ASSOCIATION BETWEEN NUTRITIONAL STATUS, FRAILTY DOMAINS, PHYSICAL ACTIVITY, PHYSICAL FITNESS, EMOTIONAL STATUS AND QUALITY OF LIFE WITH SARCOPENIA AMONG OLDER ADULTS IN KELANTAN

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UNIVERSITI SAINS MALAYSIA

2024

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by

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Thesis submitted in fulfilment of the requirements

for the Degree of

Master of Science

October 2024

ACKNOWLEDGEMENT

To begin, I would like to express my gratitude to God, for having blessed me throughout this journey, letting me through all the difficulties. I wish to express my sincere appreciation to my supervisor, Dr.Divya Vanoh for the opportunity to be a part of her research team. Her patience, guidance and support has continuously motivated me to do my best in every task, through all the stages needed to complete this research. Her hard work and encouragement inspire me to strive for greatness. I would also like to thank my co-supervisor Prof. Dr. Wan Rosli Wan Ishak for his support, comments and encouragement. I would like to thank the Ministry of Higher Education for funding my project via the Fundamental Research Grant Scheme. I am also grateful to Universiti Sains Malaysia, Kampus Kesihatan, especially School of Health Sciences, for providing me the opportunity to pursue my postgraduate study. I am extremely grateful to my study subjects from multiple villages in Kelantan for their willingness participate in this study enabling me to complete all the necessary assessments. I would also like to thank the mosques' committee members, 'Imam' and village heads for their cooperation in making this research a success. I am most grateful, especially to Mrs Nurul Syahidah binti Mohd Nazri and Miss Nur Syakirah Arissa binti Mohd Salleh who were my teammates and friends for their assistance during data collection. Lastly, the most significant acknowledgment is reserved for my parents and brothers, Mr Ganggaya, Mrs Amutha Sree, Mr Viknneshwara Rao and Mr Netaarsan for being my pillar of strength throughout this study financially and morally. A special thanks to my best friend, Mr Kishoharan Kauthaman for always being there for me and supporting me throughout this journey.

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LIST OF ABBREVIATIONS

WHO	World Health Organization
MUAC	Mid-upper arm circumference
BMI	Body mass index
RAPA	Rapid Assessment of Physical Activity
SPPB	Short Physical Performance Battery
BM-DASS-21	Bahasa Malaysia-Depression, Anxiety, Stress Scale-21
CASP-19	The Quality of Life Scale (Control, Autonomy, Self-realization and Pleasure)
IGF-1	Insulin-like growth factor-1
QoL	Quality of Life
AWGS	Asian Working Group for Sarcopenia
CDC	Centers for Disease Control and Prevention
TFR	Total fertility rate
EWGSOP	European Working Group on Sarcopenia
ADL	Activities of daily living
Akt	Serine/threonine kinase
mTOR	Mammalian target of rapamycin
GH	Growth hormone
TNFα	Tumor necrosis factor alpha
IL-6	Interleukin 6
IL-1	Interleukin-1
CRP	C-reactive protein
IWGS	International Working Group on Sarcopenia
FNIH	Foundation for the National Institute of Health
SMI	Skeletal muscle index

HS	Handgrip strength
GS	Gait speed
PPR	People's Housing Project
DXA	Dual energy X-ray absorptiometry
BIA	Bioelectrical impedance analysis
SRH	Self-rated health
CES-D	Epidemiologic Studies Depression Scale
SCD	Subjective Cognitive Decline
GDS	Geriatric depression scale
MCI	Mild cognitive impairment
MoCA	Montreal Cognitive Assessment
IADL-MV	Instrumental activities of daily living- Malay Version
TUG	Timed-up-and-go test
GLUT 4	Glucose transporter 4
IRS 1	Insulin receptor substrate-1
PI3K	Phosphoinositide 3-kinase
PKB/Akt	Protein kinase B
WWP1	WW-domain-containing E3 ubiquitin protein ligase 1
KLF15	Kruppel-like factor 15
LASI	Longitudinal Aging Study in India
OA	Osteoarthritis
RA	Rheumatoid arthritis
IL-1β	Interleukin-1β
MMSE	Mini-Mental State Examination
WAIS	Wechsler Adult Intelligence Scale
SARC-CalF	Strength, assistance walking, rising from a chair, climbing stairs and falls

SARC-F	Strength, assistance walking, rising from a chair, climbing stairs and falls
MSRA-5	5-item Mini Sarcopenia Risk Assessment
HPA	Hypothalamic-pituitary-adrenal
CRH	Corticotropin-releasing hormone
ACTH	Adrenocorticotropic hormone
11β-HSD	11 beta Hydroxysteroid Dehydrogenase
FOXO	Forkhead box O group
MuRF-1	Muscle-specific RING finger protein

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PERKAITAN ANTARA STATUS PEMAKANAN, DOMAIN KEUZURAN, AKTIVITI FIZIKAL, KECERGASAN FIZIKAL, STATUS EMOSI DAN KUALITI HIDUP DENGAN SARKOPENIA DALAM KALANGAN WARGA EMAS DI KELANTAN

ABSTRAK

Sarkopenia adalah penyakit yang menjejaskan kesihatan, kebebasan berfungsi dan kualiti hidup dalam kalangan warga emas yang membawa kepada kesan buruk seperti jatuh, hilang keupayaan fizikal, kemasukan ke hospital dan kematian. Oleh itu, kajian ini bertujuan untuk menilai perkaitan antara domain keuzuran, status pemakanan, kecergasan fizikal, aktiviti fizikal, status emosi, fungsi kognitif dan kesejahteraan warga emas dengan sarkopenia. Kajian keratan rentas ini melibatkan 287 warga emas yang tinggal dalam kalangan komuniti di Kelantan dan berumur 60 tahun dan ke atas, yang dipilih melalui persampelan rawak mudah. Data yang dikumpul telah dimasukkan dan dianalisis menggunakan perisian IBM SPSS Statistics 26. Data tentang sosiodemografi, kualiti tidur, pengambilan suplemen, sindrom geriatrik, sejarah perubatan, status kesihatan penilaian sendiri, domain kelemahan, fungsi kognitif, had fungsi, aktiviti fizikal, antropometri, komposisi badan, tekanan darah, kekuatan genggaman, kecergasan fizikal, status emosi, kualiti hidup dan sarkopenia diperoleh melalui kaedah temu bual. Analisis regresi logistik binari digunakan untuk menentukan faktor yang berkaitan dengan sarkopenia. Prevalens kemungkinan sarkopenia, sarkopenia dan sarkopenia teruk masing-masing adalah 59%, 9% dan 14% yang lebih tinggi dalam kalangan lelaki berbanding wanita ($p = 0.029$). 84.0% subjek sarkopenic kurang berat badan manakala 46.7% subjek kemungkinan sarkopenia berlebihan berat badan yang boleh menyebabkan obesiti sarkopenia. Perkaitan

yang ketara didapati antara kelemahan fizikal dan sarkopenia ($p < 0.001$) tetapi bukan kelemahan social ($p = 0.227$) dan kelemahan kognitif ($p = 0.345$). Perkaitan yang ketara didapati antara sarkopenia dan status pemakanan yang lemah, kekurangan kecergasan fizikal dan fungsi kognitif. Walau bagaimanapun, tiada perkaitan yang signifikan ditemui antara sarkopenia, status emosi dan kualiti hidup dalam kalangan warga emas di Kelantan. Selepas penyesuaian dengan faktor seperti umur, jantina, merokok dan tahun pendidikan faktor yang didapati signifikan dengan sarkopenia ialah, jisim otot, kelajuan berjalan, ujian duduk untuk berdiri dan keuzuran fizikal didapati sebagai faktor yang dikaitkan dengan sarkopenia. Lebih daripada separuh warga emas yang terlibat dalam kajian ini mempunyai kemungkinan sarkopenia (59 %). Oleh itu, warga emas harus dididik tentang langkah untuk mengurangkan risiko sarkopenia melalui amalan pemakanan sihat, aktiviti fizikal, pengurusan tekanan emosi dan penglibatan dalam aktiviti kesukarelawanan.

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ABSTRACT

Sarcopenia is a disease that affects health, functional independence and the quality of life among older adults which leads to adverse effects like falls, physical disability, hospitalization and mortality. Therefore, the current study aimed to assess the association between frailty domains, nutritional status, physical fitness, physical activity, emotional status, cognitive function and well-being of older adults with sarcopenia. This cross-sectional study involved 287 community-dwelling older adults in Kelantan aged 60 and above, recruited through simple random sampling. The data collected were entered and analyzed using IBM SPSS Statistics 26 software. Data on socio-demography, sleep quality, supplement intake, geriatric syndrome, medical history, self-rated health status, frailty domains, cognitive function, functional limitation, physical activity, anthropometry, body composition, blood pressure, handgrip strength, physical fitness, emotional status, quality of life and sarcopenia were obtained through interview administered method. Binary logistic regression analysis was used to determine the factors associated with sarcopenia. The prevalence of possible sarcopenia, sarcopenia and severe sarcopenia were 59%, 9% and 14% respectively which was higher in men than in women ($p = 0.029$). A total of 84.0% of sarcopenic subjects were underweight while 46.7% of possible sarcopenia subjects were overweight which could lead to sarcopenic obesity. Significant association was found between physical frailty and sarcopenia ($p < 0.001$) but

not social frailty (p = 0.227) and cognitive frailty (p = 0.345). Significant association was found between sarcopenia and poor nutritional status, lack of physical fitness and cognitive function. However, no significant association was found between sarcopenia, emotional status and quality of life among older adults in Kelantan. After adjusting for confounding factors such as age, gender, smoking and education years, the factors associated with sarcopenia were muscle mass, gait speed, sit-to-stand test and physical frailty were found to be factors associated with sarcopenia. Approximately, more than half of the community-dwelling older adults in this study had possible sarcopenia (59 %). Therefore, older adults should be educated on the steps to prevent sarcopenia via healthy eating, exercising, emotional stress management and involvement in voluntary activities.

CHAPTER 1

INTRODUCTION

1.1 Background of the study

Ageing is inevitable as people are living longer worldwide. World Health Organization (WHO) projects that by 2030, one-sixth of the global population will be 60 years or older (Khavinson et al., 2020). The population of those aged 60 years and older will rise from 1 billion in 2020 to 1.4 billion in 2030, and it will then double by 2050 (Jarzebski et al., 2021). The most rapid population ageing was observed in Eastern and South-Eastern Asia, Latin America, and the Caribbean. The proportion of individuals over 65 years old in Eastern and South-Eastern Asia has increased from 6% in 1990 to 11% in 2019 (Chew et al., 2022; Huynh, 2022).

In Malaysia, the total population is estimated at 32.7 million in 2022, whereby the percentage of the population aged 60 years and older increased from 10.7% in 2021 to 11.1% in 2022 which is 3.5 million people to 3.6 million people respectively. Therefore, according to the United Nations' definition, Malaysia has transitioned into an aging society (DOSM, 2022; Nik Norliati Fitri Md Nor, 2021).

Thus, it is undeniable that older adults are prone to diseases and health conditions than younger individuals. This increases the frequency of the aged group to be associated with an increase in the prevalence of health deterioration. This significant growth of the older population will put a strain on the healthcare system and support services. Furthermore, ageing comes with many consequences with sarcopenia being common (Coletta & Phillips, 2023).

Sarcopenia is a prevalent disorder in older persons characterized by a progressive decline in skeletal muscle mass and strength, leading to changes in nutritional status, frailty, functional impairment, disability, and increased risk of falls (Hollingworth et al., 2021). Sarcopenia is characterized by a loss of muscle mass, plus low muscle strength and/or low physical performance according to the Asian Working Group for Sarcopenia (AWGS 2019) (L. K. Chen et al., 2020). According to Mayhew et al. (2019), sarcopenia prevalence across the globe varies from 9.9% to 40.4% among community dwelling older adults. A study by Reshmy Ranee (2022), found that the prevalence of sarcopenia among Malaysian community-dwelling older adults was 33.6% but it was carried out only among older people residing in the Klang Valley hence the numbers are not accurate to depict and generalize the whole Malaysian population.

Nutritional status comprising of anthropometric measurements like calf circumference, mid-upper arm circumference (MUAC), body mass index (BMI) and body composition including SMI and handgrip strength are commonly used as indicators for sarcopenia presence (Ganapathy & Nieves, 2020; Maccarone et al., 2023). This is because, older sarcopenic adults are often found to be having a smaller calf circumference (Kim et al., 2022), smaller MUAC (Maccarone et al., 2023) and a low skeletal muscle mass percentage in the body (Kim et al., 2019). A low muscle mass among older adults contributes to the risk of reduced mobility (Wages et al., 2020), impaired activities of daily living and low quality of life (Beaudart et al., 2024; Xu et al., 2021), fall-related injuries, hospitalization and a need for long-term care (Kirwan et al., 2020). An adverse cycle may occur, leading to more muscle loss, greater disability, and deteriorating health, ultimately raising the chance of mortality (Tey et al., 2021).

Besides, it is also noteworthy that sarcopenia is a major cause of frailty (Martin & Ranhoff, 2021). Frailty is characterized as a state of increased susceptibility to poor homeostatic recovery following stress, which raises the potential of unfavorable consequences like falls, delirium, and disability (Kwak, 2021; Wleklik et al., 2020). Frailty can be divided into physical frailty, cognitive frailty and social frailty (Tsujishita, 2022). Physical frailty considers the body's physical capabilities and changes. According to the well-established and standardized five Fried frailty phenotype physical frailty could be denoted through unintentional weight loss, exhaustion, weakness, slowness and low physical activity (Mohd Hamidin et al., 2018b; Norazman et al., 2020). However, various adaptations of the Fried's clinical phenotypes have emerged to accommodate specific studies' requirement (Bahat et al., 2022). Social frailty refers to the state of being vulnerable to losing or having already lost social resources, behaviors, activities, and self-management skills necessary to meet fundamental social requirements (Wu, Chen, et al., 2023). The Makizako Social Frailty Index which consists of five items, is the most common assessment method to determine social frailty (Zhang et al., 2023). As for cognitive frailty, it is relatively still a new concept comprising of both physical and cognitive aspects but has yet to have a standardized consensus (Liu, Xu, et al., 2023). However, according to Malek Rivan et al. (2019) and Won et al. (2018), cognitive frailty can be assessed with a combination of physical frailty assessed through the Fried frailty phenotype, cognitive impairment via Montreal Cognitive Assessment (MoCA) and functional limitation via Lawton Instrumental Activities of Daily Living (IADL). On the contrary Nader et al. (2023), proposed that cognitive frailty can be assessed pertaining to the combination of only cognitive impairment and physical frailty.

Even though both sarcopenia and frailty have shown considerable overlapping over the years, the two are quite different terms. Sarcopenia, which is muscle loss and decreased function, is associated with aging and can lead to frailty. Frailty, in turn, is a risk factor for disability. Thus, it is from sarcopenia that one develops frailty (Wong et al., 2021). Older people who are frail are more prone to premature deaths and numerous health issues which includes injuries, falls, disabilities, psychological and cognitive problems which would eventually lead to a poor quality of life, increasing the cost and usage of health care services such as multiple visits to the emergency room, hospitalization, and institutionalization (Jaul & Barron, 2017; X. Wang et al., 2022).

Moreover, sarcopenia also causes a decline in physical fitness. This is due to older people being physically inactive (Teraž et al., 2023). It has been suggested that engaging in regular physical activity can be used as a risk-free technique to combat the natural decline in muscle mass and strength that comes with advancing age (Seo & Lee, 2022). Participating in regular physical activity, either in the form of aerobic exercise, resistance training, or a combination of the two, has been shown to prevent muscle atrophy and create beneficial preventative and therapeutic effects (Flor-Rufino et al., 2023; Shen et al., 2023). Hence, a reduced physical activity may cause sarcopenia, leading to a decline in physical fitness (Wickramarachchi et al., 2023). RAPA has been used in many studies (Azfar et al., 2019; Mohd Hamidin et al., 2018a) to identify the level of activeness of an individual. As for physical fitness, it can be broken down into five categories namely cardiovascular endurance, muscular strength, muscular endurance, flexibility and body composition (Appelqvist-Schmidlechner et al., 2020).

Various senior-friendly exams can be used to examine the physical fitness of an older adult. The SPPB was used to evaluate lower extremity functioning and it comprises

of three sets of tests namely the balance test, gait speed test and sit-to-stand test. Other tests like hand grip strength, back scratch test, 2-minute step test and chair sit-and-reach test was also used to determine physical fitness as it assesses upper body strength, upper body flexibility and lower body flexibility (Song et al., 2021).

Furthermore, sarcopenia also causes fluctuation in emotional status as well as the quality of life of an individual (Kim et al., 2021). In this study, emotional status including depression, anxiety and stress was assessed. The association between sarcopenia and depression is a very widely studied subject (Speed et al., 2019; von Zimmermann et al., 2020), however the association between anxiety and stress with sarcopenia is still lacking, despite anxiety and stress being one of the leading mental health problems worldwide (Cabanas-Sánchez et al., 2022; Seangpraw et al., 2019). Hence, the Bahasa Malaysia-Depression, Anxiety and Stress Scale (BM-DASS-21) was used to assess all three emotional status (Jiang et al., 2020). As for quality of life, sarcopenia can greatly impact an individual's life by reducing their ability to perform daily tasks. Quality of life is determined by various factors such as personal health, relationships, education, work environment, social status, wealth, security, freedom, autonomy, social belonging, and physical surroundings (McDonald & Shaw, 2019). In the current study, quality of life was determined using The Quality of Life Scale (CASP-19) that predominantly uses four domains; control, autonomy, pleasure and self-realization. Quality of life has shown to be a significant predictor of hospitalization or mortality, which reinforces the importance of this assessment (Beaudart et al., 2023a).

1.2 Problem statement

Malaysia is facing an increase in ageing population with the Kelantan state having up to 6.4% of its population made up of older people (DOSM, 2022). A previous cross-sectional study conducted among 298 low socio-economic status older adults in Kelantan found that almost 40% of the study participants had sarcopenia and poor diet quality (Nazri, 2022). Sarcopenia is a condition in older individuals characterized by a progressive decline in muscular mass, strength, and function (Foo et al., 2023). Sarcopenia may further cause frailty (Álvarez-Bustos et al., 2022), affect physical activity, physical fitness (Hämäläinen et al., 2024), nutritional status (Hua et al., 2022), quality of life and emotional status which is often worsened with the presence of polypharmacy and comorbidities (Prokopidis et al., 2023).

Besides sarcopenia, frailty prevalence in Malaysia is rising and this will further accelerate the health deterioration among older adults (Murukesu et al., 2021). Frailty especially physical frailty have been closely associated with sarcopenia (Wang, X. Guo, et al., 2023; Ye et al., 2023) however the relationship between of cognitive frailty and social frailty with sarcopenia are worth to be investigated. Sarcopenia is a condition that is not usually screened in health clinics or hospitals. Older people or caregivers are not able to detect the presence of sarcopenia till objective assessments are done. Sarcopenia will only be detected in severe conditions when patients become weak, had weight loss, or in some circumstances, weight gain with lack of skeletal muscle mass and finally become functionally dependent (Papadopoulou, 2020).

Condition has become worse post-pandemic Covid-19, when majority of older adults become sedentary with prolonged physical restriction (Y. Wang et al., 2023). This may

affect their quality of life and emotional status which further lead to various issues such as poor dietary habits due to lack of ability to prepare food, abuse by caregivers, loneliness or being neglected and increased susceptibility to various illness. As a result, undetected sarcopenia may be one of the factors of institutionalization and hospitalization among older adults (Keng et al., 2023).

1.3 Study Rationale

Older people aged 60 years and above are more prone to be affected by sarcopenia. The most widely accepted and a common cause of sarcopenia is the natural process of aging. Even though, muscle loss occurs after an individual hit the age of 30, it accelerates when they hit their 60s (Oikawa et al., 2019). People lose muscle as part of the aging process but those with sarcopenia tend to lose muscle mass faster than their normal counterparts. Sarcopenia increases risk of falls, falls-related injuries, dependency, institutionalization, hospitalization and mortality (Larsson et al., 2019). The other risk factors that increase susceptibility to sarcopenia includes physical inactivity (Wu, Li, et al., 2021), obesity (Liu, Cheng, et al., 2023a), chronic diseases like heart disease, kidney disease, diabetes, cancer (Lim et al., 2018) and loss of mobility (Yeung et al, 2019). Sarcopenia is often not screened and diagnosed in hospital setting. An individual will not know if they have sarcopenia till, they experience the adverse effect following the condition. Sarcopenia is not easily diagnosed as it requires specific equipment and expert personals. Considering that sarcopenia and frailty are reversible (Martin & Ranhoff, 2021), this study is essential to investigate the possible factors affecting sarcopenia especially among community dwelling older people. A previous study by Nazri (2022),

revealed a high prevalence of sarcopenia among older adults of low socioeconomic group in Kelantan, hence this study aims to find the association of sarcopenia and other parameters of the current study to a much bigger and broader population of the older adults in Kelantan. In Kelantan and Malaysia, as to our findings and knowledge, no studies have been conducted regarding to the association between all three domains of frailty and sarcopenia. It is essential to identify older adults who are in the category of possible sarcopenia and sarcopenia for planning intervention strategies to reverse their condition to robust.

1.4 Research questions

1. What is the proportion of physical frailty, social frailty and cognitive frailty among sarcopenic and non-sarcopenic older adults in Kelantan?
2. Is there an association between physical frailty, social frailty and cognitive frailty with sarcopenia?
3. Is there an association between nutritional status with sarcopenia among older adults in Kelantan?
4. Is there an association between physical fitness and physical activity level with sarcopenia among older adults in Kelantan?
5. Is there an association between emotional status, cognitive function and well-being with sarcopenia among older adults in Kelantan?
6. What are the factors associated with sarcopenia among older adults in Kelantan?

1.5 Research hypotheses

1. H_0: There is no association between physical frailty and sarcopenia among older adults in Kelantan.

   H_A: There is an association between physical frailty and sarcopenia among older adults in Kelantan.

2. H_0: There is no association between social frailty and sarcopenia among older adults in Kelantan.

   H_A: There is an association between social frailty and sarcopenia among older adults in Kelantan.

3. H_0: There is no association between cognitive frailty and sarcopenia among older adults in Kelantan.

   H_A: There is an association between cognitive frailty and sarcopenia among older adults in Kelantan.

4. H_0: There is no association between poor nutritional status and sarcopenia among older adults in Kelantan.

   H_A: There is an association between poor nutritional status and sarcopenia among older adults in Kelantan.

5. H_0: There is no association between lack of physical activity and physical fitness to sarcopenia among older adults in Kelantan.

   H_A: There is an association between lack of physical activity and physical fitness to sarcopenia among older adults in Kelantan.

6. H_0: There is no association between emotional status and sarcopenia among older adults in Kelantan.

   H_A: There is an association between emotional status and sarcopenia among older adults in Kelantan.

7. H_0: There is no association between quality of life and sarcopenia among older adults in Kelantan.

   H_A: There is an association between quality of life and sarcopenia among older adults in Kelantan.

1.6 Research aim and objectives

To determine the association between frailty domains, nutritional status, physical fitness, physical activity, emotional status and quality of life with sarcopenia among older adults in Kelantan.

1.6.1 Specific objectives

1. To determine and compare the proportion of physical frailty, social frailty and cognitive frailty among sarcopenia and non-sarcopenia subjects in Kelantan.
2. To determine the association between physical frailty, social frailty and cognitive frailty with sarcopenia status among older adults in Kelantan.
3. To determine the association between nutritional status with sarcopenia among older adults in Kelantan.
4. To determine the association between physical activity and physical fitness with sarcopenia among older adults in Kelantan.
5. To determine the association between emotional status and quality of life with sarcopenia among older adults in Kelantan.

6. To determine the factors associated with sarcopenia among older adults in Kelantan.

1.6.2 Conceptual framework

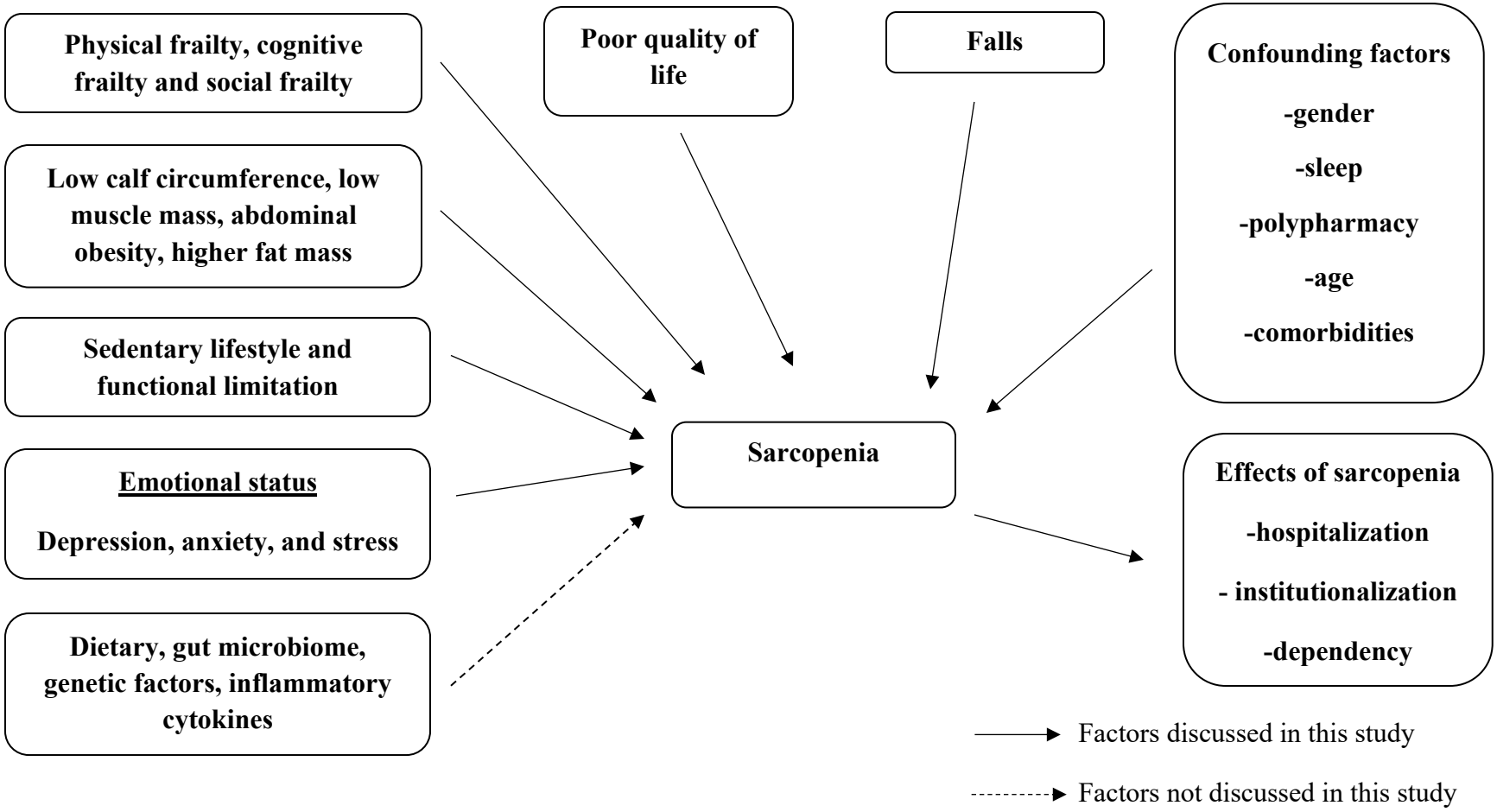

Figure 1.1: Conceptual Framework

Figure 1.1 shows the relationship between factors such as frailty domains, a low calf-circumference, lack of muscle mass, abdominal obesity, increase in fat mass, sedentary lifestyle, functional limitation, affected emotional status, poor quality of life, falls, dietary aspect, gut microbiome, genetic factors, and inflammatory cytokines with sarcopenia. When a person is frail physically, cognitively and socially this could lead to muscle loss. Frailty in these domains could lead to an increased tendency of falling, being hospitalized or institutionalized that causes dependency on others, which could lead to sarcopenia. Calf circumference is closely associated with skeletal muscle mass and can accurately identify reduced muscle mass in persons with sarcopenia (Kim et al., 2022; Kiss et al., 2024). Higher levels of body fat are linked to reduced muscle mass and muscle quality. Higher body fat percentage is associated with sarcopenia via increased cytokines levels and insulin resistance (Sun et al., 2023). Being physically active can act as a protective factor against sarcopenia (Ko et al., 2021). Being physically inactive or sedentary, may affect quality of life causing dependency on others which can also cause sarcopenia (Sánchez-Sánchez et al., 2024). When being emotionally depressed, having anxiety and experiencing stress, one could also experience sarcopenia as it can deprive them from their daily routine. Abdominal obesity can be caused by inflammation and oxidative stress which stimulates muscle protein breakdown and inhibits protein synthesis (Tomažič et al., 2022). An excessive increase in waist circumference causes abdominal obesity which may also lead to sarcopenia known as sarcopenic obesity (Wei et al., 2023).

Other factors that may cause sarcopenia are the being men, shorter sleeping hours, polypharmacy, older age and comorbidities. Elderly men are more prone to sarcopenia as their testosterone and IGF-1 depletes rapidly with age as opposed to elderly women whose

estrogen depletes during menopause but is only slightly significant (Du et al., 2019). The preservation of the circadian rhythm is very crucial to sustain physiology, function and metabolism of skeletal muscle and those who have inadequate sleep are more prone to sarcopenia (Rubio-Arias et al., 2019). Polypharmacy also contributes to sarcopenia due to its possibility to affect and interfere with various metabolic processes and circulatory homeostasis (König et al., 2018) and this is caused by multiple comorbidities and increasing age. All these factors eventually lead to increased risk of falling, hospitalization, institutionalization and dependency leading to sarcopenia.

There are other factors that contribute to sarcopenia as well but were not discussed in this study. Factors like dietary status, gut microbiome, genetic factor and inflammatory cytokines may contribute to sarcopenia.

1.6.3 Operational definition

Older adults, according to the United Nations, were defined as a person who is over 60 years of age (UNHCR, 2020).

Physical frailty was defined as a medical syndrome with multiple causes and contributors that is characterized by diminished strength, endurance and reduced physiological function that increases an individual's vulnerability for developing increased dependency and/or death (Kwak & Thompson, 2021) .

Cognitive frailty was defined as the presence of both physical frailty and cognitive impairment without a clinical diagnosis of Alzheimer's disease or dementia (Malek Rivan et al., 2019).

Social frailty was defined as being at risk of losing or have lost social support, activities or the resources that is needed to fulfill an individual's basic social needs (Ye et al., 2021).

Physical activity was defined as any bodily movement produced by the skeletal muscles that results in energy expenditure (Mohd Hamidin et al., 2018b).

Physical fitness was defined as the set of attributes or capability that people have or achieve (Lee, Lee, et al., 2022).

Emotional status was defined as the feelings and moods experienced by an individual such as depression, anxiety or stress, which can be influenced by negative events, personal characteristics or the environment (Gyasi et al., 2023).

Nutritional status includes anthropometric measurements and body composition (Słowik et al., 2019).

Anthropometric measurement is defined as noninvasive quantitative measurements of the body which includes the weight, body composition, BMI, calf circumference, waist circumference, mid upper arm circumference and blood pressure that provides a valuable assessment of nutritional status in adults (Casadei & Kiel, 2023).

Body composition quantifies various compartments of the body and in this study, division is done according to fat mass, skeletal muscle mass and skeletal muscle index (Enderle et al., 2023).

Quality of life (QoL) is defined as a multi-dimensional construct integrating physical, emotional and social well-being and functioning as perceived by the individual and as the degree of overall life satisfaction that is positively or negatively influenced by individuals'

perceptions of certain important aspects of life, both related and unrelated to health status (Rodrigues et al., 2021).

Sarcopenia was defined as age- related loss of skeletal muscle mass plus loss of muscle strength or reduced physical performance (Chen, J. Woo, et al., 2020).

CHAPTER 2

LITERATURE REVIEW

2.1 Definition of aging

Aging is a wide spectrum that cannot be defined only from a single standpoint. Throughout the years, many concepts have been proposed to define aging as a multidimensional concept. Aging is frequently associated with changes biologically (Ferrucci et al., 2020), physiologically (Preston & Biddell, 2021), environmentally, psychologically (Mitina et al., 2020), behaviorally and socially. A study by Lemoine (2021) defined aging according to features that are traditionally used to consider a person to be aged including structural damage, functional decline, depletion in regeneration of lost or damaged cells, changes in phenotype throughout life (e.g., wrinkles and white hair) and the increasing probability of death or developing diseases.

However, there are different types of aging, as functional loss occurs due to the presence of disease rather than it being a part of normal aging. There are five types of aging: chronological, biological, psychological, social, and functional (Chalise, 2019). Chronological age is the total time elapsed from birth to a specific date and is the primary method of defining age (Maltoni et al., 2022). However, chronological age may not necessarily align with an individual's biological, psychological, or social age. Biological aging is commonly linked to cell loss, reduced tissue and organ function efficiency, weakened immunological systems, and increased susceptibility to infections. Thus, an individual who maintains a healthy lifestyle with regular check-ups can appear biologically younger than those of the same age, who do not keep fit (Chalise, 2019). Psychological aging refers to the alterations in memory, learning, intelligence,

personality, and adaptability to change. Being able to stay mentally active and the ability to handle situations can be considered to be young, psychologically. In addition, social ageing can be referred to as the changes in roles and relationships as people age while functional aging is regarded to as how an individual is psychologically compared to other individuals of similar age (Takács & Nyakas, 2022).

Thus, it can be conclusively said that there is no exact, single definition of 'old' given that each society has a different concept or approach towards what they mean by 'aged' or 'old'. According to The United Nations and Centers for Disease Control and Prevention (CDC), older people are referred to as those aged 60 years and above (Shilpa et al., 2018). The same definition was stated by World Health Organization (WHO, 2022). Nevertheless, many developed countries like the United States (Fulmer et al., 2021) and Japan (Nakatani, 2019) use 65 years of age to refer to older people, as they would be retired and be entitled for pensions and older-age benefits (Ilmakunnas & Ilmakunnas, 2018). The chronological definition of older adults in Malaysia are those who are 60 years and above and this has been widely used in many studies (Chen et al., 2022; Ramoo et al., 2022)

2.2 Aging population

The world is currently undergoing a significant change in its population dynamics, with persons aged 60 years and above emerging as the fastest-growing sector internationally. It can be concluded that a country is experiencing a rise in aging population when its people of 60 years old and above reach almost 10% of the total population. The population of individuals aged 60 years and beyond is projected to rise from 1 billion in 2020 to 1.4 billion in 2030, and further to 2.1 billion in 2050 by the end

of the decade. Thus, it can easily be concluded that by 2050, 1 in 6 people will be 60 years or older (WHO, 2022).

Back in 1950, the world population was 2.5 billion and now it stands at 8 billion and UN expects the global population of 10.4 billion by the end of the century which is a 47% increment. In the 1950s, young children outnumbered the older adults. The number of children born has increased since the 1950 to 2018 which is from 97 million to 143 million respectively, with decreased mortality among children as well (Nations, 2022). This contributed for the increase of the world population. Figure 2.1 shows the evolution of the number of five age groups including children (under 5 years old) and (5 to 14 years old), youth (15 to 24 years old), adults (25 to 64 years old) and older adults (65 years and older). The figure shows that the adult population of the working ages (25 to 64 years old) make up the largest age segment (3.91 billion – 49%) of the world population, followed by children (5 to 14 years old) (1.22 billion – 15%).

Although older adults only represent 9% of the world population in 2021, it is estimated to increase to 16% in 2050 and 24% in 2100. On the contrary, the children and youth age group continue to face an estimated decline. The youth age group is expected to decline from 15% in 2021 to 13% and 11% in 2050 and 2100 respectively (Affairs, 2023). This projection can be seen in Figure 2.2. In conclusion, when projected to 2100, there will be fewer children born at the end of the century, but the number of working age people and old age will increase drastically.

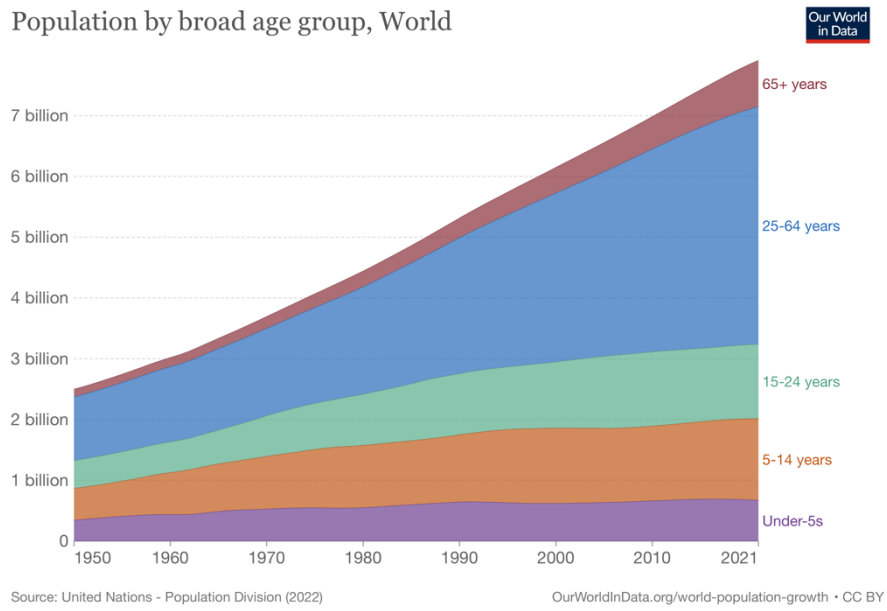

Figure 2.1: Population by broad age group, World (1950-2021)

Source: United Nations – Population Division (2022)

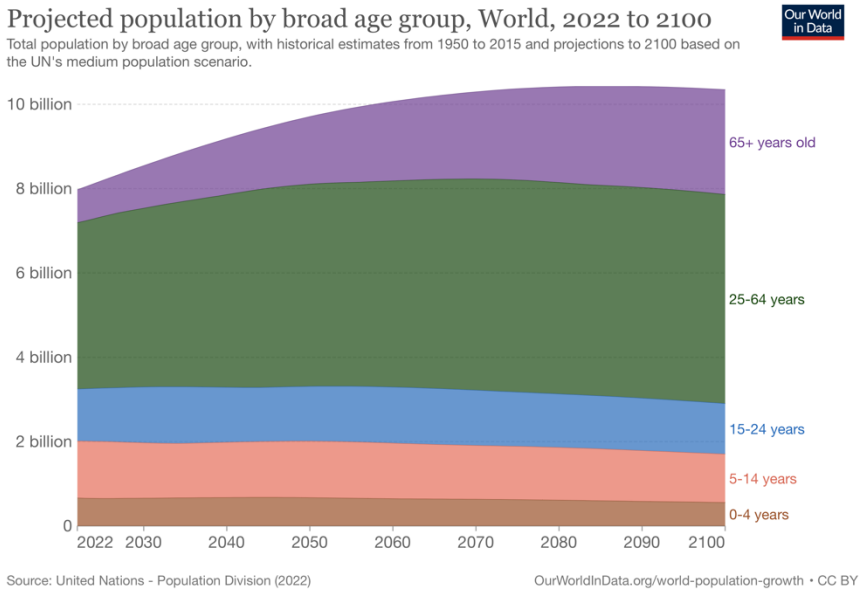

Figure 2.2: Projected population by broad age group, World (2022-2100)

Source: United Nations – Population Division (2022)

Eastern and South-Eastern Asia, Latin America and Caribbean are the regions that are and would be experiencing the most drastic changes in an aging population. Population ageing is progressing more rapidly in these regions due to the presence of more developing countries (Affairs, 2023; Nations, 2019). The aging population in developed countries is influenced by factors such as economic growth, government policies on medical advancements, and individuals' choices regarding family planning. Additionally, international organizations that aid in the welfare development of developing nations and the rising emigration rates to these countries also contribute to this trend (Nagarajan et al., 2021). This trend could be seen in Table 2.1.

Table 2.1: Number of persons aged 65 years or over by geographic region, 2019 and 2050

Region	**Number of persons aged 65 or over in 2019 (millions)**	**Number of persons aged 65 or over in 2050 (millions)**	**Percentage change between 2019 and 2050**
World	**702.9**	**1548.9**	**120**
Sub-Saharan Africa	31.9	101.4	218
Northern Africa and Western Asia	29.4	95.8	226
Central and Southern Asia	119.0	328.1	176
Eastern and South-Eastern Asia	260.6	572.5	120
Latin America and the Caribbean	56.4	144.6	156
Australia and New Zealand	4.8	8.8	84
Oceania, excluding Australia and New Zealand	0.5	1.5	190
Europe and Northern America	200.4	296.2	48

Source: United Nations, Department of Economic and Social Affairs, Population Division (2019)

2.2.1 The Causes and Implications of an Aging Population

The demographic transition is the primary factor that influences changes in the age distribution of a population. Demographic transition often involves a population moving from high birth and death rates to a lower and more consistent level of both birth and death rates (Roser, 2023). The demographic shift consists of three stages, commencing with a Malthusian world as proposed by Thomas Robert Malthus in 1798, where both death and fertility rates are high, and population increase is minimal. High death rates offset high birth rates (Miles, 2023).

During the first stage of the demographic transition, mortality rates start to decrease while fertility rates remain high, leading to a rise in the proportion of children as mortality decreases most significantly among the youngest age groups. In the second stage, fertility starts to decrease, leading to a reduction in the population growth rate while still being positive. This phase could endure for a maximum of 50 years. This results in a quicker growth rate of the working-age population compared to the overall population. During the third stage, mortality and fertility will approach a state of low equilibrium, resulting in the general population ceasing to expand and maybe decreasing (Zucker & Bloom, 2023). An increase in the old population occurs rapidly, while low birth rates hinder the growth of the working-age population. Once all three stages of transition are completed, population growth stabilizes close to zero as fertility and death reach a low level. The entire change requires almost a century to occur, leading to a significantly increased population growth. The demographic shift is expected to be accomplished worldwide by the year 2100 (Amaral, 2023).

Demographically, population aging is caused by decreasing fertility, decreasing mortality and migration. Decreasing fertility and mortality leads to the increase in life expectancy and longevity. Demographic study indicates that during the early stages of the 19th century, no country had a life expectancy exceeding 40 years, primarily due to severe poverty, famine, and little medical literacy (Davenport, 2021). 150 years later, certain regions of the world had significant advancements in health, resulting in newborns in Europe, North America, Oceania, Japan, and parts of South America having a life expectancy surpassing 60 years. This can be seen in Figure 2.3 and Figure 2.4 showing the life expectancy from different regions during the 1900 and 2021 respectively.

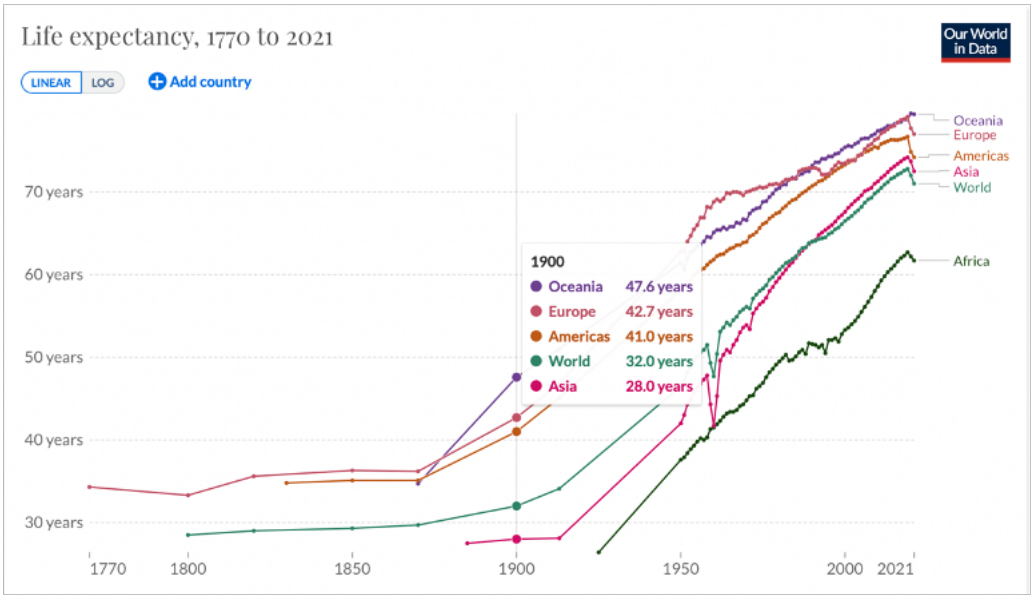

Figure 2.3: Life expectancy, 1900

Source: United Nations- Population Division, 2022

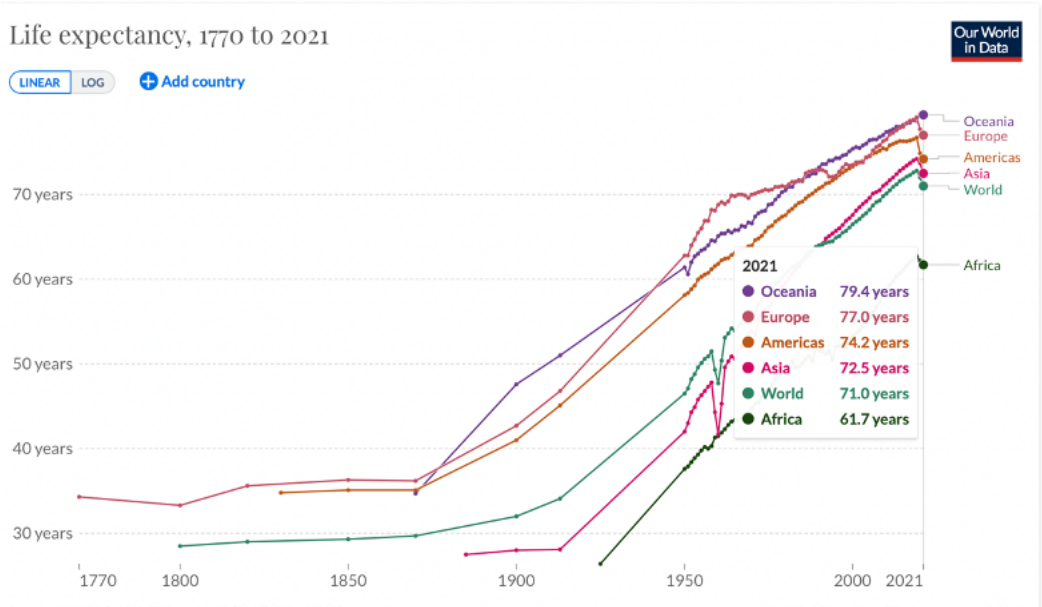

Figure 2.4: Life expectancy, 2021

Source: United Nations- Population Division, 2022

However, total fertility rate (TFR) globally has halved over the last 50 years. TFR is the mean number of offspring a woman would have in her lifetime if she were subject to the prevailing age-specific fertility rates throughout her reproductive years. Since 1965, an average woman in the world had more than 5 children which now, has reduced to below 2.5 children. This is shown in Figure 2.5. Consequently, the global population growth has declined, from a peak of 2.3% per year in 1963 to less than 1% today, hence the numbers of young children will decline. This will decrease the number of working age population. Nevertheless, it increases life expectancy resulting in an increased number of older populations (Vollset et al., 2020).