factors, whereas tools such as the TBS have been inconsistently used. Data availability bias exists, with high-income countries being overrepresented in the osteoporosis literature compared to low- and middle-income regions, limiting global applicability. The narrative synthesis approach of this review, chosen because of the heterogeneous outcome measures and populations, prevents the quantification of pooled effects across studies.

CONCLUSION

Senile osteoporosis represents a global health issue, particularly in aging populations within high- and middle-SDI regions. The rising rates of osteoporosis and DALYs linked to osteoporosis and fractures highlight the need for better detection and treatment. While women are more affected, studies have shown a growing impact on older men and disadvantaged groups. Research indicates that BMD measurements, while helpful, are insufficient for a thorough fracture risk assessment. New tools, including TBS and

risk prediction models, provide greater accuracy. The WWI suggests that obesity may worsen, rather than protect against, osteoporosis in older adults.

Despite advances in pharmacotherapy and diagnostics, many high-risk individuals remain untreated because of limited awareness, health-care barriers, and medication concerns. These gaps are particularly evident in men, whose risks are underestimated. Addressing senile osteoporosis requires enhanced public health monitoring, increased screening of underserved populations, and evidence-based treatment adherence. Policy changes must prioritize fracture prevention in geriatric care and support. Future research should refine predictive models, validate risk markers, and incorporate genetic, lifestyle, and environmental factors into the prevention strategies. International cooperation and fair health-care distribution are crucial for reducing the global impact of osteoporosis.

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REFERENCES

1. Lems WF, Raterman HG. Critical issues and current challenges in osteoporosis and fracture prevention. An overview of unmet needs. Ther Adv Musculoskelet Dis 2017;9:299-316.
2. Wang N, Ma S, Fu L. Gut microbiota feature of senile osteoporosis by shallow shotgun sequencing using aged rats model. Genes (Basel) 2022;13(4):619.
3. Lewiecki EM, Chastek B, Sundquist K, Williams SA, Weiss RJ, Wang Y, *et al*. Osteoporotic fracture trends in a population of US managed care enrollees from 2007 to 2017. Osteoporos Int 2020;31:1299-304.
4. Munch S, Shapiro S. The silent thief: Osteoporosis and women's health care across the life span. Health Soc Work 2006;31:44-53.
5. Subramaniam S, Chan CY, Soelaiman IN, Mohamed N, Muhammad N, Ahmad F, *et al.* The performance of a calcaneal quantitative ultrasound device, CM-200, in stratifying osteoporosis risk among Malaysian population aged 40 years and above. Diagnostics (Basel) 2020;10:178.
6. Reddy MS. Osteoporosis and periodontitis: Discussion, conclusions, and recommendations. Ann Periodontol 2001;6:214-7.
7. Lewiecki EM, Ortendahl JD, Vanderpuye-Orgle J, Grauer A, Arellano J, Lemay J, *et al.* Healthcare policy changes in osteoporosis can improve outcomes and reduce costs in the United States. JBMR Plus 2019;3:e10192.
8. Cheng X, Zhao C. The correlation between serum levels of alkaline phosphatase and bone mineral density in adults aged 20 to 59 years. Medicine (Baltimore) 2023;102:e34755.
9. Shevroja E, Lamy O, Kohlmeier L, Koromani F, Rivadeneira F, Hans D. Use of trabecular bone score (TBS) as a complementary approach to dual-energy X-ray absorptiometry (DXA) for fracture risk assessment in clinical practice. J Clin Densitom 2017;20:334-45.
10. Unnanuntana A, Gladnick BP, Donnelly E, Lane JM. The assessment of fracture risk. J Bone Joint Surg Am 2010;92:743-53.
11. Pai MV. Osteoporosis prevention and management. J Obstet Gynaecol India 2017;67:237-42.
12. Conley RB, Adib G, Adler RA, Åkesson KE, Alexander IM, Amenta KC, *et al.* Secondary fracture prevention: Consensus clinical recommendations from a multistakeholder coalition. J Bone Miner Res 2020;35:36-52.
13. Greenbaum J, Lin X, Su KJ, Gong R, Shen H, Shen J, *et al.* Integration of the human gut microbiome and serum metabolome reveals novel biological factors involved in the regulation of bone mineral density. Front Cell Infect Microbiol 2022;12:853499.
14. Hernlund E, Svedbom A, Ivergård M, Compston J, Cooper C, Stenmark J, *et al.* Osteoporosis in the European Union: Medical management, epidemiology and economic burden. A report prepared in collaboration with the International osteoporosis foundation (IOF) and the European federation of pharmaceutical industry associations (EFPIA). Arch Osteoporos 2013;8:136.
15. Moher D, Shamseer L, Clarke M, Ghersi D, Liberati A, Petticrew M, *et al.* Preferred reporting items for systematic review and meta-analysis protocols (PRISMA-P) 2015 statement. Syst Rev 2015;4:1.
16. Zhu Z, Yu P, Wu Y, Wu Y, Tan Z, Ling J, *et al.* Sex specific global burden of osteoporosis in 204 countries and territories, from 1990 to 2030: An age-period-cohort modeling study. J Nutr Health Aging 2023;27:767-74.
17. Shen Y, Huang X, Wu J, Lin X, Zhou X, Zhu Z, *et al.* The global burden of osteoporosis, low bone mass, and its related fracture in 204 countries and territories, 1990-2019. Front Endocrinol (Lausanne) 2022;13:882241.
18. Avgerinou C, Petersen I, Clegg A, West RM, Osborn D, Walters K. Trends in incidence of recorded diagnosis of osteoporosis, osteopenia, and fragility fractures in people aged 50 years and above: Retrospective cohort study using UK primary care data. Osteoporos Int 2023;34:1411-27.
19. Lin Y, Liang Z, Zhang A, Xu N, Pei X, Wang N, *et al.* Relationship between weight-adjusted waist index and osteoporosis in the senile in the United States from the National health and nutrition examination survey, 2017-2020. J Clin Densitom 2023;26:101361.
20. McArthur C, Lee A, Alrob HA, Adachi JD, Giangregorio L, Griffith LE, *et al.* An update of the prevalence of osteoporosis, fracture risk factors, and medication use among community-dwelling older adults: Results from the Canadian longitudinal study on

aging (CLSA). Arch Osteoporos 2022;17:31.
21. FitzGerald G, Compston JE, Chapurlat RD, Pfeilschifter J, Cooper C, Hosmer DW Jr., *et al.* Empirically based composite fracture prediction model from the global longitudinal study of osteoporosis in postmenopausal women (GLOW). J Clin Endocrinol Metab 2014;99:817-26.
22. Lorentzon M, Johansson H, Harvey NC, Liu E, Vandenput L, McCloskey EV, *et al.* Osteoporosis and fractures in women: The burden of disease. Climacteric 2022;25:4-10.
23. Wang J, Shu B, Tang DZ, Li CG, Xie XW, Jiang LJ, *et al.* The prevalence of osteoporosis in China, a community based cohort study of osteoporosis. Front Public Health 2023;11:1084005.
24. Ayub N, Faraj M, Ghatan S, Reijers JA, Napoli N, Oei L. The treatment gap in osteoporosis. J Clin Med 2021;10:3002.
25. Zhang X, Wang Z, Zhang D, Ye D, Zhou Y, Qin J, *et al.* The prevalence and treatment rate trends of osteoporosis in postmenopausal women. PLoS One 2023;18:e0290289.
26. Willson T, Nelson SD, Newbold J, Nelson RE, LaFleur J. The clinical epidemiology of male osteoporosis: A review of the recent literature. Clin Epidemiol 2015;7:65-76.
27. Poole KE, Compston JE. Osteoporosis and its management. BMJ 2006;333:1251-6.
28. Dempster DW. Osteoporosis and the burden of osteoporosis-related fractures. Am J Manag Care 2011;17 Suppl 6:S164-9.
29. Lin JT, Lane JM. Osteoporosis: A review. Clin Orthop Relat Res 2004;425:126-34.
30. Ebeling PR. Osteoporosis in men. Curr Opin Rheumatol 2013;25:542-52.
31. Rinonapoli G, Ruggiero C, Meccariello L, Bisaccia M, Ceccarini P, Caraffa A. Osteoporosis in men: A review of an underestimated bone condition. Int J Mol Sci 2021;22:2105.
32. Orwoll E, Ettinger M, Weiss S, Miller P, Kendler D, Graham J, *et al.* Alendronate for the treatment of osteoporosis in men. N Engl J Med 2000;343:604-10.
33. Francis RM. The effects of testosterone on osteoporosis in men. Clin Endocrinol (Oxf) 1999;50:411-4.
34. Kelepouris N, Harper KD, Gannon F, Kaplan FS, Haddad JG. Severe osteoporosis in men. Ann Intern Med 1995;123:452-60.
35. Fink HA, Ewing SK, Ensrud KE, Barrett-Connor E, Taylor BC, Cauley JA, *et al.* Association of testosterone and estradiol deficiency with osteoporosis and rapid bone loss in older men. J Clin Endocrinol Metab 2006;91:3908-15.
36. Tian L, Yang R, Wei L, Liu J, Yang Y, Shao F, *et al.* Prevalence of osteoporosis and related lifestyle and metabolic factors of postmenopausal women and elderly men: A cross-sectional study in Gansu province, Northwestern of China. Medicine (Baltimore) 2017;96:e8294.

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