

Osteoporosis and the Burden of Osteoporosis-Related Fractures

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Scope of the Problem

Osteoporosis, a common bone disease that is characterized by loss of bone mass and structural deterioration of bone tissue, is a potential public health problem for approximately 44 million Americans.^{1,2} In the United States, 10 million individuals over the age of 50 years—8 million women and 2 million men—are estimated to already have the disease.^{1,3} In addition, approximately 34 million individuals have low bone mass (osteopenia), which places them at risk for developing osteoporosis or an osteoporosis-related fracture.² As the population ages, these numbers are expected to increase to an estimated 14 million individuals with osteoporosis and more than 47 million cases of low bone mass by 2020.¹

The societal burden of osteoporosis includes direct medical costs, such as those associated with acute and rehabilitative care following osteoporosis-related fractures, as well as indirect costs related to poor health.⁴ Direct medical costs of osteoporosis in the United States were estimated to be between \$13.7 billion and \$20.3 billion in 2005.⁵ Also, it is projected that by 2025, there will be over 3 million fractures, with related expenditures of \$25.3 billion per year.^{1,6} Fractures can result in wide-ranging healthcare resource utilization and costs beyond the direct costs attributable to acute fracture treatment and follow-up. For example, patients whose fractures are treated in inpatient facilities may require subsequent hospitalization for postoperative complications, such as chest infection, venous thromboembolism, or pneumonia.⁶ The high morbidity and consequent dependency associated with these fractures may strain interpersonal relationships and social roles of patients and their caregivers.

Potential Consequences of Osteoporosis

Osteoporosis can lead to numerous other clinical and health-related consequences, including fracture, the need for long-term care, and excess mortality. The reduced bone density associated with the disorder is a major risk factor for fracture, especially of the hip, spine, and wrist.^{2,3} Osteoporosis is often referred to as a silent disease, as many individuals do not realize that they have the disease until a fracture occurs.⁷ Each year, about 2 million individuals

Abstract

Osteoporosis is responsible for approximately 2 million fractures annually, including hip, vertebral (spinal), wrist, and other fractures. Osteoporosis-related fractures may lead to diminished quality of life, disability, and even death. In addition, the direct and indirect costs of osteoporosis and its associated fractures are tremendous. Given the aging population, by 2025, annual direct costs from osteoporosis are expected to reach approximately \$25.3 billion. Thus, osteoporosis has significant physical, emotional, and financial consequences. With appropriate screening, healthcare providers can implement effective interventions before fractures occur and ultimately improve quality of life, as well as help curb looming osteoporosis-related costs.

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experience an osteoporosis-related fracture, which in turn is associated with increased risk of both morbidity and mortality.⁷ The risk of fracture increases dramatically with age in both men and women, as a result of both increased fragility of bones and an increased risk of falling. Roughly 24% of women 50 years or older and 16% of men 50 years or older fall each year, and this rises to nearly 50% of women age 85 or older and 35% of men age 85 or older.³

Osteoporosis-related fractures impose a heavy burden on individuals and on society, as they often lead to a variety of physical and psychological consequences, including future fractures, depression, functional impairment, pain, and disability.⁸ Fractures, especially vertebral fractures, can be associated with chronic, disabling pain.⁹ In addition, fractures can be extremely debilitating. In particular, hip fractures result in a 10% to 20% increase in mortality risk within 1 year and are associated with a 2.5-fold increased risk for the development of future fractures.^{3,10} Nearly one-third of patients with hip fracture are admitted to a long-term care facility within a year following their fracture.⁹ Approximately 20% of hip fracture patients require long-term nursing home care, and the majority of patients do not regain their pre-fracture level of independence.³ Rehabilitation is lengthy and many individuals never regain their pre-fracture level of mobility, which can have a significant impact on lifestyle and well-being.¹¹ For instance, decreased functionality often results in total or partial inability to fulfill social roles or a need to remain in long-term care facilities, which may lead to psychological issues such as depression or anxiety.

Osteoporosis is a preventable disease that can be diagnosed and managed before any fracture occurs. In patients who have already experienced a fracture, the appropriate use of available therapies can effectively decrease the risk of future fractures.³ Although osteoporosis is a common and preventable disease, the prevalence of the disease and the incidence of osteoporosis-related fractures continue to increase due to the aging population. As a result, cost estimates associated with osteoporosis will likely also continue to rise. Therefore, efforts to address the looming financial burden must focus on reducing the prevalence of osteoporosis and the incidence of costly fragility fractures.

Osteoporosis and Bone Health

Osteoporosis can be defined as a skeletal disorder that is characterized by compromised bone strength which leads to an increased risk of fracture.⁹ Whole bone strength, which is determined by the integration of bone density and bone quality, is the key to understanding fracture risk. The ability of bone to resist fracture depends on several factors including

■ **Table 1. Determinants of Bone Strength**¹²⁻¹⁴

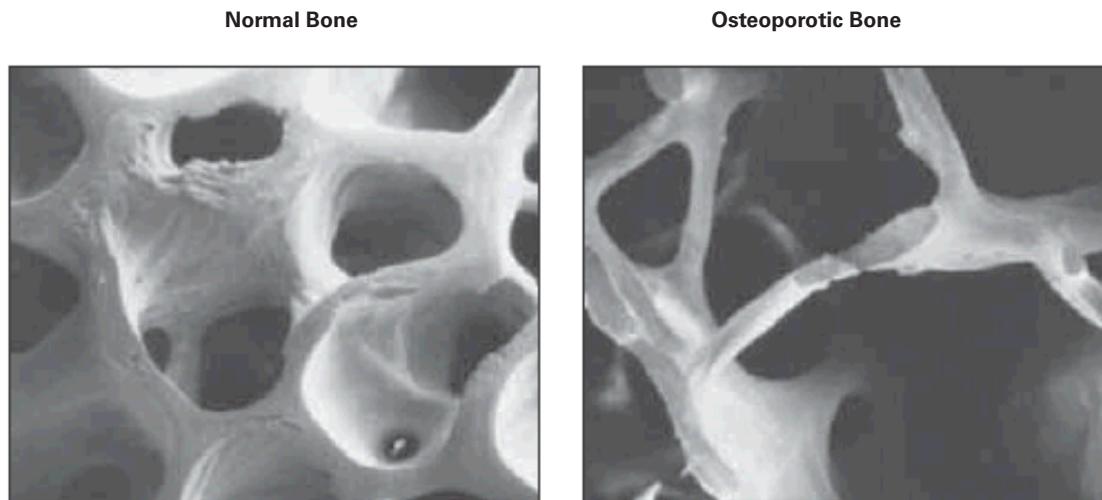
Bone mass
Bone quality
• Microarchitecture
• Microdamage
• Collagen traits
• Mineralization
Bone remodeling

bone mass, the shape and microarchitecture of the bone, and innate properties of the materials that comprise the bone (eg, mineralization and microdamage) (Table 1).¹²⁻¹⁵ Bone density measures grams of mineral per area or volume, and is determined by peak bone mass and amount of bone loss.⁹ Peak bone mass is achieved between the ages of 18 and 25 years, and is largely determined by genetic factors.⁴ Other determinants of peak bone mass include nutrition, endocrine status, physical activity, and overall health during growth.⁴

Bone quality is an amalgamation of all the factors that, in addition to bone mass, determine how well the skeleton can resist fracture, including microarchitecture, accumulated microscopic damage, the quality of collagen, the degree of mineralization, and the rate of bone turnover. Bone remodeling, specifically the balance between the formation of new bone and bone resorption (breakdown of bone), is the biologic process that maintains a healthy skeleton and mediates changes in the factors that influence bone strength. Remodeling does not change the shape of bone, but is vital for bone health as it repairs skeletal damage that can result from repeated stresses by mending small areas of damage. Remodeling also serves to renew the cellular elements of bone, in particular, the osteocytes, which are derived from osteoblasts. Osteocytes play a key role in bone health by regulating the remodeling process, among many other functions. In addition, remodeling prevents the accumulation of too much old bone, which can lose its resilience and become brittle. On a cellular level, bone remodeling involves osteoblasts (cells that form bone) and osteoclasts (cells that break down bone). When the balance between the formation of new bone and bone resorption is altered and there is greater bone breakdown than replacement, bone loss occurs. Thus diseases and pharmacologic agents that impact bone remodeling will ultimately influence bone's resistance to fracture.

As discussed, the composition of the mineral and matrix, the fine structure of trabecular bone, the porosity of cortical bone, and the presence of microfractures and other forms of bone damage are all important determinants of bone strength. Alterations in the microarchitecture of trabecular bone are especially critical as osteoporosis-related fractures

■ **Figure.** Normal Versus Osteoporotic Bone¹⁶



most commonly occur at sites that are rich in trabecular bone, such as the spine, wrist, and hip. Normal trabecular bone structure consists of resilient interconnected plates and broad beams that provide great strength. In individuals with osteoporosis, these plates are disrupted and deteriorate into weakened rod-like structures that are no longer well connected (Figure).¹⁶ These disconnected rods of bone may lead to overestimation of bone strength by bone mineral density (BMD) assessment as they may be measured as bone mass, but fail to contribute to bone strength.

Assessment of the extent of compromised bone strength can help to predict the magnitude of fracture risk; however, there is currently no accurate measure of overall bone strength. BMD is frequently used as a proxy measure and accounts for approximately 70% of bone strength. According to the World Health Organization (WHO), osteoporosis is defined as a T score of -2.5 or lower, while osteopenia or, more appropriately, “low bone density,” is defined as a T score that is higher than -2.5 but less than -1.0.¹⁷ Osteopenia indicates bone density that is lower than normal, yet not so low as to be defined as osteoporosis.

Low Bone Density (Osteopenia)

As with osteoporosis, low bone density (osteopenia) can be readily diagnosed using BMD. Low bone density, as a clinical condition, has been compared with prehypertension and impaired fasting glucose in that low bone density defines an intermediate risk group for the development of osteoporosis, osteoporosis-related fractures, and associated complications.^{12,18} In addition, data demonstrate that low bone density can increase the risk of fracture. Therefore, careful consideration needs to be given to the actions warranted by

a diagnosis of low bone density, whether it be monitoring, the initiation of preventive lifestyle and dietary modifications, or pharmacologic treatment.¹⁹ In some instances, bone density falls below average, but not below normal, and some individuals may have other risk factors that need to be taken into account. The issue is complicated, and has caused considerable controversy in the medical community; however, there is no simple formula that can accommodate every case. The management of patients with low bone density should ultimately be based on the clinician’s judgment and the individual patient’s fracture risk profile.

Risk Factors and Secondary Causes of Osteoporosis

There are a number of mechanisms by which osteoporosis can develop, leading to skeletal fragility and increased risk of fracture. Genetics, poor nutrition, or suboptimal physical activity may predict the failure to develop a strong skeleton in the first place.³ Excessive resorption may occur due to decreased production of sex hormones, calcium and/or vitamin D deficiency, increased production of parathyroid hormone, or excess production of local resorbing factors.³ Failure to replace lost bone due to impaired formation may be due to loss of ability to replenish bone cells with age, decreased production of systemic growth factors, or loss of local growth factors.³ In addition, increased tendency to fall, which may precipitate an osteoporosis-related fracture, may be due to loss of muscle strength, slowed reflexes, poor vision, or medications that impair balance.³

Recognition of individuals at risk for osteoporosis is imperative to reducing morbidity and mortality associated with osteoporosis-related fractures. A clinical evaluation should be used to assess risk factors for osteoporosis and to

■ **Table 2.** Risk Factors for Osteoporosis-Related Fracture^{3,4,11}

Biologic Risk Factors
Low bone mass
Advancing age
Personal history of osteoporosis or fracture as an adult
Parental history of fracture
Family history of bone disease
Race (Caucasian or Asian postmenopausal women)
Small, thin frame
Hypogonadism (premature estrogen deficiency in women <45 years of age; low testosterone levels in men)
Family history of bone disease
Weight loss of more than 1% per year in the elderly
Late onset of sexual development
Height loss or progressive spinal curvature
Lifestyle and Dietary Risk Factors
Low calcium intake
Vitamin D deficiency
High salt intake
Alcohol (≥ 3 drinks/day)
Inadequate physical activity
Low body mass index
Smoking
Weaker evidence:
Excess vitamin A intake
High caffeine intake
Immobilization

identify high-risk patients for additional testing or initiation of preventive or therapeutic interventions. There are numerous risk factors for osteoporosis and osteoporosis-related fractures, and knowledge and recognition of these factors is important when evaluating the need for preventive measures. The most dominant risk factor for osteoporosis is low bone mass, which alone predicts fracture risk. In addition, there are biologic risk factors (eg, advancing age, family history of fracture, and race) and lifestyle risk factors (eg, low calcium intake and vitamin D deficiency) that may increase risk of osteoporosis and osteoporosis-related fractures (Table 2).^{3,4,11} In general, the greater the number of risk factors present, the greater the risk of fracture.

Young adults and some older individuals who develop osteoporosis may do so as a consequence of another medical condition or the use of certain medications. There are a number of extrinsic causes of osteoporosis (Table 3), including genetic disorders, rheumatic diseases, autoimmune diseases,

hypogonadal conditions, endocrine disorders, gastrointestinal disorders, and hematologic disorders.^{3,4} Additionally, a variety of medications may be associated with osteoporosis, most commonly glucocorticoids.³ Individuals who have osteoporosis as a result of these extrinsic causes are considered to have secondary osteoporosis. Individuals with secondary osteoporosis typically exhibit lower bone mass than would be expected for a normal individual of the same age, gender, and race. Secondary causes of osteoporosis are common in many premenopausal women and men with the disease.³ A thorough history and physical exam may help identify potential secondary causes of osteoporosis since many of these conditions will present signs and symptoms in addition to those associated with osteoporosis.

Special Considerations in Osteoporosis

Osteoporosis and osteoporosis-related fractures become more of a concern as an individual ages. Healthcare and related services for the ever-growing elderly US population may be managed by various organizations, including managed care, integrated delivery systems, or government-based programs such as Medicare, Medicaid, and the Veterans Administration (VA) healthcare system. Within each of these organizations, there may be variations in general patient population demographics, access, or resources that impact the implementation of initiatives for improving the screening, diagnosis, and treatment of osteoporosis. Nonetheless, the development and implementation of such initiatives is imperative to prevent the potential clinical implications of osteoporosis, reduce the incidence of osteoporosis-related fractures, and help manage healthcare-related costs.

Most of the claims-based findings available regarding osteoporosis have used data from commercial plans to determine the economic impact of the disease. As a result, the burden of osteoporosis-related costs for private managed care organizations has clearly been demonstrated. The direct cost of osteoporosis-related fractures, however, is largely handled by public payers, with Medicare covering approximately 48% and Medicaid covering an estimated 24%.²⁰ Given the specific role of Medicare in providing healthcare-related benefits to elderly patients, it is fairly obvious that osteoporosis-related costs will have a significant impact on Medicare.

What might be less obvious is the impact of osteoporosis on Medicaid beneficiaries and VA patients. More specifically, Medicaid beneficiaries may be of particular interest as they have been shown to have longer inpatient stays and higher total hospital charges than Medicare beneficiaries.²¹

Table 3. Selected Secondary Causes of Osteoporosis and Osteoporosis-Related Fractures^{a,3,4}

Genetic Disorders
Cystic fibrosis
Hemochromatosis
Glycogen storage diseases
Porphyria
Homocystinuria
Hypophosphatemia
Rheumatic and Autoimmune Diseases
Ankylosing spondylitis
Lupus
Rheumatoid arthritis
Hypogonadal Disorders
Androgen insensitivity
Hyperprolactinemia
Premature ovarian failure
Athletic amenorrhea
Endocrine Disorders
Adrenal insufficiency
Diabetes mellitus
Cushing's syndrome
Hyperparathyroidism
Hypothyroidism
Thyrotoxicosis
Gastrointestinal Disorders
Celiac disease
Gastric bypass
GI surgery
Inflammatory bowel disease
Malabsorption
Pancreatic disease
Primary biliary cirrhosis
Hematologic Disorders
Hemophilia
Sickle cell disease
Thalassemia
Leukemia and lymphomas
Medications
Anticoagulants (heparin)
Anticonvulsants
Barbiturates
Chemotherapeutic agents
Glucocorticoids
Gonadotropin-releasing hormone agonists
Immunosuppressants
Lithium
Long-acting progestin
Proton pump inhibitors
GI indicates gastrointestinal.
^a List is not all-inclusive.

Private and self-pay patients paid less for their care and had shorter lengths of hospital stays.²¹ In addition, when other factors such as age, race, and specialty of treating physician were controlled for, Medicaid beneficiaries were found to be 55% less likely to receive osteoporosis-related therapy.²²

VA patients may also be overlooked when considering osteoporosis and osteoporosis-related costs, as the majority of these patients are male and osteoporosis is typically associated with postmenopausal women. It is important to remember that the VA is the largest integrated delivery system in the United States and treats over 2000 hip fracture patients annually.²³ However, data assessing the frequency of BMD testing and initiation of osteoporosis treatment in veterans are limited. While osteoporosis has not been a traditional quality improvement focus within the VA, there is growing evidence that appreciation of osteoporosis as a potential threat to veterans' health is increasing.²³

Due to the fact that healthcare coverage and provision of services for the elderly US population are fragmented, singular tactics for improved osteoporosis care and patient education may be difficult to develop and implement. Despite these barriers, there is an opportunity for all healthcare payers to utilize overarching strategies for optimizing osteoporosis management and manipulate them for use within their own organizations in order to enhance health outcomes and ultimately reduce costs.

Multifaceted initiatives that improve outcomes and conserve healthcare resources related to osteoporosis would benefit not only the payers of osteoporosis-related costs, but ultimately patients. Useful strategies that may help to reinforce optimal treatment methodologies include those that enhance physician performance by establishing clear, documentable expectations, developing clinical programs that incorporate effective and appropriate interventions, and providing clinicians with feedback and incentives. Additional resources geared toward improving patient outcomes could include site-appropriate point-of-care teaching tools, patient education materials, and motivational interviewing techniques.

Wrap-up

Osteoporosis has significant physical, emotional, and financial consequences. All too often, the first sign of osteoporosis is a fragility fracture. By appropriately screening patients for fracture risk and evaluating BMD and other risk factors in patients with low bone density (osteopenia) and osteoporosis, healthcare providers can implement effective interventions before fractures occur and ultimately improve quality of life, as well as help curb looming osteoporosis-related costs.

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Authorship Information: Analysis and interpretation of data; drafting of manuscript; and critical revision of the manuscript for important intellectual content.

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