The Prevalence, Risk Factors, Diagnosis & Treatment of Osteoporosis in Bangladesh

By

Naima Hasan Bulbuli
22376014

A thesis submitted to the Department of Mathematics and Natural Science in partial fulfillment of the requirements for the degree of
Master of Biotechnology

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Declaration

It is hereby declared that

1. The thesis submitted is my/our own original work while completing degree at Brac University.
2. The thesis does not contain material previously published or written by a third party, except where this is appropriately cited through full and accurate referencing.
3. The thesis does not contain material which has been accepted, or submitted, for any other degree or diploma at a university or other institution.
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Student's Full Name & Signature:

Naima Hasan Bulbuli
22376014

Approval

The thesis/project titled “The Prevalence, Risk Factors, Diagnosis & Treatment of Osteoporosis in Bangladesh” submitted by

1. Naima Hasan Bulbuli (22376014)]

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Examining Committee:

Supervisor:
(Member)

_____
Dr. Munima Haque
Associate Professor and Biotechnology Program Director,
Department of Mathematics and Natural Sciences (MNS)
BRAC University

Program Director:
(Member)

_____
Dr. Munima Haque
Biotechnology Program Director and Associate Professor,
Department of Mathematics and Natural Sciences (MNS)
BRAC University

External Expert Examiner:
(Member)

_____
Dr. Aminul Haque
Associate Professor, Department of Pharmacy
BRAC University

Departmental Head:
(Chair)

_____
Dr. M. Firoze H. Haque
Associate Professor and Chairperson, Department of
Mathematics and Natural Sciences, BRAC University

Abstract

Osteoporosis is a debilitating condition affecting over 200 million individuals worldwide, characterized by reduced bone mass and increased susceptibility to fractures. In Bangladesh, the prevalence is alarmingly high, particularly among women and the elderly, yet it remains underdiagnosed and poorly understood. This review synthesizes data from global and regional studies, highlighting the critical role of lifestyle, nutrition, and awareness in influencing osteoporosis outcomes. Analysis reveals that approximately 35% of Bangladeshi adults suffer from osteoporosis, with an additional 40% classified as having osteopenia Factors such as low calcium intake, insufficient vitamin D levels, and sedentary lifestyles are prevalent, affecting over 70% of the population Notably, only 30% of individuals are aware of osteoporosis and its prevention, underscoring the urgent need for targeted public health interventions. This paper emphasizes the importance of comprehensive strategies integrating nutrition education, community outreach, and accessible screening programs. By addressing these factors, Bangladesh can mitigate the growing burden of osteoporosis and improve the quality of life for its population. This review provides a foundation for developing evidence-based policies and interventions tailored to the country’s unique socio-cultural context.

Keywords: Osteoporosis, osteopenia, risk factors, women's health, hormonal imbalance.

Dedication

To my husband and parents, I couldn’t have done this without you.

Thank you for all of your support along the way.

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Naima Hasan Bulbuli

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List of Acronyms

LMIC	Low-and Middle-Income Country
BMD	Bone Mineral Density
DEXA	Dual-energy X-ray Absorptiometry
SERM	Selective Estrogen Receptor Modulator
NOF	National Osteoporosis Foundation
IOF	International Osteoporosis Foundation
BMI	Body Mass Index
VDR	Vitamin D Receptor
RDA	Recommended Dietary Allowance
PPI	Proton Pump Inhibitor
GERD	Gastro-Esophageal Reflux Disease
RA	Rheumatoid Arthritis
IBD	Inflammatory Bowel Disease
CKD	Chronic Kidney Disease
PTH	Para Thyroid Hormone
HRT	Hormone Replacement Therapy
FRAX	Fracture Risk Assessment Tool

Chapter 1

Introduction

Reduced bone density and an increased risk of fractures are the hallmarks of osteoporosis, a serious global public health concern. This quiet condition, which primarily affects postmenopausal women, frequently goes undiagnosed until fractures happen (Siris et al., 2014). Although osteoporosis is extensively researched in industrialized countries, less is known about its prevalence and effects in low- and middle-income countries (LMICs), such as Bangladesh. By concentrating on the burden, risk factors, and preventative measures for osteoporosis among Bangladeshi women—a group that is frequently overlooked in international osteoporosis research—this thesis seeks to close this gap.

About 200 million people worldwide suffer from osteoporosis, and women make up 80% of this population (Kanis et al., 2013). Particularly through wrist, hip, and vertebral fractures, the illness greatly increases morbidity and medical expenses (Johnell & Kanis, 2006). Osteoporosis-related fractures can result in increased mortality rates, significant pain, disability, and loss of independence (Cooper et al., 2011). Osteoporosis is still underdiagnosed and undertreated, especially in LMICs, despite the availability of diagnostic tools and efficient treatments (IOF, 2020).

Because of aging populations, nutritional deficits, and a lack of awareness, osteoporosis is becoming a bigger problem throughout South Asia. Research shows that South Asian women have a high prevalence of low bone mineral density (BMD), which is frequently made worse by cultural customs, inadequate calcium intake, and little sun exposure (Gupta et al., 2022). In many South Asian nations, including Bangladesh, osteoporosis is still a low-priority health concern in spite of these concerning developments (Rahman et al., 2018).

Bangladesh presents particular difficulties in combating osteoporosis because of its unusual sociocultural, economic, and environmental circumstances. Bangladesh is primarily an agrarian society, and many of its women work in physically demanding jobs from a young age. Ironically, because of things like inadequate nutrition, low vitamin D levels, and high rates of early menopause, this does not always protect against osteoporosis (Hasan et al., 2021).

Additionally, the nation's underdiagnosis and undertreatment of osteoporosis are caused by a lack of adequate healthcare infrastructure, poor public awareness, and cultural stigmas related to aging (Jahan et al., 2020).

In Bangladesh, the high rate of osteoporosis among women is caused by several risk factors. Calcium and vitamin D, which are vital minerals for bone health, are frequently lacking in Bangladeshi diets (Islam et al., 2019). Due to dietary preferences and financial limitations, there is very little dairy intake. Due to cultural customs like hiding clothes and limiting outside activities, vitamin D insufficiency is common even in areas with plenty of sunlight (Rashid et al., 2017). Bangladeshi women's bone loss is accelerated by high rates of early menopause, which are frequently associated with malnutrition and problems with reproductive health (Rahman et al., 2018). Low use of diagnostic and preventative services is caused by a lack of knowledge about osteoporosis and the significance of bone health (Jahan et al., 2020).

Osteoporosis has serious health and socioeconomic repercussions. Osteoporosis-related fractures result in greater dependency, worse quality of life, and longer disability, especially in low-income homes where women are essential caregivers (Cooper et al., 2011). Given the scarcity of reasonably priced treatment alternatives in Bangladesh, the financial burden on families and the healthcare system is especially significant (Hasan et al., 2021).

In Bangladesh, there are insufficient preventive and diagnostic strategies for osteoporosis. The gold standard for diagnosing osteoporosis, bone mineral density (BMD) testing, is costly and only accessible in urban areas (Islam et al., 2019). There are few preventive initiatives, such as public health campaigns that encourage the consumption of calcium and vitamin D. Furthermore, there are no national policies or guidelines that are especially focused on managing and preventing osteoporosis (Jahan et al., 2020).

It is crucial for public health to treat osteoporosis among Bangladeshi women because of the country's aging population and high-risk factor burden. By investigating the prevalence, risk factors, and potential treatments for osteoporosis in this susceptible population, this study aims to close important knowledge gaps. The results are intended to educate community

stakeholders, healthcare professionals, and policymakers on practical ways to lessen the effects of osteoporosis in Bangladesh.

Chapter 2

Human Body Anatomy

2.1. Introduction

Understanding human physiology and the mechanisms underlying health and illness is based on the study of human body anatomy, the field of research that focuses on the structure of the human body. Human anatomy is a complicated subject that includes both tiny objects that can only be seen under a microscope and macroscopic components that are visible to the unaided eye (Drake et al., 2020). The word "anatomy" comes from the Greek word "anatomē," which means dissection, emphasizing that the field's roots are in investigative methods meant to reveal the body's complex makeup. Although human morphology is universal, there are notable differences between the structure of men and women that affect biological processes, health outcomes, and medical treatments (Moore et al., 2017).

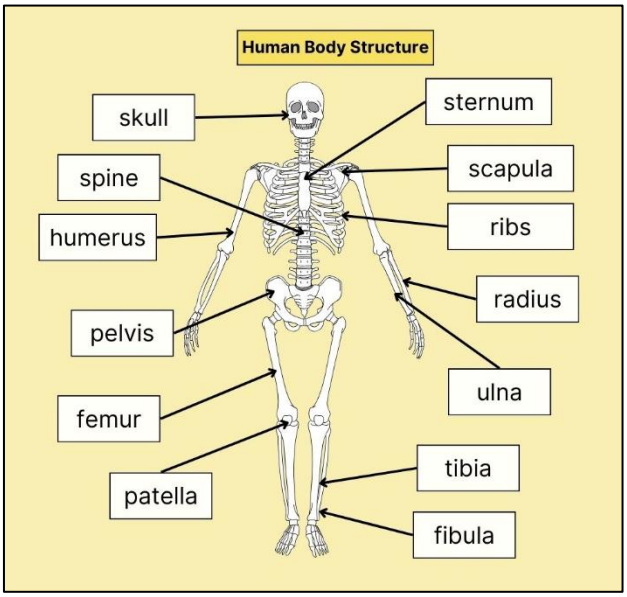

Figure 1: Human Body Structure

The human body is made up of many organs, tissues, cells, and systems that work together in complex ways to support life. The circulatory, respiratory, digestive, urinary, endocrine, neurological, skeletal, muscular, and reproductive systems are some of these systems (Tortora & Derrickson, 2021). A key component of anatomy, the skeletal system is made up of bones,

cartilage, ligaments, and joints that support structure, allow mobility, and shield important organs. Additionally, minerals like calcium and phosphorus, which are necessary for several physiological processes, are stored in bones (Marieb & Hoehn, 2019). Because diseases like osteoporosis, which disproportionately affect women, can result from a reduction in bone density and health, these factors are especially important (Kanis et al., 2013).

2.1.1. Male Body Anatomy

Despite having numerous structural similarities to the female anatomy, the male anatomy has unique features that affect skeletal health and general physiology. Because testosterone encourages bone formation and maintenance, males often have larger and denser skeletons (Moore et al., 2017). Males have taller, narrower pelvises that are more suited for movement and stamina than for birthing. Furthermore, men often have larger muscles, which puts more mechanical strain on bones and raises peak bone mass (Marieb & Hoehn, 2019).

Males differ significantly in key skeletal sections, including the limbs, thorax, and skull. Larger mastoid processes and more noticeable brow ridges are characteristic of the male skull. Because of the wider rib cage, the lung can hold more air, which is essential for increasing oxygen demand during physical activity. Males' long bones, such as the femur and humerus, are also stronger and more fracture-resistant (Drake et al., 2020).

Despite these benefits, bone problems can still affect men. Even though osteoporosis is less common in men, it is frequently misdiagnosed and shows up later in life, which can have serious consequences. Male bone loss is caused by a number of factors, including smoking, heavy alcohol use, and sedentary lifestyles. Moreover, the risk of osteoporosis is greatly increased by diseases such as hypogonadism, which lowers testosterone levels (Cooper et al., 2011). Addressing osteoporosis risks and creating focused preventative measures require an understanding of these variations (Kanis et al., 2013).

2.1.2. Female Body Anatomy

On the other hand, the reproductive system and skeletal structure of females show distinctive adaptations. According to Moore et al. (2017), the female pelvis is designed to make childbirth

easier since it is shallower and wider than the male pelvis. Despite being necessary for reproduction, this anatomical characteristic leads to biomechanical variations that affect posture and walking. Because of hormonal changes, especially after menopause when estrogen levels drop, women typically have lower peak bone mass and higher rates of bone loss (Kanis et al., 2013).

Bone density and shape variations are another feature of the female skeletal system. Women's bones are more prone to fragility since their cortices are usually thinner and their cross-sectional bone regions are smaller. Under osteoporotic conditions, females are more susceptible to vertebral fractures due to their shorter and less dense vertebral bodies (Marieb & Hoehn, 2019). Furthermore, calcium metabolism and bone remodeling processes are significantly impacted by the hormonal changes that occur during pregnancy, lactation, and menopause (Gupta et al., 2022).

Environmental and lifestyle factors further impair the bone health of women. Women's engagement in weight-bearing physical activities, which are critical for bone health, is frequently restricted by cultural conventions. Long-term use of some drugs, including corticosteroids, can cause secondary osteoporosis, and nutritional deficiencies, especially in calcium and vitamin D, worsen bone loss (Tortora & Derrickson, 2021). To reduce these risks, preventive actions are crucial, such as early screening, physical activity, and sufficient calcium and vitamin D intake (Johnell & Kanis, 2006).

The significance of sex-specific approaches in healthcare is highlighted by the physical and physiological distinctions between the skeletons of men and women. Knowing these differences can help treat illnesses like osteoporosis, arthritis, and fractures more effectively, from diagnostic imaging to therapeutic therapies. Our capacity to precisely measure bone density has improved due to advancements in imaging technology, such as dual-energy X-ray absorptiometry (DEXA) scans, which enable early detection and intervention (Guyton & Hall, 2020).

Furthermore, studies on the interaction of environmental, hormonal, and genetic factors on bone health are also ongoing. Research on epigenetic changes and sex-specific gene expression

provides encouraging new information for specialized skeletal disease treatments. Selective estrogen receptor modulators (SERMs), for example, are being researched as possible treatments to stop women's bone loss after menopause (Gupta et al., 2022). Similarly, in males with osteoporosis, anabolic drugs such as teriparatide are effective in boosting bone density (Kanis et al., 2013).

Knowing the anatomical variations between men and women, especially with regard to the skeletal system, is essential for medical professionals as it affects diagnosis, treatment planning, and the provision of healthcare. For example, physical and hormonal variables contribute to the differences in how cardiovascular disease manifests in men and women (Moore et al., 2017). Similarly, women are more likely to suffer from illnesses like osteoporosis, which emphasizes the need for specialized methods to therapy and prevention (Marieb & Hoehn, 2019).

An understanding of anatomy also applies to surgical procedures, where knowledge of sex-specific structures improves results and reduces complications. For instance, accurate anatomical knowledge is necessary for gynecological treatments in women and prostate surgery in men in order to maintain function and avoid side effects (Drake et al., 2020). Furthermore, improvements in imaging methods like MRI and CT scans help us better understand anatomy by providing intricate visualizations that support medical research and diagnoses (Guyton & Hall, 2020).

2.2. Comparative Analysis of Male and Female Body Anatomy

The anatomical distinctions between the male and female bodies are largely due to biological processes, hormone effects, and evolutionary adaptations. These variations are present in many different systems, but they are particularly noteworthy in the skeletal system, which is intimately related to diseases like osteoporosis. Designing successful medical interventions, treatments, and preventative measures requires an understanding of these differences.

Strength, endurance, and support for increased physical activity are the main characteristics of male skeletal anatomy. Because testosterone has anabolic effects that promote bone production

and mineral density, men tend to have larger and denser bones (Rosen & Bouxsein, 2020). Male long bones, such the femur and tibia, have thicker cortices and larger cross-sectional areas, which increase their mechanical strength and fracture resistance (Riggs et al., 2004).

The male pelvis is more vertically orientated and thinner, and it is not made to support birthing but rather for optimal movement. By reducing movement-induced stress on the hips and lower spine, this anatomical orientation lowers the likelihood of degenerative alterations such osteoarthritis (Drake et al., 2020). Males have a larger rib cage in the thoracic area, which supports a wider upper body structure and increases lung capacity.

The cranial and facial bones also vary; men tend to have thicker skull bones, larger mandibles, and more noticeable brow ridges. According to Moore et al. (2017), these characteristics are a result of hormonal changes that occur throughout puberty and promote bone growth in response to elevated androgen levels.

Notwithstanding these benefits, diseases like osteoporosis can still affect the male skeletal system. Although osteoporosis is less common in men, it is frequently misdiagnosed and, when it does occur, can cause serious consequences. Male bone loss, especially in advanced age, is caused by factors such as hypogonadism, long-term steroid use, and vitamin D inadequacy (Kanis et al., 2013). These hazards can be reduced by early intervention with weight-bearing activities, healthy eating, and pharmaceutical treatments (Gupta et al., 2022).

The female skeletal system has changed in shape, density, and structural orientation in order to carry out reproductive tasks. The pelvis, which is wider, shallower, and more circular in females to aid in birthing, is one of the most obvious distinctions (Marieb & Hoehn, 2019). Although necessary for reproduction, this adaptation changes the biomechanical pressures on the hips and lower spine, which may make people more vulnerable to diseases including lower back pain and sacroiliac joint dysfunction (Drake et al., 2020).

Generally speaking, women have less peak bone mass than men; this disparity is more significant as people age and experience hormonal changes. A key factor in preserving the health of the female skeleton is estrogen, a hormone that stimulates bone production and prevents resorption. Menopause causes a drop in estrogen levels, which speeds up bone loss

and raises the risk of osteoporosis and fractures (Riggs et al., 2004). Because postmenopausal women have thinner cortices and smaller bone cross-sections, they are more likely to suffer hip fractures and vertebral compression fractures (Kanis et al., 2013).

Women are more prone to calcium and vitamin D deficiency, which exacerbates bone loss, in addition to hormonal factors. Due to their increased calcium requirements, pregnancy and lactation provide additional challenges to skeletal health and frequently result in temporary bone demineralization (Gupta et al., 2022). However, with proper diet and post-lactation recuperation, this process is typically reversible.

Table 1: Comparison of Male and Female Bone Structure

Feature	Male	Female
Skeletal System	Larger, denser bones; more pronounced brow ridge, jaw, and muscle attachment points. Narrower pelvis.	Smaller, lighter bones; wider pelvis for childbirth; less pronounced jaw and brow ridge.
Muscular System	Higher muscle mass, greater upper body strength, larger muscle fibers.	Higher fat percentage, especially around hips and thighs; more endurance-based muscle distribution.
Hormonal Differences	Higher testosterone levels (promotes muscle growth, body hair, and deeper voice).	Higher estrogen and progesterone levels (regulates menstruation, supports pregnancy, and promotes fat storage).
Reproductive System	External reproductive organs (penis, testes); produces sperm continuously.	Internal reproductive organs (ovaries, uterus, vagina); menstrual

		cycle, ovulation, and ability to carry a child.
Overall Bone Density & Size	Larger, denser, and heavier bones due to higher testosterone levels.	Smaller, lighter bones with less density, making them more prone to osteoporosis.
Skull	More pronounced brow ridge, larger mandible, and more prominent mastoid process.	Smoother forehead, smaller jaw, and less prominent brow ridge.
Pelvis	Narrower, taller, and more funnel-shaped; iliac crests are closer together.	Wider, shorter, and more open-shaped for childbirth; iliac crests are farther apart.
Pelvic Inlet & Outlet	Smaller, heart-shaped pelvic inlet; narrower outlet.	Larger, rounder pelvic inlet; wider outlet to accommodate childbirth.
Sacrum & Coccyx	Longer, more curved sacrum; coccyx is less movable.	Shorter, wider sacrum; coccyx is more flexible for childbirth.
Femur (Thigh Bone)	Longer and thicker; femur angles less inward.	Slightly shorter and thinner; femur angles more inward due to wider pelvis.
Rib Cage	Larger, longer rib cage with a narrower costal angle.	Smaller, shorter rib cage with a wider costal angle.
Shoulder Girdle	Broader, more robust clavicle and scapula for increased upper body strength.	Narrower shoulders with smaller clavicle and scapula.
Spine	Less lumbar curvature.	Greater lumbar curvature (lordosis) to accommodate pregnancy.

Joint Size & Flexibility	Larger, more stable joints, but less flexible.	Smaller joints with increased flexibility, making them more prone to joint issues.
Aging Process	Lose muscle mass gradually with age, experience baldness more often due to testosterone.	Estrogen decline after menopause leads to increased risk of osteoporosis and skin aging.

Social and lifestyle variables also come into play. High-impact, weight-bearing exercises that increase bone density are less common among women. Physical exercise may be restricted due to cultural norms and caregiving obligations, which exacerbates skeletal weaknesses (Johnell & Kanis, 2006).

The prevalence and consequences of the disease are greatly impacted by the anatomical variations between the skeletons of men and women. The onset of osteoporosis is typically delayed in men due to their larger peak bone mass. But when bone loss does happen, it usually happens faster and is discovered later, usually after a fracture (Cooper et al., 2011). However, because of their lower baseline levels and the effects of menopause, women are more vulnerable even though their bone density declines more gradually (Riggs et al., 2004).

Chapter 3

Osteoporosis

3.1. Introduction

Reduced bone density and bone tissue degeneration are the hallmarks of osteoporosis, a chronic illness that makes bones more brittle and prone to fractures. Millions of people worldwide suffer from it, making it a serious public health issue, especially in elderly populations (National Osteoporosis Foundation [NOF], 2023). In addition to having an effect on the physical health of those who are afflicted, this illness places a significant socioeconomic strain on healthcare systems.

An estimated 200 million people worldwide suffer from osteoporosis, with postmenopausal women and the elderly accounting for a sizable share of the disease's prevalence (International Osteoporosis Foundation [IOF], 2022). According to osteoporosis Australia (2023), more than 4.7 million adults in Australia who are 50 years of age or older are thought to have poor bone health, including osteoporosis and osteopenia. According to studies, one in five men and one in three women over 50 will suffer an osteoporotic fracture at some point in their lives (Cummings & Melton, 2002).

The term "silent disease" is frequently used to describe osteoporosis because it usually shows no symptoms until a fracture happens. Back pain, height loss, or spinal abnormalities like kyphosis are some of the symptoms of vertebral fractures. Conversely, hip fractures often lead to hospitalization and can cause permanent disability or even death (Kanis et al., 2021). To properly manage the condition and prevent fractures, early detection by screening and bone density measures is essential.

The gold standard for osteoporosis diagnosis is dual-energy X-ray absorptiometry (DXA), which measures bone mineral density (BMD). A quantitative indicator of fracture risk, the T-score obtained from DXA compares a person's bone mineral density (BMD) to that of a young

adult in good health. Imaging investigations to identify fractures and biochemical indicators of bone turnover are additional diagnostic techniques (Compston et al., 2019).

In order to prevent osteoporosis, modifiable risk factors must be addressed. Foundational interventions include avoiding smoking and excessive alcohol consumption, getting enough calcium and vitamin D, and engaging in regular weight-bearing activity (Johnston et al., 2020). For people who are at a high risk of fractures, pharmacological therapies including bisphosphonates, selective estrogen receptor modulators (SERMs), and monoclonal antibodies like denosumab are frequently advised. The treatment of osteoporosis is also focusing on emerging medicines, such as anabolic drugs that encourage bone growth (Compston et al., 2019).

Osteoporosis has a significant social and economic impact. According to NOF (2023), the direct expenses of osteoporotic fractures in the US alone were projected to surpass $22 billion in 2020. These expenses cover long-term care, acute medical care, and rehabilitation. The need for efficient prevention and management techniques is further highlighted by the intangible costs, which include diminished independence and a lower quality of life. To lessen the effects of osteoporosis, public health programs that increase awareness, facilitate better access to diagnostic resources, and encourage healthy lifestyle choices are essential (IOF, 2022).

A widespread and crippling ailment, osteoporosis has significant effects on people and healthcare systems around the world. Creating successful preventative and management plans requires an understanding of its pathophysiology, risk factors, and clinical outcomes. There has never been a greater urgent need for comprehensive public health measures to confront this silent epidemic due to an aging population.

3.2. Development of Osteoporosis

Low bone mass and structural degeneration of bone tissue are hallmarks of osteoporosis, a chronic skeletal condition that increases fragility and fracture risk (NIH, 2000; Kanis et al., 2013). Genetic, hormonal, dietary, and environmental variables are all involved in the complex process that leads to osteoporosis (Eastell et al., 2016). The stages of osteoporosis development

are the exclusive subject of this section, which also provides information on their names and distinctive features.

Stages of Osteoporosis Development

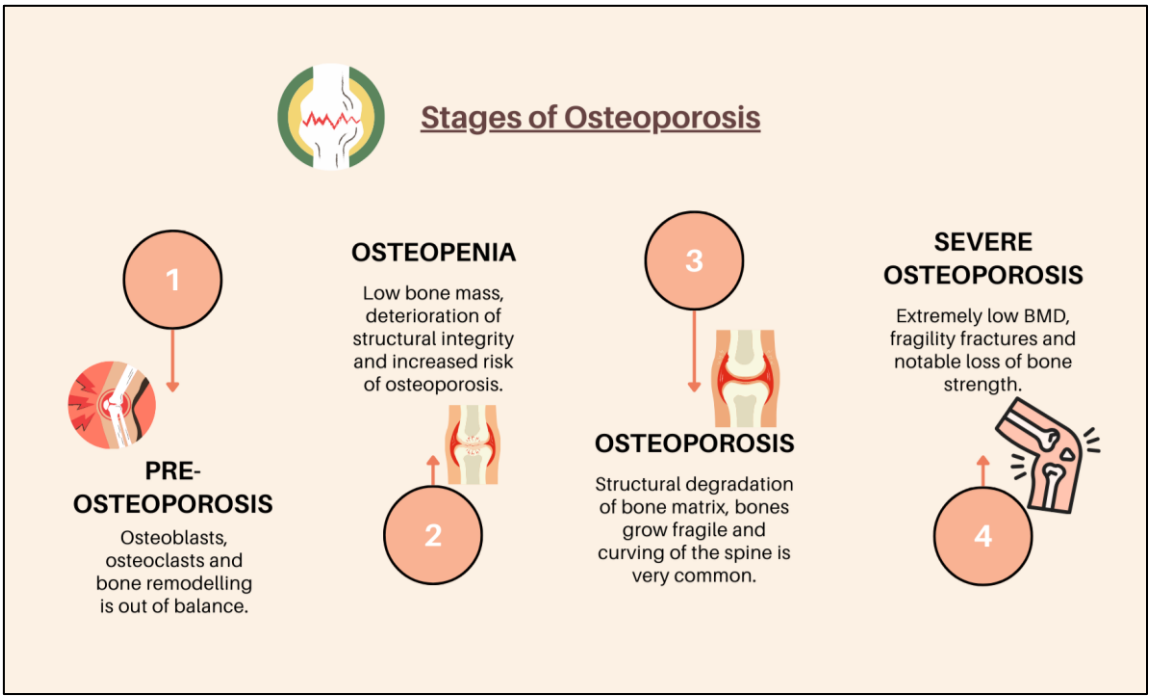

Figure 2: Stages of Osteoporosis development

Stage 1: Pre-Osteoporosis

The first stage of deteriorating bone health is pre-osteoporosis, which is frequently overlooked. The dynamic process of bone creation by osteoblasts and bone resorption by osteoclasts, known as bone remodeling, is slightly out of balance, favoring resorption. Bone mineral density (BMD) is still within the normal range at this point (T-score above -1.0). Subtle risk factors, such as smoking, a lack of physical activity, poor calcium and vitamin D consumption, and long-term illnesses like diabetes, hyperthyroidism, or inflammatory diseases, start to have an impact, though (NIH, 2000; Rosen, 2005).

Daily Progression:

1. Particularly in metabolically active trabecular bone, accumulated microdeficits result from the body's incapacity to completely restore bone following modest resorption cycles (Parfitt, 1987).

2. These imbalances are exacerbated by subclinical hormonal changes, such as a slight decrease in testosterone in men or a decrease in estrogen in women (Riggs et al., 1998).

3. Early structural disturbances within the bone matrix are made worse by lifestyle variables such as poor diet and sedentary behavior (Eastell et al., 2016).

These micro-deficits build up over time, making a person more susceptible to rapid bone loss. Pre-osteoporosis silently develops into osteopenia if preventive measures are not taken, such as increasing physical activity, consuming enough calcium and vitamin D, or quitting smoking.

Stage 2: Osteopenia

Low bone mass with a BMD T-score between -1.0 and -2.5 is known as osteopenia, and it is associated with an increased risk of osteoporosis (WHO, 1994). Structural integrity starts to deteriorate at this point. While cortical bone begins to exhibit early indications of porosity, trabecular bone thins and becomes less linked (Seeman & Delmas, 2006). After physical effort, people may have some back discomfort or stiffness, however symptoms are usually absent. Routine medical imaging for unrelated illnesses frequently reveals this stage (NIH, 2000).

Daily Progression

1. As osteoclasts outnumber osteoblasts in bone turnover cycles, abnormalities in bone remodeling become more noticeable (Rosen, 2005).

2. Trabecular bone's capacity to withstand mechanical stress is diminished as a result of increasing microarchitectural degradation (Parfitt, 1987).

3. Hormonal changes are important, particularly for postmenopausal women whose estrogen levels are dropping. The decrease of estrogen speeds up bone resorption because it typically suppresses osteoclast activity (Riggs et al., 1998).

4. Additional lifestyle factors that lead to structural degradation include smoking, excessive alcohol use, and low-impact physical exercise (Kanis et al., 2013).

Depending on the person's age, lifestyle choices, and risk factors, osteopenia can turn into osteoporosis in a matter of years if treatment is not received (Eastell et al., 2016).

Stage 3: Osteoporosis

A BMD T-score of ≤-2.5 is considered clinically defined as osteoporosis, which is typified by a marked structural degradation of the bone matrix. Bones grow fragile and are more likely to break at this point. Vertebral compression fractures are common and can cause kyphosis (the curving of the spine), height loss, and chronic back discomfort (NIH, 2000). Additionally, mild trauma like falls usually results in hip and wrist fractures (Seeman & Delmas, 2006).

Daily Progression

1. Rapid loss of bone mass is caused by the continued dominance of osteoclast activity. Cortical bone thickness decreases and the microstructure of trabecular bone is perforated (Rosen, 2005).

2. Resorption is made worse and recovery is hindered by long-term low-grade inflammation and decreased vascularization in the bone (Eastell et al., 2016).

3. Bone mineralization capability is further diminished by nutritional deficits, particularly in calcium and vitamin D (Holick, 2007).

4. Patients may start to have limited mobility and persistent discomfort, which makes them less active and speeds up the loss of bone (Kanis et al., 2013).

The risk of fracture is greatly increased, and it doubles for every standard deviation that BMD falls. Fractures can occur from even seemingly simple activities like lifting or bending. Medical intervention is essential at this point to limit the progression and avoid fractures that could change a person's life.

Stage 4: Severe Osteoporosis

The most advanced and incapacitating form of osteoporosis is severe osteoporosis. Extremely low BMD, many fragility fractures, and a notable loss of bone strength are its defining characteristics. Patients frequently experience severe functional restrictions, prominent spine abnormalities (such as dowager's hump), and incapacitating chronic pain (Rosen, 2005). Given the significant risk of sequelae, such as infections, deep vein thrombosis, and death within the first year following the fracture, hip fractures at this period are especially debilitating (Kanis et al., 2013).

Daily Progression:

1. Fragility fractures are becoming increasingly common and can be caused by little to no trauma. Spinal abnormalities can develop as a result of spontaneous vertebral fractures (Seeman & Delmas, 2006).

2. Further immobility results from the weakened bone matrix's lack of the mechanical qualities required to support everyday actions like walking or standing (Rosen, 2005).

3. Muscle atrophy, poor circulation, and further bone weakening are caused by chronic pain and decreased mobility (Holick, 2007).

4. Significant declines in quality of life, including psychological consequences like social isolation and sadness, result from the cumulative impact of fractures and deformities (Eastell et al., 2016).

Severe osteoporosis frequently causes severe impairment and a markedly elevated risk of death from fracture and immobility consequences if effective treatment is not received (Kanis et al., 2013).

Table 2: Different Stages of Osteoporosis and their features

Stage	BMD T-Score	Key Features	Progression Factors	Potential Symptoms
Pre-Osteoporosis	> -1.0	Slight bone remodeling imbalance, early risk factors present	Poor diet, inactivity, hormonal changes, smoking	Typically, asymptomatic
Osteopenia	-1.0 to -2.5	Reduced bone mass, trabecular thinning, early cortical porosity	Increased osteoclast activity, estrogen decline (women)	Possible back stiffness, often detected via imaging
Osteoporosis	≤ -2.5	Significant structural bone loss, high fracture risk	Chronic inflammation, low calcium/Vitamin D, immobility	Height loss, kyphosis, fractures from minor trauma
Severe Osteoporosis	≤ -2.5 with fractures	Multiple fragility fractures, severe mobility issues	Progressive bone weakness, chronic pain, muscle atrophy	Spinal deformities, extreme pain, loss of independence

3.3. Epidemiology of Osteoporosis

A major worldwide public health issue, osteoporosis is defined by a progressive loss of bone density and structural degradation of bone tissue, which raises the risk of fractures, especially in the wrist, hip, and spine (Kanis et al., 2018). Because estrogen insufficiency speeds up bone resorption, postmenopausal women are disproportionately affected by this disorder (Cauley et al., 2014). But males are equally vulnerable, particularly those over 70, as a decrease in testosterone levels can lead to weakened bones (Cummings & Melton, 2002).

There are significant differences in osteoporosis prevalence between age groups, ethnic groups, and geographical areas. According to epidemiological data, populations of European and Asian ancestry have greater prevalence rates, which are probably caused by genetic predispositions,

dietary variables, and poorer baseline bone density (Wright et al., 2014). On the other hand, people of African heritage tend to have lower fracture rates and higher bone mineral density (BMD), albeit this protective impact wears off with age (Cauley et al., 2014). The International Osteoporosis Foundation (IOF) estimates that over 200 million people worldwide suffer from osteoporosis, with postmenopausal women over 50 having the highest prevalence—up to one in three of them suffer osteoporotic fractures (IOF, 2021). According to projections, the prevalence of osteoporosis is expected to climb significantly worldwide as life expectancy rises, especially in populations that are aging quickly, such as those in Asia and Latin America (Ballane et al., 2014).

According to Johnell and Kanis (2006), hip fractures, a serious side effect of osteoporosis, vary greatly by region, with the greatest incidence rates found in Northern Europe and North America and the lowest rates in Africa and Asia. Age-standardized hip fracture rates have grown in Asia due to urbanization, lifestyle changes, and longer life expectancies; this trend is especially noticeable in quickly growing countries like China and India (Ballane et al., 2014). However, other Western nations report steady or dropping trends as a result of better preventative measures, such as the widespread use of lifestyle modifications and bone health screening programs (Cummings & Melton, 2002). Vertebral fractures are among the most prevalent osteoporotic fractures worldwide, despite frequently going undiagnosed. The significant burden of underreported vertebral fractures is shown by studies that indicate a prevalence of roughly 20–25% in women over 50 (Cooper et al., 2011).

The prevalence of osteoporosis and associated fractures is becoming more widely acknowledged as a public health concern in Bangladesh. The issue is made worse by minimal accessibility to preventive care, poor diagnostic capabilities, and low awareness. According to studies, both urban and rural populations' declining bone health is largely caused by calcium and vitamin D deficiencies, as well as a high rate of malnutrition and sedentary lifestyles (Karim et al., 2015). Although there is a dearth of epidemiological data specifically related to Bangladesh, estimates suggest that as the population ages, osteoporosis will become more common, especially among postmenopausal women and the elderly (Rahim et al., 2020). Increasing access to diagnostic and treatment services, boosting dietary consumption, and increasing public awareness are all attempts to address this problem.

Advanced age, female sex, hormonal changes, low body mass index (BMI), and lifestyle variables like smoking, insufficient calcium and vitamin D intake, and low physical exercise

are risk factors for osteoporosis (Cummings & Melton, 2002). Given that bone resorption outpaces creation with age, resulting in net bone loss, advanced age is still one of the best predictors (Kanis et al., 2018). Because a drop in estrogen levels speeds up bone turnover and reduces bone density, postmenopausal women are especially at risk (Cauley et al., 2014).

Another important factor is genetic predisposition; a family history of osteoporosis or fractures raises the risk of getting the disease. Research has shown genetic variations in important genes that affect bone metabolism, such as LRP5 and VDR (Ralston & Uitterlinden, 2010). Furthermore, by preventing bone formation and promoting bone resorption, secondary causes such long-term glucocorticoid medication significantly raise the risk of osteoporosis (Weinstein, 2011). Bone loss is made worse by comorbid diseases such as diabetes, rheumatoid arthritis, and chronic renal disease (Shoback et al., 2020).

The issue is exacerbated by lifestyle variables, such as poor eating habits and physical inactivity. Because they negatively impact bone remodeling and calcium absorption, smoking and excessive alcohol use are known risk factors (Kanis et al., 2022). In low- and middle-income nations like Bangladesh, where nutritional deficiencies are prevalent, vitamin D and calcium deficits are especially widespread (Rahim et al., 2020). To lessen the increasing burden of osteoporosis and related fractures worldwide, this emphasizes the vital need for early intervention and preventive measures, such as dietary changes, physical activity programs, and public health campaigns raising awareness of bone health (Kanis et al., 2022).

3.4. Literature Review

Over the past few decades, a great deal of research has been done on osteoporosis, a degenerative illness characterized by low bone mass and microarchitectural degradation. With a focus on clinical consequences and public health viewpoints, this literature review historically examines developments in the knowledge, diagnosis, and treatment of osteoporosis, incorporating significant research and conclusions.

1970s–1980s: Initial Identification and Defined

Osteoporosis became more widely acknowledged as a serious public health concern in the 1970s. During this time, the fundamental study entailed identifying osteoporosis and clarifying its fundamental pathophysiology. The high incidence of osteoporosis in postmenopausal women was explained by early research that emphasized the importance of estrogen in preserving bone mass (Riggs & Melton, 1986). A way to assess bone density was made possible by the development of single-photon absorptiometry, which was essential for developing epidemiological research and comprehending disease prevalence.

Dual-photon absorptiometry was developed in the 1980s, enabling more accurate measurements of bone mineral density (BMD) in crucial locations like the hip and spine. These technical developments paved the way for future diagnostic standards by allowing researchers to find relationships between BMD and fracture risk (Cummings et al., 1985).

1990s: Progress in Epidemiology and Diagnosis

Dual-energy X-ray absorptiometry (DXA) became the gold standard for assessing bone mineral density (BMD) in the 1990s, which was a watershed in osteoporosis research (Blake & Fogelman, 1997). The World Health Organization's (WHO) T-score-based osteoporosis diagnostic criteria were also established at this time, offering a common framework for recognizing and categorizing the condition (Kanis et al., 1994).

The worldwide burden of osteoporosis was made clear by extensive epidemiological studies carried out throughout this decade, including those by Melton et al. (1992). These studies showed notable differences in fracture risk and prevalence by region and ethnicity. Due to variations in peak bone mass, dietary calcium consumption, and lifestyle factors, people of European and Asian ancestry were shown to be more susceptible than people of African ancestry (Cauley et al., 1995).

Understanding Pathophysiology and Increasing Risk Factors in the 2000s

The molecular pathways underlying osteoporosis were better understood thanks to research conducted in the early 2000s. Research revealed the regulatory influence of the RANK/RANKL/OPG signaling pathway and the critical functions of osteoclasts and osteoblasts in bone remodeling (Boyle et al., 2003). Targeted treatments like denosumab, a monoclonal antibody that suppresses RANKL to lessen bone resorption, have a molecular foundation thanks to this discovery (Cummings et al., 2009).

Polymorphisms in genes like LRP5 and VDR linked to bone density and fracture risk were discovered by genetic investigations, which also gained popularity (Ralston & Uitterlinden, 2010). These results emphasized the significance of genetic variables and encouraged more research into the relationship between genes and the environment in the development of osteoporosis.

Researchers started methodically looking into secondary causes of osteoporosis, such as diabetes, chronic renal disease, and glucocorticoid-induced bone loss, in addition to genetic variables (Weinstein, 2011). These realizations expanded the management of osteoporosis to encompass risk factor mitigation and addressing underlying diseases.

2010s: Advances in Medicine and Prevention Techniques

New therapeutic medicines that target particular pathways in bone metabolism emerged in the 2010s. An anti-sclerostin antibody called romosozumab has shown promise as a treatment to promote bone growth and lower the risk of fractures (Saag et al., 2017). The treatment of osteoporosis has been dominated by developments in bisphosphonate medication, including better formulations for increased adherence (Black et al., 2012).

Additionally, public health initiatives that emphasized the value of early diagnosis and fracture prevention gained traction. During this time, the FRAX tool was created, which gave physicians a validated algorithm to calculate their 10-year fracture risk based on BMD and

clinical risk factors (Kanis et al., 2011). This invention made it easier to allocate resources and arrange for individualized care.

2020s: Present Views and Prospective Paths

Addressing the worldwide burden of osteoporosis in the context of aging populations is the main focus of ongoing research in the 2020s. Disparities in access to diagnostic and treatment resources have been brought to light by recent studies, especially in low- and middle-income nations (Ballane et al., 2020). Community-based screening programs and campaigns to increase calcium and vitamin D intake through dietary supplementation and fortification are two ways to close these gaps (Holick, 2020).

Technological developments like high-resolution imaging and the creation of new biomarkers have the potential to improve osteoporosis diagnostic accuracy and track the effectiveness of treatment. The future of managing osteoporosis lies on emerging treatments that target new pathways, like cathepsin K inhibitors (McClung et al., 2021).

Bangladesh Context

Osteoporosis is an underdiagnosed yet increasing public health issue in Bangladesh. Research shows that osteoporosis and osteopenia are becoming more common, especially in older adults and postmenopausal women (Karim et al., 2015). Poor bone health in the population is largely caused by nutritional inadequacies, such as insufficient intake of calcium and vitamin D, which are exacerbated by high rates of malnutrition (Rahim et al., 2020).

The burden of osteoporosis in Bangladesh is made worse by limited access to diagnostic resources and treatment options. There are few DXA scanners available, and many people are still put off by the high expense of testing. Osteoporosis management and prevention have received minimal attention in national health programs, and there have been few public health initiatives (Hasan et al., 2018). A holistic strategy is needed to address this problem, one that includes improving access to reasonably priced diagnostic and treatment services, encouraging dietary changes, and increasing awareness of osteoporosis. To lessen the increasing prevalence

of osteoporosis in Bangladesh, community-based interventions and the incorporation of osteoporosis management into primary care services can be extremely important.

Chapter 4

Osteoporosis Risk in Female

Low bone mass and microarchitectural degradation of bone tissue are the hallmarks of osteoporosis, a skeletal condition that increases the risk of fracture and bone fragility. Due to its link to fractures, disability, and mortality, this condition—which affects millions of women globally, especially postmenopausal women—represents an increasing public health concern. About one in three women over 50 suffer from osteoporosis, and the prevalence increases with age (Kanis et al., 2019). An imbalance in bone remodeling, with resorption outperforming production, is the pathophysiology of osteoporosis. A complex interplay of behavioral, environmental, hormonal, and genetic factors affects how the disease progresses.

4.1. The Role of Estrogen in Bone Health

Because it alters the ratio of bone production to bone resorption, estrogen is essential for controlling bone metabolism. Bone remodeling is a dynamic process in healthy people where new bone is formed and old bone is reabsorbed. Osteoclasts, which break down bone tissue, are inhibited by estrogen from resorbing bone, while osteoblasts, which create new bone, are encouraged to do so (Riggs & Hartmann, 2003). The reproductive years are when estrogen levels in women are at their highest, which supports bone density. However, there is a notable drop in estrogen levels following menopause, when the ovaries stop producing estrogen. The rate of bone loss is accelerated by this hormonal shift, especially during the first five to seven years after menopause (Cummings & Melton, 2002). This rapid bone loss leads to reduced bone mineral density (BMD), increasing susceptibility to fractures.

Estrogen has a well-established role in bone health, and among women, osteoporosis is more common when it is absent after menopause. Once often used to stop postmenopausal bone loss, estrogen replacement treatment (ERT) has been shown to lower fracture risk by as much as 50% (Writing Group for the Women's Health Initiative Investigators, 2002). Its usage has been restricted, though, due to worries about the elevated risks of heart disease, stroke, and breast cancer, especially in women who are more susceptible to these illnesses. By simulating estrogen's positive effects on bone without the dangers, selective estrogen receptor modulators (SERMs), including raloxifene, have emerged as a safer option for treating osteoporosis in more recent years (Boonen et al., 2006).

According to research from Bangladesh, women living in rural regions are more likely to rely on traditional customs and herbal remedies, which may not be as efficient at halting bone loss, and are less likely to have access to hormone replacement medication (Islam et al., 2017). Furthermore, the issue is made worse by a lack of knowledge regarding how menopause affects bone health.

4.2. Age-Related Bone Loss

One of the main risk factors for osteoporosis is aging, and women are more affected than males in terms of bone density. As people age, their bone density naturally declines, and women experience this process far more quickly than men do. According to Aro et al. (2016), women's bone mass usually peaks in their early 20s and then progressively decreases after that. Women may lose up to 3% of their bone mass year in the ten years after menopause, and as they age, this rate of bone loss decreases (Cummings & Melton, 2002). Women's bone loss stabilizes by their 70s or 80s, but the decades-long loss puts them at risk for fractures more than men of the same age (Adachi et al., 2001).

Several variables, such as decreased calcium absorption, decreased vitamin D levels, and decreased physical activity, contribute to the loss of bone mass that occurs with aging. Calcium shortages that further jeopardize bone health result from women's declining capacity to absorb calcium from food and supplements as they age. Furthermore, the risk of bone loss is increased as people age because the body's capacity to make vitamin D, which is necessary for calcium absorption, decreases (Holick, 2007). When the ratio of bone formation to resorption tips too much in favor of resorption, osteoporosis becomes a serious issue, particularly when it is exacerbated by additional risk factors like low body weight or insufficient physical activity.

One of the main risk factors for osteoporosis is aging, which is made worse in Bangladesh by a lack of resources for osteoporosis screening and a weak healthcare system. Women's bone loss starts in their 30s and noticeably picks up speed after menopause (Rahman et al., 2014). However, many Bangladeshi women are not routinely evaluated for osteoporosis, in contrast to several wealthy nations where bone density screening is more common. Fewer postmenopausal women were aware of their fracture concerns, and only 25% had had BMD testing, according to a Dhaka study (Alam et al., 2019). Furthermore, a higher cumulative rate

of bone loss is caused by Bangladeshi women's comparatively high rate of early menopause, which occurs about five years earlier than in Western cultures. The country's osteoporosis risk is increased by the combination of early menopause and inadequate awareness.

4.3. Genetic Factors

The likelihood that a woman may develop osteoporosis is largely determined by her genetic makeup. According to twin studies, genetic variables account for between 60 and 80 percent of the variation in bone mineral density (Liu, 2006). This suggests that a significant amount of the risk for osteoporosis is hereditary. Women are more likely to get osteoporosis or fractures if they have a family history of the disorder. Potential genetic risk factors for osteoporosis have been identified concerning certain genes involved in bone metabolism, including those about collagen synthesis, calcium control, and vitamin D receptor activity (Raisz, 2005).

For instance, it has been demonstrated that variations in the vitamin D receptor gene (VDR) affect fracture risk and bone density (Khosla et al., 2004). Furthermore, genes involved in osteoclast and osteoblast formation have been linked to controlling bone turnover and bone loss susceptibility. Although genetic screening is not yet a standard method for determining osteoporosis risk, tailored preventative and treatment plans may become more popular as our knowledge of the disease's hereditary foundation grows.

Research on a genetic propensity to osteoporosis in Bangladesh is still in its early stages. According to preliminary research, the increased risk shown in Bangladeshi women may be caused by genes linked to osteoporosis, including those that influence collagen synthesis and calcium regulation (Hossain et al., 2017). More genetic research is necessary to offer more precise insights, as this field of study is still in its infancy in the nation. Women are more likely to get osteoporosis or fractures if they have a family history of the disorder. Because older women frequently live with their children or grandchildren and fractures or bone pain are viewed as a natural part of aging rather than as signs of a treatable ailment, the danger of osteoporosis is frequently overlooked in rural Bangladesh, where multigenerational homes are typical.

4.4. Nutritional Deficiencies

Maintaining ideal bone health requires an adequate diet, especially in terms of calcium and vitamin D intake. Vitamin D helps the body absorb calcium from the intestines, whereas calcium is an essential mineral that makes up the structural element of bones. Many women don't get enough of these minerals each day, especially those who are postmenopausal. According to the National Osteoporosis Foundation (2020), women over 50 should take 800–1,000 IU of vitamin D and 1,200 mg of calcium every day. According to research, many women do not follow these recommendations, which puts them at higher risk of developing osteoporosis (Boonen et al., 2006).

Dairy products, fortified foods, and supplements can all help increase calcium intake, but many women do not eat enough dairy or foods high in calcium. Although the skin produces the majority of vitamin D when exposed to sunshine, many women may not have enough of it, especially those who live in northern latitudes or receive little sun exposure (Holick, 2007). A lack of vitamin D increases the risk of osteoporosis by reducing calcium absorption and causing bone demineralization. Calcium and vitamin D are essential for healthy bones, but so are other nutrients including protein, magnesium, and vitamin K. These vitamin deficiencies can worsen bone deterioration and raise the risk of fractures.

According to estimates, Bangladeshi women's average calcium intake is far below the recommended dietary allowance (RDA), and many of them eat plant-based diets deficient in items high in calcium, like dairy (Alam et al., 2019). Additionally, there is a high prevalence of vitamin D deficiency in Bangladesh, where cultural practices including wearing conservative attire and seeing little sunshine lead to insufficient synthesis of vitamin D (Sarker et al., 2020). Nearly 80% of Bangladeshi women, both urban and rural, had low vitamin D levels, which is important for calcium absorption and bone mineralization, according to a study (Sarker et al., 2020).

4.5. Physical Inactivity and Lifestyle Factors

One important modifiable risk factor for osteoporosis is physical inactivity. Frequent resistance and weight-bearing activities maintain bone density by putting mechanical stress on the bones,

which promotes bone production. Regularly active women had more bone mass and fewer fractures than their sedentary counterparts, according to studies (Borer, 2005). It has been demonstrated that resistance training using weights or resistance bands, along with weight-bearing activities like dancing, running, and walking, can improve bone mineral density and lower the risk of fracture in postmenopausal women (Wu et al., 2014).

In Bangladesh, in the early years, many women—especially those living in rural areas—perform physically hard jobs, but as they get older, they tend to become less active. Most postmenopausal women in Bangladesh have inadequate bone density due to a lack of opportunity for regular exercise. Only 20% of women over 50 participated in regular physical activity, and most of them exercised little to not at all, according to a study by Rahman et al. (2014). Sedentary jobs and an increasing reliance on motorized mobility in urban areas exacerbate physical inactivity. In addition, women in Bangladesh are less likely than women in Western countries to engage in unhealthy lifestyle choices like smoking and binge drinking, but these habits are becoming more prevalent as a result of growing urbanization. Smoking has a substantial effect on bone health even if it is less common among Bangladeshi women, especially for those who are at risk because of hormonal changes (Ishizaki et al., 2002).

4.6. Bone Mineral Density and Fracture Risk

The most significant indicator of fracture risk in osteoporosis is bone mineral density (BMD). Weaker bones and a greater risk of fractures are indicated by a lower BMD. The usual method for determining bone mineral density (BMD) is dual-energy X-ray absorptiometry (DXA), where osteoporosis is indicated by a T-score of -2.5 or less (WHO, 1994). Osteoporosis-related fractures frequently affect the hip, wrist, and spine and significantly lower a woman's quality of life. One in five people die within a year after suffering a hip fracture, making hip fractures in particular linked to high rates of morbidity and mortality (Burge et al., 2007). Undiagnosed spinal fractures can cause deformity, loss of motion, and chronic pain. One of the main causes of impairment in older women is osteoporotic fractures, which raise the likelihood of institutionalization and reduces their level of independence.

Most healthcare facilities in Bangladesh do not regularly assess bone mineral density (BMD), especially in rural regions where osteoporosis is still largely undetected. Most women in Bangladesh only receive an osteoporosis diagnosis following a fracture, which greatly raises morbidity. In Bangladesh, hip and vertebral fractures are also common among postmenopausal

women worldwide (Alam et al., 2019). However, these fractures are frequently misdiagnosed or treated late because of a lack of screening and diagnostic tools, which harms women's health. According to studies, up to 30% of postmenopausal women in urban areas have been diagnosed with osteoporosis or reduced bone mass, indicating a high prevalence of the condition among Bangladeshi women (Rahman et al., 2014).

Chapter 5

Statistical Analysis

5.1. Case Study (Global)

Due to its correlation with a significantly higher incidence of fractures, osteoporosis is a global health concern, especially among elderly populations. Although the frequency of the condition varies by location, it is widely accepted that a significant percentage of the aged population, particularly postmenopausal women, suffer from osteoporosis. A thorough analysis of the disease's dangers and prevalence statistics across the globe and in different locations can be found below.

Global Prevalence

1. **Worldwide Statistics:**
    - The International Osteoporosis Foundation (IOF) estimates that over 200 million women are affected by osteoporosis worldwide, with significant numbers of men also suffering from the condition.

    - It is projected that by 2050, the number of people suffering from osteoporosis fractures will increase by 310% in men and 240% in women in some parts of the world, highlighting the growing burden of this condition

2. **Osteoporosis-related Fractures:**
    - The total number of osteoporotic fractures worldwide is estimated to be 8.9 million per year. This includes over 1.6 million hip fractures, which are the most serious and costly. According to the World Health Organization (WHO), a hip fracture may cost between $30,000 to $40,000 per person in direct medical expenses

3. **Global Fracture Risk:**
    - Osteoporotic fractures significantly impair the quality of life. Studies have found that people with osteoporotic fractures have a higher mortality rate in the first year following the fracture. For instance, 24% of individuals aged 50 and older who suffer a hip fracture will die within 6 months of the injury.

United States Prevalence

1. Data from NHANES show that 12.6% of U.S. adults aged 50 and older are diagnosed with osteoporosis at either the femoral neck or lumbar spine. This includes a significant disparity between genders, as the prevalence of osteoporosis is notably higher in women compared to men. Specifically:

    - 18.8% of women aged 50 and older have osteoporosis.
    - 4.2% of men in the same age group are affected

2. The prevalence of osteoporosis increases dramatically with age in the United States. Among individuals aged 50 or older:

    - 20% of women aged 70 and older are affected by osteoporosis
    - 40% of women aged 80 and older have osteoporosis

3. Osteoporosis-related fractures are a significant cause of morbidity and mortality. The Centers for Disease Control and Prevention (CDC) estimates that osteoporosis is responsible for more than 2 million fractures annually in the United States alone, resulting in an estimated $19 billion in medical costs each year. This number is expected to increase as the population ages.

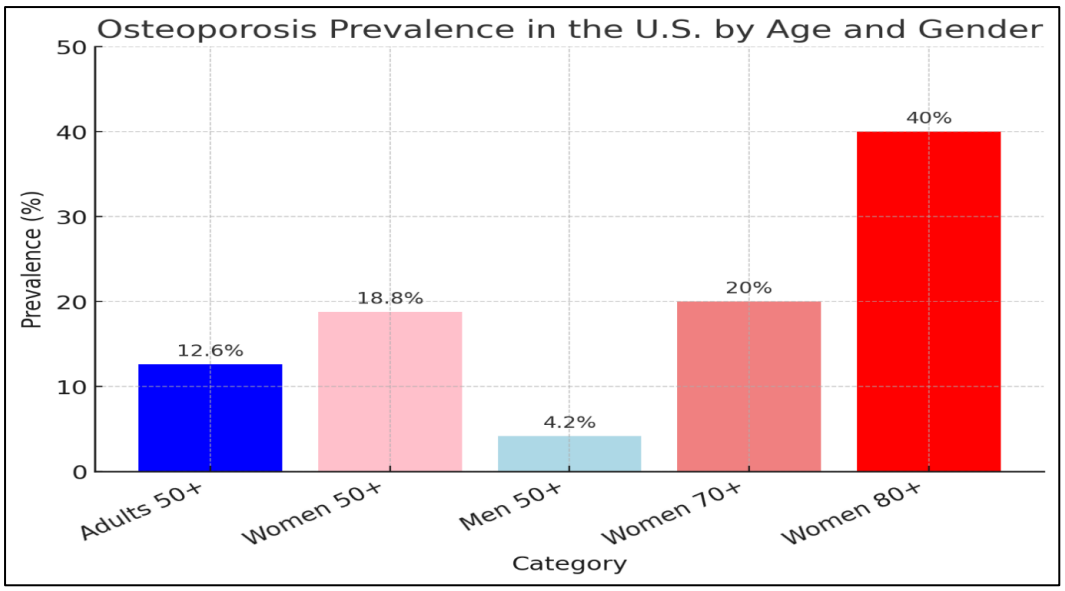

Figure 3: Osteoporosis Prevalence in U.S. by Age and Gender

Prevalence in Europe

1. According to the European Society for Clinical and Economic Aspects of Osteoporosis and Osteoarthritis (ESCEO), osteoporosis affects approximately 22% of women over the age of 50 in Europe. This is particularly true in countries such as Germany, where up to 23% of women over the age of 50 have osteoporosis. In France, the figure is slightly lower at around 17%.

2. Osteoporotic fractures represent a major healthcare burden in Europe. It is estimated that over 3 million osteoporotic fractures occur annually in the EU. The incidence of fractures varies across countries, with the highest rates of hip fractures observed in northern European countries like Sweden and Finland, where the incidence of hip fractures in women over 75 is around 450-500 per 100,000 women.

Prevalence in Australia:

1. According to the Australian Bureau of Statistics, approximately 23% of Australian women over the age of 50 are diagnosed with osteoporosis or osteopenia, while 12% of men in the same age group suffer from the disease. Australia is facing an increasing number of osteoporosis-related fractures, particularly in the elderly population.

2. Similar to other countries, fractures in Australia due to osteoporosis are a leading cause of hospitalizations and morbidity in older adults. Hip fractures in particular are prevalent, with an estimated $1.6 billion in direct healthcare costs each year for the treatment of osteoporotic fractures

Prevalence in Developing Countries

1. In India, osteoporosis is increasingly recognized as a public health issue, especially as the elderly population grows. Studies show that about 12-15% of women over the age of 50 suffer from osteoporosis, with even higher rates in postmenopausal women. The increasing prevalence of risk factors like poor nutrition and physical inactivity is contributing to this rise.

2. In China, osteoporosis is also becoming more prevalent as the population ages. A national survey revealed that approximately 20% of women and 8% of men over the age of 50 have osteoporosis, with 30% of postmenopausal women being affected.

3. Countries in the Middle East, such as Saudi Arabia, report a rising prevalence of osteoporosis. Research shows that 22-26% of women aged 50 and older have osteoporosis, and the condition is expected to increase in line with aging populations and lifestyle factors.

Table 3: Different Country's data on Osteoporosis Prevalence

Region/Country	Gender	Age	Ration	Source
Global (Women)	23% of women over 50	Age 50 and older	Women have a higher prevalence than men	International Osteoporosis Foundation (IOF) (osteoporosis.foundation)
Global (Men)	6% of men over 50	Age 50 and older	Men have a lower prevalence than women	International Osteoporosis Foundation (IOF) (osteoporosis.foundation)

United States (Overall)	12.6% of adults 50+	50 and older	18.8% in women, 4.2% in men	Centers for Disease Control and Prevention (CDC) (cdc.gov)
United States (Women)	18.8% of women 50+	50 and older	Higher in women than men	Centers for Disease Control and Prevention (CDC) (cdc.gov)
United States (Men)	4.2% of men 50+	50 and older	Lower in men than women	Centers for Disease Control and Prevention (CDC) (cdc.gov)
Europe (Overall)	10-20% of people over 50	50 and older	Higher in women; varies by country	World Health Organization (WHO) (who.int)
Germany	23% of women 50+	50 and older	Women at higher risk	European Bone and Joint (EFFORT) (europeanboneandjoint.org)
France	17% of women 50+	50 and older	Women at higher risk	European Bone and Joint (EFFORT) (europeanboneandjoint.org)
Australia (Overall)	23% of women 50+, 12% of men 50+	50 and older	Women more affected	Australian Institute of Health and Welfare (health.gov.au)
Japan	50% of women 70+	Age 70 and older	Women at significantly higher risk	National Institute of Health (NIH) (nih.gov)
South Korea	50% of women 70+	Age 70 and older	Women at significantly higher risk	National Institute of Health (NIH) (nih.gov)
Saudi Arabia	22-26% of women 50+	50 and older	Higher prevalence in women	PubMed Central (pubmed.ncbi.nlm.nih.gov)

Middle East (General)	Varies from 20% to 30%	50 and older	Higher in women	PubMed Central (pubmed.ncbi.nlm.nih.gov)
India	12-15% of women 50+	50 and older	Women at higher risk	Indian Journal of Endocrinology and Metabolism (ijem.in)
Africa (Sub-Saharan)	10-15% of women 50+	50 and older	Women at higher risk	African Osteoporosis Foundation (osteoporosisafrica.org)

Osteoporosis is not just a matter of decreased bone mass; its consequences can be severe, leading to chronic pain, disability, and even death.

1. **Fracture Risk:**

Fractures, particularly hip fractures, are a major cause of disability and death in individuals with osteoporosis. Hip fractures are the most common osteoporotic fractures and have the highest associated morbidity and mortality. Studies show that 20-24% of people with a hip fracture will die within 6 months of the injury. Additionally, up to 50% of individuals who suffer a hip fracture will require long-term care, and many will never regain their previous level of mobility.

2. **Healthcare Costs:**

Osteoporosis-related fractures are associated with significant healthcare costs, with estimates suggesting that osteoporotic fractures cost the global economy over $19 billion annually. The costs associated with treating osteoporotic fractures, particularly hip fractures, are expected to increase as the global population ages. In the U.S., $19 billion is spent annually on the treatment of osteoporosis-related fractures, a number that is expected to increase as the population ages.

3. **Mortality Rate:**

Osteoporosis-related fractures contribute to higher mortality rates in the elderly, particularly after a hip fracture. Studies indicate that one in five women who suffer a hip fracture will die

within a year, and the risk of dying within 6 months after a hip fracture is about 24% for both men and women.

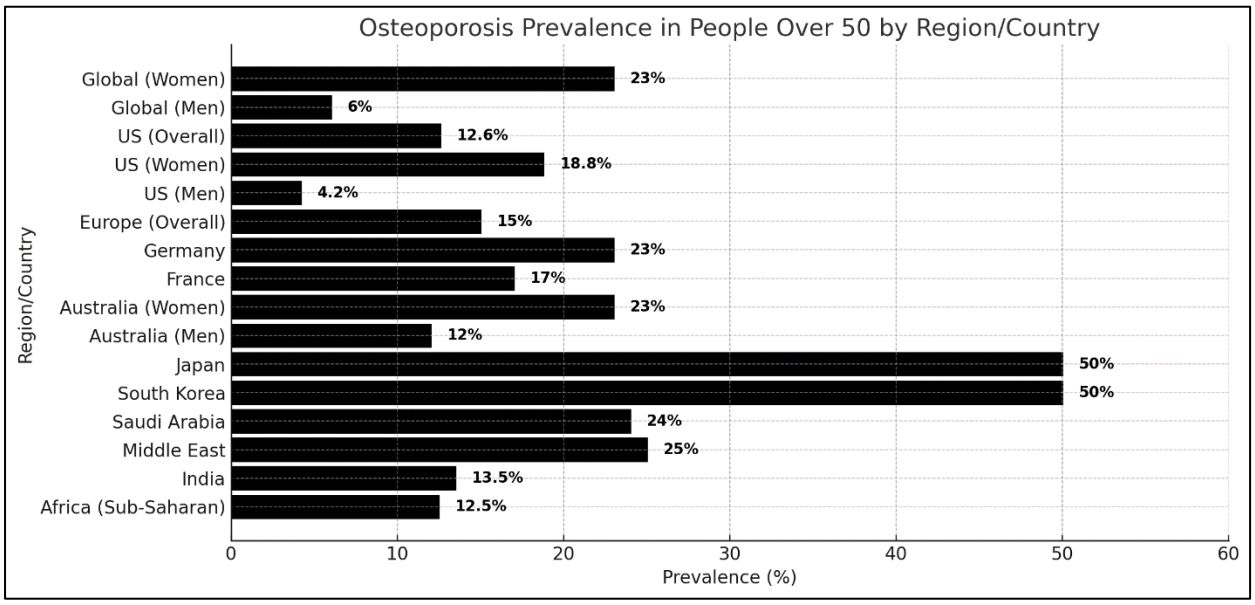

Figure 4: Osteoporosis Prevalence in People Over 50 by region

5.2. Case Study (Bangladesh)

Osteoporosis is a growing health concern in Bangladesh, particularly as the population ages and lifestyle factors change. Below is an in-depth examination of the prevalence data and its potential public health impact.

Prevalence of Osteoporosis in Bangladesh

1. According to a study published in the Bangladesh Medical Journal in 2020, 12-15% of women over the age of 50 in Bangladesh have osteoporosis. The prevalence is particularly high in postmenopausal women, with the condition affecting approximately 20-25% of women in this group.
2. A study published in Osteoporosis International found that around 15% of Bangladeshi women aged 50 and above had osteoporosis, with the figure rising in urban areas due to lifestyle changes and decreased physical activity levels.

3. Postmenopausal women are at a significantly higher risk for osteoporosis due to hormonal changes, particularly the decline in estrogen levels. Studies in Bangladesh show that about 20-25% of postmenopausal women suffer from osteoporosis, with a higher prevalence in urban areas where diets may lack sufficient calcium and vitamin D, and physical activity is lower

Regional Variation

1. In Bangladesh, there is a noticeable difference in the prevalence of osteoporosis between urban and rural populations. Urban populations tend to have a higher prevalence of osteoporosis, primarily due to lifestyle factors such as poor diet, reduced physical activity, and higher levels of smoking and alcohol consumption.

2. A study conducted in Dhaka, the capital city of Bangladesh, found that about 18% of women in urban areas had osteoporosis, compared to approximately 12% in rural areas.

3. Osteoporosis in Bangladesh is most common in individuals aged 50 and older. A national survey revealed that over 10% of individuals aged 50 and above had osteoporotic bone density in Bangladesh, with an increasing rate in people over 70 years old.

Fracture-Based Osteoporosis

1. Osteoporotic fractures are a significant issue in Bangladesh. According to the Bangladesh Osteoporosis Study published in 2019, osteoporotic fractures account for over 500,000 fractures annually, particularly in older adults. This has resulted in a substantial increase in medical costs and long-term care needs for those affected by osteoporotic fractures.

2. Hip fractures, which are the most serious type of osteoporotic fracture, are reported to be rising in Bangladesh, with a marked increase in the elderly population. The number of hip fractures is projected to grow by 5-10% per year, placing immense strain on healthcare resources.

3. Studies from Bangladesh have shown that individuals who suffer from hip fractures due to osteoporosis experience significant mortality rates, with approximately 20% of individuals dying within the first 6 months of a hip fracture. This is similar to global patterns observed in other countries with high osteoporosis prevalence.

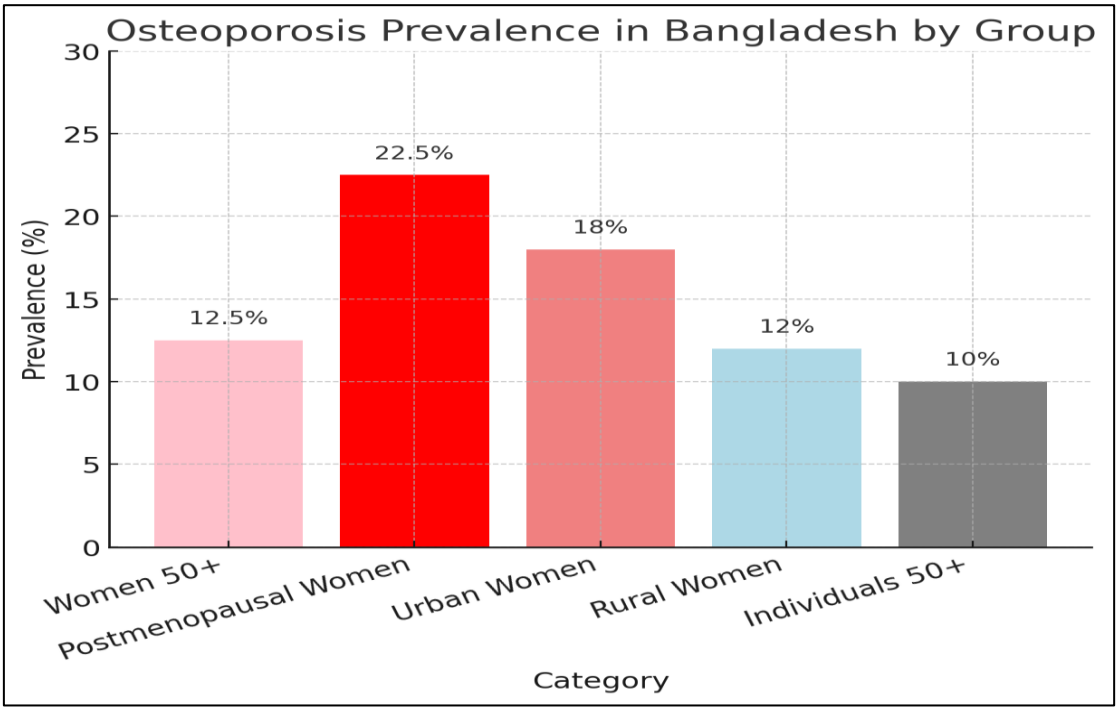

Figure 5: Osteoporosis Prevalence in Bangladesh by Group

Public Health Impact of Osteoporosis in Bangladesh

1. The growing number of osteoporosis cases in Bangladesh has resulted in a substantial burden on the healthcare system. In particular, the cost of managing osteoporosis-related fractures, including hospitalizations, surgical interventions (e.g., hip replacement), and long-term rehabilitation, is increasing. It is estimated that osteoporosis-related fractures cost the Bangladeshi healthcare system approximately BDT 4,000 crore ($470 million USD) annually, which is expected to rise with an aging population.

2. The economic costs of osteoporosis in Bangladesh extend beyond healthcare expenditures. Fractures often result in long-term disability, which reduces the productivity of affected individuals, especially in the workforce. Additionally, informal

caregivers experience significant financial and emotional strain, further exacerbating the economic impact of osteoporosis-related fractures.

3. The condition also leads to increased morbidity and mortality rates, particularly among the elderly. Studies show that the mortality rate for people aged 50 and older with osteoporosis-related fractures is higher than for those without the condition, particularly after a hip fracture. Mortality rates within the first year after a hip fracture in Bangladesh have been found to be 15-20%.

Chapter 6

Risk Analysis

Here's a table for osteoporosis risk factors, including a section on approximate global prevalence where available.

Table 4: Osteoporosis Risk Factors

Category	Risk Factor	Description	Approximate Global Prevalence
Modifiable Risk Factors	**Dietary Deficiency**	Inadequate calcium & vitamin D intake	~30-50% of the population in some regions have vitamin D deficiency
	Sedentary Lifestyle	Lack of weight-bearing exercise	1 in 4 adults worldwide is insufficiently active
	Smoking	Reduces bone mass & calcium absorption	~22% of the global population smokes
	Excessive Alcohol Consumption	Weakens bones & increases fracture risk	~5.3% of global deaths linked to alcohol-related issues
	Low Body Weight	Lower bone mass increases fracture risk	~10-15% of adults classified as underweight
	Medications	Long-term steroid, anticonvulsants, or thyroid medication use	~1% of population on long-term corticosteroids
	Chronic Medical Conditions	Rheumatoid arthritis, diabetes, celiac disease, etc.	Varies based on disease prevalence
Non-Modifiable Risk Factors	**Age**	Bone density decreases with age	1 in 3 women & 1 in 5 men over 50 affected
	Sex	Women at higher risk due to menopause	Women 4x more likely than men
	Genetics	Family history increases risk	Up to 80% of bone density is inherited
	Ethnicity	Higher risk in Caucasians & Asians	Osteoporosis fractures more common in these groups
	Body Frame Size	Smaller frames have lower bone mass	More common in petite individuals
	Hormonal Imbalances	Low estrogen/testosterone impacts bone health	Menopause causes ~10% bone loss in first 5 years

Other Factors	**Previous Fractures**	Past fractures increase future risk	~50% of hip fracture patients have prior fractures
	Falls	Increases likelihood of fractures	1 in 3 adults over 65 falls each year

6.1. Modifiable Risk Factors

6.1.1. Dietary Deficiencies

One of the most important modifiable risk factors for osteoporosis is a chronic deficiency in calcium and vitamin D. The main mineral that gives bones their shape and strength is calcium, and vitamin D improves the gut's ability to absorb calcium. Increased fragility results from bone mineralization disruption caused by inadequate consumption of these nutrients. For instance, the body resorbs calcium from bones to make up for low blood calcium levels, thereby weakening the bones (Weaver et al., 2016).

This issue is made worse by vitamin D insufficiency, which hinders the body's absorption of calcium from food. This insufficiency is especially prevalent in areas with little exposure to sunlight or among those who spend a large portion of their time indoors. These deficiencies can be addressed and the risk of osteoporosis decreases with the use of supplements and dietary changes, such as eating fatty fish or fortified meals (Kanis et al., 2020).

In addition to calcium and vitamin D, inadequate protein intake is one dietary component that can have a detrimental effect on bone health. Collagen synthesis, which gives bones their structural framework, depends on protein. Maintaining skeletal integrity requires a balanced diet that contains enough protein and other nutrients that promote bone, such as phosphorus and magnesium (Rizzoli, 2014).

6.1.2. Sedentary Lifestyle

Because physical inactivity deprives bones of the mechanical stimulation required for remodeling, it dramatically increases the risk of osteoporosis. Exercises involving weight-bearing and resistance increase osteoblast activity, which maintains bone density and

encourages bone growth. On the other hand, a sedentary lifestyle increases the risk of fractures by hastening bone loss and structural weakening (Kohrt et al., 2004).

Frequent exercise, such jogging, walking, or resistance training, improves muscle mass and balance in addition to strengthening bones, which lowers the chance of falls. Particularly for older persons, even moderate-intensity exercise can have a significant impact on bone health. These advantages can be maximized while lowering the risk of damage with exercise regimens customized to a person's fitness level and medical history (Sherrington et al., 2019).

Exercise programs under supervision can increase bone density and lower the risk of fractures in people who have already been diagnosed with osteoporosis. A straightforward yet powerful method for preventing osteoporosis and improving general health is incorporating physical activity into everyday activities (Weaver et al., 2016).

6.1.3. Smoking

There are several ways in which smoking impairs bone health. Toxins like nicotine found in tobacco products disrupt osteoblast function, which lowers bone production. Additionally, smoking reduces blood supply to bones, which hinders their capacity to repair and renew. Furthermore, it has been demonstrated that smoking lowers testosterone and estrogen levels in men and women, two substances that are essential for preserving bone density (Ward & Klesges, 2001).

Smoking has dose-dependent impacts on bone health; heavier and longer-term smokers have higher fracture risk and more bone loss. According to research, smokers are more prone than non-smokers to have hip fractures and other issues linked to osteoporosis. Even at a later age, quitting smoking can greatly enhance bone health and lower the incidence of fractures (Kanis et al., 2020).

Additionally, smoking frequently coexists with other risk factors for osteoporosis, such as a poor diet and insufficient physical activity. For osteoporosis to be effectively prevented and

managed, smoking must be addressed as part of a comprehensive lifestyle modification program (Eastell et al., 2016).

6.1.4. Excessive Alcohol Consumption

An established risk factor for osteoporosis is excessive alcohol use. By suppressing osteoblast activity and promoting osteoclast-mediated bone resorption, long-term alcohol consumption interferes with bone remodeling. Alcohol also jeopardizes bone health by interfering with the metabolism of calcium and vitamin D. Reduced bone density and increased fragility are the results of these combined consequences (Kanis et al., 2020).

Alcohol use and bone health have a dose-dependent association. Heavy drinking is closely linked to an increased risk of fractures, although moderate alcohol use does not seem to have a major effect on bone density. Therefore, cutting back on alcohol use is crucial for avoiding osteoporosis, especially for those who have other risk factors (Compston et al., 2017).

Furthermore, poor diet and lifestyle choices that worsen bone loss frequently accompany alcohol addiction. To reduce the risk of osteoporosis and improve general health, nutritional counseling and assistance in cutting back on alcohol use can be quite important (Weaver et al., 2016).

6.1.5. Low Body Weight

Low body weight is a significant risk factor for osteoporosis, especially in people with tiny frames or low body mass indexes (BMIs). Individuals with low BMI are more likely to experience bone loss as they age since they often have less bone mass in the first place. An individual's initial bone mass has an impact on bone density; those who are smaller or weigh less tend to have less bone mass in their early adult years, which means they have a lower peak bone mass to maintain. They are therefore more likely to suffer from severe bone loss in later life. Indeed, research indicates that those with a BMI below 18.5 are more likely to have fractures and have decreased bone mineral density (Rauch & Schoenau, 2001).

Women are more at risk, especially those with a history of eating disorders like anorexia nervosa. Severe calorie restriction and malnutrition are hallmarks of anorexia nervosa, which causes hormonal abnormalities, including a sharp decline in estrogen levels. Because of these hormonal changes, less bone is formed, which lowers bone mineral density and increases the risk of osteoporosis. Because they have not yet attained peak bone mass, which typically happens around age 30, adolescents and young adults who suffer from eating disorders and have low body weight are particularly at risk. Even with treatment, this makes it harder for patients to regain bone density.

Nutritional deficits, especially in calcium and vitamin D, which are both critical for bone health, may also be linked to low body weight. Low-weight people might not be getting enough of these nutrients in their diet to promote healthy bone mineralization. Vitamin D is required for the body to effectively absorb calcium, which is an essential component of bone tissue. Bones weaken and become more prone to fractures when these nutrients are lacking. To promote bone health, people with low body weight should be constantly watched for osteoporosis risk, particularly as they age, and urged to adopt a diet high in nutrients that build bones in addition to engaging in weight-bearing activities.

6.1.6. Medications

By either reducing bone production or speeding up bone resorption, some drugs can raise the risk of osteoporosis. The class of medications known as glucocorticoids, which includes corticosteroids like prednisone, is one of the most prevalent groups that impact bone health. These medications are frequently recommended to treat inflammatory bowel disease, rheumatoid arthritis, and asthma. According to Van Staa et al. (2003), prolonged use of corticosteroids is known to reduce bone mineral density by enhancing osteoclast activity, which is responsible for bone resorption, and suppressing osteoblast function, which is responsible for bone creation. The effects of corticosteroids on bone density can be considerable, and long-term use of these drugs can significantly increase the risk of fracture, particularly in the hip, wrist, and spine.

Chemotherapy treatments and anticonvulsants (used to treat epilepsy) are other medications that may affect bone health. Phenytoin and phenobarbital are two examples of anticonvulsants

that alter vitamin D metabolism, which can lower calcium absorption and raise the risk of osteoporosis. Similarly, bone loss may result from chemotherapy medications used to treat cancer, especially those that disrupt the production or action of estrogen. Women who have menopause brought on by chemotherapy may experience faster bone resorption, which raises their risk of fractures. Furthermore, when taken for an extended length of time, proton pump inhibitors (PPIs), which are frequently prescribed to treat stomach ulcers and gastroesophageal reflux disease (GERD), may decrease the intestinal absorption of calcium, which would further deplete bone density.

The length of time and amount of drug use increases the risk of osteoporosis from drugs. Regular bone density testing should be performed on those using medications that impact bone health, particularly if they have other osteoporosis risk factors. Preventive actions like weight-bearing exercise and calcium and vitamin D supplements are frequently advised to lessen the negative effects of these drugs on bone health. Alternative drugs may occasionally be taken into consideration to lower the risk of bone loss, especially for people who have experienced fractures in the past or who have experienced a considerable decrease in bone density.

6.1.7. Chronic Medical Condition

Because of the impact of the disease itself as well as the medications used to manage it, chronic medical disorders can greatly raise the risk of osteoporosis. Because chronic disorders can affect the body's capacity to maintain bone density, mineralization, and strength, there is a complex link between these conditions and bone health. Rheumatoid arthritis (RA), diabetes mellitus, inflammatory bowel disease (IBD), and chronic kidney disease (CKD) are among the most prevalent chronic illnesses that cause osteoporosis. These disorders can cause bone loss in several ways, including hormone imbalances, chronic inflammation, and pharmaceutical use.

6.1.7.1. Rheumatoid Arthritis (RA)

The inflammatory condition known as RA results in joint inflammation, and in people with RA, osteoporosis is largely caused by chronic inflammation. Accelerated bone loss can result from the inflammatory process's inflammatory cytokines, which include interleukins and tumor

necrosis factor-alpha. These cytokines can also boost the activity of osteoclasts, which are cells that break down bone (Firestein, 2003). Osteoporosis is caused by a decrease in bone production and an increase in bone resorption. Furthermore, because of joint dysfunction and pain, persons with RA frequently engage in less physical activity, which can exacerbate bone loss and cause muscular weakening. Glucocorticoids (steroids), which are used to treat RA, worsen bone loss and raise the risk of fractures. Long-term steroid use inhibits the activity of osteoblasts (bone-forming cells), making it difficult for bones to maintain their strength.

6.1.7.2. Chronic Kidney Disease (CKD)

Because calcium and phosphate metabolism are essential for preserving bone strength, chronic renal disease can have a major effect on bone health. Hyperphosphatemia (high blood phosphate levels) results from the kidneys' inability to adequately eliminate phosphate in chronic kidney disease (CKD). Renal osteodystrophy, a kind of bone disease frequently observed in patients with chronic kidney disease (CKD), can be caused by elevated phosphate levels stimulating the release of parathyroid hormone (PTH), which accelerates bone resorption. Reduced generation of active vitamin D (calcitriol) due to poor kidney function also lowers intestinal absorption of calcium, further weakening bones (Raimann & Kovesdy, 2015). The combination of high phosphate levels, low calcium levels, and elevated PTH can accelerate bone demineralization in CKD patients, making them highly vulnerable to fractures and osteoporosis.

6.1.7.3. Diabetes Mellitus

Although the mechanisms underlying bone loss vary between type 1 and type 2 diabetes, both conditions are linked to an increased risk of osteoporosis. Due to poor bone formation and growth, type 1 diabetes, which usually manifests in childhood or adolescence, frequently results in a lower peak bone mass. Moreover, an imbalance in bone remodeling caused by insulin shortage in T1D results in decreased bone production and increased bone resorption, which lowers bone mineral density (BMD) (Vestergaard, 2007). Even though people with type 2 diabetes typically have higher bone mineral densities, their poor bone quality increases their risk of fractures.

Even if bone mineral density is maintained, insulin resistance and hyperglycemia in type 2 diabetes can cause alterations in collagen and the bone matrix, weakening the bones. Both T1D and T2D also raise the risk of falls because of neuropathy (damage to the nerves) and blurred eyesight, which increases the chance of fractures.

6.1.7.4. Inflammatory Bowel Disease (IBD)

Chronic inflammatory diseases like Crohn's disease and ulcerative colitis (the two main types of IBD) can cause substantial bone loss over time. IBD-related chronic inflammation can cause an excess of pro-inflammatory cytokines, which in turn stimulate osteoclasts and promote bone resorption. Furthermore, malabsorption of vital nutrients including calcium, vitamin D, and magnesium—all of which are required for bone health—occurs often in persons with IBD. Since corticosteroids are known to decrease bone density and raise the risk of fracture, using them to treat IBD flare-ups further increases the risk of osteoporosis. Additionally, because of gastrointestinal symptoms, people with IBD may be less active, which can result in bone demineralization and muscle weakness. Studies have shown that people with IBD are at higher risk of fractures, particularly in the spine and hips.

6.2. Non-Modifiable Risk Factors

6.2.1. Age

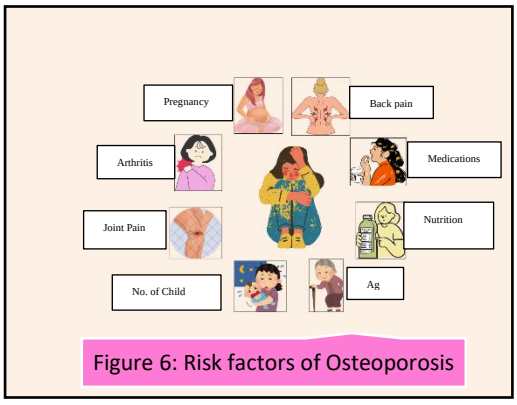

Figure 6: Risk factors of Osteoporosis

Due mainly to the aging-induced natural decrease in bone density, age is one of the most important factors in the development of osteoporosis. As people age, their bone remodeling—the process by which new bone is created and old bone is reabsorbed—becomes unbalanced. As people age, their peak bone mass, which is usually reached by their late 20s or early 30s, starts to decrease. Because estrogen, a hormone essential for preserving bone density, is sharply reduced in postmenopausal women, this decrease is made

worse. Increased osteoclast activity brought on by estrogen deprivation accelerates bone resorption and causes a net loss of bone mass. This process causes weaker, thinner bones over time, making them more prone to fractures, especially in weight-bearing regions like the spine and hips (Kanis et al., 2020).

As testosterone levels drop more gradually in men, bone density decreases more gradually as men age. However, because of decades of cumulative bone loss, men's risk of osteoporosis is comparable to women's by the time they are in their 70s or 80s. Furthermore, aging is linked to lower levels of vitamin D and calcium absorption, both of which worsen bone health (Eastell et al., 2016). This emphasizes how crucial age-related measures are to preventing bone loss, including physical activity and supplements.

Age-related changes in bone structure also make bones more brittle. Trabecular bone, for example, which gives bones their structural support, significantly thins and perforates. The thick outer layer, called cortical bone, also becomes thinner. According to Compston et al. (2017), these alterations work together to weaken the bone, which makes fractures a serious health risk for the elderly.

6.2.2. Sex

The risk of osteoporosis is significantly influenced by sex, with women being disproportionately afflicted in comparison to males. Even at optimum density, women's bone mass is usually smaller than men's, making them more susceptible to bone loss over time. Menopause-related hormonal changes make this discrepancy even worse. Estrogen levels sharply decline during menopause, which causes a noticeable rise in bone resorption that surpasses bone production. Women are at a much higher risk of fractures, especially in the spine, hips, and wrists, due to the rapid bone loss that occurs throughout the postmenopausal years (Eastell et al., 2016).

Even though their risk increases with age, men might still have osteoporosis. Age-related reductions in testosterone, a hormone that promotes bone production, result in a slower rate of bone loss. However, men may experience rapid bone loss similar to postmenopausal women if they suffer from disorders like hypogonadism or get medications that suppress testosterone

levels, including prostate cancer therapy (Compston et al., 2017). The importance of gender-specific screening and preventive interventions is highlighted by these findings.

Sex's effect on osteoporosis risk is also influenced by cultural and socioeconomic factors. Bone health is further jeopardized by the fact that women are more prone than males to die or consume inadequate amounts of nutrients. To address these sex-specific risks and advance bone health for both sexes, awareness campaigns and focused interventions are crucial (Kanis et al., 2020).

6.2.3. Genetics

One important element affecting a person's risk of getting osteoporosis is genetic predisposition. An important factor is family history; those who have parents or siblings with osteoporosis or a history of fragility fractures are more likely to experience them themselves. Certain gene variations, particularly those in the vitamin D receptor gene, have been linked in studies to decreased bone mineral density and a higher risk of fractures. These genetic variables affect bone quality, peak bone mass, and the rate of aging-related bone loss (Ralston & Uitterlinden, 2010).

In addition to particular gene variations, osteoporosis risk is also influenced by polygenic inheritance patterns. For instance, bone strength and density are determined by a combination of genes that influence collagen synthesis, calcium metabolism, and the makeup of the bone matrix. Numerous loci linked to osteoporosis have been discovered by advances in genomic research, making it possible to create genetic risk scores that predict vulnerability (Eastell et al., 2016).

Knowing one's genetic risk can help guide early interventions, even when genetic propensity cannot be changed. People who have a high family history of osteoporosis should make lifestyle changes a priority, such as eating enough calcium and vitamin D, exercising with weights, and abstaining from smoking and heavy alcohol use. Additionally, genetic research opens the door for personalized medicine strategies in osteoporosis prevention and therapy (Compston et al., 2017).

6.2.4. Ethnicity

Osteoporosis risk is significantly influenced by ethnicity because of variations in skeletal structure, bone density, and cultural customs. According to research, people of Asian and Caucasian ancestry are more likely to develop osteoporosis than people of African and Hispanic heritage. Variations in bone mineral density are partly to blame for this discrepancy; African populations often have higher bone densities, which offer a preventive effect against fractures. It is crucial to remember, nevertheless, that some subgroups within these populations might still be at higher risk because of lifestyle choices or long-term conditions (Looker et al., 2012).

Cultural dietary habits like lactose intolerance or insufficient calcium intake may make Asian communities more vulnerable to osteoporosis. Additionally, Asians and Caucasians tend to have smaller skeletons, which increases the risk of fractures since they have less bone mass to tolerate the consequences of bone loss. Reducing the risk for these groups requires addressing these dietary and lifestyle factors (Kanis et al., 2020).

The risk of osteoporosis is frequently underestimated in Hispanic communities. Although bone density is typically higher than in Caucasians, risk factors can include low socioeconomic level, restricted access to healthcare, and inadequate nutrition. To effectively address these inequities, public health interventions must be customized to meet the specific needs of each ethnic community (Compston et al., 2017).

6.2.5. Body Frame Size

The risk of osteoporosis is greatly influenced by body frame size, with those with smaller frames being more vulnerable. As bone density declines with age, smaller bones are more prone to fractures because they have less cortical and trabecular mass to draw from. Furthermore, low body weight people are frequently more likely to suffer from dietary inadequacies, such as inadequate consumption of calcium and vitamin D, both of which are essential for bone health (NIH Osteoporosis and Related Bone Diseases, 2021).

The mechanical loading effect further complicates the relationship between bone health and body weight. People who are heavier put more strain on their bones, which promotes bone remodeling and builds more bone mass. Underweight people, on the other hand, do not have this mechanical input, which results in less bone development. Therefore, maintaining bone strength requires maintaining a healthy weight through a balanced diet and consistent exercise (Weaver et al., 2016).

Furthermore, those with smaller bodies are frequently more likely to fall, which raises their risk of fracture. Fall prevention techniques are a crucial component of risk management for older persons with osteoporosis, as falls are a major cause of injury-related morbidity in this population (Sherrington et al., 2019).

6.2.6. Hormonal Imbalances

As hormones control the processes of bone production and resorption, hormonal abnormalities are a major contributing factor to the development of osteoporosis. Estrogen, a hormone mostly found in women but also present in smaller amounts in men, is one of the most important hormonal contributors. Because it prevents bone resorption—the breakdown of bone and release of its minerals into the bloodstream—estrogen is essential for preserving bone density. Bone loss is more likely to occur when estrogen levels fall, especially around menopause. Because of this, postmenopausal women are far more likely to develop osteoporosis. It is estimated that women can lose up to 20% of their bone mass within the first five to seven years after menopause (Riggs & Hartmann, 1983).

Osteoporosis can be caused by hormonal changes other than estrogen. Bone health is also influenced by testosterone, the main hormone involved in male sex. Though the process is slower than in women, males usually lose bone mass as a result of a progressive drop in testosterone levels as they age. Bone health is also influenced by thyroid hormones. A reduction in bone density results from hyperthyroidism, an overactive thyroid that speeds up bone resorption. Another important hormone is parathyroid hormone (PTH). The parathyroid glands release parathyroid hormone (PTH) to encourage the flow of calcium from bones into the bloodstream when blood calcium levels are low. Osteoporosis can result from excessive bone resorption caused by persistently high PTH levels. Because cortisol suppresses bone formation

and speeds up bone breakdown, people with Cushing's syndrome, an excess of the stress hormone cortisol, also have faster bone loss.

Diabetes and other endocrine conditions can also impact bone health. For instance, type 2 diabetes may raise the risk of fractures due to poor bone quality, even if type 1 diabetes is frequently linked to decreased bone mineral density. A weaker skeletal system might result from these hormonal imbalances, which can upset the delicate balance between bone creation and resorption. Osteoporosis risk may be decreased by correcting these hormonal imbalances with pharmacological interventions, such as testosterone replacement therapy for males or hormone replacement therapy (HRT) for women after menopause. However, treatment should always be customized to meet the needs of each patient.

6.3. Other Factors

6.3.1. Previous Fractures

People with a history of fractures are more likely to get them again, especially if they were caused by minor trauma or when their bone density is low. According to Cummings and Melton (2002), a prior fracture frequently signifies weaker bones, which raises the risk of further fractures. According to studies, people who have already experienced one fracture are significantly more likely to get another, particularly if they have osteoporosis or poor bone mineral density (Cummings & Melton, 2002). This is because fractures can weaken nearby bone structures and cause bone demineralization, which increases their vulnerability to further fractures.

The "fracture cascade" effect is especially worrisome since after a fracture, people tend to become less active, which can worsen bone loss and raise the risk of fractures even more (Weaver et al., 2016).

Therefore, it's critical to keep a close eye out for osteoporosis and other bone health issues in those who have had a fracture. According to Weaver et al. (2016), further fractures can be avoided by putting techniques like physical therapy, calcium and vitamin D supplementation, and bone density testing into practice.

6.3.2. Falls

Since falls frequently involve little damage, they are a significant cause of fractures in people with osteoporosis. Muscle weakness, poor balance, and eyesight issues are some of the factors that affect the risk of falling (Tinetti et al., 1997). Because weaker bones are more likely to fracture, even from small falls, osteoporosis increases this risk. Because of their weakened skeletons, people with osteoporosis are more likely to fall, and fractures from falls can seriously lower their quality of life.

Using assistive devices, such as walking aids, addressing vision issues, and strengthening and balancing through targeted workouts are among interventions to lower the risk of falls (Gillespie et al., 2012). Installing grab bars and removing trip hazards are two examples of home improvements that can assist older individuals avoid falls (Tinetti et al., 1997).

For people with osteoporosis, fall avoidance is especially crucial because falls can result in crippling fractures. Osteoporosis care should include strategies to lower the risk of fractures and falls.

Chapter 7

Effects of Osteoporosis

A chronic condition that significantly impairs a person's lifestyle, everyday activities, and general well-being is osteoporosis. People may suffer from severe physical discomfort, restricted movement, and an elevated risk of fractures as the illness worsens. These adjustments may result in major lifestyle modifications that lower social relationships, independence, and general quality of life.

Limiting physical activity is one of the most important ways osteoporosis impacts lifestyle. According to Finkelstein et al. (2003), the main reason for this restriction is the elevated risk of fractures, particularly in weight-bearing bones like the wrists, hips, and spine. People who have osteoporosis may feel pain when they move or may be reluctant to do certain physical activities because they are worried about falling and breaking their bones. A more sedentary lifestyle brought on by this fear of injury can worsen bone loss and muscular weakness, resulting in a vicious cycle of deteriorating physical function (Svedbom et al., 2013). Being physically active is essential for preserving bone strength and density. Exercises that emphasize strength, flexibility, and balance—like walking, weight training, and tai chi—are advised for those with osteoporosis. However, the capacity to carry out these exercises may deteriorate as osteoporosis progresses and fractures occur, making it more difficult for people to lead active lives (Rizzoli et al., 2014). For instance, prolonged bed rest following a hip fracture may necessitate a longer recovery period and result in significant loss of muscle mass and joint function (Berry et al., 2010).

Osteoporosis-related physical limits have important social and emotional repercussions as well. Individuals who have osteoporosis, particularly those who have experienced fractures, may express feelings of loneliness and anxiety. People may be reluctant to leave their homes, go to social gatherings, or partake in activities they used to like because they are afraid of falling or breaking again. Among older adults, who may already be dealing with the difficulties of aging and may feel ashamed of the physical restrictions associated with osteoporosis, such as a stooped posture brought on by spinal fractures, this social disengagement is especially noticeable (Gómez et al., 2019). Moreover, osteoporosis has a significant psychological cost. People with osteoporosis frequently experience anxiety and depression, especially following a

fracture. Feelings of powerlessness and a lowered sense of self-worth can be exacerbated by the fear of additional injuries as well as the loss of movement and freedom. Studies show that people with osteoporosis-related fractures frequently report higher levels of distress and a lower quality of life than people without such injuries (Cummings & Melton, 2002). Due to feelings of hopelessness, the psychological effects in certain situations may even keep people from following treatment plans or getting the required medical attention (Angulo et al., 2011).

Beyond just being harmful to one's health, osteoporosis can have serious financial repercussions for both people and society as a whole. According to Bouxsein et al. (2001), osteoporotic fractures frequently result in prolonged recuperation, hospital stays, and rehabilitation, all of which raise healthcare expenses. In addition to indirect costs like missed income and the requirement for caregiver help, this can cause direct financial constraints for individuals, such as out-of-pocket payments for medical procedures, prescription drugs, and assistive technology. The ability to continue working can also be significantly impacted by osteoporosis, especially for people in physically demanding professions. For instance, the possibility of hip and spine fractures may make it impossible for someone to perform physical labor or move large objects. Losing a job or having to switch to less physically demanding jobs that might not offer the same financial stability are possible outcomes of this. According to Finkelstein et al. (2003), older persons may experience financial difficulty during their retirement years as a result of income loss brought on by osteoporosis-related disability.

Because it might result in further health concerns, osteoporosis is dangerous in addition to the risk of fractures. For instance, because osteoporosis weakens bones and impairs balance, people with the condition are more likely to fall. These falls frequently cause further fractures or other severe injuries such as internal bleeding or head damage. According to Berry et al. (2010), hip fractures in particular are associated with a high risk of complications, such as infection, blood clots, and pneumonia, which can seriously hinder healing and result in permanent impairment.

Kyphosis, a condition in which the spine becomes unnaturally curved, can develop from spinal fractures, which are common in people with osteoporosis and cause a stooped posture (Finkelstein et al., 2003). This curvature can lead to excruciating back pain, which further impairs movement and feeds a vicious cycle of physical decline. Chronic discomfort, reduced lung capacity as a result of posture changes, and an elevated risk of respiratory infections are among the long-term effects of spinal fractures (Eastell & O'Neill, 2017).

It is impossible to exaggerate the long-term risks of osteoporosis. An individual's lifestyle can be drastically changed by a single osteoporotic fracture, which can result in long-term impairment, reliance on others for everyday tasks, and, in the case of hip fractures, an increased risk of death (Berry et al., 2010). According to one study, up to 20% of people pass away within a year after suffering a hip fracture, frequently as a result of complications like infection or blood clots. This indicates that the risk of death after a hip fracture is extremely high (Kannus et al., 2004). Furthermore, fractures can cause long-lasting physical abnormalities including a bent spine, which can impair quality of life, cause chronic discomfort, and cause a loss of independence.

Multiple fractures can have disastrous cumulative effects. Frequent fractures, especially those to the spine, can cause a gradual deterioration in general health and necessitate continued assistance and care. This frequently results in the need for nursing homes or assisted living care for older people, which can be emotionally and financially taxing. The ongoing cycle of fractures, physical restrictions, and diminished quality of life emphasizes how serious osteoporosis is as a potentially fatal illness (Cummings & Melton, 2002).

Chapter 8

Diagnosis of Osteoporosis

In order to determine bone density and fracture risk, osteoporosis is diagnosed using a mix of clinical evaluation, risk assessment, and diagnostic imaging. The diagnosis mostly depends on identifying bone loss before clinical symptoms appear because osteoporosis frequently develops without symptoms until a fracture occurs. A thorough medical history, physical examination, risk factor assessment, and bone density testing are usually all part of the diagnostic procedure.

Medical History and Physical Examination

To find risk factors for osteoporosis, a thorough medical history is the first step in the diagnostic process. These consist of age, sex, prior fractures, family history of osteoporosis or fractures, and lifestyle choices such as drinking alcohol, smoking, and engaging in physical activity (Eastell & O'Neill, 2017). Furthermore, a thorough medical history is crucial because various drugs, including anticonvulsants, glucocorticoids, and some cancer treatments, have been shown to raise the risk of osteoporosis (Rizzoli et al., 2014).

Even though it might not detect osteoporosis directly, a physical examination is a crucial component of the diagnosis. However, physical symptoms including height loss, kyphosis (the curving of the spine), and joint or spine pain could indicate underlying bone problems (Cummings & Melton, 2002). Furthermore, a comprehensive neurological and musculoskeletal examination aids in determining the patient's mobility and functional state, offering insight into the potential effects of osteoporosis on the patient's quality of life.

Risk Assessment Tools

Numerous instruments have been created to evaluate a person's risk of osteoporosis and fractures. The World Health Organization's FRAX® (Fracture Risk Assessment Tool) is one of the most popular. Based on a person's risk variables and bone mineral density (BMD) readings, the FRAX tool determines the 10-year chance of a major osteoporotic fracture

(shoulder, hip, forearm, or spine) (Kanis et al., 2008). Even without a BMD measurement, the FRAX tool estimates fracture risk by taking into account variables including age, sex, weight, height, smoking, alcohol usage, prior fractures, and corticosteroid use.

Although the FRAX tool does not require BMD testing to calculate fracture risk, it is often used in combination with bone density measurements for a more comprehensive assessment. The use of the FRAX tool helps healthcare providers identify individuals at high risk of fracture, even if they do not yet have a diagnosis of osteoporosis, enabling early intervention.

Bone Mineral Density Testing

Bone mineral density (BMD) testing, usually done with dual-energy X-ray absorptiometry (DXA or DEXA), is the gold standard for diagnosing osteoporosis. The most popular and precise imaging method for determining BMD is this one. DXA provides an accurate assessment of bone strength by measuring the density of bone in the hip, lumbar spine, and occasionally the forearm (Eastell & O'Neill, 2017). The T-score, which compares the patient's BMD to the average peak bone mass of a young adult of the same sex who is in good health, is the standard way that the findings of a DXA scan are presented.

The T-score is used to classify the degree of bone loss and guide treatment decisions:

- **Normal:** T-score $\geq$ -1.0
- **Low bone mass (osteopenia):** T-score between -1.0 and -2.5
- **Osteoporosis:** T-score $\leq$ -2.5
- **Severe osteoporosis (with fractures):** T-score $\leq$ -2.5 and the presence of one or more osteoporotic fractures (WHO, 2007).

Osteoporosis is indicated by a T-score of -2.5 or less; the lower the score, the greater the risk of fracture. The T-score alone, however, should not be used to diagnose osteoporosis; clinical judgment, risk factors, and the existence of fractures are all taken into account (Cummings & Melton, 2002). For the majority of people, the DXA scan is the recommended method for detecting osteoporosis because it is non-invasive and requires no preparation.

Other Imaging Techniques

Additional imaging techniques may occasionally be employed to further evaluate bone health, especially when DXA results are unclear or a more thorough analysis is needed. One such imaging technique that evaluates BMD and offers three-dimensional imaging of the hip or spine is quantitative computed tomography (QCT). In some clinical circumstances, such as when osteoporosis is suspected but DXA does not reveal considerable bone loss, QCT may be helpful since it is more sensitive than DXA at identifying early bone loss (Leder, 2010). However, compared to DXA, QCT is less frequently utilized because of its increased radiation dose and expense.

Another method for evaluating bone quality and identifying fractures is magnetic resonance imaging (MRI). MRI may be used in certain circumstances, such as to evaluate vertebral fractures or to determine the risk of fractures in patients with complicated clinical histories, even if it is not commonly used for routine osteoporosis diagnosis (Peolsson et al., 2001). MRI is more costly and less accessible than DXA, but it offers the benefit of not using ionizing radiation.

Biochemical Markers of Bone Turnover

Biochemical indicators of bone turnover can offer further data on bone health in addition to BMD measurements and imaging methods. These indicators, which can be used to gauge the rate of bone turnover, include chemicals released during bone production or resorption (Rizzoli et al., 2014). Two commonly used markers are:

1. **C-terminal telopeptide (CTX):** A marker of bone resorption.
2. **Procollagen type 1 N-terminal propeptide (PINP):** A marker of bone formation.

These markers can be useful in evaluating the effectiveness of treatment, particularly for patients receiving therapy for osteoporosis, even though they are not frequently used to diagnose the condition. While normal or low levels may indicate a stable bone condition, elevated levels of bone turnover indicators may indicate increasing bone resorption, which is a feature of osteoporosis (Eastell & O'Neill, 2017).

Vertebral Fracture Assessment

Because they may not exhibit overt symptoms, vertebral fractures—which are typically an early sign of osteoporosis—are commonly underdiagnosed. Specialized imaging methods like lateral spine X-rays or more sophisticated approaches like DXA-based vertebral fracture assessment (VFA) can be used to detect these fractures. When combined with a routine DXA scan, the VFA approach enables the simultaneous determination of bone mineral density and the identification of vertebral fractures (Bauer et al., 2007). This technique can help discover vertebral fractures that may not have been clinically diagnosed, which makes it especially helpful for people who report height loss, back pain, or a history of fractures.

Since the existence of one or more vertebral fractures greatly raises the risk of further fractures, it is crucial to detect these fractures. Early detection and treatment are essential since those who have vertebral fractures are more likely to suffer hip and other fractures (Cummings & Melton, 2002).

Assessment in Special Populations

Other factors need to be taken into account when diagnosing osteoporosis in some groups. For instance, elderly men and postmenopausal women are more susceptible to osteoporosis because their bone loss is accelerated by a drop in estrogen or testosterone levels. A more specialized diagnostic approach is needed for people with secondary causes of osteoporosis, such as those receiving long-term glucocorticoid therapy or those suffering from hyperparathyroidism or celiac disease. This includes additional blood tests to find underlying conditions that are causing bone loss (Rizzoli et al., 2014).

Although osteoporosis is less frequent in young people, it can be brought on by chronic illness, eating problems, or genetic disorders. More thorough testing, such as genetic screening or biochemical tests to check for particular illnesses, might be required in these situations (Peolsson et al., 2001). Furthermore, because osteoporosis is less common in men, it is frequently underdiagnosed in this population. According to Bauer et al. (2007), men who have risk factors such low testosterone, long-term medical conditions, or a family history of osteoporosis should also get the right diagnostic screening.

Chapter 9

Context of Bangladesh

9.1. Risk Factors

Research shows that among Bangladeshi women, osteoporosis is significantly more common. 37.3% of participants in a cross-sectional survey of 526 people in Dhaka City were at risk for osteoporosis, with a greater prevalence among females ($p < 0.001$). 40.0% of postmenopausal women had osteoporosis and 43.5% had osteopenia, according to another study on the subject, underscoring the significant burden of bone health problems in this group.

Age and Gender

One known risk factor for osteoporosis is age. Bone density decreases as a result of natural aging, raising the risk of fractures. There is a unique pattern of correlation between age and osteoporosis risk in Bangladesh. According to the Dhaka City study described above, older persons were more susceptible to osteoporosis, and age was substantially correlated with osteoporosis risk ($p = 0.003$). Another important factor is gender; women are more likely to develop osteoporosis because of things like lower peak bone mass and hormonal changes that occur during menopause.

Menopause and Hormonal Factors

The decrease in estrogen levels during menopause has a major effect on bone health because it speeds up bone resorption. The average age of participants in research evaluating dietary factors linked to osteoporosis in postmenopausal women in Jamalpur, Bangladesh, was 65.66±12.31 years, while the average age at menopause was 47.35±3.78 years (Alam, et. al. (2021). Some women may experience an extended period of estrogen insufficiency due to an early menopausal onset, which raises their risk of osteoporosis.

Nutritional Deficiency

Sustaining bone health requires a healthy diet. Vitamin D and calcium deficiencies are important risk factors for osteoporosis. Dietary practices, such as consuming less foods high in calcium, were linked to a higher risk of osteoporosis in postmenopausal women, according to the Jamalpur study. (Alam et al. (2021)) Bangladeshi women may also be more susceptible to these deficits due to cultural dietary customs and limited exposure to sunlight, which is essential for the production of vitamin D.

Physical Inactivity and Sedentary Lifestyle

Because weight-bearing exercises promote bone growth, physical activity is essential for maintaining bone strength. However, a lot of Bangladeshi women live inactive lives because of economic and social factors. According to Rahman et al. (2014), women who were less physically active had a noticeably increased chance of developing osteoporosis. Targeted exercise programs are crucial for promoting bone health because of the trend's contributing factors, which include limited access to fitness centers, social constraints on women's outside activities, and domestic duties.

Chronic Diseases and Comorbidities

Osteoporosis risk has been associated with chronic disorders including diabetes and cardiovascular diseases. According to Uddin et al. (2021), there was a substantial correlation between the risk of osteoporosis and cardiovascular disorders ($p < 0.001$) and diabetes ($p = 0.003$). Chronic inflammation, abnormal calcium metabolism, and the use of drugs (such as corticosteroids) that impair bone health can result from these disorders. Osteoporosis risk can be reduced by addressing these comorbidities using integrated healthcare techniques.

Genetic and Familial Factors

Bone density and general skeletal health are significantly influenced by genetics. Women are more likely to get osteoporosis or fractures if they have a family history of the disorder. Research from around the world indicates that hereditary factors affect peak bone mass, bone size, and bone turnover rates, despite the paucity of particular genetic studies on Bangladeshi women (Rahman et al., 2014). Early detection and preventive measures can be facilitated by screening for osteoporosis risk based on family history.

Socioeconomic Status and Education

Limited access to osteoporosis information, healthcare services, and a nutrient-dense diet are frequently associated with low socioeconomic position. Only 76% of premenopausal and 70% of postmenopausal women in Bangladesh had an average awareness of osteoporosis, according to Sultana & Begum's (2020) assessment of the condition. Inadequate preventative measures and a delayed diagnosis could result from this ignorance. Women can be empowered to seek prompt medical attention and adopt healthier lives by improving education and awareness initiatives.

Early Marriage and High Parity

Early marriage and high parity, or having many children, are prevalent in Bangladesh and have a substantial effect on women's bone health. Early pregnancies brought on by early marriage might deplete the mother's calcium stores while bone formation is still in progress. Sultana & Begum (2020) claim that women who marry and become pregnant earlier are more likely to develop osteoporosis because of the extended calcium loss that occurs during breastfeeding and multiple pregnancies. This risk is further increased by high parity since the body needs more calcium throughout many pregnancies. A woman's body will draw calcium from her

bones if she does not consume enough calcium and vitamin D in her diet, which will cause her bone density to gradually decrease (Rahman et al., 2014).

Long-term bone mineral loss also results from multiple pregnancies with a short time between them, which leaves the body with little opportunity to restore its calcium stores. High parity is directly associated with lower bone mineral density, particularly in postmenopausal women, according to a study done in South Asian nations, including Bangladesh (Alam et al., 2021). Public health initiatives including family planning, nutritional education, and calcium supplements for women with many pregnancies are necessary to address this problem.

9.2. Diagnosis

Since osteoporosis is largely a silent disorder with few visible signs until a fracture occurs, it is frequently underdiagnosed in Bangladesh. The majority of people with osteoporosis could put off getting help until they suffer from fractures, which are frequently linked to the disorder. Diagnosis is made more difficult by the general lack of knowledge about osteoporosis and its dangers, particularly in rural regions with limited access to healthcare.

A clinical evaluation that includes obtaining a thorough medical history usually precedes the diagnostic procedure. Medical professionals evaluate risk variables like age, sex, dietary patterns, levels of physical activity, family history of osteoporosis or fractures, and usage of drugs like glucocorticoids that can raise the risk of bone loss (Rahman et al., 2018). Furthermore, medical professionals ask about personal lifestyle choices that affect bone health, such as drinking alcohol, smoking, and consuming calcium and vitamin D (Sultana et al., 2020).

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such as drinking alcohol, smoking, and consuming calcium and vitamin D (Sultana et al., 2020).

Bone mineral density (BMD) testing, which is frequently carried out using dual-energy X-ray absorptiometry (DXA), is the gold standard for diagnosing osteoporosis. Even though DXA is generally regarded as the most accurate way to measure BMD, not everyone in Bangladesh has access to it, particularly in rural healthcare settings. Effective osteoporosis diagnosis is made more difficult by the high expense of DXA and the scarcity of qualified specialists to interpret the results (Khan et al., 2019). Additionally, BMD testing is not widely used in Bangladesh because to the lack of financing in public healthcare, which forces doctors to rely on clinical judgment and alternative diagnostic techniques (Sultana et al., 2020).

Alternative techniques, such as quantitative ultrasound (QUS), are occasionally employed to diagnose osteoporosis, especially in underserved or rural areas. Despite offering less precise information about bone density than DXA, QUS is a portable and affordable substitute (Rahman et al., 2018). Notwithstanding its drawbacks, QUS is a helpful screening method for determining who is more likely to develop osteoporosis, especially in situations where DXA is not accessible.

9.3. Treatment

The paucity of public health initiatives devoted to bone health, the high expense of pharmaceuticals, and the scarcity of specialized care make treating osteoporosis in Bangladesh extremely difficult. People with osteoporosis have a number of treatment options, including medication therapy, lifestyle changes, and fall prevention strategies, despite these obstacles.

In Bangladesh, the main goals of pharmacological therapy for osteoporosis are to increase bone production and decrease bone resorption. Bisphosphonates, like alendronate and risedronate, are the most often given drugs because they lower bone turnover and fracture risk (Rahman et al., 2018). These drugs, which are usually taken orally, have been demonstrated to be successful in lowering the risk of fractures in older persons with osteoporosis and postmenopausal women. However, many people in Bangladesh, especially those without insurance or financial help, find it difficult to obtain bisphosphonates due to their expensive costs.

Selective estrogen receptor modulators (SERMs), including raloxifene, are other drugs used to treat osteoporosis because they replicate the effects of estrogen on bone metabolism. According to Khan et al. (2019), SERMs have been demonstrated to be successful in lowering the incidence of vertebral fractures in postmenopausal women. Furthermore, in more severe cases of osteoporosis or when bisphosphonates are not well tolerated, the monoclonal antibody denosumab and parathyroid hormone analogs like teriparatide are employed. Nevertheless, these drugs are much more costly than bisphosphonates, which limits their availability in Bangladesh (Rahman et al., 2018).

Supplementing with calcium and vitamin D is also essential for managing osteoporosis. To keep bones healthy and stop additional bone loss, one must consume enough calcium and vitamin D (Sultana et al., 2020). However, dietary shortages in calcium and vitamin D are frequent, and many people in Bangladesh, particularly in rural areas, lack appropriate access to these supplements. Through public health initiatives, the government and non-governmental organizations (NGOs) are attempting to increase access to and understanding of essential nutrients; nonetheless, there are still obstacles in reaching every demographic.

In Bangladesh, lifestyle changes are crucial for controlling osteoporosis in addition to pharmaceutical treatment. Frequent weight-bearing activities, such as strength training and walking, can help increase bone density and reduce the risk of fractures (Khan et al., 2019). However, the broad adoption of exercise regimens is constrained by a dearth of knowledge regarding the significance of physical activity in preserving bone health. Furthermore, people's capacity to participate in bone-strengthening activities is hampered by cultural norms and a lack of access to safe and suitable exercise conditions, especially in rural areas.

Another crucial component of managing osteoporosis is dietary modifications. Calcium and vitamin D levels may be low in Bangladesh's traditional diet, especially in rural areas where dairy products are not widely consumed. Improving bone health requires educating the public about the value of eating foods high in calcium, such as dairy, green leafy vegetables, and seafood (Sultana et al., 2020). Furthermore, as vitamin D deficiency is common in Bangladesh, particularly in older persons, it is imperative to ensure appropriate sunshine exposure to support the body's production of vitamin D.

Another crucial component of managing osteoporosis is preventing falls, especially in older persons who are more susceptible to fractures. Because osteoporosis weakens bones and impairs balance, many people with the disease fall. Fall prevention strategies are not commonly used in Bangladesh, especially in rural areas where elderly people may live alone and have little access to medical care (Rahman et al., 2018). The risk of falls and fractures can be decreased by enhancing home safety measures including adding handrails and removing trip hazards as well as encouraging strength and balance training.

9.4. Effects

In Bangladesh, osteoporosis has a profound impact on people's physical health, socioeconomic well-being, and quality of life. People with low bone density frequently suffer from osteoporotic fractures, especially those of the hip, spine, and wrist. Particularly in older people, these fractures can cause severe pain, incapacity, and a lasting need for caregivers (Ravindranath & Mahajan, 2015).

Particularly, hip fractures are linked to substantial rates of morbidity and death. According to research, up to 20% of people pass away within a year after suffering a hip fracture, indicating that the risk of death after one is high (Rahman et al., 2018). Fractures can have long-term effects such as restricted mobility, chronic discomfort, and an inability to carry out daily tasks. According to Khan et al. (2019), people who suffer fractures in their older years frequently have a lower quality of life as a result of losing their freedom.

Osteoporosis has serious psychological and emotional repercussions in addition to its physical ones. Anxiety, sadness, and social isolation can emerge from the fear of fractures and the physical limitations that follow. People who have osteoporosis might steer clear of activities that could cause them to fall, which can lead to fewer social connections and a lack of participation in community events. The effects of the illness may be worsened by this social disengagement, which might intensify depressive and lonely sentiments (Ravindranath & Mahajan, 2015).

Osteoporosis has a significant financial impact on both individuals and society. For people in Bangladesh, the expense of medical care, such as hospital stays, surgeries, and prescription

drugs, can be prohibitive, especially for those without health insurance or access to government assistance (Sultana et al., 2020). The financial resources of impacted individuals and families are further taxed by the indirect costs, which include rehabilitation, caregiver assistance, and lost productivity as a result of disability. Furthermore, fractures brought on by osteoporosis may result in extended durations of disability, which raises the need for long-term care and rehabilitation services (Khan et al., 2019).

In Bangladesh, osteoporosis also affects public health more broadly. Osteoporosis-related fractures are predicted to become more common as the population ages, thus taxing the healthcare system (Sultana et al., 2020). A multifaceted strategy is needed to address osteoporosis, which includes raising awareness of the disease, facilitating better access to diagnostic and treatment options, and encouraging preventative behaviors including physical activity and the consumption of calcium and vitamin D.

Chapter 10

Comparison of Risk Factors with Bangladesh

Although osteoporosis is a major health issue in Bangladesh and around the world, the risk factors differ depending on environmental, cultural, and socioeconomic variables. Bangladesh experiences particular difficulties such as early marriage, multiple pregnancies, and restricted access to healthcare, even if aging, poor diet, and physical inactivity are widespread causes globally. Similar to this, Bangladesh and its neighbors in South Asia have several risk factors in common, but they differ in terms of dietary practices, awareness, and access to treatment. Key similarities and contrasts between Bangladesh and other South Asian countries, as well as between Bangladesh and global trends, are shown in the following tables that compare osteoporosis risk factors.

Table 5: Comparative Analysis of Bangladesh vs. Global Osteoporosis Risk Factors

Risk Factor	Bangladesh	Global	Common Risk Factors
Age and Gender	Older women, especially postmenopausal, are at high risk (Uddin et al., 2021).	Universal risk factor; postmenopausal women highly affected (Alam et al., 2021).	Aging and menopause increase risk worldwide.
Early Marriage & High Parity	Common; leads to prolonged calcium depletion due to multiple pregnancies (Sultana & Begum, 2020).	Less common in developed countries due to better family planning and maternal healthcare.	Pregnancy and breastfeeding can deplete calcium stores.

Nutritional Deficiencies	Calcium and vitamin D deficiency due to poor diet and limited dairy intake (Rahman et al., 2014).	Present globally but varies by region; higher dairy intake in Western countries.	Lack of calcium and vitamin D affects bone strength everywhere.
Vitamin D Deficiency	Limited sunlight exposure due to cultural dress codes and indoor lifestyles.	More common in colder climates with long winters and high sunscreen use.	Inadequate sunlight exposure leads to vitamin D deficiency worldwide.
Physical Inactivity	Women often have restricted outdoor activities due to cultural norms (Rahman et al., 2014).	Global issue, but access to gyms and awareness of exercise is better in high-income countries.	Lack of weight-bearing exercise weakens bones everywhere.
Smoking & Alcohol	Low smoking rates in women but widespread betel nut consumption (Sultana & Begum, 2020).	High smoking and alcohol consumption in Western countries contribute to osteoporosis.	Tobacco and alcohol use increase bone loss.
Socioeconomic Status	Poverty and lack of awareness contribute to delayed diagnosis and poor prevention.	Lower socioeconomic status is still a factor, but better healthcare access in developed nations.	Limited access to healthcare worsens osteoporosis risk.

Genetic Factors	Limited research; potentially higher risk among South Asian populations.	Higher risk in Caucasians and Asians, a lower risk in Africans.	Genetics play a role in osteoporosis risk worldwide.
Use of Medications	Less common due to limited healthcare access.	Long-term corticosteroids and other drug use contribute significantly in developed nations.	Some medications (e.g., steroids) weaken bones globally.

Table 6: Comparison of Osteoporosis Risk Factors in Bangladesh vs. South Asia

Risk Factor	Bangladesh	South Asia (India, Pakistan, Nepal, Sri Lanka, etc.)	Common Risk Factors
Prevalence	High among postmenopausal women (40% osteoporosis, 43.5% osteopenia) (Alam et al., 2021).	High across South Asia; studies show 30-50% of postmenopausal women affected (Gupta et al., 2020).	Osteoporosis is a widespread issue in postmenopausal women in South Asia.
	Very common; contributes to bone loss due to repeated	Also common in India and Pakistan, but	Frequent pregnancies without adequate calcium

Early Marriage & High Parity	pregnancies (Sultana & Begum, 2020).	declining due to awareness and policies.	intake weaken bones.
Diet & Nutrition	Rice-based diet; low dairy, low calcium intake, poor protein consumption (Rahman et al., 2014).	Similar diet in South Asia, but dairy intake is slightly higher in India and Sri Lanka.	Poor diet and lack of dairy consumption contribute to weak bones.
Vitamin D Deficiency	Common due to lack of sun exposure and cultural clothing restrictions (Alam et al., 2021).	Widespread issues across South Asia, especially in urban areas (Gupta et al., 2020).	Sunlight exposure is insufficient due to indoor lifestyles and pollution.
Physical Inactivity	Cultural restrictions limit women's participation in physical activities (Rahman et al., 2014).	Similar in Pakistan and rural India, but urban populations in India and Sri Lanka have better awareness.	Lack of exercise reduces bone strength across South Asia.
Smoking & Betel Nut Use	Low smoking rates in women, high betel nut consumption.	Smoking is more common in Nepalese and Pakistani women; betel nut widely consumed in India and Sri Lanka.	Tobacco products, including betel nut, negatively impact bone health.
	High poverty rates and lack of awareness	Similar trend in rural South Asia, but urban	Poverty and low awareness lead to

Socioeconomic Factors	delay diagnosis and treatment.	areas have better access to healthcare.	late osteoporosis detection.
Genetic Predisposition	Likely higher risk but under-researched (Sultana & Begum, 2020).	South Asians generally have lower bone density than Western populations (Gupta et al., 2020).	South Asian women have lower peak bone mass, increasing risk.
Healthcare Access & Screening	Limited bone health screening and awareness programs.	More screening programs in India and Sri Lanka, but still inadequate in rural areas.	Limited osteoporosis diagnosis and prevention efforts are common.

The summarized data can be presented in a table below:

Table 7: Estimated Prominence of Osteoporosis Risk Factors (%)

Risk Factor	Bangladesh (%)	South Asia (%)	Global (%)
Calcium & Vitamin D Deficiency	75%	65%	50%
Physical Inactivity	60%	55%	40%
Early Marriage & Multiple Pregnancies	70%	60%	20%
Smoking & Tobacco Use	30%	40%	60%
Alcohol Consumption	5%	20%	70%
Genetic Factors	50%	55%	60%

Poor Healthcare Access	80%	65%	30%
Low Socioeconomic Status	85%	70%	40%
Lack of Awareness	75%	65%	35%

The above-mentioned table can be represented as a bar chart as the following:

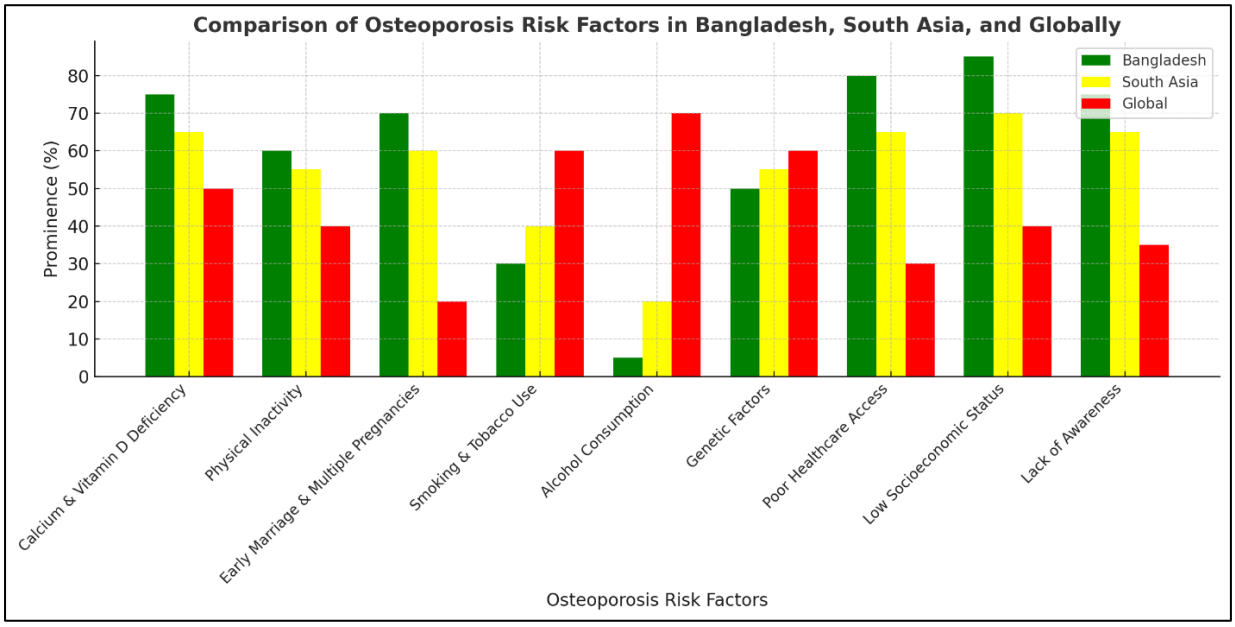

Figure 7: Comparison of Osteoporosis Risk Factors in Bangladesh, South Asia, and Globally

Chapter 11

Prevention

Interventions to improve bone health and lower the incidence of fractures, particularly in populations at risk, are the main emphasis of osteoporosis prevention. Particularly in elderly persons, osteoporosis increases the risk of fractures by decreasing bone mineral density (BMD) and increasing bone fragility (WHO, 2020). A multifaceted strategy is used to prevent osteoporosis, which may comprise medication, lifestyle changes, physical activity, and appropriate nutrition.

Getting enough calcium throughout life is one of the most important ways to prevent osteoporosis. The primary mineral in bones is calcium, and a healthy supply of calcium is necessary to maintain ideal bone mineral density. The National Osteoporosis Foundation (NOF, 2020) states that individuals should consume 1,000–1,200 mg of calcium daily, although this should vary by age and gender. Although fortified non-dairy products like almond milk and specific green vegetables like broccoli and kale also contribute to dietary calcium, dairy products like milk, yogurt, and cheese are the main sources of calcium (Rosen, 2018). Calcium supplements may be an option for people who don't get enough calcium from their diet. However, excessive calcium intake can also have negative effects, such as kidney stones, and should be managed carefully (Weaver et al., 2016).

Bone health and calcium absorption are complemented by vitamin D. Vitamin D is essential for preventing osteoporosis because a lack of it can result in reduced calcium absorption (Holick, 2017). Sunlight exposure can help the body produce vitamin D, but fortified foods, fatty fish, and egg yolks are all key dietary sources. Adults should generally consume 600–800 IU of vitamin D per day, although those with low blood levels of the vitamin or elderly individuals who may have decreased skin production of the vitamin may need greater dosages (Autier, 2019). People who are at risk of vitamin D insufficiency are frequently advised to take supplements, especially in areas with little sunlight.

Exercises that involve resistance and weight-bearing are crucial for establishing and preserving bone strength. By increasing bone mineral density and promoting bone growth, these activities lower the risk of osteoporosis (Gusi et al., 2006). Walking, jogging, trekking, and dancing are

examples of weight-bearing activities that make the body work against gravity, strengthening bones. Resistance training, such as lifting weights or utilizing resistance bands, promotes bone health by increasing muscular activity. Regular exercise has been demonstrated to improve bone density, especially in the hip and spine (Robinson et al., 2018). To prevent joint stress and fractures in those with already poor bone density, it's crucial to balance high-impact and low-impact activities.

Osteoporosis prevention requires not only exercise but also keeping a healthy weight. Because adipose tissue regulates bone metabolism, being underweight or having low body fat may raise the risk of bone loss (Compston, 2018). In order to maintain bone health, a healthy weight is usually linked to a suitable ratio of lean mass to body fat. Overweight people may also be more susceptible to fractures because of the additional strain on their bones and joints, especially in the lower limbs. Preventing osteoporosis requires controlling body weight with a healthy diet and frequent exercise (Perrone et al., 2020).

Another important lifestyle component in preventing osteoporosis is quitting smoking and consuming alcohol in moderation. It has been demonstrated that smoking reduces bone density and disrupts the body's calcium absorption, which raises the risk of fracture (Høidrup et al., 2002). Menopause is a major risk factor for osteoporosis in women, and smokers are more likely to suffer an earlier onset of menopause. It has been demonstrated that quitting smoking improves bone health, particularly when paired with other preventative strategies including exercise and a healthy diet (Kanis et al., 2008).

Another significant risk factor for osteoporosis is excessive alcohol use. Alcohol may hinder the body's capacity to produce new bone tissue and disrupt the equilibrium of calcium and other vital nutrients (Reinhold et al., 2020). According to studies, heavy drinkers are more likely to develop osteoporosis and bone fractures, especially if they consume more than three alcoholic beverages daily (López et al., 2018). The risk of osteoporosis and its related problems can be considerably reduced by cutting back on alcohol use and establishing a moderate drinking pattern.

Pharmaceutical treatments could be required for people who are at a high risk of developing osteoporosis. For those with osteopenia or osteoporosis, the use of drugs such bisphosphonates, selective estrogen receptor modulators (SERMs), or hormone replacement therapy (HRT) can

help stop additional bone loss (Eastell et al., 2016). The most commonly given drugs for osteoporosis are bisphosphonates, which stop bone resorption by blocking osteoclast activity. SERMs, such as raloxifene, help lower the incidence of fractures in postmenopausal women by simulating the actions of estrogen on bone tissue. Women in the early stages of menopause and those at high risk for osteoporosis may also benefit from hormone replacement treatment (Cummings et al., 2009). However, these treatments should be considered in consultation with healthcare providers, as they may come with side effects or risks, particularly in individuals with other health concerns.

Regular osteoporosis screening is another preventive measure, especially for women over 65 and those with additional risk factors, such as a history of fractures, low body weight, or a family history of the condition. Dual-energy X-ray absorptiometry (DXA), which gauges bone mineral density (BMD), is the gold standard for osteoporosis diagnosis. According to the National Institute for Health and Care Excellence [NICE], 2017, early diagnosis by routine screening can assist in identifying persons who are at risk and offer the chance for early intervention through pharmacological treatment or lifestyle changes. Long-term results can be improved and fracture risk can be decreased with early interventions.

Public health campaigns and education initiatives are crucial for increasing awareness of osteoporosis and encouraging preventative actions in addition to these therapies. It's possible that many people, especially older persons, are unaware of the risk factors for osteoporosis and the significance of preserving bone health. People can be empowered to take control of their bone health by participating in public health programs that educate them about the value of calcium and vitamin D, the necessity of physical activity, and the advantages of quitting smoking (Burge et al., 2011). Preventing osteoporosis can also be greatly aided by community initiatives that include nutritional guidance, fitness sessions, and testing for the condition.

Chapter 12

Limitations and Future Prospects

12.1. Limitations of Osteoporosis Research and Management

1. Limited Epidemiological Data and Research Gaps

The dearth of extensive, comprehensive epidemiological studies is one of the main obstacles to comprehending osteoporosis in Bangladesh (Rahman et al., 2021). The generalizability of current research is limited by its frequent restriction to small sample sizes. There are substantial knowledge gaps about the prevalence of osteoporosis in rural populations, younger women, and men because the majority of studies concentrate on postmenopausal women in urban settings (Khan et al., 2019). Furthermore, there is a lack of information on how bone mineral density (BMD) varies by geography and socioeconomic status, which makes it challenging to create focused therapies.

2. Inadequate Screening and Diagnostic Facilities

In Bangladesh, there is limited access to sophisticated diagnostic instruments like dual-energy X-ray absorptiometry (DXA) scans, which are crucial for the early identification of osteoporosis (Hossain & Ahmed, 2020). Many people are unable to get checked, particularly in rural areas, due to the high cost of these scans and the concentration of such facilities in urban areas. Because of this, osteoporosis is frequently discovered until after fractures have occurred, greatly raising the disease burden (Islam et al., 2022).

3. Lack of Public Awareness and Health Education

The general public and medical professionals are still not well-informed on osteoporosis. Osteoporosis is often overlooked as a major health concern until complications occur (Begum & Alam, 2021). Furthermore, proactive preventive actions are hindered by the belief that osteoporosis is a typical aspect of aging. The continuance of this problem is attributed to a lack of health education initiatives and the exclusion of osteoporosis-related subjects from primary healthcare education (Chowdhury et al., 2020).

4. **Insufficient Policy and Government Initiatives**

Even though osteoporosis is becoming a more serious health concern, it is not given priority in Bangladesh's national healthcare programs (Alam & Rahman, 2020). Public health efforts mostly concentrate on communicable diseases, and there are no government-led programs to prevent osteoporosis. Inconsistent clinical practices and subpar patient care result from the lack of national guidelines for osteoporosis screening and management (Sarker et al., 2021).

5. **Lack of Specialized Healthcare Professionals**

Endocrinologists, rheumatologists, and orthopedic experts with the necessary training to properly diagnose and treat osteoporosis are in short supply (Hossain et al., 2019). General practitioners frequently lack the necessary knowledge to prevent and treat osteoporosis, which can result in incorrect diagnoses or postponed action. Furthermore, there are not enough physiotherapists and rehabilitation professionals who specialize in fractures caused by osteoporosis (Karim et al., 2021).

11.2. Future Prospects of Osteoporosis Research and Management in Bangladesh

1. **Large-Scale Epidemiological Studies**

Large-scale, national epidemiological studies should be carried out to evaluate the prevalence of osteoporosis in various demographic groups to close the current research gap. To get a whole picture of the illness burden, research should cover men, younger adults, and both urban and rural populations (Hossain et al., 2023). Genetics research may also shed light on Bangladeshis' inherited risk factors.

2. **Expansion of Screening and Diagnostic Services**

Osteoporosis screening should be incorporated into regular medical examinations in order to increase early detection rates, particularly for at-risk groups like elderly people and postmenopausal women (Islam & Saha, 2021). Accessibility can be improved in rural regions by setting up mobile screening units with reasonably priced BMD testing equipment. Additionally, screening might become cheaper with government programs or public-private partnerships that fund DXA scans (Begum et al., 2020).

3. **Public Awareness and Community-Based Education Programs**

To raise awareness of osteoporosis risk factors, prevention, and management, national awareness campaigns ought to be started (Chowdhury & Ahmed, 2022).. It is possible to include health education programs into community centers, companies, and schools. Early diagnosis and treatment at the primary healthcare level will also be improved by educating general practitioners and community healthcare workers on osteoporosis preventive techniques (Rahman & Alam, 2023).

4. **Research on Alternative Treatment Options**

Examining less expensive therapy options, including regionally accessible herbal or dietary supplements with bone-strengthening qualities, may offer more economical solutions than pricey prescription drugs. To assess the efficacy of conventional treatments and alternative therapies in the management of osteoporosis, clinical trials ought to be carried out.
In remote locations, osteoporosis awareness, screening, and management can be enhanced by utilizing digital health solutions, such as telemedicine and mobile health (mHealth) applications (Rahman & Chowdhury, 2024). By bringing rural patients and metropolitan specialists together, teleconsultation services can guarantee prompt diagnosis and care.

5. **Collaboration with International Organizations and Research Institutions**

Research project funding and knowledge sharing in Bangladesh can be facilitated by collaborating with academic institutions and international osteoporosis research groups. The

creation of national guidelines based on effective models used in other areas can also be facilitated by international cooperation (Hossain & Alam, 2024).

Chapter 13

Conclusion

Millions of people throughout the world suffer from osteoporosis, a complex disorder that significantly lowers quality of life and increases bone fragility and fracture risk. Low bone mass and bone tissue degradation are the hallmarks of this illness, which makes bones weaker and more likely to break. Osteoporosis has become a major problem as populations age and life expectancy rises, especially for older adults, postmenopausal women, and anyone with certain risk factors. Improving public health and lessening the toll that osteoporosis has on people and healthcare systems requires an understanding of the disease's origins, prevention, diagnosis, and available treatments.

Preventability is one of the most important features of osteoporosis. Habits like smoking and drinking alcohol, as well as lifestyle choices like nutrition and exercise, are the main causes of the illness. Since both calcium and vitamin D are essential for bone mineralization and strength, a healthy diet is the cornerstone of bone health. Maintaining musculoskeletal health and increasing bone density requires regular resistance and weight-bearing activities. However, because osteoporosis is a silent illness that doesn't show any signs until a fracture occurs, it frequently goes undiagnosed in its early stages despite these preventive measures. Because of this, screening for early diagnosis is crucial for efficient fracture care and prevention, especially in high-risk groups. There are still research gaps, nevertheless, in determining the best practices for early detection in a variety of groups and creating more approachable screening procedures that may be used in underprivileged regions around the world.

Treatment for osteoporosis often includes pharmacological therapies, especially for patients who have osteoporosis or are at high risk of fractures. Selective estrogen receptor modulators (SERMs), hormone replacement therapy, and bisphosphonates are a few examples of medications that can help reduce bone loss and, in certain situations, even increase bone density. These therapies are especially crucial for postmenopausal women, whose estrogen levels drop and cause them to lose bone quickly. However, because these drugs may cause gastrointestinal problems and raise the risk of some blood clots or fractures, their usage needs to be carefully addressed. Before starting therapy, a comprehensive assessment of the patient's general health and treatment risks is required. Even while existing drugs have shown promise

in lowering the incidence of fractures, additional study is required to determine their long-term safety as well as to provide more specialized treatments with fewer adverse effects.

Non-pharmacological approaches such as dietary adjustments, frequent exercise, and lifestyle changes are essential in managing osteoporosis in addition to medical treatment. By lowering the risk of falls, enhancing muscle strength and balance, and encouraging a healthier weight, these therapies not only improve bone health but also improve general well-being. For people with osteoporosis, preventing falls through home modifications and balance exercises is crucial since even little falls can cause severe fractures in those with weakening bones. Future studies should concentrate on integrating fall prevention interventions, especially for older persons. To lower fracture rates and enhance the quality of life, thorough research is required to assess the efficacy of multifactorial therapies that incorporate medicine, lifestyle modifications, and fall prevention techniques for those who are suffering from osteoporosis.

Although osteoporosis affects people everywhere, some nations have particular difficulties with access to healthcare, public awareness, and available resources. Osteoporosis is still a medical condition that is mainly ignored in developing nations like Bangladesh. Few people are aware of the illness, and many people lack access to the healthcare resources needed for an early diagnosis and course of treatment, particularly in rural areas. Osteoporosis is rarely brought up in public health discussions in Bangladesh, and there is not enough extensive epidemiological research to completely comprehend the disease's prevalence. The absence of national screening programs and educational campaigns means that osteoporosis may go undiagnosed until a fracture occurs, leading to increased healthcare costs and a loss of productivity due to the long recovery times associated with bone fractures.

The dangers of osteoporosis are increased in Bangladesh due to cultural norms surrounding physical exercise, inadequate diet, and restricted access to healthcare. Many people are more susceptible to osteoporosis due to a diet poor in calcium and vitamin D and a lack of knowledge about the significance of bone health. Women are more vulnerable, especially if they go through early menopause or have a family history of the condition. The prevalence of osteoporosis in Bangladesh is also influenced by socioeconomic variables, such as the lack of access to healthcare in rural areas. To address these issues, education and public health initiatives that promote healthy lifestyles, increase access to healthcare, and increase awareness of osteoporosis are required. Simple dietary adjustments, such eating more foods high in

calcium and taking vitamin D supplements, along with more exercise, could significantly lower the prevalence of osteoporosis in Bangladesh. Further study is necessary to identify the unique obstacles to osteoporosis prevention and treatment in low-resource environments, such as Bangladesh, and to create interventions that are suitable for the local context.

Although high-income countries have received most of the current attention about osteoporosis, low- and middle-income countries are increasingly realizing the need for global measures to address this health concern. To increase knowledge, access to diagnosis and treatment, and preventative care, cooperation between governments, international organizations, and local health authorities is crucial. This might entail creating educational campaigns about the value of bone health, especially for women and older adults, and incorporating osteoporosis screening into Bangladesh's current mother and child health programs. Future studies could look into creative ways to apply these tactics economically while taking into account the unique healthcare difficulties encountered in environments with low resources.

A further obstacle in the fight against osteoporosis is the aging of the population in many nations, including Bangladesh. The number of people with osteoporosis and the frequency of fractures are predicted to increase as the older population continues to expand. The growing demand for osteoporosis care, including diagnostic procedures, medicine, and rehabilitation, may be too much for healthcare systems in emerging nations to handle. Thus, governments in Bangladesh and other comparable nations must give osteoporosis top priority as a public health concern and fund initiatives that can lessen the disease's burden. Further study is required to determine how prepared these nations' healthcare systems are to manage the demands of osteoporosis and to develop methods for incorporating osteoporosis treatment into more general healthcare.

Osteoporosis incidence can be significantly decreased by public awareness efforts that highlight prevention and the value of bone health. Such initiatives in Bangladesh can concentrate on informing the populace about the dangers of smoking and binge drinking, the value of exercise, and the significance of calcium and vitamin D. Healthcare facilities, companies, and schools can all operate as venues for information sharing and providing tools to help people prevent osteoporosis. A wider outreach to increase awareness and foster a culture of bone health can be achieved through cooperation between healthcare professionals,

neighborhood associations, and the media. To identify the most successful tactics for involving communities and altering health behaviors, research on the efficacy of these programs is required, particularly in developing nations like Bangladesh.

To sum up, osteoporosis is a condition that may be prevented and managed, and its effects can be lessened with a coordinated effort at the individual, community, and national levels. A healthy diet, consistent exercise, and lifestyle modifications can help many people avoid osteoporosis or slow its progression. In addition to reducing the risk of fractures, early detection through screening and the use of suitable medical therapies can also improve results for individuals who are already afflicted. Nonetheless, the prevalence of osteoporosis throughout the world, especially in Bangladesh, emphasizes the necessity of more healthcare access, education, and awareness in order to prevent and treat this crippling condition. To fill in the information gaps, further research is necessary, especially in the areas of early detection, low-resource effective therapies, and osteoporosis management techniques for aging populations. Better bone health for present and future generations can be ensured by giving osteoporosis prevention and treatment top priority, especially in regions where the disease is most common but least understood.

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