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Osteoporosis in Females: An Interdisciplinary Approach Integrating Nursing Care, Family Support, Social Determinants, Physiotherapists, and Laboratory Evaluation.

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Abstract

Background: Osteoporosis is a systemic skeletal disease characterized by reduced bone mineral density (BMD) and microarchitectural deterioration, leading to increased fragility and fracture risk. It represents a major global public health challenge, disproportionately affecting postmenopausal females due to the abrupt decline in estrogen, which accelerates bone resorption. The condition is often asymptomatic until a fragility fracture occurs, resulting in significant pain, disability, mortality, and societal cost.

Aim: This article synthesizes the etiology, epidemiology, and pathophysiology of osteoporosis in females and advocates for an interdisciplinary management approach. It aims to outline comprehensive evaluation strategies and evidence-based treatments, integrating the roles of nursing, family medicine, laboratory services, and social care to close pervasive screening and treatment gaps.

Methods: A comprehensive review is presented, covering the disease's historical context, pathophysiological mechanisms (including the RANKL/RANK/OPG axis), and diagnostic criteria using dual-energy X-ray absorptiometry (DXA). Risk assessment tools like FRAX and laboratory evaluations for secondary causes are detailed. Management strategies, including pharmacological and non-pharmacological interventions, are systematically reviewed.

Results: Osteoporosis management requires a multifaceted strategy. First-line pharmacotherapy includes bisphosphonates and denosumab, while anabolic agents (e.g., teriparatide, romosozumab) are reserved for very high-risk patients. Non-pharmacological foundations encompass calcium, vitamin D, weight-bearing exercise, and fall prevention. Successful outcomes depend on coordinated, interprofessional care to improve diagnosis, treatment adherence, and persistence.

Conclusion: A proactive, interdisciplinary model is essential to transform osteoporosis from a "silent epidemic" into a managed chronic condition, thereby reducing the immense personal and economic burden of fragility fractures.

Keywords: Osteoporosis, postmenopausal, fragility fracture, bone mineral density (BMD), FRAX, bisphosphonates, interdisciplinary care, fracture prevention..

Introduction

Osteoporosis—derived from the Greek *osteon* (bone) and *poros* (passage or pore)—is a systemic skeletal disorder defined by reduced bone mineral density (BMD) and deterioration of bone microarchitecture, culminating in heightened skeletal fragility and fracture susceptibility [1]. The clinical burden extends far beyond the index fracture; downstream consequences include pain, functional decline, loss of independence, and increased all-cause mortality, with a pronounced impact on quality of life and societal costs through long-term care and productivity losses [1]. Frequently termed the “silent disease,” osteoporosis is typically asymptomatic until a low-trauma fracture unmasks the underlying skeletal vulnerability, at which point opportunities for primary prevention have already been missed [1]. This asymptomatic latency underscores the importance of proactive risk stratification, evidence-based screening, and early therapeutic intervention in populations at risk, particularly postmenopausal females, who bear a disproportionate share of disease burden [1]. Historical observations emphasize that osteoporosis is neither a modern nor a culturally bounded entity. Paleopathologic studies of ancient human remains, including Egyptian mummies with compressed and collapsed vertebrae, attest to the millennia-long presence of fragility fractures consistent with osteoporotic processes [2]. These findings align with the notion that bone fragility emerges from universal biological trajectories—aging, hormonal transitions, and cumulative environmental exposures—rather than contemporary lifestyle alone [2]. The recognition of osteoporotic patterns in antiquity enriches our understanding of the natural history of skeletal aging and encourages a longitudinal perspective on prevention and care that

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integrates historical, biological, and societal determinants [2].

Modern clinical insight into osteoporosis rests on seminal observations from the early nineteenth and twentieth centuries that linked bone structure to fracture propensity. British surgeon Sir Astley Cooper's systematic association of abnormal bone characteristics with fractures laid the conceptual groundwork for viewing skeletal fragility as a pathologic state rather than an inevitable consequence of aging [3]. Shortly thereafter, French pathologist Jean Lobstein introduced the term "osteoporosis," describing the porous morphology that mirrored clinical fragility and further cemented a structural paradigm for disease understanding [3]. Mid-twentieth-century advances by American endocrinologist Fuller Albright profoundly reshaped the field by delineating the role of ovarian hormone depletion in vertebral weakening and fracture risk; his observations of fracture risk escalation following the loss of ovarian function and its mitigation with estrogen anticipated contemporary frameworks of bone remodeling and postmenopausal pathophysiology [3]. Collectively, these milestones established the endocrine, structural, and clinical axes that continue to guide diagnostic and therapeutic strategies [3]. From a population health standpoint, osteoporosis affects both sexes but exhibits a marked predominance in postmenopausal females due to the abrupt decline in estrogen that accelerates bone turnover and compromises microarchitectural integrity [1][3]. With global population aging, the absolute number of fragility fractures is projected to rise substantially, amplifying the urgency of scalable prevention, early detection, and longitudinal management strategies [1]. Despite the availability of validated tools—dual-energy X-ray absorptiometry (DXA) for BMD assessment, fracture risk algorithms, and effective antiresorptive and anabolic therapies—gaps persist in awareness, screening uptake, and treatment adherence. These gaps translate into underdiagnosis and undertreatment at every stage of the care continuum, from primary prevention to secondary fracture prevention, reinforcing the label of osteoporosis as a "silent epidemic" in contemporary practice [1]. The pathway to improved outcomes begins with systematic identification of at-risk individuals, targeted education that reframes osteoporosis as a preventable and treatable chronic condition, and timely initiation of guideline-concordant therapy after fragility fractures to interrupt the cycle of recurrent injury [1]. Embedding osteoporosis evaluation into routine clinical workflows—especially in settings where sentinel events such as wrist or vertebral fractures first present—can shorten time to diagnosis and therapy, reduce excess morbidity, and lower mortality [1][3]. In parallel, historical lessons remind us that skeletal fragility has long been a human constant; our distinctive opportunity today lies in applying modern diagnostics and therapeutics, rooted in the foundational insights of Cooper, Lobstein, and Albright, to transform a silent, progressive condition into a managed, monitored disease across the lifespan [2][3].

Etiology

The etiologic framework of osteoporosis reflects a convergence of hormonal, metabolic, genetic, and environmental factors that disrupt the dynamic balance between bone formation and resorption. In 1983, Drs. Riggs and Melton proposed a pivotal classification delineating two forms of primary osteoporosis, which profoundly influenced both preventive and therapeutic paradigms [4]. Their schema divided osteoporosis into Type 1 (postmenopausal) and Type 2 (senile), each governed by distinct pathogenic mechanisms but united by a common endpoint—progressive skeletal fragility and heightened fracture risk.

Figure-1: Normal bone vis osteoporosis.

This classification continues to inform risk assessment, treatment selection, and clinical research nearly four decades later. Type 1 osteoporosis, colloquially known as *postmenopausal osteoporosis*, arises primarily from estrogen deficiency, a hallmark of the menopausal transition. The decline in estrogen—typically occurring between the ages of 50 and 70—precipitates a surge in bone resorption that outpaces bone formation, leading to a net loss of trabecular bone mass [4][5]. Trabecular bone, found in metabolically active regions such as vertebral bodies and the distal radius, is particularly vulnerable due to its high surface area and turnover rate. Consequently, vertebral compression fractures and distal forearm fractures are the characteristic skeletal manifestations of this subtype [6]. Quantitatively, the vertebral body demonstrates a trabecular-to-cortical bone ratio of approximately 75:25, making it especially susceptible to the accelerated trabecular loss driven by estrogen withdrawal [7]. Beyond the endocrine milieu, secondary contributors such as inadequate calcium intake, sedentary behavior, and nutritional deficiencies may exacerbate the trajectory of postmenopausal bone loss.

In contrast, Type 2 osteoporosis, or *senile osteoporosis*, reflects the cumulative effects of aging on bone remodeling and mineralization. It is characterized by a gradual reduction in both cortical and trabecular bone mass, though cortical loss predominates [5][7]. This low-turnover state results from diminished osteoblast activity, reduced calcium absorption, and impaired renal hydroxylation of vitamin D, leading to chronic secondary hyperparathyroidism and further bone demineralization. Unlike Type 1, which predominantly affects women, Type 2 occurs in both sexes, typically manifesting after the age of 70. The femoral neck, with its cortical bone predominance (approximately 70% cortical to 30% trabecular), is the prototypical site of senile osteoporotic fracture [7]. Environmental influences, such as insufficient physical activity and sarcopenia, further destabilize the musculoskeletal system, compounding fall risk and fracture susceptibility. As research advanced, it became evident that osteoporosis can also arise secondary to a broad spectrum of systemic diseases, nutritional deficiencies, endocrine disorders, and pharmacologic exposures—collectively

termed secondary osteoporosis [8]. In these cases, bone loss is not a primary aging or hormonal phenomenon but the downstream effect of another pathophysiologic process. Epidemiologically, men are more likely to have a secondary cause for osteoporosis, with studies estimating secondary etiologies in approximately 50% to 80% of affected males, compared to around 30% in females [8]. The mechanisms by which these conditions provoke skeletal fragility vary widely, encompassing hormonal imbalances, chronic inflammation, altered nutrient metabolism, and direct drug-induced suppression of osteoblast function.

Risk factors for secondary osteoporosis are traditionally divided into *modifiable* and *non-modifiable* domains [9][10]. Among modifiable factors, lifestyle behaviors—such as cigarette smoking, excessive alcohol and caffeine intake, low calcium and vitamin D consumption, physical inactivity, and eating disorders like anorexia nervosa—play a prominent role in accelerating bone loss. Endocrine disturbances, including hyperparathyroidism, hyperthyroidism, diabetes mellitus, hypogonadism, and Cushing syndrome, disrupt bone homeostasis through hormonal excess or deficiency. Gastrointestinal conditions such as celiac disease, inflammatory bowel disease, cirrhosis, and malabsorption syndromes impair nutrient absorption critical to bone integrity. Genetic and connective tissue disorders—such as osteogenesis imperfecta, Marfan syndrome, and Ehlers-Danlos syndrome—introduce inherent defects in collagen synthesis and bone matrix structure, predisposing individuals to fragility fractures even in youth. The list of medication-induced bone loss is extensive and clinically relevant. Long-term glucocorticoid therapy remains the leading pharmacologic cause, driving osteoblast apoptosis and suppressing bone formation. Other agents—heparin, anticonvulsants (e.g., phenytoin, barbiturates), aromatase inhibitors, gonadotropin-releasing hormone agonists, and certain antiretrovirals (notably tenofovir)—are well-established contributors. Likewise, medications affecting calcium balance or endocrine function, including thyroxine, thiazolidinediones, lithium, cyclosporine, and tacrolimus, can exacerbate skeletal demineralization. Chronic hematologic diseases such as multiple myeloma, sickle cell disease, and thalassemia further erode bone mass through marrow expansion and cytokine-mediated remodeling. Miscellaneous conditions—ranging from chronic kidney disease and chronic obstructive pulmonary disease to congestive heart failure and HIV/AIDS—add systemic stressors that indirectly promote osteopenia [10].

Epidemiology

Osteoporosis represents a worldwide public health challenge whose magnitude continues to expand alongside population aging and shifting demographic structures. Contemporary estimates suggest that between 200 and 500 million individuals are affected globally, with point prevalence data indicating that approximately 6.3% of men and 21.2% of women older than 50 years have been diagnosed with this skeletal disease, underscoring a marked sex disparity that is further magnified after menopause [11]. Regional heterogeneity in disease burden is striking developing regions frequently report higher prevalence than developed ones, reflecting differences in nutrition, health system capacity, screening penetration, and access to preventive therapies [12]. Asia, in particular, bears the highest reported prevalence worldwide, a pattern that correlates with a tendency toward below-average bone mineral density (BMD) measurements in many Asian populations and the sheer size of aging cohorts across the region [12]. These epidemiologic contours frame osteoporosis as both a clinical condition and a structural health-systems problem, requiring strategies that account for geography, ethnicity, and resource variability [11][12]. The epidemiologic weight of osteoporosis is most directly experienced through fragility fractures, which occur from low-energy mechanisms that would not normally cause fracture in healthy bone. Worldwide, as many as 37 million fragility fractures occur annually in adults older than 55 years—an astonishing pace that equates to roughly 70 fractures per minute—illustrating the relentless, minute-to-minute clinical and societal toll of skeletal fragility [13]. Health authorities have recognized the breadth of this burden: within the European Union (EU), fragility fractures are ranked as the fourth most burdensome noncommunicable disease, following ischemic heart disease, dementia, and lung cancer, a placement that emphasizes the complex intersection between chronic disease epidemiology, disability, and aging [14]. Economically, the costs are profound and escalating. Annual direct expenditures approximate £4 billion in the United Kingdom, €56 billion across the EU, and about $19 billion in the United States, with projections anticipating further growth as longevity increases and larger cohorts enter high-risk age brackets [15][16]. Measuring beyond cost, the EU has estimated 1,180,000 quality-adjusted life-years (QALYs) lost due to fragility fractures—with roughly double the QALY loss in women compared with men—alongside 26,300 life-years lost from incident fractures in 2010 alone, highlighting the combined clinical and humanistic ramifications [14][17].

In the United States, current data indicate approximately 1.9 million fragility fractures each year, a figure that maps onto substantial healthcare utilization: roughly 700,000 clinical vertebral fractures and 300,000 hip fractures are recorded annually, associated with about 500,000 hospital admissions, 2.5 million office visits, and 180,000 nursing home admissions [18][19][20]. The fiscal load of these events is borne largely by public payers; Medicare covers around 80% of fracture costs, with hip fractures alone accounting for approximately 72% of expenditures [20]. Projections suggest a steep ascent in the coming decades: by 2040, fragility fractures are anticipated to increase to 3.2 million per year, with aggregate care costs expected to reach $95 billion annually, an outlook that crystallizes the urgency of primary and secondary prevention strategies at scale [21]. Sex-stratified analyses consistently show that women shoulder a disproportionate share of osteoporosis and fracture burden, particularly after menopause when accelerated bone turnover and trabecular loss translate into heightened fragility risk [11]. In the EU in 2010, an estimated 43,000 deaths followed fracture events among women, with hip fractures responsible for 50% of those deaths, vertebral fractures 28%, and other fracture types 22%; for men, the corresponding proportions were 37%, 29%, and 14%, respectively, a distribution that underscores both the high lethality of hip fractures and sex-specific differences in fracture patterns [17]. Notably, although women experience more fractures overall, men often have higher post-fracture mortality, a phenomenon attributed to greater comorbidity burden, older age at the time of fracture, and differences in post-acute care pathways [22]. Contextualizing osteoporosis against other major female health threats further clarifies its importance: the lifetime risk of hip fracture in a White woman is approximately 1 in 6, compared with a 1 in 9 risk of a breast

cancer diagnosis; the remaining-life risk of death from a hip fracture for a 50-year-old White woman in the U.S. is estimated at 2.8%, comparable to the risk of death from breast cancer and four times greater than that from endometrial cancer [International Osteoporosis Foundation-Epidemiology of osteoporosis and fragility fractures. 2024.

The absolute numbers are staggering when aggregated at the population level. In 2010, roughly 22 million women aged 50 to 84 years in the EU were estimated to have osteoporosis, with projections anticipating a 23% increase by 2025 to approximately 33.9 million, figures that mirror demographic aging and emphasize the need for scalable interventions [17][23]. Global estimates further suggest a steep age gradient among women: about one-tenth of those aged 60, one-fifth at 70, two-fifths at 80, and two-thirds over 90 years are affected, illustrating how cumulative risk grows with age [24]. Country-specific prevalence estimates from 2010 reinforce regional variability: 9% in the United Kingdom, 15% in both France and Germany, and 38% in Japan, the latter reflecting the intersection of demographics, baseline BMD distributions, and health-system case-finding practices [25]. Prospective observational data illuminate the epidemiology of incident fractures and their contexts. The Global Longitudinal Study of Osteoporosis in Women (GLOW), which followed 60,000 postmenopausal women across North America, Europe, and Australia, documented 4,122 fractures over three years; 86% were non-hip/nonvertebral, 8% clinical vertebral, and 6% hip fractures [26]. Intriguingly, GLOW identified seasonality and setting patterns: hip fractures were more likely in spring relative to other seasons, 65% of non-hip/nonvertebral fractures occurred outdoors, 61% of vertebral fractures occurred indoors, and hip fracture risk was approximately equivalent indoors and outdoors, patterns that speak to environmental and behavioral mediators of fall risk [26]. Crucially, GLOW affirmed that falls are the proximate precipitant for most fragility events: 68–86% of non-hip/nonvertebral fractures and 68–83% of hip fractures were fall-related, and even about 45% of vertebral fractures were associated with falls, emphasizing the importance of fall prevention embedded within fracture prevention strategies [26].

U.S. prevalence data further underscore the scale of disease. In 2010, about 10.3% of Americans older than 50 were estimated to have osteoporosis, translating to roughly 10.3 million individuals, of whom nearly 8 million (around 80%) were women [25][27][28]. The lifetime risk of a low-trauma fracture for an American woman older than 50 is approximately 40%, distributed across hip (17.5%), forearm (16.0%), and clinical vertebral fractures (15.6%); approximately one in two White women will sustain an osteoporotic fracture during their lifetime [15][19]. Annual hip fracture rates exhibit racial and ethnic differences among U.S. women: the highest rates are observed in White women (140.7 per 100,000), followed by Asian (85.4 per 100,000), Black (57.3 per 100,000), and Hispanic (49.7 per 100,000) women, differences likely influenced by a mix of BMD distributions, body composition, fall mechanics, comorbidity profiles, and social determinants of health [12]. Equity gaps emerge starkly in screening and treatment. Despite, on average, higher BMD among African American women, once osteoporosis is diagnosed the risk of fragility fractures can be comparable to that of White women, highlighting that BMD alone does not fully capture fracture risk across groups [29]. The U.S. Preventive Services Task Force (USPSTF) has reported that African American women are about 40% less likely than White women to receive BMD screening, a disparity that extends into post-fracture care, where African American women are less likely to undergo densitometry or to be offered osteoporosis therapy for either primary prevention or secondary prevention after a fragility fracture [12]. Hispanic women likewise experience lower referral rates for densitometry compared with White counterparts, indicating broad cross-group deficits in case finding and linkage to care [12]. These disparities likely reflect a blend of structural barriers, access limitations, differential referral patterns, and patient-level factors including awareness and competing health priorities [12][28].

Hip fractures constitute a sentinel event in osteoporosis epidemiology and health policy because of their high morbidity, mortality, and cost. Globally, more than 14 million hip fractures occur in individuals older than 65 years, with modeling suggesting a doubling of case numbers from 2018 to 2050; relative to the 1990s, the increase in women is projected at approximately 240%, reflecting both demographic expansion and the longevity of cohorts at risk [30][31]. Approximately three-quarters of all hip fractures occur in women, a distribution consistent with sex-specific differences in bone loss trajectories and fall patterns [32]. Geographic variation remains notable: Nordic countries report among the highest hip fracture incidences worldwide, which has been attributed to differences in latitude, vitamin D status, fall risk, and registration practices [33]. Within the U.S., annual hip fracture incidence among women ranges from 511 to 553 per 100,000, with a mean age at fracture around 82 years and a second-hip-fracture incidence of 2% to 10% over the subsequent years (on average about two years after the first), reinforcing the imperative for aggressive secondary prevention [12][19]. For an individual U.S. woman aged 50, the lifetime risk of hip fracture is approximately 17.5%, translating epidemiology into tangible personal risk [34]. Upper-extremity fragility fractures, especially distal radius (wrist) fractures, display distinct age patterns. In women, age-adjusted incidence climbs between ages 45 and 60 and then stabilizes, reflecting the early manifestation of fracture susceptibility relative to vertebral or hip fractures; wrist fractures thus often serve as an early warning sign of systemic skeletal fragility [International Osteoporosis Foundation-Epidemiology. In contrast, men account for a smaller share of wrist fractures (about 15%) and do not exhibit a comparable age-linked incidence rise [35]. In the U.S., over 326,000 wrist fractures occur annually, and a 50-year-old woman faces a lifetime risk of approximately 16% for a Colles' fracture, figures that justify wrist fracture as a key entry point for secondary prevention programs [36][37]. UK data parallel these trends: among individuals older than 50, the incidence of distal forearm fractures is about 39.7 per 10,000 person-years in women versus 8.9 per 10,000 person-years in men, quantifying the sex differential in a European context [15]. Unlike hip and vertebral fractures, distal forearm fractures are not consistently linked to increased mortality, though they do predict future fractures at other sites, making them critical markers for intervention [15].

Vertebral compression fractures are the most common osteoporotic fractures, yet they remain largely hidden in the epidemiologic record because only about one-third come to clinical attention; the remainder are discovered incidentally or not at all, which leads to underestimation in registries and claims data [38][19]. The presence of an existing vertebral fracture increases the risk of subsequent

fractures five-fold, illustrating potent risk amplification and the crucial importance of early detection [39]. Nearly one-quarter of postmenopausal women have at least one vertebral fracture, and radiographs reveal that about 55% of patients presenting with hip fracture already had evidence of a prior vertebral fracture, a fact that underscores missed opportunities for intervention before catastrophic events [39][40]. On a global clock, vertebral fractures from osteoporosis are estimated to occur roughly once every 22 seconds in adults aged 50 and older, emphasizing their ubiquity and the invisibility that cloaks much of their burden [41]. For a 65-year-old woman with one vertebral fracture, the probability of another fracture within five years is about 1 in 4, a risk that can be reduced to approximately 1 in 8 with effective treatment, translating evidence-based therapy into quantifiable prevention [42]. In the U.S., a White woman older than 50 faces a lifetime vertebral fracture risk near 16%, framing vertebral fracture epidemiology in practical terms for counseling and policy [43]. Longitudinal European data add nuance: the European Vertebral Osteoporosis Study observed higher vertebral deformity incidence in men before age 65, after which women predominate; the European Prospective Osteoporosis Study reported age-standardized vertebral fracture incidences of 10.7 per 1,000 person-years in women versus 5.7 per 1,000 person-years in men, while the Tromsø Study from Norway found vertebral fracture prevalence of 3% in women younger than 60 versus 19% in those older than 70, all of which collectively confirm powerful age and sex gradients in vertebral fragility [44][45]. Despite the disease's scope and the availability of effective therapies, a pervasive and persistent "treatment gap" undermines fracture prevention efforts. Defined as the difference between the number of patients who meet indications for therapy and the number who receive it, this gap is substantial across health systems. The International Osteoporosis Foundation documented a 73% treatment gap among women in France, Germany, Italy, Spain, and the UK, and estimated that, in 2019, approximately 15 million eligible European women were untreated, reflecting both system-level and patient-level barriers [14][21][16]. Care fragmentation after sentinel events is particularly concerning: up to 95% of patients discharged after hip fracture repair receive neither osteoporosis pharmacotherapy nor a structured management plan, with men being even less likely than women to receive treatment, indicating missed opportunities for secondary prevention at the highest-risk moment [21][46]. Persistence with therapy is another weak link; approximately 70% of patients discontinue pharmacologic treatment within the first year, eroding the long-term benefits that hinge on sustained adherence [47].

Screening deficits mirror treatment gaps. Less than one-third of patients with a fragility fracture undergo BMD testing or receive osteoporosis therapy, despite the predictive value of a prior fracture for subsequent events [48]. Among U.S. women older than 65 with a previous fragility fracture, about 91% remain unscreened for osteoporosis, illustrating a profound disconnect between risk and action [28]. Age-stratified data show that only about 21% of women aged 60–64, 27% aged 65–79, and 13% older than 80 undergo screening, reinforcing that many highest-risk individuals are least likely to be evaluated [49]. Following a new osteoporotic fracture, only about 9% of female Medicare fee-for-service beneficiaries receive BMD testing within six months, while broader 2012 data suggest that fewer than 10% of approximately two million Americans with 2.3 million osteoporotic fractures underwent BMD testing within six months of the index fracture—a gap accompanied by more than 300,000 second fractures within three years, quantifying the downstream consequences of under-screening [28][15]. Patient perceptions and health-seeking behaviors further shape epidemiology by influencing who gets diagnosed and treated. A U.S. survey of women with postmenopausal osteoporosis found that only 31% reported receiving follow-up or a referral after seeing a healthcare professional for a recent osteoporotic fracture, and roughly 35% were unaware that osteoporosis caused their fracture; nearly half attributed it to "clumsiness," reflecting a common tendency to misattribute low-trauma fractures to external mishaps rather than underlying bone fragility [49]. More than half were unaware that one osteoporotic fracture substantially elevates the risk of another, highlighting the need for more robust, standardized post-fracture education [49]. Even when follow-up occurred, patient refusal accounted for half of the cases in which therapy was not initiated; among those who began treatment, 27% reported taking a drug holiday or stopping medication, and 47% of those discontinuations occurred without medical advice, illustrating how adherence challenges blunt real-world effectiveness [49]. Across settings, up to 30% of patients do not start prescribed osteoporosis medications, and up to 70% discontinue by one year, underscoring persistence as a central epidemiologic modifier and a prime target for quality improvement [50][51].

Collectively, these data paint a coherent, if sobering, portrait of osteoporosis epidemiology: a highly prevalent, sex-skewed, age-dependent disease associated with immense fracture counts, substantial mortality and morbidity, and staggering costs that threaten the sustainability of health systems [11][14][15][16][21]. The specific fracture archetypes—hip, vertebral, and distal forearm—contribute distinct epidemiologic signatures; hip fractures dominate in cost and lethality, vertebral fractures in frequency and silent progression, and wrist fractures as early harbingers of systemic fragility [18][19][33][38]. Regional differences in prevalence and fracture incidence reflect underlying demographic profiles, BMD distributions, lifestyle factors, sun exposure and vitamin D status, nutrition, and case-finding practices [12][25][33]. Superimposed on these biological and system-level factors are inequities in screening and treatment that disproportionately affect racial and ethnic minorities and men after fracture, sharpening the focus on implementation gaps and structural determinants of bone health [12][22][28][29]. From a public health standpoint, the implications are clear. First, fracture-liaison services and post-fracture care pathways are essential to convert sentinel events into opportunities for secondary prevention, reducing the risk of second fractures that cluster in the years following the first [15][21][46]. Second, expanding risk-based screening—targeting women over 65, younger postmenopausal women with risk factors, and men with clinical risk profiles—can close the diagnostic gap that allows silent bone loss to progress unchecked [28][49]. Third, systematized fall-prevention programs addressing vision, medications, balance, strength, and environmental hazards align with GLOW's demonstration that falls precipitate the majority of fragility fractures, including a meaningful fraction of vertebral events [26]. Fourth, adherence interventions that encompass patient education, simplified dosing, pharmacist-led counseling, and feedback loops between primary and specialty care are likely to yield

substantial epidemiologic dividends by increasing persistence with effective therapies [47][49][50][51]. Finally, policy levers—reimbursement for DXA testing, quality metrics tied to post-fracture evaluation, and coverage continuity for evidence-based medicines—can help align incentives with outcomes and reduce the massive treatment gap documented across high-income health systems [14][16][21][28].

Pathophysiology

Bone is a dynamic tissue maintained by a tightly regulated coupling of formation and resorption, orchestrated principally by osteoblasts, which synthesize osteoid, and osteoclasts, which dissolve mineralized matrix; a third, numerically dominant cell, the osteocyte, integrates mechanical and hormonal signals to modulate this balance at the tissue level [52]. A central molecular axis governing this coupling is the RANKL/RANK/OPG triad. Osteoblast-lineage cells express receptor activator of nuclear factor κB ligand (RANKL), which binds the RANK receptor on osteoclast precursors to drive osteoclastogenesis and activate bone resorption [53]. Counterbalancing this, osteoprotegerin (OPG)—released from osteocytes—acts as a soluble decoy receptor that sequesters RANKL, thereby preventing RANK activation and suppressing osteoclast maturation (see Image. Role of RANKL/RANK/OPG Axis on Bone Homeostasis and Immune System) [53]. Osteoporosis emerges when this axis is persistently skewed toward resorption, whether by endocrine transitions, aging biology, or secondary insults, yielding net loss of mineralized tissue and microarchitectural integrity. Across the lifespan, bone mineral density (BMD) reflects two principal determinants: the peak bone mass achieved by early adulthood and the rate of subsequent decline [54]. In females, approximately half of peak bone mass accrues during adolescence, with consolidation into the third decade, at which point maximal skeletal mass and strength are realized [28][54]. Heritability is substantial—estimates suggest that 60% to 80% of peak bone mass is genetically predetermined—highlighting the profound influence of genetic architecture on adult skeletal reserve [19]. Notably, women begin adulthood from a lower baseline: peak bone mass in females averages about 10% below that of males, reflecting sex-specific differences in modeling and growth; consequently, women commence the downward slope of skeletal aging with less structural margin for loss [55]. Interventions that augment peak bone mass during growth confer outsized downstream benefit: modeling studies indicate that enhancing peak accrual in childhood and adolescence can cut adult fragility fracture risk nearly in half, an effect that underscores the long shadow of early-life skeletal health on geriatric outcomes [28].

Sex hormones shape not only the magnitude of peak bone mass but also the macro-geometry of bone. Compared with males, females exhibit less periosteal apposition and relatively more endocortical apposition, a pattern driven in part by estrogen's inhibitory effects on periosteal expansion; androgens, conversely, stimulate periosteal apposition, yielding wider bones in men with favorable mechanical leverage against bending forces [56]. These geometric differences, laid down during growth and modified across adulthood, partly explain sex-divergent fracture patterns and the heightened vulnerability of slender cortices in aging women [56][59]. Decline in bone mass begins insidiously for both sexes in the mid-third decade, but the tempo and microarchitectural signature of loss diverge. Women may lose up to 50% of trabecular bone and 35% of cortical bone over the lifespan, whereas men experience relatively greater trabecular thinning without the same degree of trabecular perforation and loss of connectivity that typifies female deterioration (see Image. Normal Versus Osteoporotic Bone) [7][59]. Prospective cohorts quantify the secular slope: the Dubbo Osteoporosis Epidemiological Study estimated annual femoral neck loss at ~0.96% for women—with accelerated decline between ages 65 and 69—and the Framingham Osteoporosis Study documented up to 4.8% four-year loss at the hip, lumbar spine, and radius, illuminating both site-specific and age-accelerated dynamics [57][58]. Because trabecular plates and rods contribute disproportionately to vertebral strength, perforation-driven connectivity loss in women translates into early vulnerability to vertebral compression fractures, even before substantial cortical thinning at appendicular sites becomes dominant [59]. The menopausal transition superimposes a powerful endocrine perturbation on this aging substrate. Menopause—cessation of menses for ≥1 year, with a U.S. mean age of 51 years—ushers in abrupt estrogen decline, a principal switch that accelerates remodeling imbalance [12]. Epidemiologically, longer life expectancy means women now spend over one-third of life postmenopausal, enlarging the window during which estrogen deprivation exerts skeletal effects [12]. Mechanistically, the accelerated phase of bone loss begins in the year preceding the final menstrual period and persists for roughly three years, characterized by an upsurge in RANKL-mediated osteoclast activity and a disproportionate assault on trabecular connectivity; this phase then transitions to a slower phase over the next 4 to 8 years, during which cortical porosity and endocortical resorption predominate as osteoblast number and formation rates decline with age [60][61]. Clinically, the steepest BMD decrement can reach ~5% in the first postmenopausal year, attenuating to ~1%–1.5% per year thereafter, with cumulative losses across the menopausal transition averaging 10%–12% at the spine and hip (roughly 1 T-score unit) [25][60]. Importantly, heterogeneity abounds: up to 20% of bone mass may be lost in the seven years around menopause in the faster-losing tail, and about one-quarter of postmenopausal women are "fast bone losers," a phenotype that calls for vigilant assessment and early intervention [60].

Body composition modifies these trajectories. Thin women tend to lose bone faster than those with higher body mass, likely reflecting differences in mechanical loading and aromatization-derived estrogen [19]. Over longer horizons, cumulative loss is substantial: by age 80, approximately 30% of peak bone mass can be gone, a structural attrition that maps onto an exponential rise in fragility events [19]. The translation from BMD decline to fracture risk is steeply nonlinear: a 10% reduction in hip BMD corresponds to an estimated 2.5-fold higher hip fracture risk, and a 10% decrement in vertebral BMD confers roughly 2-fold higher vertebral fracture risk, quantifying the clinical stakes of moderate densitometric changes [62]. Although estrogen deficiency is a dominant driver of trabecular loss, careful partitioning studies reveal that aging biology independently exerts a large effect. Between menopause and age 75, total body bone mineral loss approximates 22%, of which only ~7.75% is attributable to estrogen deprivation; the remainder (~13.3%) is due to age-related mechanisms such as osteoblast senescence, oxidative stress, microvascular rarefaction, and impaired calcium/vitamin D homeostasis [63]. Site-specific parsing is similar: at the femoral neck, about 5.3% of loss is linked to estrogen deficiency, while ~14% reflects aging processes, a

distribution that helps explain why hip fracture risk rises sharply even decades after the menopausal transition [63]. Together, these data underscore a two-engine model: an early, estrogen-linked acceleration predominantly affecting trabecular networks, and a later, aging-linked decline that elevates cortical porosity and compromises whole-bone strength [60][61][63]. Special physiologic states highlight the plasticity of bone remodeling and its systemic integration. Lactation-associated osteoporosis—though uncommon—illustrates a reversible, high-turnover state driven by the calcium demands of milk production [64]. During lactation, parathyroid hormone-related protein (PTHrP) secreted by mammary tissue rises, stimulating osteoclast-mediated resorption to mobilize calcium; in some women this endocrine milieu produces rapid, asymptomatic BMD declines and, rarely, hypercalcemia, with bone mass typically recovering during or after weaning [65]. Case reports document fractures in this window, yet larger cohorts suggest that a history of breastfeeding may be associated with lasting BMD benefits and a reduction in fracture risk later in life; similarly, preliminary data indicate that higher parity may correlate with lower fracture risk at the onset of menopause, potentially via cumulative bone accrual and post-weaning recovery cycles that re-equilibrate skeletal mass [64]. These observations reinforce the concept that bone is a calcium reservoir dynamically regulated by reproductive physiology, with remodeling set points that can shift in response to systemic demands and later re-normalize.

When these physiologic, genetic, and environmental forces push the RANKL/RANK/OPG system toward chronic resorption, microarchitecture deteriorates in a site-specific manner. In vertebrae rich in trabecular bone (≈75% trabecular:25% cortical), perforation and plate-to-rod transitions erode load-bearing connectivity, precipitating large stiffness losses for modest BMD declines; in the femoral neck, where composition approximates 30% trabecular:70% cortical, inexorable increases in cortical porosity and endosteal resorption undermine bending resistance and elevate hip fracture susceptibility with advancing age [7]. Superimposed contributors—from low vitamin D intake and reduced renal 1-α hydroxylation to sarcopenia and impaired balance—magnify applied loads at the moment of a fall, converting compromised bone strength into clinical fractures [25][58][59]. In aggregate, the pathophysiology of osteoporosis in females is best conceived as multifactorial remodeling imbalance: an early, hormone-triggered acceleration in resorption and connectivity loss; a lifelong, aging-linked decline in formation and cortical integrity; and episodic physiologic states (e.g., lactation) that transiently re-prioritize calcium economy, all converging on the RANKL/RANK/OPG axis and the cellular choreography of osteoblasts, osteoclasts, and osteocytes [52][53][60][61][63][64][65].

Histopathology

Histopathologic examination in osteoporosis serves as a specialized diagnostic adjunct rather than a routine tool. In standard clinical practice, bone biopsy is reserved for atypical or diagnostically ambiguous presentations where secondary or metabolic bone disorders are suspected and clarification would alter management [66]. These situations may include cases with unexpectedly severe bone loss, non-responsiveness to standard antiresorptive or anabolic therapy, or biochemical abnormalities suggesting concurrent conditions such as mastocytosis, multiple myeloma, osteomalacia, or renal osteodystrophy. The biopsy not only assists in ruling out these mimicking entities but also offers quantitative insight into the rate of bone formation and resorption, thereby providing a dynamic view of skeletal metabolism that static imaging such as dual-energy X-ray absorptiometry (DXA) cannot capture [66][67]. The standard technique employed is the transiliac bone biopsy, as the iliac crest offers both accessibility and reliable representation of systemic skeletal metabolism. A key methodological refinement is double tetracycline labeling, which allows measurement of dynamic bone formation. Tetracycline, a fluorescent antibiotic that chelates calcium and binds avidly to sites of new mineral deposition, is administered orally to the patient in two separate courses approximately two weeks apart [67]. Under ultraviolet light microscopy, each course of tetracycline produces a distinct linear fluorescent band along mineralizing bone surfaces. The distance between these two fluorescent labels represents the quantity of bone formed during the inter-label interval; by dividing this distance by the time elapsed, investigators calculate the mineral apposition rate (MAR), a quantitative index of osteoblastic activity and bone formation velocity [67].

This technique is fundamental to understanding turnover dynamics. In osteoporosis, biopsy typically demonstrates low bone volume and thin trabeculae, reflecting the chronic imbalance between resorption and formation. The trabecular network shows generalized thinning, reduced connectivity, and multiple perforations, signifying the architectural disintegration responsible for reduced mechanical strength [68]. The trabecular plates are often converted into slender rods, decreasing load-bearing capacity, and the wall width, or thickness of newly formed bone packets, is diminished, indicating suppressed osteoblastic formation. Cortical bone may reveal porosity enlargement due to increased endosteal resorption, consistent with the progressive fragility observed clinically. Histomorphometric analysis further distinguishes high-turnover from low-turnover forms of osteoporosis, which has therapeutic implications. In postmenopausal osteoporosis, the hallmark finding is increased activation frequency—that is, more remodeling units initiated per unit time—reflecting estrogen deficiency's permissive effect on osteoclastogenesis via the RANKL pathway. Osteoclast surfaces appear expanded, and resorption cavities are more numerous and deeper than normal, while osteoblast-lined surfaces are reduced, signifying incomplete refilling of remodeling units. The trabecular packet thickness is reduced, and bone formation rate is modestly elevated but insufficient to compensate for the heightened resorption. In contrast, in senile osteoporosis, biopsy reveals low bone turnover with fewer active remodeling sites, decreased osteoblast numbers, and thin trabecular packets, mirroring age-related declines in cellular recruitment and differentiation [67][68].

Importantly, the histologic spectrum of osteoporosis must be differentiated from that of other metabolic bone diseases. For instance, osteomalacia is characterized by widened unmineralized osteoid seams and delayed mineralization lag time, features absent in pure osteoporosis. Hyperparathyroid bone disease exhibits increased osteoclastic resorption and trabecular tunneling with fibrous marrow replacement, while Paget disease shows mosaic lamellar patterns and disorganized cement lines. Similarly, myeloma or metastatic infiltration reveals replacement of normal marrow fat by malignant cells, a feature easily identified on biopsy but radiographically confounding. Therefore, histopathology remains

indispensable when clinical, biochemical, or imaging findings suggest mixed or secondary pathology [66][67]. Biopsy-based evaluation can also be applied longitudinally to assess treatment response. Repeat biopsies after antiresorptive therapy, such as bisphosphonates or denosumab, typically show reduced osteoclast surface area, decreased resorption lacunae, and slower mineral apposition rates, whereas anabolic therapy with agents like teriparatide produces thicker trabeculae, increased double labeling, and elevated MAR values [67]. However, excessive suppression of remodeling—seen in long-term potent antiresorptive therapy—may lead to adynamic bone, characterized by nearly absent double labels and very low bone formation rates, an important observation that informs duration-of-therapy decisions.

History and Physical — Summary (≈500 words, citations preserved)

A meticulous clinical history anchors accurate diagnosis, risk stratification, and individualized management of osteoporosis. Age is among the strongest independent predictors of fracture, beyond its association with declining bone mass. With advancing age, cortical porosity rises markedly—by an estimated 176% to 259% from ages 20 to 90—contributing to skeletal fragility [70]. Notably, at the same BMD, a 20-year age increase multiplies overall fracture risk roughly fourfold and raises femoral neck fracture risk tenfold, underscoring the primacy of age as a risk modifier [71][59]. The burden in long-term care settings highlights this gradient: approximately 85% of female nursing-home residents older than 80 carry a diagnosis of osteoporosis [69]. Fracture history is equally pivotal; a prior low-trauma fracture after menopause confers an average twofold excess risk for subsequent fractures that peaks in the first two years yet persists for up to a decade. Mechanism matters—differentiating fragility events from high-energy trauma—and the involved skeletal site informs prognosis and secondary prevention planning [19][72]. Family history adds predictive weight. About 20% of U.S. women with osteoporosis report an affected relative, and risk is greatest with two or more affected family members; maternal hip fracture particularly elevates a woman's hip fracture risk. Accordingly, guidelines recommend explicit inquiry about parental hip fractures during assessment [73][74]. Functional status and strength require routine attention because sarcopenia drives falls: beginning in the fourth decade, 3% to 5% of muscle mass is lost per decade, accelerating by 1% to 2% annually after age 50 [75]. Women experience more falls than men and are more likely to fracture after a fall, so systematic fall history and home-hazard review are essential components of care and counseling [76].

A review of comorbid conditions should screen broadly for secondary causes across gastrointestinal, endocrine, hematologic, rheumatologic, pulmonary, renal, and hepatic systems (see Table. Risk Factors for Secondary Osteoporosis). Medication reconciliation at each encounter is mandatory because many agents diminish BMD, hinder healing, weaken muscle, or increase fall risk through sedation or orthostasis; in older adults, the Beers Criteria provide a useful framework to minimize iatrogenic contributors [77]. Social history nuances risk: cigarette smoking depletes BMD directly and indirectly via lower estrogen and earlier menopause; alcohol intake beyond two daily units in women (three in men) compromises bone and increases falls through central nervous system depression; and exposure to exogenous anabolic steroids or opioids can induce hypogonadism and fracture susceptibility. Habitual physical activity, occupational loading, sunlight exposure (as a proxy for vitamin D), and dietary history (daily calcium and vitamin D intake and any restrictive patterns or supplementation) complete the risk profile [19]. The physical examination refines risk estimation and may reveal secondary etiologies. Serial height measurements can unmask occult vertebral compression; a loss of ≥1.5 inches warrants vertebral imaging. Progressive collapse may manifest as thoracic kyphosis—the classic "Dowager's hump" [19][78]. Low body weight (e.g., <127 lb or BMI <21 kg/m² in older U.S. women) signals increased risk for low BMD and fractures [19]. At every visit, assess gait, balance, and lower-extremity strength to estimate imminent fall risk and to triage patients for targeted exercise or physical therapy. Signs of malnutrition—hair/nail changes, sarcopenia, dry skin, menstrual irregularity, low BMI—flag diminished bone health. Focused endocrine findings may expose reversible secondary causes: features of hormonal excess such as hyperthyroidism (goiter, tremor, exophthalmos, tachycardia) or Cushing syndrome (moon facies, dorsocervical fat pad, violaceous striae), and signs of hormonal deficiency (hypogonadism or menopausal changes) guide laboratory evaluation and treatment timing. An oral examination at baseline is recommended when planning antiresorptive therapy (bisphosphonates or denosumab), both to document dental health and to mitigate the small risk of osteonecrosis of the jaw through preventive dental care and hygiene optimization [74]. Synthesizing these domains—age and prior fracture, family predisposition, sarcopenia and fall risk, comorbidities and medications, lifestyle and nutrition, and corroborating physical signs—yields a comprehensive, patient-specific risk portrait that directly informs decisions on imaging, laboratory evaluation for secondary osteoporosis, fall-prevention strategies, nutrition optimization, and initiation of evidence-based pharmacotherapy [19][69][70][71][72][73][74][75][76][77][78].

Evaluation

Evaluating osteoporosis in females requires an integrated approach that synthesizes clinical risk factors, structured history taking, targeted examination, and judicious use of diagnostic technologies. Early identification is pivotal because fracture risk accumulates silently until a low-trauma event occurs; timely case finding allows initiation of effective, guideline-concordant therapy and secondary prevention. Osteoporosis was defined in 1993 by the World Health Organization (WHO) as a systemic skeletal disease characterized by low bone mass and microarchitectural deterioration that increase fragility and fracture susceptibility [79]. In 1994, the WHO operationalized a radiologic definition based on dual-energy x-ray absorptiometry (DEXA), specifying osteoporosis as a T-score ≤ −2.5 SD at the lumbar spine, femoral neck, total hip, or distal one-third (33%) radius relative to young adult women [32]. The nosology has since expanded to include patients with fragility fractures of the hip or spine irrespective of bone mineral density (BMD), acknowledging that many fractures in postmenopausal women occur without a densitometric diagnosis of osteoporosis [International Osteoporosis Foundation - Epidemiology of osteoporosis and fragility fractures. 2024. WHO BMD categories are as follows: normal (≥ −1.0 SD), osteopenia (−1.0 to −2.5 SD), and osteoporosis (≤ −2.5 SD) [80]. WHO also designates "severe" or established osteoporosis as a T-score ≤ −2.5 SD plus one or more fragility fractures [81]. Because the

osteopenic range contains far more individuals, absolute fracture counts are greater in this group despite their lower per-person risk; accordingly, several societies permit diagnosing osteoporosis within the T-score range −1.0 to −2.5 SD when fracture risk is elevated by validated tools using country-specific thresholds, or when fragility fractures involve the proximal humerus, pelvis, or distal forearm [20][74]. The Study of Osteoporotic Fractures (SOF) further validated DEXA as a predictor of incident fractures over three decades of follow-up, anchoring densitometry in routine risk assessment [82].

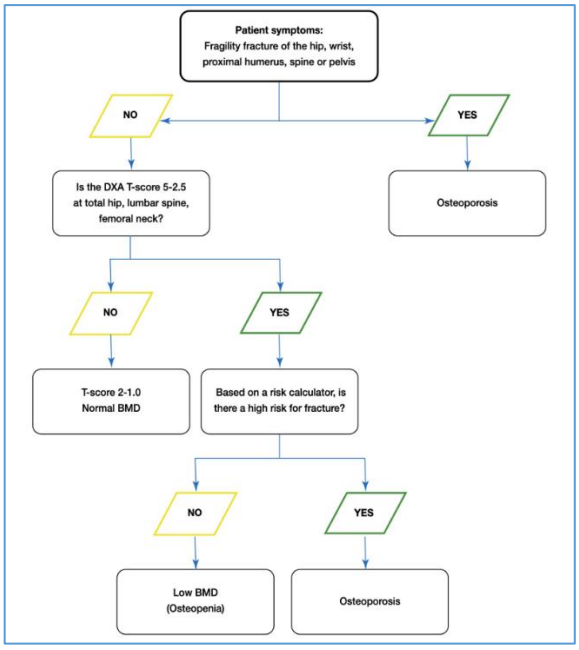

Figure-2: Diagnosis of osteoporosis.

Interpretation must be tailored to age and context. The T-score compares a patient to a young adult reference population and is the standard for postmenopausal women and men ≥50 years; the Z-score compares to age-matched peers, with Z ≤ −2.0 SD considered below expectations for age and prompting evaluation for secondary causes [20]. The International Society for Clinical Densitometry advises using WHO T-score criteria for postmenopausal women and men aged ≥50, but not for those younger than 50 years [83]. BMD is among the strongest fracture predictors across sites, and decrements at one skeletal site predict fractures elsewhere. A 1 SD decrease confers the following approximate relative risks: for the lumbar spine, 1.7 for all fractures, 2.3 for vertebral, 1.6 for hip, and 1.5 for forearm; for the femoral neck, 1.6 for all fractures, 2.6 for hip, 1.8 for vertebral, and 1.4 for forearm; and for the distal radius, 1.4 for all fractures, 1.7 for forearm, 1.7 for vertebral, and 1.8 for hip [84]. Site selection matters. The North American Menopause Society notes the strongest correlation between BMD and fracture risk at the hip, whereas the spine—though more sensitive to treatment-related change—is susceptible to artifact from aortic calcification and osteophytes [19]. When neither hip nor spine is evaluable, the 33% radius is acceptable and preferred in primary hyperparathyroidism [19]. Measuring at two central sites can generate T-score discordance without improving prediction; each unit of discordance shifts fracture risk by roughly 10% [85][17].

Screening strategies combine age-based and risk-based triggers. The Bone Health and Osteoporosis Foundation, the American Association of Clinical Endocrinologists (AACE), and the U.S. Preventive Services Task Force (USPSTF) recommend DEXA for all women aged ≥65 years, typically at intervals no more frequent than every 1–2 years [28][74]. NAMS further supports testing in women ≥50 years with additional risk factors, in those discontinuing estrogen with other fracture risks, and in anyone with a postmenopausal fracture or a known medical cause of bone loss [19]. In 2025, the USPSTF issued a Grade B recommendation to screen females younger than 65 with one or more risk factors, reflecting the value of targeted earlier case finding [86]. Risk triage tools assist selection: the Osteoporosis Self-Assessment Tool uses age and weight to identify likely low BMD in younger postmenopausal women [19]. More broadly, the FRAX algorithm—endorsed by AACE, the Endocrine Society, and the American Society for Bone and Mineral Research—estimates 10-year major osteoporotic and hip fracture probabilities using clinical risks with or without femoral neck BMD [87][74][20]. FRAX limitations include omission of falls, inability to model dose and duration for corticosteroids, alcohol, and tobacco, lack of explicit diabetes modeling, and potential underestimation when spine and femoral neck BMD are discordant or when pharmacotherapy is current or prior [19]. As an illustration, a 65-year-old White woman with BMI 25 kg/m² and no clinical risk factors, without BMD input, has an estimated 10-year risk of 9.3% for major osteoporotic fracture and 1.3% for hip fracture; while the USPSTF does not advocate strict treatment thresholds based on FRAX alone, these probabilities inform the decision to obtain DEXA [86]. For pharmacologic treatment decisions, many guidelines consider initiation reasonable when the 10-year hip fracture risk is ≥3% or the major osteoporotic fracture risk is ≥20%.

Laboratory evaluation complements imaging by uncovering secondary contributors. AACE recommends a baseline complete blood count; comprehensive metabolic panel including calcium, phosphate, protein, albumin, alkaline phosphatase, liver enzymes, creatinine, and electrolytes; serum 25-hydroxy-vitamin D; and 24-hour urine for calcium, sodium, and creatinine to screen for malabsorption and hypercalciuria [74]. Based on clinical suspicion, further testing may include thyroid-stimulating hormone, intact parathyroid hormone, serum protein electrophoresis with free light chains, celiac evaluation by intestinal biopsy, 24-hour urinary free cortisol, serum tryptase or urine N-methylhistidine for mastocytosis, rheumatoid factor, gonadotropins and prolactin for hypogonadism, selected skin biopsies for connective tissue disorders, and genetic testing such as COL1A variants in suspected osteogenesis imperfecta [20]. Bone turnover markers can refine risk and monitor therapy; the International Federation of Clinical Chemistry recommends serum P1NP as a reference formation marker and CTX-1 as a reference resorption marker [88]. Elevated turnover portends faster bone loss and higher fracture risk and may forecast response to antiresorptives [74].

Beyond DEXA, adjunctive technologies address limitations in cortical-trabecular discrimination and geometry. Trabecular bone score, derived from lumbar spine DEXA textures, does not diagnose osteoporosis or direct therapy but can enhance fracture prediction, particularly when integrated with FRAX [74]. Vertebral fracture assessment, accomplished via lateral spine radiographs or lateral spine DEXA, detects morphometric fractures at low dose and cost; societies recommend its use in women with T-score ≤ −1.0 accompanied by age ≥70, height loss ≥4 cm, self-reported prior vertebral fracture, or prolonged

prednisone therapy ≥5 mg daily for ≥3 months [17][91]. Peripheral DEXA at the calcaneus, finger, or forearm is portable but hampered by technical variability and nonstandardized T-score references, limiting its role in diagnosis and risk stratification [92]. Quantitative heel ultrasound measures stiffness, not BMD, is radiation-free and convenient, but cannot diagnose osteoporosis, monitor therapy, or demonstrably reduce fracture risk [92]. Quantitative computed tomography provides volumetric density and separates cortical from trabecular compartments, can identify fractures and healing, and helps evaluate metastases; however, despite costs similar to DEXA, it entails higher radiation and is not used to diagnose osteoporosis, though it can aid prediction and monitoring when central DEXA is unavailable [20][92][The International Society For Clinical Densitometry, 2019. Emerging structural assessments such as hip structural analysis from DEXA geometry and finite element analysis from CT or DEXA estimate strength and simulate loads but currently remain adjunctive or research tools without roles in routine diagnosis or treatment decisions [93][94]. Novel ultrasound-based techniques including radiofrequency echographic multispectrometry at axial sites and pulse-echo ultrasonography for cortical thickness offer nonionizing assessments of bone properties, but their roles are still being defined relative to established standards [95][96]. Together, these elements provide a coherent pathway from risk identification to confirmatory testing and targeted evaluation of secondary causes, enabling timely, precise interventions that reduce fracture burden.

Treatment / Management

Regardless of improvement in the T-score, the diagnosis of osteoporosis persists once established, so management should pair durable risk reduction with ongoing surveillance and reinforcement of lifestyle foundations [74]. Nonpharmacological therapy begins with counseling on alcohol, tobacco, nutrition, exercise, and fall prevention, as these behaviors both modulate bone remodeling and determine real-world fracture risk. The AACE advises postmenopausal women to limit alcohol consumption to no more than two units daily; intake exceeding three units per day is associated with a 38% higher rate of major osteoporotic fractures and a 68% higher rate of hip fractures, though cohort data such as EPIDOS have observed a protective association with moderate drinking and higher trochanteric BMD in older women, emphasizing dose–response nuance [19][97]. Smoking cessation is essential: women who smoke have lower BMD and approximately 30% higher fracture risk that is independent of BMD; cessation favorably shifts bone turnover, with increases in formation markers such as osteocalcin and observable gains in BMD over time [19][98][99]. Physical activity is a lifelong prescription because skeletal adaptations are slow—roughly one remodeling cycle takes four months—and benefits are lost with deconditioning; weight-bearing, balance, and strengthening programs practiced most days of the week improve BMD, muscle power, and postural stability, thereby reducing falls and fractures, with supportive evidence from EFOPS, EPOS, and LIFTMOR demonstrating fracture risk reduction and BMD gains with sustained training [21][38][100][101][102][103]. Diet should ensure adequate protein—particularly in sarcopenic or post-fracture patients where higher protein supports functional recovery—and baseline calcium sufficiency from dairy and fortified foods [104]. Most societies recommend approximately 1200 mg/day of elemental calcium for women over 50, prioritizing dietary sources and reserving supplements for intakes <800 mg/day; cardiovascular safety data are mixed, but the National Osteoporosis Foundation considers daily intakes up to 2000–2500 mg safe from a cardiovascular standpoint [17][74][105][106]. Vitamin D should be maintained at serum 25-hydroxy-vitamin D ≥30 ng/mL, usually with 1000–2000 IU/day of cholecalciferol, recognizing that higher doses may be required in obesity or malabsorption; evidence is inconsistent for using vitamin D alone to prevent falls or fractures, and the USPSTF does not recommend supplementation solely for fall prevention, though concomitant calcium and vitamin D are typically provided in pharmacotherapy trials and recommended alongside bone-protective medications [74][107][108][17]. Other nutraceuticals, including probiotics, magnesium, vitamin K1, and phytoestrogens, are not recommended given insufficient evidence, while excessive vitamin A may harm bone; caffeine intake is best limited because of observational links to reduced calcium absorption and higher fracture rates [19][74][109]. For patients with gait impairment or recurrent falls, assistive devices and hip protectors may lower injury risk, and clinicians should offer structured fall-prevention counseling and physical therapy when appropriate [74].

Pharmacologic therapy aims to reduce incident fractures and should be layered on lifestyle measures. The AACE recommends treatment for women with low BMD plus prior fragility fracture of the hip or spine; those with T-scores ≤ −2.5 at the total hip, femoral neck, or one-third radius; or those with osteopenia (−1.0 to −2.5) and elevated FRAX probabilities (≥20% for major osteoporotic fracture or ≥3% for hip fracture). Therapy can also be considered after recent fracture, fracture on therapy, multiple fractures, exposure to skeletal-harming medications, or other high-risk scenarios [74]. Many agents are approved for “prevention” or “treatment,” and indications, dosing, and labeling differ; calcium and vitamin D are standard adjuncts across regimens [110][19]. Bisphosphonates remain first-line antiresorptives for most women not at very high risk. Oral alendronate (5–10 mg daily or 35–70 mg weekly) improves BMD and reduces vertebral, hip, and nonvertebral fractures, with evidence from FIT, FLEX, and FOSIT; risedronate (5 mg daily, 35 mg weekly, or 150 mg monthly) is similarly effective and available in a delayed-release formulation; ibandronate (2.5 mg daily or 150 mg monthly orally, or 3 mg IV quarterly) reduces vertebral but not hip or nonvertebral fractures; and IV zoledronic acid (5 mg yearly for treatment, 5 mg every two years for prevention) reduces vertebral, hip, and nonvertebral fractures in HORIZON and related trials [74][38][111][112][113][114][115][116][117][118][119][120][121][122][123][124][125][126][127][128][129].

Nitrogen-containing bisphosphonates inhibit farnesyl pyrophosphate synthase, suppressing osteoclast function at remodeling sites; their skeletal half-life is long, so effects persist after cessation, enabling later “drug holidays” in selected patients [38][74][130]. Oral bioavailability is <3% fasting, and administration requires strict fasting and upright posture to minimize esophageal irritation; IV routes are preferred for malabsorption, esophageal disease, or adherence barriers [74][110]. All patients should have vitamin D repletion before initiation to mitigate hypocalcemia risk, and renal thresholds apply (e.g., avoid risedronate/ibandronate if eGFR <30 mL/min and alendronate/zoledronic acid if <35 mL/min) [74]. Acute-phase reactions can follow first-dose IV zoledronic acid, and signals for atrial fibrillation have been inconsistent; rare adverse events include uveitis, atypical femoral fractures,

and osteonecrosis of the jaw, necessitating dental assessment and counseling. Despite proven efficacy, about half of patients discontinue therapy within a year, underscoring the need for adherence support [74][131][132][17][38].

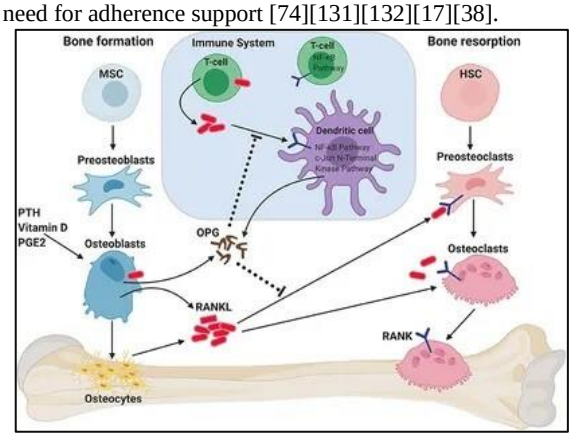

Figure-3: Role of RANKL/RANK/OPG Axis on Bone Homeostasis and Immune System.

Denosumab, a monoclonal antibody to RANKL, is administered 60 mg subcutaneously every six months and reduces vertebral, hip, and nonvertebral fractures as shown in FREEDOM and DANCE; it is useful in renal impairment and in women on aromatase inhibitors or glucocorticoids [133][134][135][137]. Transitioning from bisphosphonates to denosumab can produce further BMD gains, but abrupt discontinuation causes rapid bone loss and rebound multiple vertebral fractures, especially after longer exposure or in those with prior vertebral fractures; therefore, an antiresorptive—preferably a bisphosphonate such as alendronate or zoledronic acid—must immediately follow discontinuation [136][133][138][139]. Long-term risks overlap with bisphosphonates (rare osteonecrosis of the jaw, atypical femoral fractures) and include cutaneous infections, so monitoring and dental care remain prudent [74][133]. Selective estrogen receptor modulators provide vertebral fracture protection with particular niches. Raloxifene 60 mg daily reduces vertebral but not hip fractures (MORE, CORE, STAR), may worsen vasomotor symptoms, and carries venous thromboembolism and stroke risks, but has the unique advantage of reducing invasive breast cancer in high-risk women; benefits dissipate within one to two years of discontinuation [74][110][142][143][144][145][146]. Bazedoxifene is available in combination with conjugated estrogens for women with a uterus requiring vasomotor symptom control and bone-loss prevention; gains are chiefly vertebral, with risks of leg cramps and thrombosis and unknown effect on breast cancer prevention [19][110][140][141]. Menopausal hormone therapy, in appropriately selected younger postmenopausal women near the menopausal transition with vasomotor symptoms and low vascular/thrombotic risk, improves BMD and lowers vertebral, hip, and nonvertebral fractures (WHI, PEPI, KEEPS); however, risks necessitate the lowest effective dose for the shortest duration, with progestin added if the uterus is intact, and benefits dissipate quickly after cessation [38][149][150][151][152][74][110][60][148].

Calcitonin retains a limited role for short-term analgesia in acute painful vertebral fractures and for lowering serum calcium; fracture-reduction efficacy is restricted to vertebral sites with nasal formulations, and regulatory agencies have raised malignancy concerns, prompting individualized risk–benefit discussions [38][74][157][158][159][160][110]. Strontium ranelate and tibolone are not available in the U.S.; both showed fracture benefits in trials but were limited by safety concerns or regulatory status [19][153][154][155][156]. For women at very high risk—for example, recent fractures, multiple fractures, very low T-scores, high fall propensity, or high FRAX probabilities—an osteoanabolic-first strategy is preferred, followed by an antiresorptive to preserve gains [74]. Teriparatide (PTH 1-34) and abaloparatide (PTHrP analog) are daily subcutaneous agents that increase trabecular and endocortical formation, reduce vertebral and nonvertebral fractures, and require antiresorptive consolidation after completion; teriparatide may be extended beyond two years in select patients, whereas abaloparatide remains limited to two years, with hypercalcemia generally milder for abaloparatide [19][74][162][163][165][166][167][168][169][170][171][172][173][174][175]. Romosozumab, a sclerostin-inhibiting monoclonal antibody with dual anabolic and antiresorptive effects, is given monthly for up to one year and reduces vertebral, hip, and nonvertebral fractures (FRAME, ARCH, STRUCTURE); because of a signal for higher rates of myocardial infarction and stroke in ARCH relative to alendronate, it is contraindicated in women with prior such events, and must be followed by an antiresorptive when the course ends [74][176][177][178][179][180]. Procedural options such as vertebroplasty or kyphoplasty are reserved for carefully selected cases of persistent, severe pain after vertebral fractures, given mixed evidence for benefit and concerns about adjacent-level fractures and cement complications; several societies advise caution or avoidance, recommending optimized analgesia and rehabilitation first [17][74][181]. A local osteo-enhancement procedure for the femoral neck is investigational and not standard of care [17].

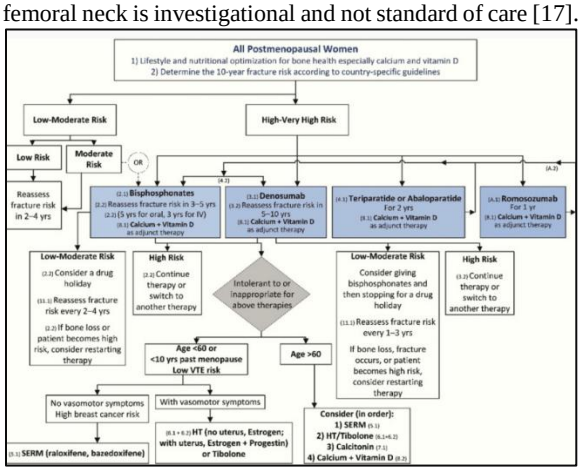

Figure-4: Nutritional Management of Osteoporosis.

Treatment sequencing and duration should reflect baseline risk and response. Many guidelines recommend an oral bisphosphonate as first-line for high-risk (but not very high-risk) women, with IV zoledronic acid favored after hip fracture in some pathways; denosumab is an alternative when bisphosphonates are contraindicated or poorly tolerated [182]. In very high-risk women, begin with teriparatide, abaloparatide, or romosozumab, then transition to a bisphosphonate or denosumab to maintain gains, with site-specific efficacy guiding selection (e.g., romosozumab when hip protection is paramount) [74]. Routine combination therapy is not recommended due to cost, adverse effects, and limited fracture-reduction data, though selected scenarios—such as adding a bisphosphonate or denosumab to ongoing raloxifene for breast cancer risk reduction—may be considered [74]. Glucocorticoid-induced

osteoporosis merits proactive assessment and early antiresorptive therapy, typically a bisphosphonate, with denosumab or teriparatide as alternatives in higher-risk patients [185][186]. Monitoring focuses on adherence, densitometric stability, and turnover suppression or formation response. The AACE defines success as stable or rising BMD without incident fractures; a single fracture does not, by itself, prove failure, but two or more fractures should prompt evaluation for adherence, malabsorption, or secondary causes [74]. DEXA is typically repeated every 1–2 years until stable, then at longer intervals; during bisphosphonate therapy, reassessment at five years (oral) or three years (IV) informs a potential drug holiday in lower-risk women, with earlier resumption if BMD falls or bone turnover markers rise [111][110]. Non-bisphosphonate antiresorptives do not allow holidays; denosumab discontinuation must be bridged with a bisphosphonate to prevent rebound vertebral fractures, a vulnerability highlighted during pandemic-related care interruptions [74]. Bone turnover markers, especially serum CTX (resorption) and P1NP (formation), change within 3–6 months and help detect adherence problems, gauge biologic effect relative to least significant change, and guide timing of holidays or switches; typical least significant change thresholds are ~56% for CTX and ~38% for P1NP, and up to 90% of women demonstrate a favorable biochemical response to oral bisphosphonates by 12 weeks [74][110][187]. Collectively, a structured blend of lifestyle optimization, targeted pharmacotherapy, careful sequencing, and data-driven monitoring yields the most durable fracture risk reduction while minimizing adverse effects and treatment fatigue [17][19][21][74][110].

Enhancing Healthcare Team Outcomes

Optimizing outcomes in osteoporosis depends on a deliberately coordinated, role-clear model that integrates nursing, epidemiology, family medicine, clinical laboratory services, social care, and physiotherapy. Each discipline brings a complementary lens—education and adherence, population surveillance, primary-care risk stratification, analytic confirmation, social-determinant mitigation, and functional restoration—that, when synchronized, transforms episodic fracture care into continuous fracture prevention. Nursing is the operational backbone of osteoporosis programs, translating guidelines into daily behaviors that actually reduce fractures. Nurses standardize intake screening for age, prior fragility fracture, glucocorticoid exposure, low BMI, tobacco and alcohol use, falls, and functional limitations, ensuring that risk factors are captured consistently at every visit. They deliver structured education on calcium and protein intake, vitamin D sufficiency, medication administration for agents with complex instructions, and home safety modifications that reduce fall hazards. In fracture liaison services, nurse coordinators identify eligible patients from radiology and inpatient lists, arrange dual-energy x-ray absorptiometry when indicated, close care loops after discharge, and deploy reminder systems to improve persistence with antiresorptive or anabolic therapy. Critically, nurses monitor for early adverse effects, triage red flags such as jaw pain or thigh discomfort, and escalate promptly, thereby improving safety while sustaining adherence. Epidemiologists extend this clinical work to the population level, building registries and dashboards that quantify screening rates, treatment gaps, time-to-therapy after fracture, and re-fracture incidence. They develop and validate risk-prediction pathways tailored to local demographics, calibrating tools such as FRAX with region-specific fracture data. Through interrupted time-series and cohort designs, epidemiologists evaluate the impact of interventions—post-fracture pathways, pharmacist counseling, telehealth follow-up—on real-world outcomes and costs. They also lead equity audits that surface racial, ethnic, and socioeconomic disparities in DEXA access, initiation of therapy, and persistence, informing targeted improvement projects and culturally responsive education materials. Their implementation science expertise helps convert evidence into sustainable workflows with audit-and-feedback cycles, reducing unwarranted variation across clinics and hospitals.

Family medicine clinicians are the gateway to case finding and longitudinal management. They weave opportunistic screening into routine visits, apply age- and risk-based criteria for DEXA, and interpret T- and Z-scores in the context of comorbidities and medications. Family physicians deprescribe agents that harm bone, manage multimorbidity that amplifies fracture risk—diabetes, COPD, chronic kidney disease—optimize nutrition and physical activity, and coordinate vaccinations and vision care that indirectly reduce falls. After any low-trauma fracture, they initiate secondary prevention, reconcile discharge plans, ensure timely initiation of antiresorptive or anabolic therapy, and schedule follow-up for bone turnover markers and densitometry. In perimenopausal and early postmenopausal women, they align management of vasomotor symptoms with bone protection, discussing benefits and risks of selective estrogen receptor modulators or menopausal hormone therapy where appropriate. Clinical laboratory professionals ensure analytic precision that underpins diagnosis and monitoring. They maintain quality systems for serum 25-hydroxy-vitamin D, calcium, phosphate, alkaline phosphatase, creatinine, and albumin, and they standardize preanalytical variables that can confound results. For secondary osteoporosis workups, laboratories validate intact parathyroid hormone, thyroid-stimulating hormone, serum protein electrophoresis with free light chains, and celiac serology, and they provide clear interpretive comments and reflex pathways when patterns suggest hyperparathyroidism, malabsorption, or monoclonal gammopathy. For monitoring, labs harmonize bone turnover markers—P1NP for formation and CTX for resorption—using traceable methods and biologic-variability–based least significant change thresholds so clinicians can distinguish true treatment effects from noise. By integrating decision support into reports, laboratory medicine accelerates accurate diagnosis and timely therapeutic adjustments.

Social care specialists address the nonmedical barriers that often determine whether evidence translates into outcomes. They assess food security to sustain adequate protein and calcium intake, arrange transportation for DEXA and infusion visits, and link patients to community resources for home safety modifications, including grab bars, improved lighting, and stair support. Social workers screen for depression, isolation, or intimate partner violence—factors that increase fall risk and reduce adherence—and facilitate benefits enrollment that offsets costs of medications and supplements. In multicultural settings, they tailor education to language and health literacy, recruit family caregivers into medication routines and exercise plans, and coordinate with community centers to provide fall-prevention classes such as tai chi. Their advocacy narrows the treatment gap by ensuring that high-risk patients actually access and continue therapy. Physiotherapists convert risk stratification into functional resilience. They

perform gait, balance, and strength assessments; prescribe progressive resistance training to increase hip and back extensor strength; and implement balance and perturbation training that reduces falls. After vertebral compression or hip fracture, they lead early mobilization, posture training to reduce kyphosis and pain, safe transfer techniques, and graded weight-bearing, while educating patients on spine-sparing strategies for daily tasks. Physiotherapists tailor programs for sarcopenia, integrate impact or hopping drills where safe to stimulate bone, and measure outcomes such as Timed Up and Go, single-leg stance, and five-times-sit-to-stand to document functional gains. Collaboration with nursing and family medicine ensures exercise prescriptions are synchronized with analgesia, vitamin D repletion, and pharmacologic therapy, maximizing adherence and minimizing fear of movement. When these disciplines operate as a single system, care becomes both faster and safer. A nurse-led fracture liaison service flags fractures in real time; family medicine confirms secondary prevention and orders labs; the laboratory returns standardized, interpretable results; the physiotherapist initiates mobility and fall-prevention therapy; the social specialist removes logistical and financial barriers; and the epidemiology team tracks performance and equity, feeding back actionable metrics to the front line. Clear referral criteria, shared order sets, and concise patient education materials maintain coherence across settings. Ethical practice—centered on informed consent, shared decision-making, and the intentional correction of screening and treatment disparities—anchors the model. The result is fewer missed diagnoses, shorter time-to-therapy after fractures, better adherence and persistence, lower re-fracture rates, and improved quality of life at lower overall cost.

Conclusion:

In conclusion, osteoporosis in females is a pervasive and debilitating condition whose silent progression culminates in fragility fractures, carrying severe consequences for mortality, morbidity, and quality of life. Its pathophysiology, driven by estrogen deficiency and aging, underscores the necessity for proactive, lifelong management strategies that begin with maximizing peak bone mass and continue through the postmenopausal years. Despite the availability of effective diagnostic tools like DXA and FRAX, and a robust arsenal of pharmacological agents ranging from antiresorptives to anabolic, significant gaps in screening, diagnosis, and treatment adherence persist. Overcoming these challenges requires a fundamental shift from a reactive, fracture-focused model to a proactive, preventive, and patient-centered paradigm. The most effective approach is inherently interdisciplinary, integrating the distinct yet complementary roles of various healthcare professionals. Nurses provide crucial education and adherence support, family physicians ensure early case-finding and longitudinal care, laboratory professionals enable accurate diagnosis and monitoring, and social care addresses the non-medical determinants of health that often dictate real-world outcomes. Physiotherapists contribute essential fall prevention and functional rehabilitation. By synchronizing these efforts within a coordinated framework, healthcare systems can systematically identify at-risk individuals, initiate timely evidence-based therapy, and provide sustained support to ensure long-term adherence. This collaborative model is the cornerstone for reducing the immense personal and economic burden of osteoporosis, transforming it from a silent epidemic into a effectively managed chronic disease.

References:

1. Varo N. Bone remodeling markers: monitoring the changing bone. Adv Lab Med. 2024 Mar;5(1):1-3.
2. Stride PJ, Patel N, Kingston D. The history of osteoporosis: why do Egyptian mummies have porotic bones? J R Coll Physicians Edinb. 2013;43(3):254-61.
3. Lorentzon M, Cummings SR. Osteoporosis: the evolution of a diagnosis. J Intern Med. 2015 Jun;277(6):650-61.
4. Riggs BL, Melton LJ. Evidence for two distinct syndromes of involutional osteoporosis. Am J Med. 1983 Dec;75(6):899-901.
5. Poduval M, Vishwanathan K. Definition and Evolution of the Term Osteoporosis. Indian J Orthop. 2023 Dec;57(Suppl 1):42-44.
6. Ji MX, Yu Q. Primary osteoporosis in postmenopausal women. Chronic Dis Transl Med. 2015 Mar;1(1):9-13.
7. Hunter DJ, Sambrook PN. Bone loss. Epidemiology of bone loss. Arthritis Res. 2000;2(6):441-5.
8. Sheu A, Diamond T. Secondary osteoporosis. Aust Prescr. 2016 Jun;39(3):85-7.
9. Thulkar J, Singh S, Sharma S, Thulkar T. Preventable risk factors for osteoporosis in postmenopausal women: Systematic review and meta-analysis. J Midlife Health. 2016 Jul-Sep;7(3):108-113.
10. Anastasopoulou C, Barnett MJ, Rodrigues Silva Sombra L, Garla VV. StatPearls [Internet]. StatPearls Publishing; Treasure Island (FL): Jan 22, 2025. Osteoporosis in Males.
11. Kanis JA, McCloskey EV, Johansson H, Oden A, Melton LJ, Khaltaev N. A reference standard for the description of osteoporosis. Bone. 2008 Mar;42(3):467-75.
12. Onizuka N, Onizuka T. Disparities in Osteoporosis Prevention and Care: Understanding Gender, Racial, and Ethnic Dynamics. Curr Rev Musculoskelet Med. 2024 Sep;17(9):365-372.
13. Hassan AB, Almarabheh A, Almekhyal A, Karashi AR, Saleh J, Shaikh M, Alawadhi A, Jahrami H. Frequency of Osteoporosis-Related Fractures in the Kingdom of Bahrain. Healthcare (Basel). 2024 Dec 12;12(24)
14. Borgström F, Karlsson L, Ortsäter G, Norton N, Halbout P, Cooper C, Lorentzon M, McCloskey EV, Harvey NC, Javaid MK, Kanis JA., International Osteoporosis Foundation. Fragility fractures in Europe: burden, management and opportunities. Arch Osteoporos. 2020 Apr 19;15(1):59.
15. Clynes MA, Harvey NC, Curtis EM, Fuggle NR, Dennison EM, Cooper C. The epidemiology of osteoporosis. Br Med Bull. 2020 May 15;133(1):105-117.
16. Kanis JA, Norton N, Harvey NC, Jacobson T, Johansson H, Lorentzon M, McCloskey EV, Willers C, Borgström F. SCOPE 2021: a new scorecard for osteoporosis in Europe. Arch Osteoporos. 2021 Jun 02;16(1):82.
17. Kanis JA, Cooper C, Rizzoli R, Reginster JY., Scientific Advisory Board of the European Society for Clinical and Economic Aspects of Osteoporosis (ESCEO) and the Committees of Scientific Advisors and National Societies of the International Osteoporosis Foundation (IOF). European guidance for the diagnosis and management of osteoporosis in postmenopausal women. Osteoporos Int. 2019 Jan;30(1):3-44.
18. Lewiecki EM, Ortendahl JD, Vanderpuye-Orgle J, Grauer A, Arellano J, Lemay J, Harmon AL, Broder MS, Singer AJ. Healthcare Policy Changes in Osteoporosis Can Improve Outcomes and Reduce

Costs in the United States. JBMR Plus. 2019 Sep;3(9):e10192.
19. Management of osteoporosis in postmenopausal women: the 2021 position statement of The North American Menopause Society. Menopause. 2021 Sep 01;28(9):973-997.
20. Cosman F, de Beur SJ, LeBoff MS, Lewiecki EM, Tanner B, Randall S, Lindsay R., National Osteoporosis Foundation. Clinician's Guide to Prevention and Treatment of Osteoporosis. Osteoporos Int. 2014 Oct;25(10):2359-81.
21. LeBoff MS, Greenspan SL, Insogna KL, Lewiecki EM, Saag KG, Singer AJ, Siris ES. The clinician's guide to prevention and treatment of osteoporosis. Osteoporos Int. 2022 Oct;33(10):2049-2102.
22. Kannegaard PN, van der Mark S, Eiken P, Abrahamsen B. Excess mortality in men compared with women following a hip fracture. National analysis of comedications, comorbidity and survival. Age Ageing. 2010 Mar;39(2):203-9.
23. Hernlund E, Svedbom A, Ivergård M, Compston J, Cooper C, Stenmark J, McCloskey EV, Jönsson B, Kanis JA. 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(1):136.
24. Salari N, Darvishi N, Bartina Y, Larti M, Kiaei A, Hemmati M, Shohaimi S, Mohammadi M. Global prevalence of osteoporosis among the world older adults: a comprehensive systematic review and meta-analysis. J Orthop Surg Res. 2021 Nov 13;16(1):669.
25. Hemmati E, Mirghafourvand M, Mobasseri M, Shakouri SK, Mikaeli P, Farshbaf-Khalili A. Prevalence of primary osteoporosis and low bone mass in postmenopausal women and related risk factors. J Educ Health Promot. 2021;10:204.
26. Costa AG, Wyman A, Siris ES, Watts NB, Silverman S, Saag KG, Roux C, Rossini M, Pfeilschifter J, Nieves JW, Netelenbos JC, March L, LaCroix AZ, Hooven FH, Greenspan SL, Gehlbach SH, Díez-Pérez A, Cooper C, Compston JE, Chapurlat RD, Boonen S, Anderson FA, Adachi JD, Adami S. When, where and how osteoporosis-associated fractures occur: an analysis from the Global Longitudinal Study of Osteoporosis in Women (GLOW). PLoS One. 2013;8(12):e83306.
27. Carlson BC, Robinson WA, Wanderman NR, Sebastian AS, Nassr A, Freedman BA, Anderson PA. A Review and Clinical Perspective of the Impact of Osteoporosis on the Spine. Geriatr Orthop Surg Rehabil. 2019;10:2151459319861591.
28. McPhee C, Aninye IO, Horan L. Recommendations for Improving Women's Bone Health Throughout the Lifespan. J Womens Health (Larchmt). 2022 Dec;31(12):1671-1676.
29. Cauley JA. Defining ethnic and racial differences in osteoporosis and fragility fractures. Clin Orthop Relat Res. 2011 Jul;469(7):1891-9.
30. Dong Y, Zhang Y, Song K, Kang H, Ye D, Li F. What was the Epidemiology and Global Burden of Disease of Hip Fractures From 1990 to 2019? Results From and Additional Analysis of the Global Burden of Disease Study 2019. Clin Orthop Relat Res. 2023 Jun 01;481(6):1209-1220.
31. Gullberg B, Johnell O, Kanis JA. World-wide projections for hip fracture. Osteoporos Int. 1997;7(5):407-13.
32. Lorentzon M, Johansson H, Harvey NC, Liu E, Vandenput L, McCloskey EV, Kanis JA. Osteoporosis and fractures in women: the burden of disease. Climacteric. 2022 Feb;25(1):4-10.
33. Meyer AC, Ek S, Drefahl S, Ahlbom A, Hedström M, Modig K. Trends in Hip Fracture Incidence, Recurrence, and Survival by Education and Comorbidity: A Swedish Register-based Study. Epidemiology. 2021 May 01;32(3):425-433.
34. Lips P. Epidemiology and predictors of fractures associated with osteoporosis. Am J Med. 1997 Aug 18;103(2A):3S-8S; discussion 8S-11S.
35. Owen RA, Melton LJ, Johnson KA, Ilstrup DM, Riggs BL. Incidence of Colles' fracture in a North American community. Am J Public Health. 1982 Jun;72(6):605-7.
36. Edwards BJ, Song J, Dunlop DD, Fink HA, Cauley JA. Functional decline after incident wrist fractures--Study of Osteoporotic Fractures: prospective cohort study. BMJ. 2010 Jul 08;341:c3324.
37. Cummings SR, Black DM, Rubin SM. Lifetime risks of hip, Colles', or vertebral fracture and coronary heart disease among white postmenopausal women. Arch Intern Med. 1989 Nov;149(11):2445-8.
38. Zaheer S, LeBoff MS. Osteoporosis: Prevention and Treatment. In: Feingold KR, Ahmed SF, Anawalt B, Blackman MR, Boyce A, Chrousos G, Corpas E, de Herder WW, Dhatariya K, Dungan K, Hofland J, Kalra S, Kaltsas G, Kapoor N, Koch C, Kopp P, Korbonits M, Kovacs CS, Kuohung W, Laferrère B, Levy M, McGee EA, McLachlan R, Muzumdar R, Purnell J, Rey R, Sahay R, Shah AS, Singer F, Sperling MA, Stratakis CA, Trence DL, Wilson DP, editors. Endotext [Internet]. MDText.com, Inc.; South Dartmouth (MA): Dec 27, 2022.
39. Alexandru D, So W. Evaluation and management of vertebral compression fractures. Perm J. 2012 Fall;16(4):46-51.
40. Gonnelli S, Caffarelli C, Maggi S, Rossi S, Siviero P, Gandolini G, Cisari C, Rossini M, Iolascon G, Letizia Mauro G, Crepaldi G, Nuti R., BREAK Study Group. The assessment of vertebral fractures in elderly women with recent hip fractures: the BREAK Study. Osteoporos Int. 2013 Apr;24(4):1151-9.
41. Nicolaes J, Liu Y, Zhao Y, Huang P, Wang L, Yu A, Dunkel J, Libanati C, Cheng X. External validation of a convolutional neural network algorithm for opportunistically detecting vertebral fractures in routine CT scans. Osteoporos Int. 2024 Jan;35(1):143-152.
42. Kaptoge S, Armbrecht G, Felsenberg D, Lunt M, O'Neill TW, Silman AJ, Reeve J., EPOS Study Group. When should the doctor order a spine X-ray? Identifying vertebral fractures for osteoporosis care: results from the European Prospective Osteoporosis Study (EPOS). J Bone Miner Res. 2004 Dec;19(12):1982-93.
43. Litwic A, Edwards M, Cooper C, Dennison E. Geographic differences in fractures among women. Womens Health (Lond). 2012 Nov;8(6):673-84.
44. Khosla S, Amin S, Orwoll E. Osteoporosis in men. Endocr Rev. 2008 Jun;29(4):441-64.

45. Waterloo S, Ahmed LA, Center JR, Eisman JA, Morseth B, Nguyen ND, Nguyen T, Sogaard AJ, Emaus N. Prevalence of vertebral fractures in women and men in the population-based Tromsø Study. BMC Musculoskelet Disord. 2012 Jan 17;13:3.
46. Cawthon PM. Gender differences in osteoporosis and fractures. Clin Orthop Relat Res. 2011 Jul;469(7):1900-5.
47. Rosen CJ. The Epidemiology and Pathogenesis of Osteoporosis. In: Feingold KR, Ahmed SF, Anawalt B, Blackman MR, Boyce A, Chrousos G, Corpas E, de Herder WW, Dhatariya K, Dungan K, Hofland J, Kalra S, Kaltsas G, Kapoor N, Koch C, Kopp P, Korbonits M, Kovacs CS, Kuohung W, Laferrère B, Levy M, McGee EA, McLachlan R, Muzumdar R, Purnell J, Rey R, Sahay R, Shah AS, Singer F, Sperling MA, Stratakis CA, Trence DL, Wilson DP, editors. Endotext [Internet]. MDText.com, Inc.; South Dartmouth (MA): Jun 21, 2020.
48. Ross BJ, Lee OC, Harris MB, Dowd TC, Savoie FH, Sherman WF. Rates of Osteoporosis Management and Secondary Preventative Treatment After Primary Fragility Fractures. JB JS Open Access. 2021 Apr-Jun;6(2)
49. Lewiecki EM, Leader D, Weiss R, Williams SA. Challenges in osteoporosis awareness and management: results from a survey of US postmenopausal women. J Drug Assess. 2019;8(1):25-31.
50. Hall SF, Edmonds SW, Lou Y, Cram P, Roblin DW, Saag KG, Wright NC, Jones MP, Wolinsky FD. Patient-reported reasons for nonadherence to recommended osteoporosis pharmacotherapy. J Am Pharm Assoc (2003). 2017 Jul-Aug;57(4):503-509.
51. Tai TW, Chen HY, Shih CA, Huang CF, McCloskey E, Lee JK, Yeap SS, Cheung CL, Charatcharoenwitthaya N, Jaisamrarn U, Kuptniratsaikul V, Yang RS, Lin SY, Taguchi A, Mori S, Li-Yu J, Ang SB, Chan DC, Chan WS, Ng H, Chen JF, Tu ST, Chuang HH, Chang YF, Chen FP, Tsai KS, Ebeling PR, Marin F, Nistal Rodríguez FJ, Shi H, Hwang KR, Kim KK, Chung YS, Reid IR, Chandran M, Ferrari S, Lewiecki EM, Hew FL, Ho-Pham LT, Nguyen TV, Nguyen VH, Lekamwasam S, Pandey D, Bhadada S, Chen CH, Hwang JS, Wu CH. Asia-Pacific consensus on long-term and sequential therapy for osteoporosis. Osteoporos Sarcopenia. 2024 Mar;10(1):3-10.
52. Florencio-Silva R, Sasso GR, Sasso-Cerri E, Simões MJ, Cerri PS. Biology of Bone Tissue: Structure, Function, and Factors That Influence Bone Cells. Biomed Res Int. 2015;2015:421746.
53. Tobeiha M, Moghadasian MH, Amin N, Jafarnejad S. RANKL/RANK/OPG Pathway: A Mechanism Involved in Exercise-Induced Bone Remodeling. Biomed Res Int. 2020;2020:6910312.
54. Bonjour JP, Theintz G, Law F, Slosman D, Rizzoli R. Peak bone mass. Osteoporos Int. 1994;4 Suppl 1:7-13.
55. Rył A, Szylińska A, Skonieczna-Żydecka K, Miazgowski T, Rotter I. The Impact of Metabolic Syndrome on Bone Mass in Men: Systematic Review and Meta-Analysis. Biomedicines. 2023 Jul 06;11(7)
56. Seeman E. Pathogenesis of bone fragility in women and men. Lancet. 2002 May 25;359(9320):1841-50.
57. Alswat KA. Gender Disparities in Osteoporosis. J Clin Med Res. 2017 May;9(5):382-387.
58. Jones G, Nguyen T, Sambrook P, Kelly PJ, Eisman JA. Progressive loss of bone in the femoral neck in elderly people: longitudinal findings from the Dubbo osteoporosis epidemiology study. BMJ. 1994 Sep 17;309(6956):691-5.
59. Chen H, Zhou X, Fujita H, Onozuka M, Kubo KY. Age-related changes in trabecular and cortical bone microstructure. Int J Endocrinol. 2013;2013:213234.
60. Yong EL, Logan S. Menopausal osteoporosis: screening, prevention and treatment. Singapore Med J. 2021 Apr;62(4):159-166.
61. Feng X, McDonald JM. Disorders of bone remodeling. Annu Rev Pathol. 2011;6:121-45.
62. Klotzbuecher CM, Ross PD, Landsman PB, Abbott TA, Berger M. Patients with prior fractures have an increased risk of future fractures: a summary of the literature and statistical synthesis. J Bone Miner Res. 2000 Apr;15(4):721-39.
63. Almeida M, Laurent MR, Dubois V, Claessens F, O'Brien CA, Bouillon R, Vanderschueren D, Manolagas SC. Estrogens and Androgens in Skeletal Physiology and Pathophysiology. Physiol Rev. 2017 Jan;97(1):135-187.
64. Herath M, Cohen A, Ebeling PR, Milat F. Dilemmas in the Management of Osteoporosis in Younger Adults. JBMR Plus. 2022 Jan;6(1):e10594.
65. John Levy Barnett M. A Scoping Review of the Apparent Phenomenon of the Improvement in Hypoparathyroidism in Pregnant and Postpartum Females. Cureus. 2023 Sep;15(9):e46123.
66. Kann PH, Pfützner A, Delling G, Schulz G, Meyer S. Transiliac bone biopsy in osteoporosis: frequency, indications, consequences and complications. An evaluation of 99 consecutive cases over a period of 14 years. Clin Rheumatol. 2006 Feb;25(1):30-4
67. Colazo JM, Quirion J, Judice AD, Halpern J, Schwartz HS, Tanner SB, Lawrenz JM, Dahir KM, Holt GE. Utility of iliac crest tetracycline-labelled bone biopsy in osteoporosis and metabolic bone disease: An evaluation of 95 cases over a period of 25 years. Bone Rep. 2023 Dec;19:101715.
68. Marcu F, Bogdan F, Muţiu G, Lazăr L. The histopathological study of osteoporosis. Rom J Morphol Embryol. 2011;52(1 Suppl):321-5.
69. Duque G, Lord SR, Mak J, Ganda K, Close JJ, Ebeling P, Papaioannou A, Inderjeeth CA. Treatment of Osteoporosis in Australian Residential Aged Care Facilities: Update on Consensus Recommendations for Fracture Prevention. J Am Med Dir Assoc. 2016 Sep 01;17(9):852-9.
70. Macdonald HM, Nishiyama KK, Kang J, Hanley DA, Boyd SK. Age-related patterns of trabecular and cortical bone loss differ between sexes and skeletal sites: a population-based HR-pQCT study. J Bone Miner Res. 2011 Jan;26(1):50-62.
71. Naot D, Watson M, Choi AJ, Musson DS, Callon KE, Zhu M, Gao R, Caughey W, Pitto RP, Munro JT, Horne A, Gamble GD, Dalbeth N, Reid IR, Cornish J. The effect of age on the microarchitecture and profile of gene expression in femoral head and neck bone from patients with osteoarthritis. Bone Rep. 2020 Dec;13:100287.
72. Söreskog E, Ström O, Spångéus A, Åkesson KE, Borgström F, Banefelt J, Toth E, Libanati C, Charokopou M. Risk of major osteoporotic fracture

after first, second and third fracture in Swedish women aged 50 years and older. Bone. 2020 May;134:115286.
73. Robitaille J, Yoon PW, Moore CA, Liu T, Irizarry-Delacruz M, Looker AC, Khoury MJ. Prevalence, family history, and prevention of reported osteoporosis in U.S. women. Am J Prev Med. 2008 Jul;35(1):47-54.
74. Camacho PM, Petak SM, Binkley N, Diab DL, Eldeiry LS, Farooki A, Harris ST, Hurley DL, Kelly J, Lewiecki EM, Pessah-Pollack R, McClung M, Wimalawansa SJ, Watts NB. AMERICAN ASSOCIATION OF CLINICAL ENDOCRINOLOGISTS/AMERICAN COLLEGE OF ENDOCRINOLOGY CLINICAL PRACTICE GUIDELINES FOR THE DIAGNOSIS AND TREATMENT OF POSTMENOPAUSAL OSTEOPOROSIS-2020 UPDATE. Endocr Pract. 2020 May;26(Suppl 1):1-46.
75. Zacker RJ. Health-related implications and management of sarcopenia. JAAPA. 2006 Oct;19(10):24-9.
76. Gale CR, Cooper C, Aihie Sayer A. Prevalence and risk factors for falls in older men and women: The English Longitudinal Study of Ageing. Age Ageing. 2016 Nov;45(6):789-794.
77. By the 2023 American Geriatrics Society Beers Criteria® Update Expert Panel. American Geriatrics Society 2023 updated AGS Beers Criteria® for potentially inappropriate medication use in older adults. J Am Geriatr Soc. 2023 Jul;71(7):2052-2081.
78. Katzman WB, Wanek L, Shepherd JA, Sellmeyer DE. Age-related hyperkyphosis: its causes, consequences, and management. J Orthop Sports Phys Ther. 2010 Jun;40(6):352-60.
79. Aibar-Almazán A, Voltes-Martínez A, Castellote-Caballero Y, Afanador-Restrepo DF, Carcelén-Fraile MDC, López-Ruiz E. Current Status of the Diagnosis and Management of Osteoporosis. Int J Mol Sci. 2022 Aug 21;23(16)
80. Akkawi I, Zmerly H. Osteoporosis: Current Concepts. Joints. 2018 Jun;6(2):122-127.
81. Maclaughlin EJ, Sleeper RB, McNatty D, Raehl CL. Management of age-related osteoporosis and prevention of associated fractures. Ther Clin Risk Manag. 2006 Sep;2(3):281-95.
82. Black DM, Cauley JA, Wagman R, Ensrud K, Fink HA, Hillier TA, Lui LY, Cummings SR, Schousboe JT, Napoli N. The Ability of a Single BMD and Fracture History Assessment to Predict Fracture Over 25 Years in Postmenopausal Women: The Study of Osteoporotic Fractures. J Bone Miner Res. 2018 Mar;33(3):389-395.
83. Leslie WD, Adler RA, El-Hajj Fuleihan G, Hodsman AB, Kendler DL, McClung M, Miller PD, Watts NB., International Society for Clinical Densitometry. Application of the 1994 WHO classification to populations other than postmenopausal Caucasian women: the 2005 ISCD Official Positions. J Clin Densitom. 2006 Jan-Mar;9(1):22-30.
84. Marshall D, Johnell O, Wedel H. Meta-analysis of how well measures of bone mineral density predict occurrence of osteoporotic fractures. BMJ. 1996 May 18;312(7041):1254-9.
85. Kanis JA, McCloskey EV, Johansson H, Cooper C, Rizzoli R, Reginster JY., Scientific Advisory Board of the European Society for Clinical and Economic Aspects of Osteoporosis and Osteoarthritis (ESCEO) and the Committee of Scientific Advisors of the International Osteoporosis Foundation (IOF). European guidance for the diagnosis and management of osteoporosis in postmenopausal women. Osteoporos Int. 2013 Jan;24(1):23-57.
86. US Preventive Services Task Force. Nicholson WK, Silverstein M, Wong JB, Chelmow D, Coker TR, Davis EM, Jaén CR, Krousel-Wood M, Lee S, Li L, Mangione CM, Ogedegbe G, Rao G, Ruiz JM, Stevermer J, Tsevat J, Underwood SM, Wiehe S. Screening for Osteoporosis to Prevent Fractures: US Preventive Services Task Force Recommendation Statement. JAMA. 2025 Feb 11;333(6):498-508.
87. Kanis JA, Johansson H, Harvey NC, McCloskey EV. A brief history of FRAX. Arch Osteoporos. 2018 Oct 31;13(1):118.
88. Vasikaran S, Cooper C, Eastell R, Griesmacher A, Morris HA, Trenti T, Kanis JA. International Osteoporosis Foundation and International Federation of Clinical Chemistry and Laboratory Medicine position on bone marker standards in osteoporosis. Clin Chem Lab Med. 2011 Aug;49(8):1271-1274.
89. Dhainaut A, Hoff M, Syversen U, Haugeberg G. Technologies for assessment of bone reflecting bone strength and bone mineral density in elderly women: an update. Womens Health (Lond). 2016;12(2):209-16.
90. Zebaze RM, Ghasem-Zadeh A, Bohte A, Iuliano-Burns S, Mirams M, Price RI, Mackie EJ, Seeman E. Intracortical remodelling and porosity in the distal radius and post-mortem femurs of women: a cross-sectional study. Lancet. 2010 May 15;375(9727):1729-36.
91. Chou SH, Vokes TJ, Ma SL, Costello M, Rosen HR, Schousboe JT. Simplified criteria for selecting patients for vertebral fracture assessment. J Clin Densitom. 2014 Jul-Sep;17(3):386-91.
92. Lewiecki EM, Lane NE. Common mistakes in the clinical use of bone mineral density testing. Nat Clin Pract Rheumatol. 2008 Dec;4(12):667-74.
93. Beck TJ. Extending DXA beyond bone mineral density: understanding hip structure analysis. Curr Osteoporos Rep. 2007 Jun;5(2):49-55.
94. Danielson ME, Beck TJ, Karlamangla AS, Greendale GA, Atkinson EJ, Lian Y, Khaled AS, Keaveny TM, Kopperdahl D, Ruppert K, Greenspan S, Vuga M, Cauley JA. A comparison of DXA and CT based methods for estimating the strength of the femoral neck in post-menopausal women. Osteoporos Int. 2013 Apr;24(4):1379-88.
95. Al Refaie A, Baldassini L, Mondillo C, Giglio E, De Vita M, Tomai Pitinca MD, Gonnelli S, Caffarelli C. Radiofrequency Echographic Multi Spectrometry (R.E.M.S.): New Frontiers for Ultrasound Use in the Assessment of Bone Status-A Current Picture. Diagnostics (Basel). 2023 May 09;13(10)
96. Dovjak P, Iglseder B, Rainer A, Dovjak G, Weber M, Pietschmann P. Pulse-echo ultrasound measurement in osteoporosis screening: a pilot study in older patients. Aging Clin Exp Res. 2023 Jun;35(6):1221-1230.
97. Ganry O, Baudoin C, Fardellone P, Dubreuil A., EPIDOS Group. Alcohol consumption by non-institutionalised elderly women: the EPIDOS Study. Public Health. 2001 May;115(3):186-91.
98. Park JS, Kang KC, Park SJ, Kim JK, Han K, Hong JY. The positive impact of smoking cessation on fracture risk in a nationwide cohort study. Sci Rep. 2024 Apr 30;14(1):9892.

99. Kiyota Y, Muramatsu H, Sato Y, Kobayashi T, Miyamoto K, Iwamoto T, Matsumoto M, Nakamura M, Tateno H, Sato K, Miyamoto T. Smoking cessation increases levels of osteocalcin and uncarboxylated osteocalcin in human sera. Sci Rep. 2020 Oct 08;10(1):16845.
100. Zhang Y, Chen H. Effect of Tai Chi exercise on bone health and fall prevention in postmenopausal women: a meta-analysis. J Orthop Surg Res. 2024 Aug 10;19(1):471.
101. Kemmler W, Bebenek M, Kohl M, von Stengel S. Exercise and fractures in postmenopausal women. Final results of the controlled Erlangen Fitness and Osteoporosis Prevention Study (EFOPS). Osteoporos Int. 2015 Oct;26(10):2491-9.
102. Silman AJ, O'Neill TW, Cooper C, Kanis J, Felsenberg D. Influence of physical activity on vertebral deformity in men and women: results from the European Vertebral Osteoporosis Study. J Bone Miner Res. 1997 May;12(5):813-9.
103. Watson SL, Weeks BK, Weis LJ, Harding AT, Horan SA, Beck BR. High-Intensity Resistance and Impact Training Improves Bone Mineral Density and Physical Function in Postmenopausal Women With Osteopenia and Osteoporosis: The LIFTMOR Randomized Controlled Trial. J Bone Miner Res. 2018 Feb;33(2):211-220.
104. Schürch MA, Rizzoli R, Slosman D, Vadas L, Vergnaud P, Bonjour JP. Protein supplements increase serum insulin-like growth factor-I levels and attenuate proximal femur bone loss in patients with recent hip fracture. A randomized, double-blind, placebo-controlled trial. Ann Intern Med. 1998 May 15;128(10):801-9.
105. Drewnowski A. The contribution of milk and milk products to micronutrient density and affordability of the U.S. diet. J Am Coll Nutr. 2011 Oct;30(5 Suppl 1):422S-8S.
106. Kopecky SL, Bauer DC, Gulati M, Nieves JW, Singer AJ, Toth PP, Underberg JA, Wallace TC, Weaver CM. Lack of Evidence Linking Calcium With or Without Vitamin D Supplementation to Cardiovascular Disease in Generally Healthy Adults: A Clinical Guideline From the National Osteoporosis Foundation and the American Society for Preventive Cardiology. Ann Intern Med. 2016 Dec 20;165(12):867-868.
107. US Preventive Services Task Force. Grossman DC, Curry SJ, Owens DK, Barry MJ, Caughey AB, Davidson KW, Doubeni CA, Epling JW, Kemper AR, Krist AH, Kubik M, Landefeld S, Mangione CM, Silverstein M, Simon MA, Tseng CW. Vitamin D, Calcium, or Combined Supplementation for the Primary Prevention of Fractures in Community-Dwelling Adults: US Preventive Services Task Force Recommendation Statement. JAMA. 2018 Apr 17;319(15):1592-1599.
108. Grigorie D, Sucaliuc A. PREVENTION OF FALLS AND FRACTURES - TO "D" OR NOT TO "D"? Acta Endocrinol (Buchar). 2018 Apr-Jun;14(2):235-237.
109. Yee MMF, Chin KY, Ima-Nirwana S, Wong SK. Vitamin A and Bone Health: A Review on Current Evidence. Molecules. 2021 Mar 21;26(6)
110. Eastell R, Rosen CJ, Black DM, Cheung AM, Murad MH, Shoback D. Pharmacological Management of Osteoporosis in Postmenopausal Women: An Endocrine Society* Clinical Practice Guideline. J Clin Endocrinol Metab. 2019 May 01;104(5):1595-1622.
111. Adler RA, El-Hajj Fuleihan G, Bauer DC, Camacho PM, Clarke BL, Clines GA, Compston JE, Drake MT, Edwards BJ, Favus MJ, Greenspan SL, McKinney R, Pignolo RJ, Sellmeyer DE. Managing Osteoporosis in Patients on Long-Term Bisphosphonate Treatment: Report of a Task Force of the American Society for Bone and Mineral Research. J Bone Miner Res. 2016 Jan;31(1):16-35
112. Quesnel AM, Seton M, Merchant SN, Halpin C, McKenna MJ. Third-generation bisphosphonates for treatment of sensorineural hearing loss in otosclerosis. Otol Neurotol. 2012 Oct;33(8):1308-14.
113. Cummings SR, Santora AC, Black DM, Russell RGG. History of alendronate. Bone. 2020 Aug;137:115411.
114. Black DM, Cummings SR, Karpf DB, Cauley JA, Thompson DE, Nevitt MC, Bauer DC, Genant HK, Haskell WL, Marcus R, Ott SM, Torner JC, Quandt SA, Reiss TF, Ensrud KE. Randomised trial of effect of alendronate on risk of fracture in women with existing vertebral fractures. Fracture Intervention Trial Research Group. Lancet. 1996 Dec 07;348(9041):1535-41.
115. Black DM, Schwartz AV, Ensrud KE, Cauley JA, Levis S, Quandt SA, Satterfield S, Wallace RB, Bauer DC, Palermo L, Wehren LE, Lombardi A, Santora AC, Cummings SR., FLEX Research Group. Effects of continuing or stopping alendronate after 5 years of treatment: the Fracture Intervention Trial Long-term Extension (FLEX): a randomized trial. JAMA. 2006 Dec 27;296(24):2927-38.
116. Pols HA, Felsenberg D, Hanley DA, Stepán J, Muñoz-Torres M, Wilkin TJ, Qin-sheng G, Galich AM, Vandormael K, Yates AJ, Stych B. Multinational, placebo-controlled, randomized trial of the effects of alendronate on bone density and fracture risk in postmenopausal women with low bone mass: results of the FOSIT study. Fosamax International Trial Study Group. Osteoporos Int. 1999;9(5):461-8
117. Wang YK, Zhang YM, Qin SQ, Wang X, Ma T, Guo JB, Zhu C, Luo ZJ. Effects of alendronate for treatment of glucocorticoid-induced osteoporosis: A meta-analysis of randomized controlled trials. Medicine (Baltimore). 2018 Oct;97(42):e12691.
118. Pyon EY. Once-monthly ibandronate for postmenopausal osteoporosis: review of a new dosing regimen. Clin Ther. 2006 Apr;28(4):475-90.
119. Felsenberg D, Miller P, Armbrecht G, Wilson K, Schimmer RC, Papapoulos SE. Oral ibandronate significantly reduces the risk of vertebral fractures of greater severity after 1, 2, and 3 years in postmenopausal women with osteoporosis. Bone. 2005 Nov;37(5):651-4.
120. Reginster JY, Adami S, Lakatos P, Greenwald M, Stepan JJ, Silverman SL, Christiansen C, Rowell L, Mairon N, Bonvoisin B, Drezner MK, Emkey R, Felsenberg D, Cooper C, Delmas PD, Miller PD. Efficacy and tolerability of once-monthly oral ibandronate in postmenopausal osteoporosis: 2 year results from the MOBILE study. Ann Rheum Dis. 2006 May;65(5):654-61.
121. Eisman JA, Civitelli R, Adami S, Czerwinski E, Recknor C, Prince R, Reginster JY, Zaidi M, Felsenberg D, Hughes C, Mairon N, Masanauskaite D, Reid DM, Delmas PD, Recker RR. Efficacy and tolerability of intravenous ibandronate injections in postmenopausal

osteoporosis: 2-year results from the DIVA study. J Rheumatol. 2008 Mar;35(3):488-97.
122. Wells GA, Hsieh SC, Zheng C, Peterson J, Tugwell P, Liu W. Risedronate for the primary and secondary prevention of osteoporotic fractures in postmenopausal women. Cochrane Database Syst Rev. 2022 May 03;5(5):CD004523.
123. Iolascon G, Sirico F, Ferrante A, Gimigliano R, Gimigliano F. Risedronate's efficacy: from randomized clinical trials to real clinical practice. Clin Cases Miner Bone Metab. 2010 Jan;7(1):19-22.
124. Deal CL. Risedronate prevents hip fractures, but who should get therapy? Cleve Clin J Med. 2002 Dec;69(12):964, 968-70, 973-6
125. Silverman SL, Watts NB, Delmas PD, Lange JL, Lindsay R. Effectiveness of bisphosphonates on nonvertebral and hip fractures in the first year of therapy: the risedronate and alendronate (REAL) cohort study. Osteoporos Int. 2007 Jan;18(1):25-34.
126. Grey A. Intravenous zoledronate for osteoporosis: less might be more. Ther Adv Musculoskelet Dis. 2016 Aug;8(4):119-23.
127. D'Andrea E, Schneeweiss S, Franklin JM, Kim SC, Glynn RJ, Lee SB, Wang SV. Efficacy Versus Effectiveness: The HORIZON-Pivotal Fracture Trial and Its Emulation in Claims Data. Arthritis Rheumatol. 2025 Jan;77(1):12-21.
128. Adachi JD, Lyles KW, Colón-Emeric CS, Boonen S, Pieper CF, Mautalen C, Hyldstrup L, Recknor C, Nordsletten L, Moore KA, Bucci-Rechtweg C, Su G, Eriksen EF, Magaziner JS. Zoledronic acid results in better health-related quality of life following hip fracture: the HORIZON-Recurrent Fracture Trial. Osteoporos Int. 2011 Sep;22(9):2539-49.
129. Nakamura T, Fukunaga M, Nakano T, Kishimoto H, Ito M, Hagino H, Sone T, Taguchi A, Tanaka S, Ohashi M, Ota Y, Shiraki M. Efficacy and safety of once-yearly zoledronic acid in Japanese patients with primary osteoporosis: two-year results from a randomized placebo-controlled double-blind study (ZOledroNate treatment in Efficacy to osteoporosis; ZONE study). Osteoporos Int. 2017 Jan;28(1):389-398.
130. Watts NB, Diab DL. Long-term use of bisphosphonates in osteoporosis. J Clin Endocrinol Metab. 2010 Apr;95(4):1555-65.
131. Black DM, Delmas PD, Eastell R, Reid IR, Boonen S, Cauley JA, Cosman F, Lakatos P, Leung PC, Man Z, Mautalen C, Mesenbrink P, Hu H, Caminis J, Tong K, Rosario-Jansen T, Krasnow J, Hue TF, Sellmeyer D, Eriksen EF, Cummings SR., HORIZON Pivotal Fracture Trial. Once-yearly zoledronic acid for treatment of postmenopausal osteoporosis. N Engl J Med. 2007 May 03;356(18):1809-22.
132. Chartrand NA, Lau CK, Parsons MT, Handlon JJ, Ronquillo YC, Hoopes PC, Moshirfar M. Ocular Side Effects of Bisphosphonates: A Review of Literature. J Ocul Pharmacol Ther. 2023 Jan-Feb;39(1):3-16.
133. Kendler DL, Cosman F, Stad RK, Ferrari S. Denosumab in the Treatment of Osteoporosis: 10 Years Later: A Narrative Review. Adv Ther. 2022 Jan;39(1):58-74.
134. Shoback D, Rosen CJ, Black DM, Cheung AM, Murad MH, Eastell R. Pharmacological Management of Osteoporosis in Postmenopausal Women: An Endocrine Society Guideline Update. J Clin Endocrinol Metab. 2020 Mar 01;105(3
135. Abduelkarem AR, Guella A, Hamrouni AM, Hassanein MM, Nasr A, Rana O. Denosumab Use in Chronic Kidney Disease Associated Osteoporosis: A Narrative Review. Risk Manag Healthc Policy. 2023;16:1809-1813.
136. Mok CC, Ho LY, Ma KM. Switching of oral bisphosphonates to denosumab in chronic glucocorticoid users: a 12-month randomized controlled trial. Bone. 2015 Jun;75:222-8.
137. Silverman SL, Siris E, Belazi D, Recknor C, Papaioannou A, Brown JP, Gold DT, Lewiecki EM, Quinn G, Balasubramanian A, Yue S, Stolshek B, Kendler DL. Persistence at 24 months with denosumab among postmenopausal women with osteoporosis: results of a prospective cohort study. Arch Osteoporos. 2018 Aug 07;13(1):85.
138. Walker MD, Shane E. Postmenopausal Osteoporosis. N Engl J Med. 2023 Nov 23;389(21):1979-1991.
139. Yu EW, Tsourdi E, Clarke BL, Bauer DC, Drake MT. Osteoporosis Management in the Era of COVID-19. J Bone Miner Res. 2020 Jun;35(6):1009-1013.
140. Umland EM, Karel L, Santoro N. Bazedoxifene and Conjugated Equine Estrogen: A Combination Product for the Management of Vasomotor Symptoms and Osteoporosis Prevention Associated with Menopause. Pharmacotherapy. 2016 May;36(5):548-61.
141. Pinkerton JV, Harvey JA, Lindsay R, Pan K, Chines AA, Mirkin S, Archer DF., SMART-5 Investigators. Effects of bazedoxifene/conjugated estrogens on the endometrium and bone: a randomized trial. J Clin Endocrinol Metab. 2014 Feb;99(2):E189-98.
142. Messalli EM, Scaffa C. Long-term safety and efficacy of raloxifene in the prevention and treatment of postmenopausal osteoporosis: an update. Int J Womens Health. 2010 Aug 09;1:11-20.
143. Ettinger B, Black DM, Mitlak BH, Knickerbocker RK, Nickelsen T, Genant HK, Christiansen C, Delmas PD, Zanchetta JR, Stakkestad J, Glüer CC, Krueger K, Cohen FJ, Eckert S, Ensrud KE, Avioli LV, Lips P, Cummings SR. Reduction of vertebral fracture risk in postmenopausal women with osteoporosis treated with raloxifene: results from a 3-year randomized clinical trial. Multiple Outcomes of Raloxifene Evaluation (MORE) Investigators. JAMA. 1999 Aug 18;282(7):637-45.
144. Siris ES, Harris ST, Eastell R, Zanchetta JR, Goemaere S, Diez-Perez A, Stock JL, Song J, Qu Y, Kulkarni PM, Siddhanti SR, Wong M, Cummings SR., Continuing Outcomes Relevant to Evista (CORE) Investigators. Skeletal effects of raloxifene after 8 years: results from the continuing outcomes relevant to Evista (CORE) study. J Bone Miner Res. 2005 Sep;20(9):1514-24.
145. Vogel VG. The NSABP Study of Tamoxifen and Raloxifene (STAR) trial. Expert Rev Anticancer Ther. 2009 Jan;9(1):51-60.
146. Eng-Wong J, Reynolds JC, Venzon D, Liewehr D, Gantz S, Danforth D, Liu ET, Chow C, Zujewski J. Effect of raloxifene on bone mineral density in premenopausal women at increased risk of breast cancer. J Clin Endocrinol Metab. 2006 Oct;91(10):3941-6.
147. Stefanick ML. Estrogens and progestins: background and history, trends in use, and guidelines and regimens approved by the US Food and Drug

Administration. Am J Med. 2005 Dec 19;118 Suppl 12B:64-73.
148. Manson JE, Bassuk SS, Kaunitz AM, Pinkerton JV. The Women's Health Initiative trials of menopausal hormone therapy: lessons learned. Menopause. 2020 Aug;27(8):918-928.
149. Miller VM, Naftolin F, Asthana S, Black DM, Brinton EA, Budoff MJ, Cedars MI, Dowling NM, Gleason CE, Hodis HN, Jayachandran M, Kantarci K, Lobo RA, Manson JE, Pal L, Santoro NF, Taylor HS, Harman SM. The Kronos Early Estrogen Prevention Study (KEEPS): what have we learned? Menopause. 2019 Sep;26(9):1071-1084.
150. Effects of hormone therapy on bone mineral density: results from the postmenopausal estrogen/progestin interventions (PEPI) trial. The Writing Group for the PEPI. JAMA. 1996 Nov 06;276(17):1389-96
151. Lorentzon M, Johansson H, Harvey NC, Liu E, Vandenput L, Crandall CJ, Cauley JA, LeBoff MS, McCloskey EV, Kanis JA. Menopausal hormone therapy reduces the risk of fracture regardless of falls risk or baseline FRAX probability-results from the Women's Health Initiative hormone therapy trials. Osteoporos Int. 2022 Nov;33(11):2297-2305.
152. Fink HA, MacDonald R, Forte ML, Rosebush CE, Ensrud KE, Schousboe JT, Nelson VA, Ullman K, Butler M, Olson CM, Taylor BC, Brasure M, Wilt TJ. Long-Term Drug Therapy and Drug Discontinuations and Holidays for Osteoporosis Fracture Prevention: A Systematic Review. Ann Intern Med. 2019 Jul 02;171(1):37-50.
153. Kolitz E, McKesey J, Kwan E, Gill JG, Mauskar M. Strontium citrate associated drug reaction with eosinophilia and systemic symptoms syndrome with granulomatous dermatitis. JAAD Case Rep. 2021 Apr;10:85-88.
154. Blake GM, Fogelman I. Strontium ranelate: a novel treatment for postmenopausal osteoporosis: a review of safety and efficacy. Clin Interv Aging. 2006;1(4):367-75.
155. Cummings SR, Ettinger B, Delmas PD, Kenemans P, Stathopoulos V, Verweij P, Mol-Arts M, Kloosterboer L, Mosca L, Christiansen C, Bilezikian J, Kerzberg EM, Johnson S, Zanchetta J, Grobbee DE, Seifert W, Eastell R., LIFT Trial Investigators. The effects of tibolone in older postmenopausal women. N Engl J Med. 2008 Aug 14;359(7):697-708.
156. Bundred NJ, Kenemans P, Yip CH, Beckmann MW, Foidart JM, Sismondi P, Schoultz Bv, Vassilopoulou-Sellin R, Galta RE, Lieshout EV, Mol-Arts M, Planellas J, Kubista E. Tibolone increases bone mineral density but also relapse in breast cancer survivors: LIBERATE trial bone substudy. Breast Cancer Res. 2012 Jan 17;14(1):R13.
157. Keller J, Catala-Lehnen P, Huebner AK, Jeschke A, Heckt T, Lueth A, Krause M, Koehne T, Albers J, Schulze J, Schilling S, Haberland M, Denninger H, Neven M, Hermans-Borgmeyer I, Streichert T, Breer S, Barvencik F, Levkau B, Rathkolb B, Wolf E, Calzada-Wack J, Neff F, Gailus-Durner V, Fuchs H, de Angelis MH, Klutmann S, Tsourdi E, Hofbauer LC, Kleuser B, Chun J, Schinke T, Amling M. Calcitonin controls bone formation by inhibiting the release of sphingosine 1-phosphate from osteoclasts. Nat Commun. 2014 Oct 21;5:5215
158. Srinivasan A, Wong FK, Karponis D. Calcitonin: A useful old friend. J Musculoskelet Neuronal Interact. 2020 Dec 01;20(4):600-609.
159. Boucher E, Rosgen B, Lang E. Efficacy of calcitonin for treating acute pain associated with osteoporotic vertebral compression fracture: an updated systematic review. CJEM. 2020 May;22(3):359-367.
160. Chesnut CH, Silverman S, Andriano K, Genant H, Gimona A, Harris S, Kiel D, LeBoff M, Maricic M, Miller P, Moniz C, Peacock M, Richardson P, Watts N, Baylink D. A randomized trial of nasal spray salmon calcitonin in postmenopausal women with established osteoporosis: the prevent recurrence of osteoporotic fractures study. PROOF Study Group. Am J Med. 2000 Sep;109(4):267-76.
161. Jilka RL, O'Brien CA, Ali AA, Roberson PK, Weinstein RS, Manolagas SC. Intermittent PTH stimulates periosteal bone formation by actions on post-mitotic preosteoblasts. Bone. 2009 Feb;44(2):275-86.
162. Krege JH, Gilsenan AW, Komacko JL, Kellier-Steele N. Teriparatide and Osteosarcoma Risk: History, Science, Elimination of Boxed Warning, and Other Label Updates. JBMR Plus. 2022 Sep;6(9):e10665.
163. Eastell R, Walsh JS. Anabolic treatment for osteoporosis: teriparatide. Clin Cases Miner Bone Metab. 2017 May-Aug;14(2):173-178
164. Fernández-Carneado J, Vallès-Miret M, Arrastia-Casado S, Almazán-Moga A, Macias MJ, Martin-Malpartida P, Vilaseca M, Díaz-Lobo M, Vazquez M, Sanahuja RM, Gambús G, Ponsati B. First Generic Teriparatide: Structural and Biological Sameness to Its Reference Medicinal Product. Pharmaceutics. 2024 Apr 13;16(4)
165. Lee HC, Breitbart H, Berman M, Forte JG. Potassium-stimulated ATPase activity and hydrogen transport in gastric microsomal vesicles. Biochim Biophys Acta. 1979 May 03;553(1):107-31.
166. Geusens P, Marin F, Kendler DL, Russo LA, Zerbini CA, Minisola S, Body JJ, Lespessailles E, Greenspan SL, Bagur A, Stepan JJ, Lakatos P, Casado E, Moericke R, López-Romero P, Fahrleitner-Pammer A. Effects of Teriparatide Compared with Risedronate on the Risk of Fractures in Subgroups of Postmenopausal Women with Severe Osteoporosis: The VERO Trial. J Bone Miner Res. 2018 May;33(5):783-794.
167. Nakamura T, Sugimoto T, Nakano T, Kishimoto H, Ito M, Fukunaga M, Hagino H, Sone T, Yoshikawa H, Nishizawa Y, Fujita T, Shiraki M. Randomized Teriparatide [human parathyroid hormone (PTH) 1-34] Once-Weekly Efficacy Research (TOWER) trial for examining the reduction in new vertebral fractures in subjects with primary osteoporosis and high fracture risk. J Clin Endocrinol Metab. 2012 Sep;97(9):3097-106.
168. Eastell R, Nickelsen T, Marin F, Barker C, Hadji P, Farrerons J, Audran M, Boonen S, Brixen K, Gomes JM, Obermayer-Pietsch B, Avramidis A, Sigurdsson G, Glüer CC. Sequential treatment of severe postmenopausal osteoporosis after teriparatide: final results of the randomized, controlled European Study of Forsteo (EUROFORS). J Bone Miner Res. 2009 Apr;24(4):726-36.
169. Silverman S, Miller P, Sebba A, Weitz M, Wan X, Alam J, Masica D, Taylor KA, Ruff VA, Krohn K. The Direct Assessment of Nonvertebral Fractures in Community Experience (DANCE) study: 2-year nonvertebral

fragility fracture results. Osteoporos Int. 2013 Aug;24(8):2309-17.
170. Shirley M. Abaloparatide: First Global Approval. Drugs. 2017 Aug;77(12):1363-1368.
171. Tella SH, Kommalapati A, Correa R. Profile of Abaloparatide and Its Potential in the Treatment of Postmenopausal Osteoporosis. Cureus. 2017 May 31;9(5):e1300.
172. Akel M, Patel P, Parmar M. StatPearls [Internet]. StatPearls Publishing; Treasure Island (FL): Jan 29, 2024. Abaloparatide.
173. Miller PD, Hattersley G, Riis BJ, Williams GC, Lau E, Russo LA, Alexandersen P, Zerbini CA, Hu MY, Harris AG, Fitzpatrick LA, Cosman F, Christiansen C., ACTIVE Study Investigators. Effect of Abaloparatide vs Placebo on New Vertebral Fractures in Postmenopausal Women With Osteoporosis: A Randomized Clinical Trial. JAMA. 2016 Aug 16;316(7):722-33.
174. Bone HG, Cosman F, Miller PD, Williams GC, Hattersley G, Hu MY, Fitzpatrick LA, Mitlak B, Papapoulos S, Rizzoli R, Dore RK, Bilezikian JP, Saag KG. ACTIVExtend: 24 Months of Alendronate After 18 Months of Abaloparatide or Placebo for Postmenopausal Osteoporosis. J Clin Endocrinol Metab. 2018 Aug 01;103(8):2949-2957.
175. Matsumoto T, Sone T, Soen S, Tanaka S, Yamashita A, Inoue T. Abaloparatide Increases Lumbar Spine and Hip BMD in Japanese Patients With Osteoporosis: The Phase 3 ACTIVE-J Study. J Clin Endocrinol Metab. 2022 Sep 28;107(10):e4222-e4231.
176. Miller SA, St Onge EL, Whalen KL. Romosozumab: A Novel Agent in the Treatment for Postmenopausal Osteoporosis. J Pharm Technol. 2021 Feb;37(1):45-52.
177. Krupa KN, Parmar M, Delo LF. StatPearls [Internet]. StatPearls Publishing; Treasure Island (FL): Jul 19, 2024. Romosozumab.
178. Brown JP, Engelke K, Keaveny TM, Chines A, Chapurlat R, Foldes AJ, Nogues X, Civitelli R, De Villiers T, Massari F, Zerbini CAF, Wang Z, Oates MK, Recknor C, Libanati C. Romosozumab improves lumbar spine bone mass and bone strength parameters relative to alendronate in postmenopausal women: results from the Active-Controlled Fracture Study in Postmenopausal Women With Osteoporosis at High Risk (ARCH) trial. J Bone Miner Res. 2021 Nov;36(11):2139-2152.
179. Cosman F, Crittenden DB, Ferrari S, Khan A, Lane NE, Lippuner K, Matsumoto T, Milmont CE, Libanati C, Grauer A. FRAME Study: The Foundation Effect of Building Bone With 1 Year of Romosozumab Leads to Continued Lower Fracture Risk After Transition to Denosumab. J Bone Miner Res. 2018 Jul;33(7):1219-1226.
180. Langdahl BL, Libanati C, Crittenden DB, Bolognese MA, Brown JP, Daizadeh NS, Dokoupilova E, Engelke K, Finkelstein JS, Genant HK, Goemaere S, Hyldstrup L, Jodar-Gimeno E, Keaveny TM, Kendler D, Lakatos P, Maddox J, Malouf J, Massari FE, Molina JF, Ulla MR, Grauer A. Romosozumab (sclerostin monoclonal antibody) versus teriparatide in postmenopausal women with osteoporosis transitioning from oral bisphosphonate therapy: a randomised, open-label, phase 3 trial. Lancet. 2017 Sep 30;390(10102):1585-1594.
181. Robinson Y, Tschöke SK, Stahel PF, Kayser R, Heyde CE. Complications and safety aspects of kyphoplasty for osteoporotic vertebral fractures: a prospective follow-up study in 102 consecutive patients. Patient Saf Surg. 2008 Jan 15;2:2.
182. Gregson CL, Compston JE. New national osteoporosis guidance-implications for geriatricians. Age Ageing. 2022 Apr 01;51(4
183. Cosman F, Eriksen EF, Recknor C, Miller PD, Guañabens N, Kasperk C, Papanastasiou P, Readie A, Rao H, Gasser JA, Bucci-Rechtweg C, Boonen S. Effects of intravenous zoledronic acid plus subcutaneous teriparatide [rhPTH(1-34)] in postmenopausal osteoporosis. J Bone Miner Res. 2011 Mar;26(3):503-11.
184. Tsai JN, Uihlein AV, Lee H, Kumbhani R, Siwila-Sackman E, McKay EA, Burnett-Bowie SA, Neer RM, Leder BZ. Teriparatide and denosumab, alone or combined, in women with postmenopausal osteoporosis: the DATA study randomised trial. Lancet. 2013 Jul 06;382(9886):50-6.
185. Buckley L, Guyatt G, Fink HA, Cannon M, Grossman J, Hansen KE, Humphrey MB, Lane NE, Magrey M, Miller M, Morrison L, Rao M, Robinson AB, Saha S, Wolver S, Bannuru RR, Vaysbrot E, Osani M, Turgunbaev M, Miller AS, McAlindon T. 2017 American College of Rheumatology Guideline for the Prevention and Treatment of Glucocorticoid-Induced Osteoporosis. Arthritis Rheumatol. 2017 Aug;69(8):1521-1537
186. Lekamwasam S, Adachi JD, Agnusdei D, Bilezikian J, Boonen S, Borgström F, Cooper C, Diez Perez A, Eastell R, Hofbauer LC, Kanis JA, Langdahl BL, Lesnyak O, Lorenc R, McCloskey E, Messina OD, Napoli N, Obermayer-Pietsch B, Ralston SH, Sambrook PN, Silverman S, Sosa M, Stepan J, Suppan G, Wahl DA, Compston JE., Joint IOF-ECTS GIO Guidelines Working Group. A framework for the development of guidelines for the management of glucocorticoid-induced osteoporosis. Osteoporos Int. 2012 Sep;23(9):2257-76.
187. Bauer D, Krege J, Lane N, Leary E, Libanati C, Miller P, Myers G, Silverman S, Vesper HW, Lee D, Payette M, Randall S. National Bone Health Alliance Bone Turnover Marker Project: current practices and the need for US harmonization, standardization, and common reference ranges. Osteoporos Int. 2012 Oct;23(10):2425-33