Inquiry Question:

What are the modifiable risk factors of osteoporosis to prevent the debilitating consequences of this disease?

Evaluating the inquiry question:

1. Is the investigation worth doing?
2. Will the investigation deepen my understanding of a scientific phenomenon?
3. Can the investigation be completed within the given time frame?
4. Can I access the resources required to undertake the investigation and are the resources available?

Aim:

The purpose of this second-hand investigation is to **investigate** and **determine** the modifiable risk factors of osteoporosis and to critically **analyse** and **identify** the debilitating consequences of this disease and its possible prevention.

Hypothesis:

The modifiable risk factors investigated will include lifestyle changes such as diet and exercise whereas other risk factors investigated will include gender which is unable to be modified. Through identifying modifiable risk factors, individuals with osteoporosis will be able to reduce the identified debilitating consequences of osteoporosis, such as fracturing, and if there is early intervention, detection or alteration of modifiable risk factors determined, individuals can reduce their risk of diagnosis.

Methodology:

1. Determining topic and formulating the question

The development of a specific research topic and area is an essential first step in order to begin and ultimately complete a successful depth study. Due to the requirements of our depth study, our question has to be in relation to the content covered in Module Five ('Heredity'), Module Six ('Genetic Change'), Module Seven ('Infectious Disease') and Module Eight ('Non-Infectious Diseases'). It is advised to inquire about a topic of personal interest as research will be more engaging and provide a more comprehensive understanding.

After the establishment of a topic, it is then required to formulate a question in regards to a specific aspect of this topic. It is important to not include 'closed' statements in the question. The question must be able to have subtopic questions and/or areas to be researched. It ultimately must be able to be either proved or disproved and address the following questions:

1. Is the investigation worth doing?
2. Will the investigation deepen my understanding of a scientific phenomenon?
3. Can the investigation be completed within the given time frame?
4. Can I access the resources required to undertake the investigation and are the resources available?

2. Initial collection of sources and information

The initial collection of sources and information is a key step that establishes the framework of knowledge and then understanding surrounding the topic and question of the depth study. This can be done by generalised searches regarding the topic by using keywords, for me, these keywords included 'osteoporosis', 'bone loss' or 'bone mineral density', 'effects of' previous terms and other similar terms. This step is completed throughout the initial stages of the depth study and assists with the formation of an aim, hypothesis and often helps to refine the overall research question.

3. Review of the topic

In order to complete the rest of the depth study, it is important to review the chosen topic and question that has been developed. This provides the opportunity to modify both the topic and particularly the question in regards to the initial research conducted in step 2.

4. a) Further accumulation of a wider variety of sources and information

b) Analysing credibility

Conducting further in-depth research that is directly specific to the overall question will not only allow a deeper understanding but provide the information needed to construct a conclusion, discussion and possibly an evaluation.

In order to increase reliability and accuracy, it is extremely important to accumulate information from a wide variety of sources. These may include relevant books (printed and digitalised), academic articles, journal articles, peer-reviewed papers, government endorsed sites and/ or information found on scientific databases that are provided by the school (such as JSTOR and EBSCO).

It is essential to use and reference credible sources as that increases the reliability and accuracy of the final conclusion and results of the depth study. To assess sources, utilisation of the the following criteria is effective;

1. **Currency:** determining the date of publication and whether it has been updated since.
2. **Relevance:** assessing the relation of the information to your topic and addressing the inquiry question.
3. **Authority:** evaluating the individual/ organisation responsible for the information.

4. **Accuracy:** investigate reliability and truthfulness of the content, which can be achieved through comparison with other sources of information.
5. **Purpose:** identifying the intention of the information.

5. Critical analysis of collected information
Using all collected information from credible sources, tested using the above criteria, it is important to then critically analyse this data. This is essential in determining what information is necessary, assisting in both the development of a discussion and conclusion and categorising collected information in a cohesive and well-organised manner. It also determines any limits evident in the data and exposes information that is missing and will need to be researched.

6. Peer Feedback
Following the completion of steps 1-6, where a comprehensive depth study including a question, aim, hypothesis, background, results, conclusion and discussion should be developed, I will then gain feedback from both an adult such as my parents, a science teacher or older siblings and also a peer. This feedback will allow the depth study to be refined accordingly, ensuring all elements of the depth study to be both accurate and described in an appropriate manner.

7. a) Finalise information
b) Method of communication
The finalisation of information relates to the peer feedback received (above) as well as the process of refining collected data, as demonstrated in step 6. However, it also relates to necessary editing in terms of grammatical errors and comprehensive spelling checks. This enables the final depth study to be produced to an increased standard and reduces any possible margins of error. It is also important to ensure that all quotes or extracts from reputable sources are correctly in-text referenced and included in a formatted reference list in order to recognise all sources of information used.
The final stage of completing the depth study is the method of communication of information to the readers. Some communication methods can include a scientific poster, a report, a video or a website. I have decided to create a website as I believe that will be the most effective, suitable and engaging method to communicate the information I have gathered in relation to my topic and inquiry question.

Ongoing Steps:
Some steps that must be completed throughout the entirety of the depth study include:

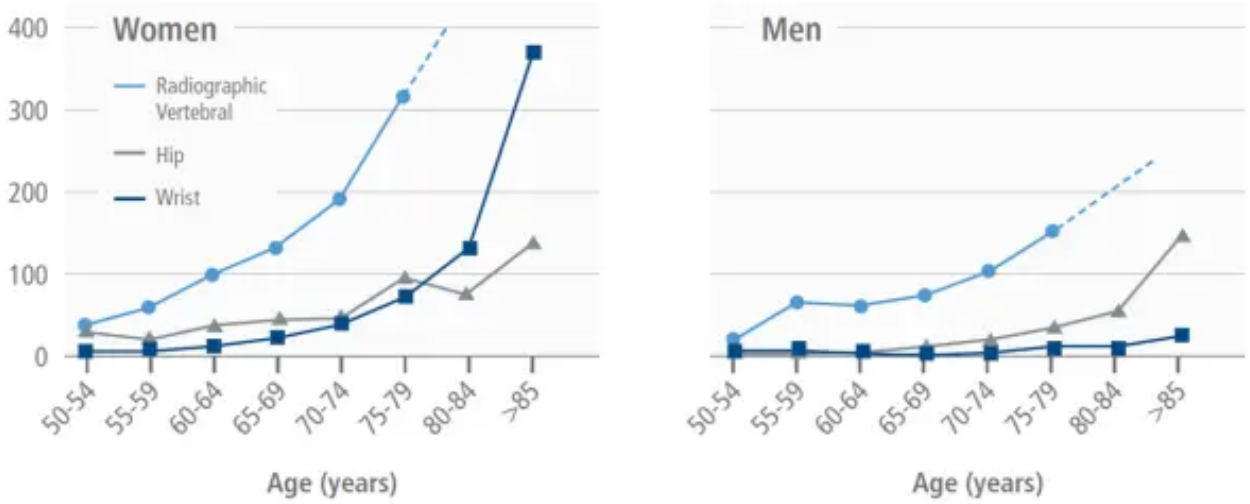
- Journal Entries: to account for progress and the development of depth study.
- Recording all sites visited: for future reference and accurate in-text referencing.

Background Research:

1. What is Osteoporosis?

The non-infectious disease, osteoporosis, is a condition of porous bones (Tortora and Grabowski, 1999) as it is characterised by increased porosity of the skeleton and alterations in bone strength (The American Journal of Nursing, 2006), resulting from the reduced bone mass. The associated structural changes and disruptions of the microarchitecture of the bone (Poole & Compston, 2006) result in a predisposition to increased risk of bone fractures, (Robbins & Cotran, 2005) particularly of the spine, hip, wrist, humerus and pelvis (Poole & Compston, 2006). The risk of fractures increases steeply with age (examined in the graph below) where most of those affected are elderly, over 65 years of age for females and 70 years of age for males (Johns Hopkins Medicine, 2013).

Figure 1: (below) Age-specific and sex-specific incidence of radiographic vertebral, hip and distal forearm fractures (International Osteoporosis Foundation, 2006)



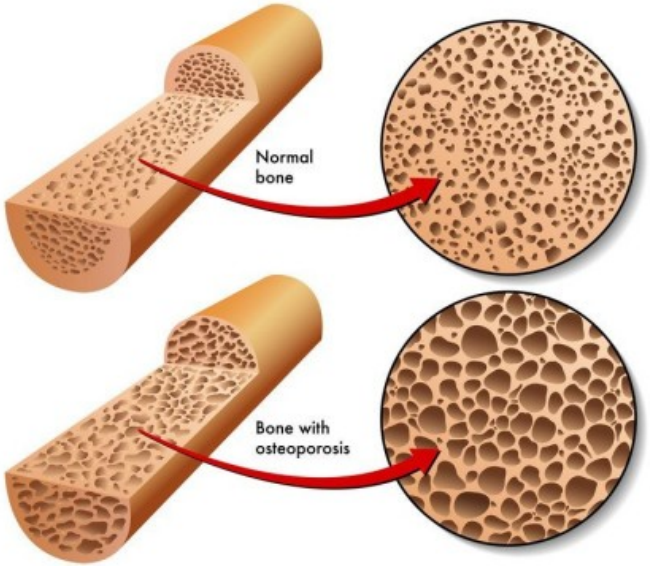


Figure 2: (above) Comparison of normal bones and bones with osteoporosis (Radiology Affiliates Imaging, 2017)

2. Treatment

The treatment goal for osteoporosis, much like the management goal, is to prevent fractures, which are extremely debilitating consequences of the condition. As a result of effective treatment, in some cases, bone mass can improve. For patients with osteoporosis, the goal is to build bone mass (The American Journal of Nursing, 2006).

Medicated treatment of osteoporosis aims to reduce the breakdown of the bone by inhibiting osteoclast function and promoting osteoblast function (Dr Lavings, 2022). The most common treatment of osteoporosis are bisphosphonates. Bisphosphonates are a group of drugs that work by slowing and reversing bone loss. They can be used to reduce the risk of hip and spine fractures in osteoporosis patients(Versus Arthritis, 2018). These include:

- Alendronate (Fosamax), a weekly pill
- Risedronate (Actonel), a weekly or monthly pill.
- Zoledronic acid (Reclast), an annual intravenous (IV) infusion (Mayo Clinic, 2020).

Another common medication that is first used to treat osteoporosis for individuals who have reduced kidney function is denosumab (Prolia) which is delivered by shallow injections under the skin every six months (Mayo Clinic, 2020). It can reduce the risk of spine fractures by 50% - 60% and hip fractures by 50% (Johns Hopkins Medicine, 2013). This is the most common medication used in Australia for osteoporosis treatment. It has been shown to increase bone mineral density and protect bones from spinal, non-spinal and hip fractures in postmenopausal women (Amigen, 2022).

The main side effects of bisphosphonate pills are stomach pain and heartburn, however, these are avoidable if individuals taking the tablets do not bend over or lie down for 30 to 60 minutes after taking them. Intravenous bisphosphonates have the potential to cause mild cold-like symptoms but only after the first infusion (Mayo Clinic, 2020). Another risk of this treatment is osteonecrosis of the jaw and atypical femoral fractures (Dr Lavings, 2022).

Oestrogen was once commonly used to treat osteoporosis however this treatment can increase the risk of blood clots, endometrial cancer, breast cancer and possibly heart disease. It is now only used for females at high risk of fracture who are unable to take any other treatment medication for osteoporosis. It is recommended that individuals using this treatment use a low dose of hormones for a short period of time. It blocks oestrogen's action in some tissues and stimulates it in others, reducing spine fractures by 30% (Johns Hopkins Medicine, 2013), however, there is no data indicating that it reduces the risk of hip and other non-spine fractures (Bone Heath & Osteoporosis Foundation, 2016).

3. Management

As there is no known cure for osteoporosis, management has to be undertaken if individuals are diagnosed with it, or individuals can take steps to prevent its onset (Osteoporosis and Related Bone Diseases National Resource Center, 2019).
In order to manage osteoporosis, dietary and lifestyle changes are huge factors (Dr Lavings, 2022). Making lifestyle changes such as consistently participating in weight-bearing exercise instead of endurance exercise or having a sedentary lifestyle, smoking cessation and reducing alcohol consumption, can significantly increase bone density, reducing the debilitating ramifications of osteoporosis. According to Healthy Bones Australia, which is an initiative of Osteoporosis Australia (OA), the three main elements contributing to developing healthy bones in an individual's lifetime are calcium, exercise and sunshine (vitamin D) (The American Journal of Nursing, 2006).

4. Symptoms: How does the disease present?

Osteoporosis is referred to as the 'silent disease' (Osteoporosis and Related Bone Diseases National Resource Center, 2019) as there are no obvious signs of its development (Morrison, 2019) until one or more vertebrae collapses or fractures. Symptoms of these fractures include severe back pain, loss of height, or spine malformations such as a stooped or hunched posture and/ or curvature of the spine (kyphosis) (Osteoporosis and Related Bone Diseases National Resource Center, 2019), (Poole & Compston, 2006). Osteoporosis cannot be reliably detected in plain radiographs until 30% to 40% of the bone mass is lost. Osteoporosis is thus a difficult condition to diagnose accurately since it remains asymptomatic until skeletal fragility is well advanced (Robbins & Cotran, 2005).

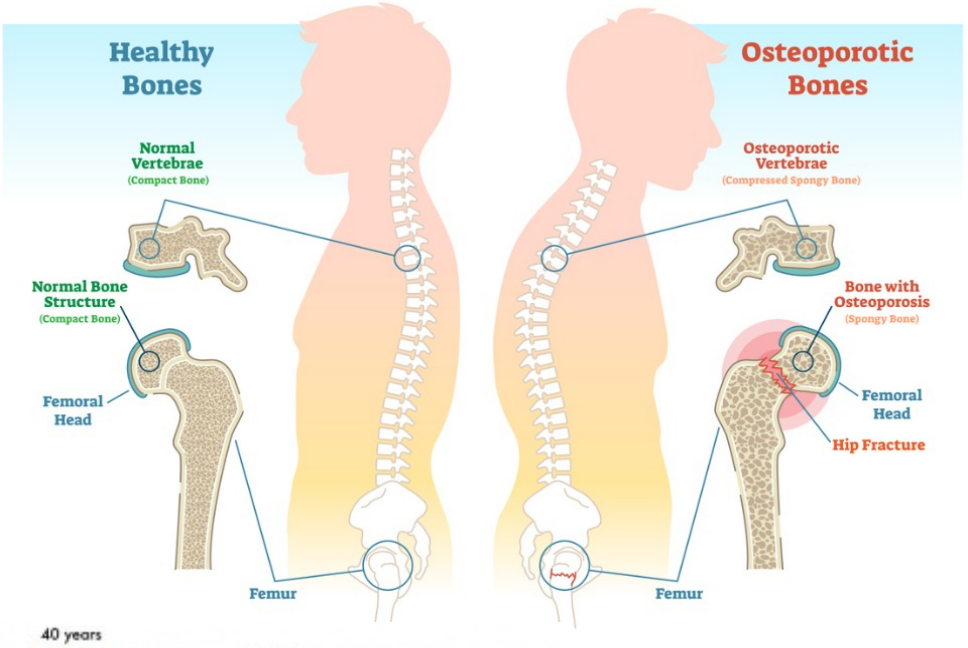
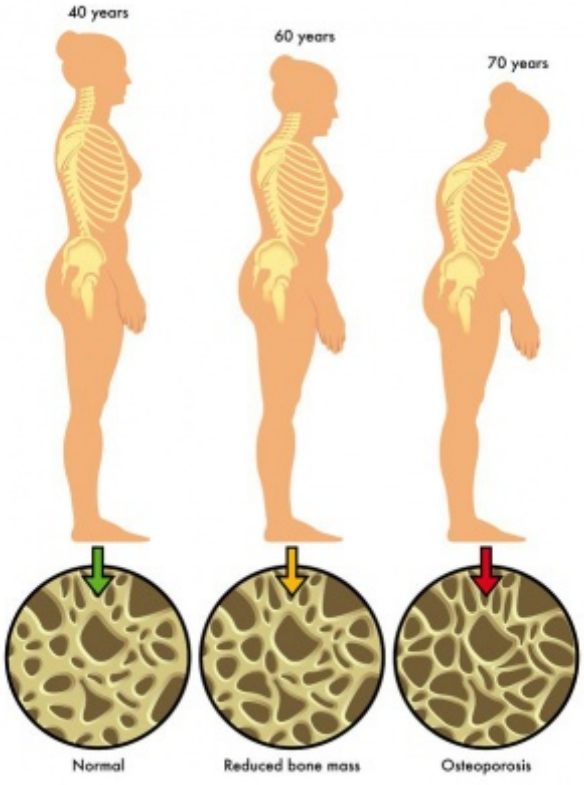


Figure 3 : (left) 'Osteoporosis means that that your bones are becoming thinner and weaker, increasing your risk of life threatening fractures.' (Camacho, 2020)



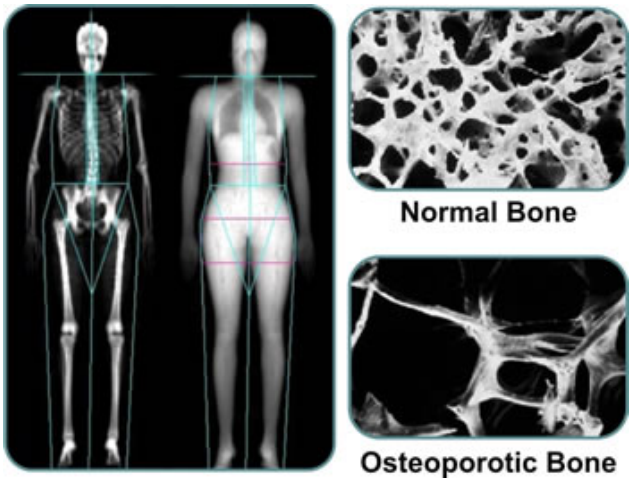


Figure 4: (left) 'Early in the disease there may be no symptoms." (Lieberman, 2019)
Figure 5: (above) 'Example of a DEXA Scan with a comparison of a normal bone scan and an osteoporotic bone.', (Fox Valley Imaging, 2013)

5. Diagnosis

Osteoporosis is diagnosed through a bone density scan, which assesses bone mineral density (BMD). It is most commonly performed using DEXA (Dual Energy X-Ray Absorptiometry), where the amount of x-rays absorbed by tissues and bone is measured which correlates with BMD (RSNA, 2021).

If an individual's GP suspects they are at risk of osteoporosis, they can order them a DEXA scan, however, if that individual has just suffered from a recent fracture, an X-ray will suffice (The Big Osteoporosis, 2017). DEXA scans are subsidised by a Medicare rebate, meaning individuals over 70 are eligible for their first scan. (Amgen, 2022).

6. Susceptibility to osteoporosis

According to the British Medical Journal, ‘Lower peak bone mass, increased bone loss at menopause, and greater longevity all confer a greater risk of osteoporosis in women than in men, and the disease is most commonly seen in postmenopausal women.’ (Poole & Compston, 2006). In addition to this, females’ bones and builds are generally smaller than males’ bones, therefore the loss of bone mass in old age typically has a greater adverse effect in women (Tortora and Grabowski, 1999). According to Healthy Bones Australia, 'Osteoporosis is common in Australia. Women and men can be affected, with up to 25% of cases in men. People 50 years and over are mostly at risk however osteoporosis can occur in younger people, depending on risk factors.' (Healthy Bones Australia, 2021).

7. Risk factors contributing to the development of Osteoporosis

i. Impact of calcium

When the depletion of calcium from the body, such as loss from urine, faeces and sweat is greater than what is absorbed from the diet, it can result in low levels of calcium, which is a major risk factor contributing to the development of osteoporosis (Tortora & Grabowski, 1999). Adults require 1,000 mg per day of calcium intake. This requirement increases to 1,300 mg per day for women over 50 and men over 70 years (Healthy Bones Australia, 2021).

By increasing calcium intake, individuals are less susceptible to the development of osteoporosis. Some good sources of calcium through altering diet include:

- Low-fat dairy products
- Dark green leafy vegetables
- Canned salmon or sardines with bones
- Soy products, such as tofu
- Calcium-fortified cereals and orange juice (Mayo Clinic, 2021).

ii. Impact of vitamin D

Vitamin D is essential to bone health, where low levels of vitamin D are associated with rickets, osteoporosis, and osteomalacia (Poole & Compston, 2006). Vitamin D insufficiency causes muscle weakness, contributing to muscle density loss and consequently, bone density loss as the mechanism of muscles are not being utilised to stimulate osteoblast function. (van der Mei, et al, 2007). In addition to this, vitamin D is necessary to absorb calcium, therefore a lack of sun exposure can lead to low vitamin D levels, making individuals susceptible to developing osteoporosis (Healthy Bones Australia, 2021). Increasing consumption of mushrooms, egg yolks, tofu, orange juice or taking a vitamin D supplement can increase vitamin D levels (Hill, 2019).

iii. Impact of exercise

Reduced physical activity increases the rate of bone loss because mechanical forces involved with exercise are important stimuli for normal bone remodelling. Muscle contraction is the dominant source of skeletal loading, therefore exercise such as weight training or weight-bearing exercise that promote balance and good posture are more effective stimuli for increasing and retaining (Tortora and Grabowski, 1999) bone mass than repetitive endurance activities (Robbins & Cotran, 2005). Therefore, individuals who regularly sit down or have an overall sedentary lifestyle have a higher risk of osteoporosis than those who are more active (Mayo Clinic, 2021).

iv. Family history

There is a hereditary link to poor bone health, meaning individuals whose family members, particularly parents or siblings, have osteoporosis or health conditions associated with poor bone health have an increased susceptibility to developing osteoporosis (Healthy Bones Australia, 2021).

v. Medical history; Conditions and medications which can impact bone health:

Some medical conditions may predispose individuals to osteoporosis, even if the condition is treatable or manageable. These include other endocrine and hormonal diseases, gastrointestinal diseases, rheumatoid arthritis, certain types of cancer, HIV/AIDS, and anorexia nervosa (Osteoporosis and Related Bone Diseases National Resource Center, 2019). According to Healthy Bones Australia, (Healthy Bones Australia, 2021), which is an initiative of Osteoporosis Australia (OA), other conditions such as the following also predispose individuals to osteoporosis;

- Breaking a bone from a minor bump or fall should be investigated in anyone 50 years +
- Low hormone levels: early menopause in women or low testosterone in men
- Coeliac disease, inflammatory bowel disease and other malabsorption disorders
- Diabetes
- Certain breast cancer treatment or prostate cancer
- Corticosteroids which are commonly used for asthma, rheumatoid arthritis or other inflammatory conditions
- Thyroid conditions: overactive thyroid or parathyroid
- Chronic liver or kidney disease
- Certain epilepsy or antidepressant treatment

<u>Osteopenia</u>

Osteopenia is the first stage of bone loss, which affects nearly 6.3 million Australians. It is a sign that an individual's bones are at risk of further bone loss and developing osteoporosis (The Big Osteoporosis, 2012).

vi. Lifestyle factors

Lifestyle factors refer to factors of a particular person as a result of their direct lifestyle choices, such as living conditions, behaviour and other habits that impact their quality of life or health. There are many modifiable lifestyle factors that contribute to the development of osteoporosis, including;

- Low levels of physical activity that involve muscle contraction (Healthy Bones Australia, 2021).
- Regular smoking. (Healthy Bones Australia, 2021). Studies indicate that smoking is a risk factor for osteoporosis and fracture. Researchers are still studying if the impact of smoking on bone health is from tobacco use alone or if people who smoke have more risk factors for osteoporosis. (Osteoporosis and Related Bone Diseases National Resource Center, 2019).
- Excessive and/ or chronic alcohol intake (Healthy Bones Australia, 2021).

- Body build, where an extremely thin body build can increase your risk (Healthy Bones Australia, 2021).
- Weight, particularly individuals with obesity. Studies suggest hormone changes associated with obesity can impact bones. (Healthy Bones Australia, 2021).

Females are at a greater risk of developing osteoporosis, as they tend to start losing bone density at an earlier age and at a faster rate than men, a contributing factor being menopause and hormonal changes associated as well as the different body builds to males (Alswat, 2017). Additionally, females are at an increased risk if they have:

- chronic kidney disease
- early menopause
- an eating disorder resulting in low body weight
- rheumatoid arthritis (Morrison, 2018).

vii. Steroids

Steroids, also called corticosteroids, are anti-inflammatory medicines used to treat a range of conditions (NHS, 2020). They are a man-made version of hormones normally produced by 2 small glands found above the kidneys (NHS, 2020). Steroids have major effects on how the body uses and stores calcium and vitamin D to build bones. As a consequence, steroids can lead to bone loss, osteoporosis and fracturing. This is heightened when steroids are used in high doses, as fracture risk increases as the daily doses of steroids increase.

<u>Glucocorticoid-induced osteoporosis (GIO)</u>

Glucocorticoids are a type of steroid, typically used to treat autoimmune and inflammatory diseases. They diminish bone mass by increasing bone resorption and reducing bone formation, (Robbins & Cotran, 2005), meaning these osteoclastic and osteoblastic cells are unable to function in equilibrium. Therefore, the prevalence of glucocorticoid-induced osteoporosis (GIO) is high globally, where, of the individuals who take glucocorticoids for an extended period of time, 30-40% of them may have a history of fragile fractures (Liu, et al, 2020).

viii. Medications

In addition to steroid use, certain medications individuals take can also be a contributing factor to the development of osteoporosis. These medications include;

- Antiepileptic medicines, which treat seizures and other neurological disorders.
- Cancer medications, which use hormones to treat breast and prostate cancer.
- Proton pump inhibitors, which lower stomach acid.
- Selective serotonin reuptake inhibitors, which treat depression and anxiety.
- Thiazolidinediones, which treat type 2 diabetes (Osteoporosis and Related Bone Diseases National Resource Center, 2019).

ix. Changes to hormones

1. Menopause (oestrogen)

The decrease in oestrogen level at menopause is the main cause of bone loss and osteoporosis. Hormones such as oestrogen suppresses the osteoclast formation activity, therefore slowing resorption by inducing osteoclast apoptosis (apoptosis is the process of programmed cell death) (National Human Genome Research Institute, 2022). Low estrogen levels in women generally occur after menopause or in premenopausal women, which occurs from the abnormal absence of menstrual periods due to hormone disorders or extreme levels of physical activity (Osteoporosis and Related

Bone Diseases National Resource Center, 2019). Hormones such as parathyroid hormone and vitamin D govern remodelling and also influence blood calcium levels (Tortora and Grabowski, 1999).

According to Robbins & Cotran's Pathologic Basis of Disease, 7th Edition, women may lose as much as 35% of their cortical bone and 50% of their trabecular bone within the 30-40 years after menopause. Postmenopausal osteoporosis is characterised by a hormone-dependent acceleration of bone loss that occurs during the decades after menopause. Decreased levels of oestrogen result in increased secretion of certain proteins which are stimulators of osteoclasts. In attempts to counteract the increased activity of osteoclasts, compensatory osteoblastic activity occurs but it cannot keep pace, leading to what is termed a 'high turnover form' of osteoporosis (Robbins & Cotran, 2005).

2. Low levels of testosterone in men.

Men with conditions that cause low testosterone levels, (these can include metabolic disorders such as hemochromatosis, dysfunctions or tumours of the pituitary gland, infection of the testes/ orchitis and chemotherapy treatment (Cleveland Clinic, 2018) are at a heightened risk for developing osteoporosis (Osteoporosis and Related Bone Diseases National Resource Center, 2019).

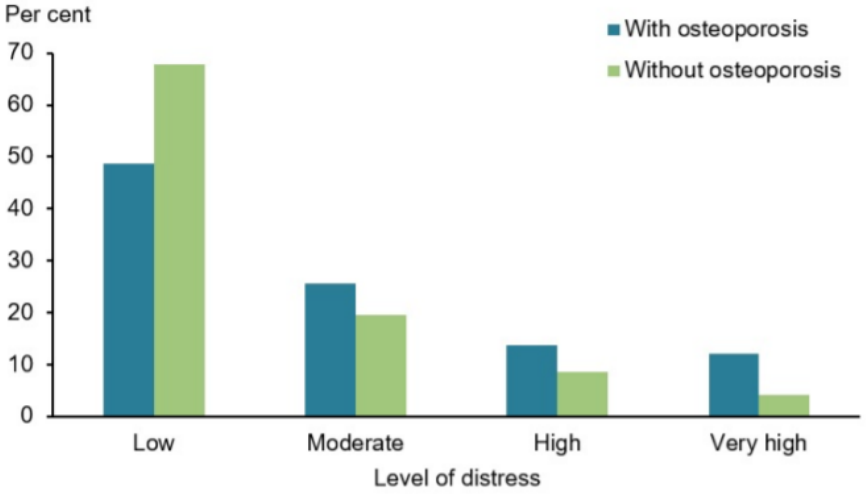
8. Ramifications/ Consequences

Bone mass becomes so depleted that bones fracture, often spontaneously. A fracture is any break in a bone. Common fractures include;

- Open fracture: broken ends of the bone protrude through the skin
- Comminuted fracture: bone splinters at the site of impact and smaller fragments lie between
- Greenstick fracture: partial fracture where one side of the bone is broken and the other side bends
- Impacted fracture: the end of the fractured bone is forcefully driven into the interior of the other
- Colles fracture: a fracture of the distal end of the lateral forearm bone
- Stress fracture: a series of microscopic fissures in the bone that forms without any evidence of injury to other tissues. Stress fractures can result from diseases that disrupt normal bone mineralisation such as osteoporosis (Tortora and Grabowski, 1999).

Vertebral fractures that frequently occur in the thoracic and lumbar regions are painful. Multilevel fractures can cause significant loss of height and various deformities such as lumbar lordosis and kyphoscoliosis (Robbins & Cotran, 2005).

Figure 6: (below) Psychological distress experienced by people aged 45 and over with and without osteoporosis, 2017-18 (Australian Institute of Health and Welfare, 2020).



In addition to increased susceptibility to fractures, osteoporosis causes shrinkage of vertebrae, height loss, hunches backs and bone pain (Tortora and Grabowski, 1999). Osteoporosis can also lead

to various other health ramifications including limited mobility, development of depression and/ or anxiety, pain, increased hospital admissions or potential for nursing home care. The condition can be debilitating, meaning it can limit an individual's physical activity, consequently resulting in weight gain. This increases stress on an individual's bones, such as knees and hips, and increases the risk of developing heart disease or type 2 diabetes. Lack of physical activity and loss of independence can increase the risk of developing depression or increase anxiety surrounding activities (Morrison, 2019).

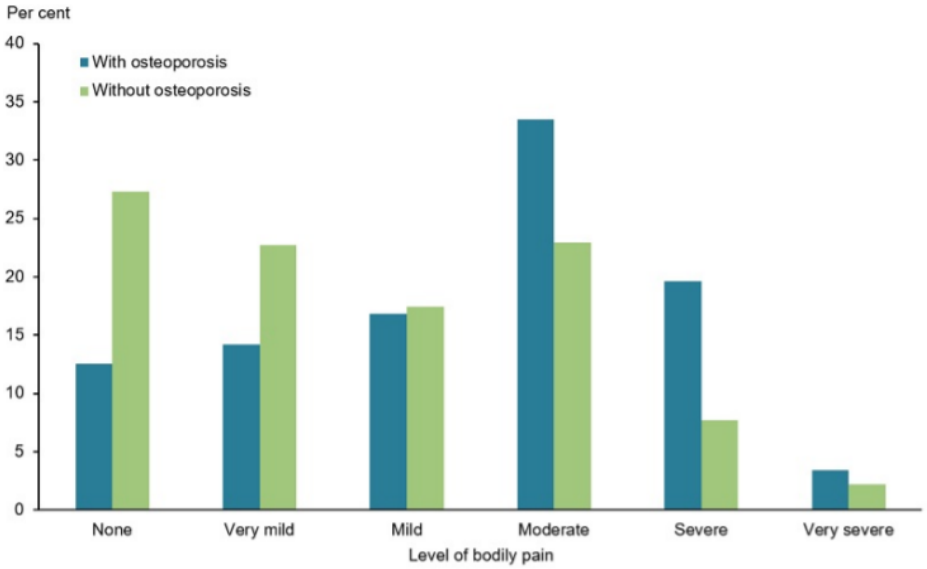


Figure 7: (right) Pain experienced by people aged 45 and over with and without osteoporosis, 2017–18. (Australian Institute of Health and Welfare, 2020).

Actions to help avoid broken bones: Undiagnosed osteoporosis means an individual is at a much greater risk of fracture meaning early investigation of any risk factors will help to diagnose osteoporosis (Healthy Bones, 2021). Bones fracture as a result of osteoporosis or undiagnosed osteoporosis is considered a serious medical emergency, typically requiring a hospital visit, possibly surgery, hospital stay, rehabilitation and home care.
Consequently, it is recommended that adults 50 years or older who have broken a bone from a minor bump or fall should take the necessary steps (such as seeing their GP or getting a DEXA Scan) to check for osteoporosis. Although broken bones can still occur in patients with diagnosed osteoporosis or osteopenia, ongoing treatment through medication and lifestyle changes as well as developing management plans with the individual's GP will significantly decrease this debilitating risk (Healthy Bones, 2021).

9. Role of Bones in the body

Bones play an essential role of locomotion, support and protection of soft tissues, calcium and phosphate storage, and storage of bone marrow. It is continuously reabsorbed by osteoclasts and reformed by osteoblasts (Florencio-Silva, et al, 2015). The matrix of the bone contains inorganic mineral salts that, as they are deposited in the framework formed by the collagen fibres (which determine a bone's flexibility) of the matrix, crystallise and the tissue hardens. This process of calcification or mineralisation is initiated by osteoblasts. This process only occurs in the presence of collagen fibres, as mineral salts begin to crystallise in the microscopic spaces between collagen fibres. The combination of crystallised salts and collagen fibre is responsible for the hardness that is characteristic of bone, (Tortora & Grabowski, 1999) therefore its structure is directly essential to bone fulfilling its function.

10. Bone Mineral Density (BMD)

Bone mineral density (BMD) or bone mass, is a measurement of the amount of inorganic mineral content in bone tissue. (Kranioti, et al, 2018).

Factors affecting Bone Mass

Factors affecting bone mass include nutrition (such as calcium and vitamin D intake), hormonal status and physical activity all influence peak bone mass (Poole & Compston, 2006). There are two principal effects of ageing on bone tissue: loss of bone mass and brittleness.

- The first effect results from the loss of calcium and other minerals from bone matrix (demineralisation). This loss usually begins after age 30 in females, accelerates greatly around age 45 as levels of estrogens decrease and continues until as much as 30% if the calcium in bones is lost by age 70. Once bone loss begins in females, about 8% of bone mass is lost every ten years. This loss of calcium from bones is one of the problems in osteoporosis.
- The second principal effect of ageing, brittleness, results from a lowered rate of protein synthesis, which diminishes the organic portion of bone matrix, mainly collagen fibres, that gives bone its tensile strength. The loss of tensile strength causes the bones to become very brittle and susceptible to fracture (Tortora & Grabowski, 1999).

11. Osteoclasts and Osteoblasts

Bone remodelling

Bone is in a constant and continuous state or process of remodelling, which is important for the maintenance of normal skeletal structure and function, therefore, when an imbalance in the process of bone resorption and formation (which is called osteogenesis or ossification) (Tortora & Grabowski, 1999) arises, it can result in disease such as osteoporosis (Chen, et al, 2018). Excessive resorption by osteoclasts without the corresponding amount of reformed bone by osteoblasts contributes to bone loss and osteoporosis. This balance (or equilibrium) of bone formation and resorption is necessary and depends on the action of several local and systemic factors including hormones, cytokines, chemokines and biochemical stimulation (Florencio-Silva, et al, 2015).

Bone remodelling is a highly complex process by which old bone is replaced by new bone, in a cycle comprised of three phases;

1. Initiation of bone resorption by osteoclasts
2. The transition (or reversal period) from resorption to new bone formation
3. The bone formation by osteoblasts (Florencio-Silva, et al, 2015).

Many types of cells and factors are involved in the process of bone remodelling (Chen, et al, 2018).

Osteoblasts and osteoclasts cells communicate with each other through cell-cell contact which occurs in a basic multicellular unit (BMU) at the initiation, transition and termination phases of bone remodelling (Osteoporosis and Related Bone Diseases National Resource Center, 2019). Including osteoblasts and osteoclasts, bones contain four types of cell tissue;

1. **Osteogenic cells** are stem cells derived from mesenchyme (which is the tissue from which all connective tissues are formed). They are the only bone cells to undergo cell division where the resulting daughter cells develop into osteoblasts.
2. **Osteoblasts** are bone-building cells that synthesise and secrete collagen fibres and other organic components needed to build the matrix of bone tissue (Tortora & Grabowski, 1999). Osteoblasts are responsible for the synthesis and mineralisation of bone during initial bone formation and bone remodelling (Nesterova, et al, 2020). They are critically important for

bone formation and remodelling (Bourdieu & Hirschi, 2019), originating from osteoblast progenitor cells and aid in the formation of the bone matrix by secreting osteoid (Bano & Mahmood, 2020). Osteoid is a protein mixture secreted by osteoblasts that forms the organic matrix of the bone (Weerakkody, 2010).

3. **Osteocytes** are mature bone cells that are the principal cells of bone tissue. They are derived from osteoblasts and maintain daily cellular activities of bone tissue, such as the exchange of nutrients and wastes with the blood (Tortora & Grabowski, 1999).
4. **Osteoclasts** are derived from the fusion of as many as 50 monocytes (a type of white blood cell). The cell releases powerful lysosomal enzymes and acids that digest the protein and mineral components of the underlying bone. This destruction of the bone matrix is part of the normal development, growth, maintenance and repair of bone (Tortora & Grabowski, 1999)

To achieve **homeostasis** in bone, the bone-resorbing actions of osteoclasts must balance the bone-making actions of osteoblasts, where, for instance, a loss of too much calcium or inadequate formation of new tissue weakens bone tissue (Tortora & Grabowski, 1999).

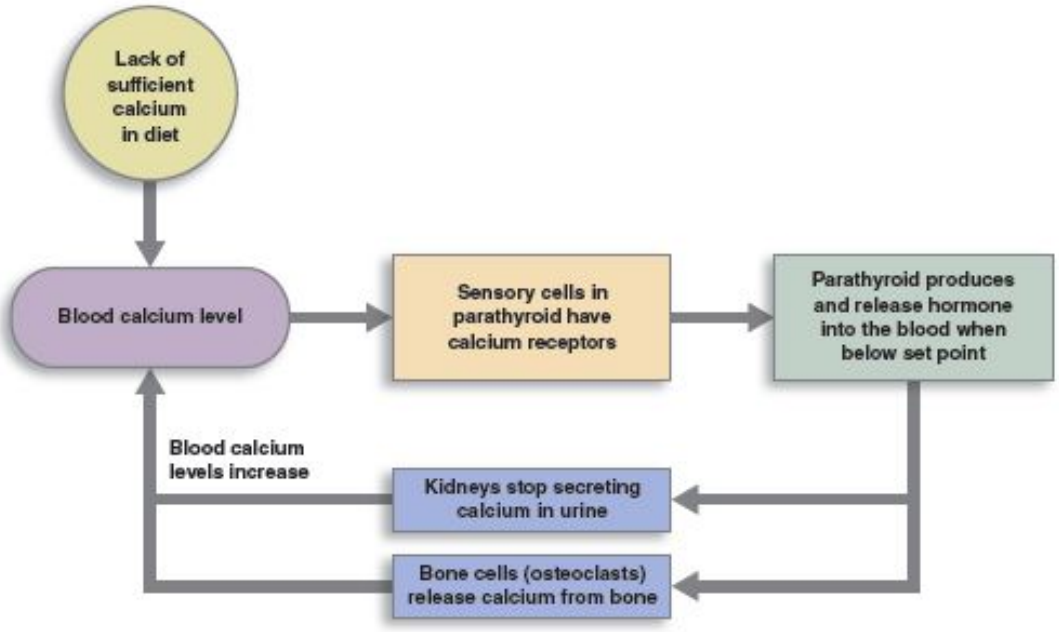


Figure 8: (left) Homeostasis maintenance (LibreTexts, 2020)

12. Statistics

Hip fractures result in loss of independence for at least a third of people with osteoporosis, and vertebral fractures cause height loss, chronic pain, and difficulty with normal daily activities (Poole & Compston, 2006).

According to Poole & Compston, writing for the British Medical Journal, 'Fractures caused by osteoporosis affect one in two women and one in five men over the age of 50.'

According to Healthy Bones Australia, 2021:

- over 173,000 broken bones occur each year from poor bone health

- Hip fracture remains the most serious and costly type of fracture. Studies have shown up to half of all hip fracture patients had a prior fracture and many of these were related to undiagnosed osteoporosis.
- 30% of all fractures related to poor bone health are in men

In 2010, there were an estimated 158 million individuals at high fracture risk, by 2040 it was estimated that this figure will double because of demographic shifts (International Osteoporosis Foundation, 2019).

According to the Australian Governments Institute of Health and Welfare,

- The hip was the most common site for minimal trauma fractures (32% of fractures)
- An estimated 924,000 Australians have osteoporosis, representing 3.8% of the population
- Osteoporosis is most common in older women, affecting over 1 in 4 women aged over 75
- In 2017–18 there were 93,321 hospitalisations for minimal trauma fractures in people aged 50 and over

Two in three Australians aged over 50 years are affected by osteoporosis or have ‘thin bones’ that can lead to osteoporosis (The Big Osteoporosis, 2012).

Results and Discussion:

After completing extensive background research regarding osteoporosis, its modifiable risk factors, treatment and debilitating consequences, it can be determined that the modifiable risk factors of this disease include sufficient calcium and vitamin D intake, consistent weight-bearing exercises, certain medications taken such as steroids, lifestyle factors such as regular smoking and alcohol intake and excess weight (obesity). Therefore, the risk factors that cannot be modified include gender, where females (particuarly post-menopausal women) are at a heightened risk, body build and various pre-exisiting medical conditions. As a result of osteoporosis, bone mineral density (BMD) becomes so depleted that the individual's risk of fracture is substantially increased, which, if fracturing does occur, subsequent physical and psychological ramifications has an increased potential of occurence. These findings are supported by both the extensive background research conducted and is also discussed in the source analysis of a journal article below.

The journal article titled Clinician's Guide to Prevention and Treatment of Osteoporosis was, as stated in the abstract, 'developed by an expert committee of the National Osteoporosis Foundation (NOF) in collaboration with a multispecialty council of medical experts'. It was recently published online in the National Library of Medicine, which is operated by the US government, in 2014. The 'council of medical experts', as stated in the abstract, include Felicia Cosman, Suzanne Marie Jan de Beur, Meryl Leboff and Michael Leniecki (as the main contributors). Their respective qualifications are as follows;

- Cosman is a Professor of Clinical Medicine at the Columbia University College of Physicians and Surgeons.
- de Beur is an associate professor of Medicine at the John Hopkins School of Medicine.
- Dr Leboff is the Director of the Skeletal Health and Osteoporosis Centre and Bone Density Unit, located in Boston.
- Dr Leniecki is the Director of New Mexico Clinical Research and Osteoporosis Center as well as a Clinical Assistant Professor of Medicine at the University of New Mexico Health Sciences Center.

The main purpose of this credible journal article is to 'offer concise recommendations regarding prevention, risk assessment, diagnosis, and treatment of osteoporosis'. The journal article comprehensively covers the following areas;

Osteoporosis and Fractures:

The article states that 'osteoporosis affects both sexes and all races, and its prevalence will increase as the population ages', however, it is 'preventable and treatable'. It characterises osteoporosis by low bone mass, deterioration of bone tissue and disruption of bone architecture, compromised bone strength and an increased risk of fracture, where the risk of fracture is highest in those with the lowest BMD. The most common fractures, according to the journal article, are of the vertebrae, proximal femur and distal forearm. All fractures have the potential to cause psychological symptoms and distress, 'most notably depression and loss of self-esteem.'.

Prevention recommendations:

The article includes universal recommendations that aim to prevent the loss of bone mineral density (BMD) and consequently the development of osteoporosis. These recommendations include;

- A diet that includes adequate amounts of total calcium intake: 1000mg/day for males aged 50 to 70 and 1200mg/day for females over 50 and males over 70, where 'lifelong adequate calcium intake is necessary for the acquisition of peak bone mass and subsequent maintenance of bone health.'.

- Adequate amount of vitamin D intake: around 800 to 1000 IU/day. This is because vitamin D 'plays a major role in calcium absorption, bone health, muscle performance, balance and risk of falling.'.
- Regular weight-bearing and muscle-strengthening exercise, which can 'improve agility, strength, posture and balance.'.
- The cessation of tobacco smoking and avoidance of excessive alcohol intake.

These modifiable lifestyle risk factors are supported by many reputable sources, such as Healthy Bones Australia, who state that calcium is the major building block for bones as bones store calcium, and when individuals do not get enough calcium in their diet, the body will use the calcium stored in their bones to fulfil other functions, resulting in porous bones if this calcium is not replaced. In addition to this, Healthy Bones Australia also emphasise the importance of weight-bearing exercise, resistance training, high impact exercise or balance training. They also state the importance of vitamin D, stating, 'Vitamin D is essential to bone health. It increases the amount of calcium that's absorbed from the gut, adjusts the amount of calcium that's in the blood and strengthens the skeleton.' (Healthy Bones Australia, 2021).

Diagnosis:
The article states that DEXA scans of the hip and spine are used to establish a diagnosis of osteoporosis, predict future fracture risk and monitor the disease in patients. The Radiological Society of North America support this, and also state that the individual's information is collected and then converted into a T and Z score;

- T score measures the amount of bone the individual has in comparison to a normal population of younger individuals
- Z score measures the amount of bone you have in comparison to those in your age group

(RSNA, 2021). According to the journal article, peak bone mass is achieved in early adulthood, which then faces a steady decline in BMD. The rate of bone loss accelerates substantially in women during menopause, progressing at a slightly slower pace in postmenopausal women and in older men. BMD testing is 'a vital component in the diagnosis and management of osteoporosis' as it has been shown to 'correlate with bone strength and is a predictor of future fracture risk'.

Pharmacological recommendations:
If individuals are diagnosed with osteoporosis, the article examines current pharmacologic treatment recommendations. It states that 'current pharmacologic options for osteoporosis are bisphosphonates, calcitonin, and estrogen agonist/antagonist such as raloxifene, which according to the Mayo Clinic, mimics estrogen's beneficial effects on bone density in postmenopausal women, without some of the risks associated with estrogen. (Mayo Clinic, 2020). However, the journal article emphasises that no pharmacologic therapy should be considered indefinite in duration and that there is no uniform recommendation that applies to all patients, meaning decisions regarding management treatments must be individualised. The journal article stresses that managing osteoporosis involves preventing consequences such as fractures. This is supported by the Osteoporosis and Related Bone Diseases National Resource Center, which outlined that the goal for managing osteoporosis is to slow the progression of the disease, including the depletion of bone density and bone loss, and prevent consequences or ramifications such as fractures (Osteoporosis and Related Bone Diseases National Resource Center, 2019).

Bone Homeostasis:
According to the journal article, 'the process of bone remodelling, which maintains a healthy skeleton, may be considered a preventative maintenance as it continually removes older bone and replaces it

with new bone.'. Bone loss occurs when this continual cycle is disrupted in some way. This is supported by Tortora and Grabowski's 'Principles of Anatomy and Physiology', which states that bone remodelling serves two purposes; It renews bone tissue before deterioration sets in and it redistributes bone matrix along lines of mechanical stress, as well as healing injured bones (Tortora & Grabowski, 1999). Figure 1 shows an architecturally weakened bone structure with significantly reduced mass as individual trabecular plates of bone are lost. Additionally, according to the 2015 journal article title Biology of Bone Tissue: Structure, Function, and Factors That Influence Bone Cells, published online by the National Library of Medicine, several studies have shown that oestrogen maintains bone homeostasis by inhibiting osteoblast and osteocyte apoptosis and preventing excessive bone resorption (Florencio-Silva, et al, 2015).

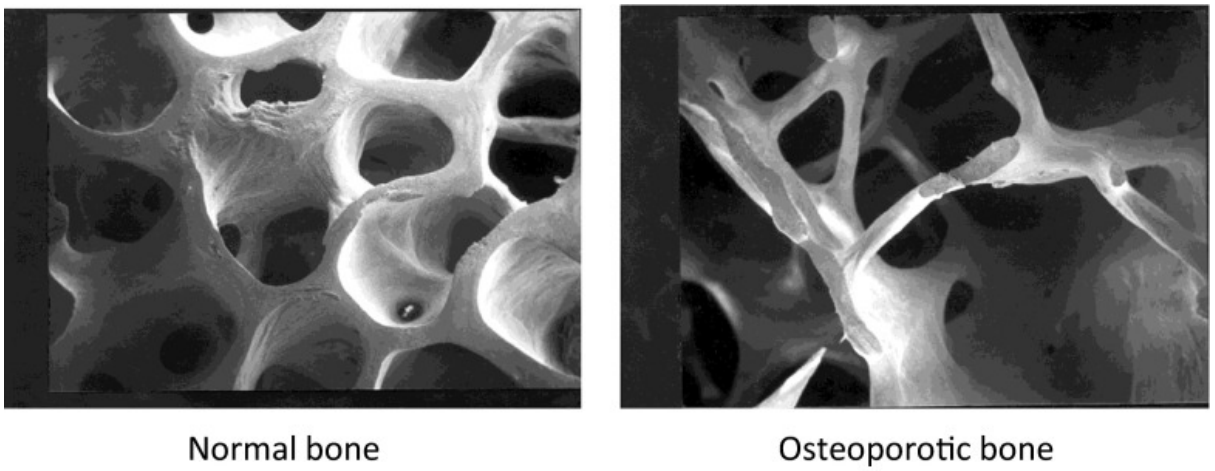


Figure 9: (above)Micrographs of normal and osteoporotic bones to show the changes within the cancellous bone as a consequence of bone loss.

Steroids:

The article analyses that the use of steroids, such as glucocorticoids can decrease bone formation and cause bone loss, therefore reducing bone quality. This is supported by the Helen Hayes Rehabilitation Hospital, which states that almost one in three postmenopausal women who routinely take steroids will have a spine fracture and a person on steroids is more than twice as likely to have a spine fracture compared to a person not taking steroids (Helen Hayes Hospital, 2021) and is also supported by the 2020 journal article titled Efficacy and safety of 18 anti-osteoporotic drugs in the treatment of patients with osteoporosis caused by glucocorticoid, which states that the duration and dose of glucocorticoids can have a serious impact on the risk of fracture (Liu, et al, 2020).

Risk Factors:

According to the journal article, 'the more risk factors that are present, the greater risk there is of fracture.'. Many factors have been associated with an increased risk of osteoporosis-related fracture, examined in Table 1 and the risk for falling is examined in Table 2, as many osteoporosis-related fractures are a result of falls.

Table 1: *Conditions, diseases and medications that cause or contribute to osteoporosis and fractures.*

Lifestyle factors	Alcohol abuse Frequent falling Inadequate physical activity Vitamin D insufficiency Excessive thinness High salt intake Low calcium intake Excess vitamin A Immobilisation Smoking (active or passive)
Genetic diseases	Cystic fibrosis Glycogen storage diseases Hypophosphatasia Osteogenesis imperfecta Riley-Day syndrome Ehler-Danlos Hemochromatosis Marfan syndrome Parental history of hip fracture Gaucher's disease Homocystinuria Menkes steely hair syndrome Porphyria
Hypogondal states	Androgen insensitivity Hyperprolactinemia Anorexia nervosa Panhypopituitarism Athletic amenorrhea Premature menopause Turner's and Klinefelter's syndrome
Endocrine disorders	Central obesity Hyperparathyroidism Cushing's syndrome Thyrotoxicosis Diabetes mellitus (types 1 and 2)
Gastrointestinal disorders	Celiac disease Inflammatory bowel disease Primary biliary cirrhosis Gastric bypass Malabsorption Gastrointestinal surgery Pancreatic disease
Hematologic disorders	Haemophilia Multiple myeloma Thalassemia Leukaemia and lymphomas Sickle cell disease Monoclonal gammopathies Systemic mastocytosis

Rheumatologic and autoimmune diseases	Ankylosing spondylitis Rheumatoid arthritis Systemic lupus Other rheumatic and autoimmune diseases
Neurological and musculoskeletal risk factors	Epilepsy Parkinson's disease Multiple sclerosis Spinal cord injury Muscular dystrophy Stroke

Table 2: *Risk factors for falls*

Environmental risk factors	Lack of assistive devices in bathrooms Obstacles in the walking path Loose throw rugs Slippery conditions Low level lighting
Medical risk factors	Medications causing sedation (narcotic analgesics, anticonvulsants, psychotropics) Anxiety and agitation Orthostatic hypotension Arrhythmias Poor vision Dehydration Previous falls or fear of falling Depression Reduced problem solving or mental acuity and diminished cognitive skills Vitamin D insufficiency Urgent urinary incontinence Malnutrition
Neurological and musculoskeletal risk factors	Kyphosis Reduced proprioception Poor balance Weak muscles/sarcopenia Impaired transfer and mobility Deconditioning

This journal article was written recently in 2014 by a panel of authors who have both credibility and authority in this topic due to their field of study and occupation. Additionally, it was developed by the National Osteoporosis Foundation and published in the National Library of Medicine, both respected and credible organisations. The purpose of this journal article is to inform individuals (eg; clinicians) about the treatment and prevention of osteoporosis, which therefore has direct relevance to my depth study topic. In addition to this, the information presented was highly accurate and has been validated by various credible sources, as seen throughout the analysis.

Conclusion:

The purpose of this second-hand investigation was to investigate and determine the modifiable risk factors of osteoporosis and to critically analyse and identify its debilitating consequences as a result of the development of this disease in addition to its possible prevention (which relates to the modifiable risk factors).

Osteoporosis can be defined as a condition of porous bones (Tortora and Grabowski, 1999), in which increased porosity results in alterations in bone strength (The American Journal of Nursing, 2006) and reduced bone mass (bone mineral density, BMD). As a result of this, there is a substantially increased risk of bone fractures (Robbins and Cotran, 2005) which are the main debilitating consequence of this disease. If fracturing does occur, subsequent physical and psychological ramifications has an increased potential of occurence. These include shrinkage of the vertebrae, height loss, hunches, limited mobility and subsequent loss of independence, development of anxiety and/ or depression and weight gain (which can lead to increased risk of developing heart disease or type II diabetes). Osteoporosis affects everyone, with its prevalence increasing as the population ages (Cosman et al, 2014).

There are many risk factors that individuals can modify in their lifestyle in order to prevent the development of this disease. These include;

- If individuals are not meeting the recommended daily intake of calcium, they are at an increased risk of osteoporosis. According to Healthy Bones Australia, the recommended daily intake is 1000mg/day for adults, and 1300mg/day for females over 50 and males over 70.
- Vitamin D insufficiency causes muscle weakness and therefore BMD loss as the mechanism of muscles are not being utilised to stimulate osteoblast function. Vitamin D is also essential to absorb calcium.
- Lack of weight-bearing or weight-training exercise results in little muscle mechanism stimulation. Therefore, by regularly participating in this type of exercise, individuals reduce their rate of bone loss.
- Additionally, excessive smoking, weight and alcohol consumption also increase an individual's rate of bone loss and therefore susceptibility to osteoporosis.

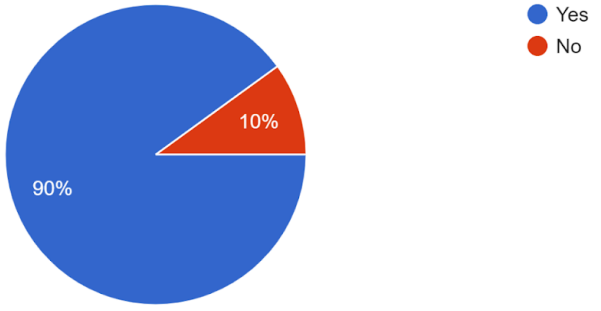
However, there are many factors individuals are unable to modify in order to further reduce their risk of osteoporosis, consequently increasing their susceptibility. These include a family medical history of poor bone health, certain diseases (even if they are manageable or treatable), the use of certain medication such as steroids, females and natural changes to hormone levels that occur with age (eg; menopause) or due to certain endocrine conditions.

My hypothesis stated that the modifiable risk factors investigated will include lifestyle modifications such as diet and exercise whereas other risk factors investigated will include gender, which are unable to be modified.'. It also stated that by 'identifying modifiable risk factors, individuals with osteoporosis will be able to reduce the identified debilitating consequences of osteoporosis, such as fracturing, and if there is early intervention, detection or alteration of modifiable risk factors determined, individuals can reduce their risk of diagnosis.'. Therefore, my hypothesis was supported by the research undertaken and the data collected to some extent, however, my hypothesis did not account for other risk factors such as vitamin D levels, weight, smoking, alcohol intake, family medical history, certain diseases and medications and hormone levels, and the psychological and physical impacts the the debilitating consequence of fractures has, that were identified and determined throughout the process of my investigation.

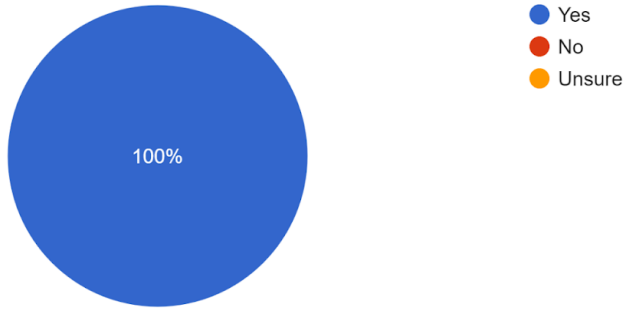
Peer Feedback:

In order to obtain insightful, critical, helpful and valuable peer feedback regarding my depth study, I created a survey with yes/ no style questions to obtain general feedback from individuals who have read through my depth study. The following are the results;

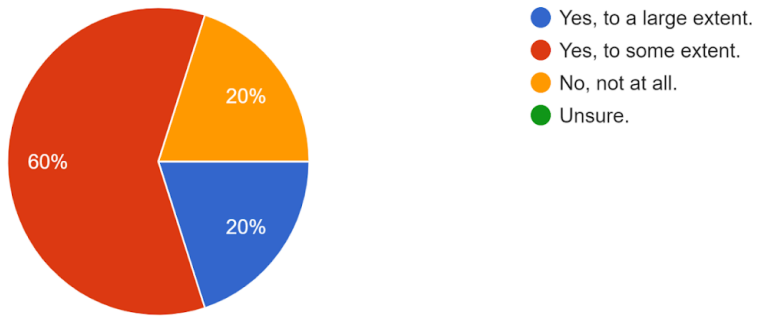
Did you understand the purpose of this investigation?
10 responses



Was the method of delivery (presented as a website) effective in engaging you?
10 responses

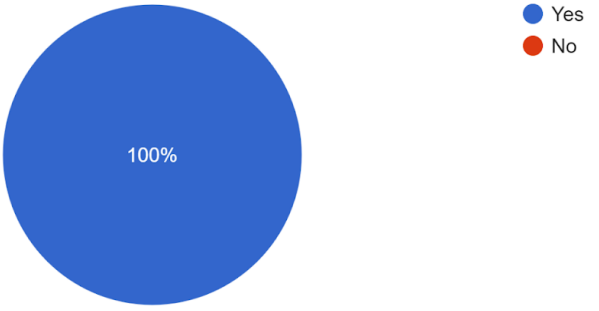


Had you heard of or were aware of the modifiable risk factors of osteoporosis prior to reading this study?
10 responses



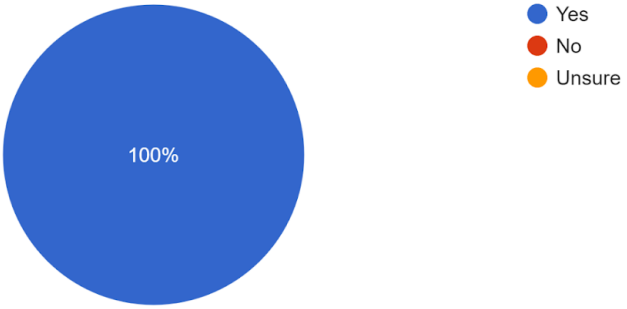
Is this investigation successful in assisting your own personal knowledge of Osteoporosis?

10 responses



Was the information presented written in a way that was comprehensible and understandable?

10 responses



Do you have any suggestions or improvements in any area of this study? Please specify.

10 responses

No
Including more stats
No I do not
This study taught me alot about a topic I had previously not learnt about.
More visual aids
Improve the purpose
N/a
It would possibly help to add in information regarding factors affecting bone health in the BMD section.
I think it should include statistics

The responses and feedback collected from the online form was extremely insightful, critical, helpful and valuable as each response highlighted areas in my investigation that needed to be improved as well as what areas were successful. In order to address the feedback, I have made alterations to the following areas of my depth study;

- I have included statistics as a part of my background research. These are important as they effectively illuminate the current data regarding individuals who have this disease and additionally add more credibility to my research.
- I have included much more diagrams, tables and images to act as a visual aid, assisting the portrayal and understanding of my research.
- I have re-visited my original aim and created a more thorough one, in order to clear mis-understanding regarding the purpose of my investigation.
- I have added comprehensive information regarding specific factors that affect bone health in the Bone Mineral Density section of my background research.

After making these changes, I feel extremely confident in my depth study in regards to the information presented, the way it is presented, and in achieving a comprehensive understanding of my topic and inquiry question.

Evaluation:

In order to thoroughly assess and evaluate the research conducted and results obtained during a secondary investigation, factors such as relevancy, accuracy, validity and reliability must be considered. These factors can alter the final results or conclusions of the investigation.

Assessing the relevancy, accuracy, validity and reliability of primary and secondary data
Throughout my research process, I have maintained the reliability of the results obtained by testing each source used for its currency, how relevant it is to my topic and in addressing my inquiry question, the authority of the author/s or organisation, the accuracy of the information presented and the purpose of the source, author/s and organisation. In order to test for these factors, I applied a range of questions, including;

- When was the information published and has it been updated since?
- Does the information hold direct relevance to the topic of interest?
- Who is the author/ publisher of the information and what are their credentials?
- Can the information presented by verified across a range of other sources (cross-referencing)?
- What is the main purpose of this source?

By applying these comprehensive techniques, I was able to collect information that held direct relevancy to the topic I was investigating, a factor that was heightened through my development of specific investigation areas when conducting my background research. Obtaining relevant data ensured that I was able to comprehensively and directly answer my inquiry question as I developed an extensive understanding of all areas of my topic.

Furthermore, in order to assess the accuracy of the information I collected, I tested for any bias and ensured the information presented was unanimous across other sources by employing the technique of cross-referencing.

In order to maintain reliability and validity, I used sources written by individuals, predominantly medical professionals, whose work specialises in the specific field that I was investigating. I also accessed government or government endorsed websites or organisations as the information is immediately credible, reputable and valid. Additionally, I predominately accessed journal articles that were often peer-reviewed and published on trusted databases such as GALE, Science Direct, the National Library of Medicine and the EBSCO databases.

By extracting both qualitative and quantitative data, I was able to provide altering insight into the modifiable risk factors of osteoporosis and its debilitating consequences as well as surrounding areas, comprehensively addressing my inquiry question. This was completed through the utilisation of an abundance of varied sources such as films, videos, articles, journal and/ or peer-reviewed articles, reliable websites, printed media and government organisations. Relevancy, reliability, accuracy and validity was then further tested as I tested my research against the following questions:

- How consistent is the information with information from other reputable sources?
- Is the data presented based on repeatable processes/ results?
- Is this information similar to the information presented in peer-reviewed scientific journals?
- Do the findings relate to the inquiry question?
- Are the findings accurate and the source is reliable?

An additional step completed in my depth study was the completion of peer feedback, as discussed earlier, which provided necessary additional qualitative data. This was completed through both a survey regarding my yes/ no questions on my investigation and direct and specific feedback on my entire investigation. This feedback proved to be invaluable as it provided me with insight regarding what my depth study was lacking and how to improve it, which has since been acted upon.

Improving the relevancy, accuracy, validity and reliability of collected data

A way to improve the relevancy of the data collected for my depth study is to refine the date parameters of data that my testing, as previously described, allowed. Instead of including information created within the past 25 years, my data could have been more relevant, and as a result more accurate, reliable and valid, if it was created within the past 15 years. Furthermore, accuracy, reliability and validity could have all been improved in gathering additional and more in-depth responses from my peer feedback, however this has the potential to be unrealistic.

Identifying and assessing error, uncertainty and limitations in data

Although I did not encounter many errors in my investigation due to the vigorous testing I conducted on all my collected information (as discussed above), a major limitation I encountered while conducting my depth study was a lack of high level scientific-based articles and papers on my topic. This is because the majority of information available on the topic of osteoporosis is directed at a health consumer audience, rather than an in-depth scientific level research. As a consequence, I had to conduct much more in-depth and time consuming research in order to gain both perspectives of a health consumer, but more importantly, the high-level thinking provided in scientific-based research and articles. Due to the identification of this limitation and therefore the additional research conducted, I was able to overcome this limitation and collect relevant, accurate, valid and reliable primary and secondary data.

Additionally, I encountered uncertainty whilst conducting my investigation regarding the location of the information sourced. Whilst I originally aimed to collect information that was primarily created/ conducted in Australia, such as Osteoporosis Australia and Healthy Bones Australia, I found this extremely difficult to obtain the necessary depth. Therefore, I used information collected globally, ensuring that it was created recently. As a result of this, uncertainty arose regarding the validity of this information. In order to overcome this uncertainty, I conducted thorough research regarding the authority and credibility of the authors, publishers and organisations of websites.

Final Comments

Overall, my investigation, through my thorough research process that has proven to be invaluable, was highly reliable, accurate, relevant and valid. This is due to the techniques and tools implemented, as discussed above, that ensured this, ultimately meaning the results and conclusions drawn were extremely reliable.

Additional Information:

1. Test Your Bone Health:

The Australian website 'The Big Osteoporosis', founded by Amgen (a biotechnology company), offers a simple four-part test for any individuals to part-take, allowing them to determine whether they are at risk of osteoporosis and should seek further help (The Big Osteoporosis, 2017).
Link: https://www.thebigo.com.au/education-tool.

Healthy Bones Australia, an initiative of Osteoporosis Australia, offers a comprehensive self-assessment which allows individuals to know whether they are at risk of developing osteoporosis and the steps they should take (Know Your Bones, 2021).
Link: https://start.knowyourbones.org.au/questions.

According to The Clinician's Guide to Prevention and Treatment of Osteoporosis, FRAX wass developed to calculate the 10-year probability of a hip fracture and the 10-year probability of a major osteoporotic fracture by taking into account femoral neck bone mass density (BMD) and the clinical risk factors.
Link to FRAX test (Australia): https://www.sheffield.ac.uk/FRAX/tool.aspx?country=31.

2. Videos

- **a.** 'Osteoporosis 101': https://youtu.be/F1KJq6Pdp54
- **b.** 'Postmenopausal Osteoporosis': https://youtu.be/c5tc01WFYks
- **c.** 'Osteoporosis Exercises': https://youtu.be/0Hl2UTJw9D4

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Journal Entries:

Entry One - 11/2/22
Receiving the brief.
The other day we received the assessment task notification for our Year 12 Biology Depth Study, it focuses on Modules 5,6, 7 and 8 of the HSC Syllabus. Since we have received it, I have brainstormed and completed some initial research into what topic I want to investigate. This initial research will help me to develop and formulate my question and also ensure the topic my question is based on is appropriate in terms of the amount of information it has.

The topics I have an interest in from my initial research include;

- Autoimmune conditions (endocrine focus)
    - Type One Diabetes
        - Prevention
        - Cure (research going into finding prevention and cure)
        - Long term ramifications (complications, heredity risk)
        - Management (technology and advances)
    - Hashimoto's
- Infectious Diseases
    - Staphylococcus infections (bacterial infection)
        - Explore mutations (bacteria) with a focus on Staphylococcus aureus (golden staph)
        - Long term effect, predispositions it causes
        - Different strains
        - Evolutionary nature
    - Measles epidemic
        - Analysing the need and effectiveness of vaccines
- Genetic disorders
    - Hematopoietic - Sickle cell anaemia (autosomal recessive, Mendelian disease).
    - Nervous system - Huntington disease (autosomal dominant, Mendelian).
    - Nervous - Fragile X Syndrome (X-linked recessive disorder)
    - Nervous system - Degenerative diseases affecting the cerebral cortex
        - Alzheimer Disease

Entry Two - 14/2/22
Developing inquiry questions.
This afternoon I've been figuring out my possible topic based on the ones I have listed previously and then developing some possible questions based on this. The topics I have developed some possible inquiry questions for include Staphylococcus bacteria, Alzheimer's disease and Type One Diabetes. These questions include;

- How do Staphylococcus bacteria mutate and what are the health ramifications associated when an individual contracts this infection?
- What is Alzheimer's disease and how does this disease affect brain function and consequently an individual's ability to function? Or What is Alzheimer's disease and how does this disease affect an individual's ability to function?
- What causes Alzheimer's disease?

- What are the long term health complications associated with a youth diagnosis of Type One Diabetes?
- What is Type One Diabetes and what are ways in which it can be prevented in the near future? (Eg; targeting T-cell proteins and immunotherapy)
- What genetic and environmental factors trigger the onset of the autoimmune condition, Type One Diabetes?

Entry Three - 16/2/22

Further research for inquiry question

After completing some more research/ readings of articles found on databases that are associated with my topics above, I've decided to shift my focus away from these topics. I've decided to focus on Non-infectious diseases, particularly hypothyroidism and osteoporosis.

Some questions I have brainstormed for this include;

- What has contributed to the rise of hypothyroidism in the last decade?
- What are the modifiable risk factors for developing hypothyroidism that can be addressed?
    - Modifiable risk: diet, treated with radioactive iodine (a treatment for thyroid cancer), exposed to radiation to your neck or upper chest area.
- What are the modifiable and unmodifiable risk factors of osteoporosis?
- What are the modifiable risk factors of osteoporosis to prevent the debilitating consequences of this disease?

Entry Four - 18/2/22

Finalising my Inquiry Question!

After discussing my possible inquiry questions with my biology teacher, I have taken on her considerations, advice and comments as well as my own interests and have <u>modified</u> and finalised my inquiry question! It is;

What are the modifiable risk factors of osteoporosis to prevent the debilitating consequences of this disease?

I am <u>extremely</u> happy with this topic and inquiry question as it is very relevant to our contemporary context and I am interested in learning more about this disease. I will now focus on conducting in-depth background research using a wide range of resources available to me.

Entry Five - 25/2/22

Developing background research subtopics/ areas.

Today's lesson was a depth study lesson. This was extremely helpful as it meant I was able to dedicate time to create subtopics or areas of specific research that I need to undertake in order to effectively conduct my background research. By creating specific areas of research into my topic I will be able to not only stay on track with my approach but I will also be able to gain a deeper understanding of my topic, enabling me to thoroughly understand by inquiry question topic and to therefore answer my inquiry questions with success and understanding.

These specific areas include;

1. What is Osteoporosis? - an overview
2. Treatment
3. Management
4. Symptoms - How does the disease present?
5. Susceptibility to osteoporosis - Who is at risk?
6. Possible risk factors contributing to the development of Osteoporosis:

    a. Impacts on Bone Health;
        i. impact of calcium
        ii. impact of vitamin D
        iii. impact of exercise
        iv. Family history
        v. Medical history
        vi. Lifestyle factors
7. Predisposition to other diseases
8. Ramifications - Consequences
    a. Low
    b. Moderate
    c. High (Debilitating)
9. Prevention
10. Bone Mineral Density (BMD)
11. Statistics

Entry Six - 27/2/22

Conducting Background Research

Today I conducted more background research under a few different headings, including an overview of what osteoporosis is, its ramifications and its symptoms.

In addition to this, I created the new heading of osteoblasts and osteoclasts after completing some in-depth research in bone mineral density (BMD). This then led me to do some research on both of these topics in relation to each other to fully understand them. Following this, I conducted some research into menopause and its relation to individuals with osteoporosis. This was extremely fascinating as I discovered that when a female undergoes menopause, it predisposes them to develop osteoporosis. After this, I conducted some initial research into treatments, such as medicines.

Entry Seven - 2/3/22

Conducting further background research

During the last few days I have been completing further background research for my depth study. Some of these areas of research I've been working on include further research on the symptoms of osteoporosis, complications associated, and completing research under the headings of osteoporosis overview and its treatment.

I have also started to synthesise all the information I have collected and fill in areas that are missing necessary information.

Entry Eight - 9/3/22

Synthesising background information

The last few days, I have been focussing on synthesising all the information I have collected for my background research in order to refine it, including what is needed to answer my inquiry question and to find areas that are lacking certain aspects of information. Although this has been a long process as I have also been making sure to include the source reference/ information I access and the date I accessed it, it has been extremely beneficial as I feel confident in my knowledge of my topic as well as the accuracy, reliability and validity of the information I have collected.

Entry Nine - 16/3/22

Depth Study Lesson

Today we had a depth study lesson in class which was a great opportunity to complete my synthesis of background research. In this lesson I was able to critically go through each subtopic within my background research and refine it, ensuring it was directly relevant to my question and was accurate when compared with a variety of other reputable and updated sources. By doing this, I am able to ensure that this information is valid to draw conclusions from when addressing my inquiry question. In addition to this, I also started to in-text reference using the source references/ information I have included in each step of my background research. By including these dates and information prior to finalising my references, it meant I was able to double-check the validity, accuracy, relevance and reliability of these sources while I was finalising my references.
I plan to finish my in-text references and subsequently my background research by the end of this week, meaning I will be able to move on to further aspects of my depth study.

Entry Ten - 25/3/22
Hypothesis and aim
Today I moved on to identify and construct the aim of my investigation as well as the hypothesis. The aim of the investigation identifies the purpose of it, therefore it will enable me to consolidate information and assess its relevance to my question. After edits, alterations and critical feedback from some of my peers in my class, the aim of my investigation is;

- 'The purpose of this second-hand investigation is to investigate the modifiable risk factors of osteoporosis'.

This aim directly addresses what I have outlined in my inquiry question and also uses key verbs to establish what I will be doing. In addition to this, I also completed my hypothesis. I identified that I need to address both risk factors, consequences of osteoporosis and its possible prevention in my hypothesis as that is what I have outlined in my inquiry question and aim. It reads as;

- 'The modifiable risk factors investigated will include lifestyle changes such as diet and exercise whereas other risk factors investigated will include gender, build, and genetics (family medical history), which are unable to be modified. Through identifying modifiable risk factors, individuals with osteoporosis will be able to reduce the identified debilitating consequences of osteoporosis, such as fracturing, and if there is early detection or alteration of modifiable risk factors determined, individuals can reduce their risk of diagnosis.'.

Entry Eleven - 30/3/22
Methodology
In today's depth study lesson, I discussed my progress with my biology teacher and I also completed my methodology. It was extremely helpful to discuss with my teacher the direction I am heading with my depth study and whether I am on the right track. We briefly went through my background research, discussed my aim and hypothesis and she also provided me with some general feedback regarding how I am progressing. This was both extremely helpful and motivating as she approved what I have done!
In addition to this, I completed my methodology after working on it after school during the last few days. In order to do this, I researched ways to write a methodology for a second-hand investigation which examined the necessity of including them and also provided me with a variety of alternate ways to structure a methodology. Furthermore, I viewed previous students' approaches to writing their investigations methodology by accessing previous students' depth studies on the One Note. With this research, I made summary notes on key features and styles that made the most sense to me and were most suitable to the aim of my investigation. The structure that I am using follows an overarching step which then contains a small description of the requirements of this particular step. I actually really

enjoyed working on this step of my depth study as it provided me with a structure of what my end goal of the investigation is and how I can achieve it within the given time frame.

Entry Twelve - 5/4/22

Planning Peer Feedback

I have been working on planning my peer feedback, ensuring I address each component of my investigation when others assess it as a whole or in sections. After considering how previous depth studies have approached this section, I have decided to approach this via a survey. I will create a short yes/no answer question form regarding my depth study. These questions are general however they will provide feedback regarding how my depth study is understood (such as its purpose and method of delivery), the awareness regarding this topic and their knowledge after reading my depth study. These questions are extremely straightforward and will therefore reveal areas that my depth study is lacking. Additionally, the final question is an open question, allowing responders to suggest improvements. I will then address how these responses through the form helped me and how I will act upon the suggestions to improve my depth study.

As well as working on the above, I have been drafting my results and discussion. This has already proven to be a lengthy process as I am consolidating all information gathered, however, it has also been super rewarding to finally be up to this step!

Entry Thirteen - 12/4/22

Completing results and discussion.

I have completed my results and discussion! As it is now the first week of holidays, I have been using some of this time to work on my depth study. In order to complete my results and discussion, I decided to research and source a reputable journal article that covers my topic extensively. This was found in the article titled Clinician's Guide to Prevention and Treatment of Osteoporosis. By choosing to do this, I was able to analyse the relevancy, reliability, accuracy, validity and credibility of this article extensively in order to use it as evidence supporting the conclusions drawn in my background research. I really enjoyed this approach as it not only increased the validity, reliability and accuracy of my previous research (as I was essentially applying the tool of cross-referencing), but it also provided me with a comprehensive source regarding the nature of my topic and inquiry question, both of which assisted me to complete my results and discussion! I am now moving on to my conclusion.

Entry Fourteen - 15/4/22

Completing Conclusion and Bibliography

In order to complete my conclusion, I referred to previous years depth studies as well as researching various scaffolds in combination with prior knowledge. Both of these aspects assisted me to draw evidence-based conclusions in my research to ultimately answer my inquiry question thoroughly and effectively. Additionally, my biology textbook outlined necessary elements in a conclusion as well as an evaluation (which will assist me when I conduct this step) and an entire depth study (which allowed me to go through and edit my previous work to improve it).

Additionally, I have also completed my bibliography using the online bibliography generator provided to us by the school through destiny. Although this was time-consuming, I had bookmarked every link accessed during the development of my depth study alongside the date which made it much easier to complete. Overall, it was very rewarding to see the final (alphabetised!) result.

Entry Fifteen - 18/4/22

Peer feedback responses and evaluation

Since I have completed my conclusion, according to my methodology, I am now up to my evaluation of my depth study. However, in order to complete this I must collect my responses to my peer feedback and act upon any suggestions made. These changes made in accordance to my peer feedback include;

- I have included statistics as a part of my background research. These are important as they effectively illuminate the current data regarding individuals who have this disease and additionally add more credibility to my research.
- I have included much more diagrams, tables and images to act as a visual aid, assisting the portrayal and understanding of my research.
- I have re-visited my original aim and created a more thorough one, in order to clear mis-understanding regarding the purpose of my investigation.
- I have added in comprehensive information regarding specific factors that affect bone health in the Bone Mineral Density section of my background research.The purpose of this second-hand investigation is to **investigate** and **determine** the modifiable risk factors of osteoporosis and to critically **analyse** and **identify** the debilitating consequences of this disease and its possible prevention.

By doing this, I am confident in my depth studies ability to effectively engage and present my collected information in a way that creates a deeper understanding of both the topic and the conclusions drawn regarding my inquiry question within my viewers.

By completing this step, I have been able to write and complete my evaluation! I really enjoyed writing my evaluation as it was an opportunity to critically analyse how I conducted my research and to identify any ways I could improve on this in addition to identifying any challenges I can across. I will now move on to final editing of my depth study and also formatting all my information into a website!

Entry Sixteen - 26/4/22

Formatting into a website

After going through my entire depth study and editing & checking it, the last aspect of my depth study is formatting all my collected information into a website. I originally started to do this using SquareSpace however I wasn't finding success in the process nor the result, so I changed to WordPress, which is what I used for my Year 11 depth study. I was able to use WordPress as I used my dad's log-in details, meaning there were no payments necessary to host it. Using this instead was extremely better and the results look incredible. Although this process was extremely time consuming (and also extremely frustrating at times…), I was able to figure out how to use each tool because I have successfully used this site previously as well as referring to some YouTube videos for extra help! Overall, I am extremely proud of the final outcome of my website and how it effectively presents my depth study in an extremely engaging way. Additionally, I decided to also format my research into a report that is able to be downloaded as a PDF through my website. By doing this, it allows individuals to access every part of my depth study as a whole.

This means I have finally finished my depth study! I have enjoyed learning about a topic that holds direct relevance to both our biology modules (particularly non-infectious disease) and to my family. Although I found this process challenging, I have developed my critical thinking skills as well as my ability to research widely and thoroughly.