THE RELATIONSHIP BETWEEN DIETARY VITAMIN B12 INTAKE, BODY MASS INDEX (BMI) AND WAIST-TO-HIP RATIO (WHR), WITH THE RISK OF DEMENTIA AMONG OLDER ADULTS IN HOSPITAL PAKAR UNIVERSITI SAINS MALAYSIA, KELANTAN

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by

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DECLARATION

I hereby declare that this dissertation is the result of my own investigations, except where otherwise stated and duly acknowledged. I also declare that it has not been previously or concurrently submitted as a whole for any other degrees at Universiti Sains Malaysia or other institutions. I grant Universiti Sains Malaysia the right to use the dissertation for teaching, research and promotional purposes.

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SITI NUR ATIKAH BINTI SHAIFUL NIZAM
Date: 1 July 2025

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LIST OF ABBREVIATION

ABBREVIATION	DESCRIPTION
ACE III	Addenbrooke's Cognitive Examination III
BBB	Blood Brain Barrier
BMI	Body Mass Index
CRP	C-Reactive Protein
DNA	Deoxyribonucleic Acid
DOSM	Department Of Statistics Malaysia
ESRD	End Stage Renal Disease
FFQ	Food Frequency Questionnaire
HPUSM	Hospital Pakar Universiti Sains Malaysia
IL-6	Interleukin-6
IQR	Interquatile Range
KRK	Klinik Rawatan Keluarga
SD	Standard Deviation
SPSS	Statistical Package for Social Sciences
TNF-α	Tumor Necrosis Factor-alpha
USM	Universiti Sains Malaysia
WHO	World Health Organization
WHR	Waist to Hip Ratio

PERKAITAN DI ANTARA TAHAP PENGAMBILAN VITAMIN B12 DALAM PEMAKANAN, INDEKS JISIM BADAN DAN NISBAH PINGGANG DAN PINGGUL, DENGAN RISIKO DEMENTIA DALAM KALANGAN WARGA EMAS DI HOSPITAL PAKAR UNIVERSITI SAINS MALAYSIA, KELANTAN

ABSTRAK

Demensia merupakan salah satu isu kesihatan awam yang semakin meningkat dalam kalangan populasi warga emas dan dipengaruhi oleh pelbagai faktor, termasuk pemakanan dan komposisi badan. Oleh itu, kajian keratan rentas ini dijalankan untuk mengkaji hubungan antara Indeks Jisim Badan (BMI), nisbah pinggang-ke-pinggul (WHR), dan tahap Vitamin B12 dengan risiko demensia dalam kalangan 132 warga emas berumur 60 tahun ke atas di Hospital Pakar Universiti Sains Malaysia (HPUSM), Kelantan. Maklumat sosiodemografi, data antropometri, pengambilan makanan, dan skor fungsi kognitif telah dikumpul. Untuk menilai tahap pengambilan vitamin B12, kaedah rekod diet 24 jam telah digunakan bagi menangkap keseluruhan corak pemakanan harian peserta. Sementara itu, status kognitif dinilai menggunakan *Addenbrooke's Cognitive Examination III (ACE-III)* sebagai alat saringan untuk mengenal pasti sama ada peserta berisiko tinggi untuk mengalami demensia atau tidak. Hasil kajian menunjukkan terdapat hubungan negatif yang signifikan antara BMI ($r = -0.185$, $p = 0.034$) dan WHR ($r = -0.191$, $p = 0.029$) dengan status kognitif, menunjukkan bahawa peratusan lemak badan yang lebih tinggi dikaitkan dengan prestasi kognitif yang lebih rendah. Sebaliknya, tahap vitamin B12 menunjukkan hubungan positif yang signifikan ($r = 0.395$, $p < 0.001$), menunjukkan bahawa vitamin B12 mungkin berperanan dalam melindungi kesihatan otak. Walau bagaimanapun, ketiga-tiga pemboleh ubah ini bukanlah satu-satunya faktor yang mempengaruhi risiko demensia. Terdapat juga pelbagai faktor lain seperti peningkatan usia, tahap pendidikan yang rendah, atau pendapatan isi rumah yang terhad yang mungkin turut menyumbang kepada risiko demensia dalam kalangan warga emas. Justeru itu, lebih banyak kajian disarankan agar dapat memberikan pemahaman yang lebih mendalam terhadap pelbagai faktor yang menyumbang kepada kemerosotan fungsi kognitif dalam kalangan warga emas, khususnya yang berkaitan dengan pengambilan pemakanan dan komposisi badan, agar strategi pencegahan demensia dapat dirancang dan dilaksanakan secara berkesan.

THE RELATIONSHIP BETWEEN DIETARY VITAMIN B12 INTAKE, BODY MASS INDEX (BMI) AND WAIST-TO-HIP RATIO (WHR), WITH THE RISK OF DEMENTIA AMONG OLDER ADULTS IN HOSPITAL PAKAR UNIVERSITI SAINS MALAYSIA, KELANTAN

ABSTRACT

Dementia is a growing public health concern among the aging population and is influenced by multiple factors including nutrition and body composition. Therefore, this cross-sectional study aimed to investigate the relationship between Body Mass Index (BMI), Waist-to-hip ratio (WHR), and vitamin B12 intake with the risk of dementia among 132 older adults aged 60 years and above in Hospital Pakar Universiti Sains Malaysia (HPUSM), Kelantan. Sociodemographic information, anthropometric data, dietary intake, and cognitive function scores were collected. 24 hours diet recall is used to measure the vitamin B12 intake, so that the entire's diet of the participants can be captured. Then, for the cognitive status, Addenbrooke's Cognitive Examination III is used as a screening tool to identify if the participants have the high risk of develop dementia or not. The results revealed a significant negative correlation between BMI ($r = -0.185$, $p = 0.034$) and WHR ($r = -0.191$, $p = 0.029$) with cognitive status, indicating that higher body fat was associated with lower cognitive performance. In contrast, vitamin B12 intake showed a significant positive correlation ($r = 0.395$, $p < 0.001$), showing that vitamin B12 might help protect brain health. However, these three variables are not the only factors influencing dementia risk. There are many other factors like increasing age, lower education level, or limited household income may also influence the risk of dementia among older adults. Nonetheless, it is suggested that more studies should be conducted to provide a clearer understanding of the multiple factors contributing to cognitive decline among older adults, particularly in relation to nutritional intake and body composition, to ensure effective strategies can be implemented for the prevention of dementia.

CHAPTER 1
INTRODUCTION

1.1 Background of study

The aging population is a growing trend observed across all regions, and Malaysia is no exception and by the year 2030, the propotion of Malaysians aged 60 and above is expected to reach 15.3 percent. This shift is important because as the population gets older, health problems like dementia are also expected to increase (Abdullah et al., 2024).

Dementia which is a progressive neurodegenerative disorder that significantly impairs cognitive functions, including memory, thinking, language, and the ability to perform daily activities (Kumar et al., 2024). Dementia is not a disease, but it is a clinical syndrome arising from range of medical conditions that cause abnormal brain changes. It is defined as progressive decline in memory and other cognitive functions that becomes severe enough to interfere with the usual activities and independent living (Chertkow et al., 2013). Alzheimer's disease is the most common type of dementia, accounting for 60–70% of cases, followed by vascular dementia and other, rarer types (World Health Organization, 2025). Since it calls for exhaustive treatment over an extensive period, dementia is a serious burden to households, health care systems and the populations the total number of individuals with dementia continues to grow (Cloak et al., 2024). Therefore, knowing about dementia and its risk factors is important to formulate effective prevention strategies and facilitate the quality of life for older adults. As this cognitive decline may be reversible, early detection and awareness of the disease can lead to interventions that can slow the development of cognitive change.

Though aging is a natural process, certain risk factors, including nutrition, physical activity, and body composition, may be modifiable factors that impact the risk of cognitive decline. One of these modifiable factors includes vitamin B12 intake, as it is an essential water-soluble vitamin for neurological health and cognitive function (Hasbaoui et al., 2021). Vitamin B12 is involved in the production of myelin that protects nerve fibres and in the synthesis of neurotransmitters essential for brain function (Baik, 2024). According to the research conducted by Sah et al., (2023) a lack of vitamin B12 could contribute to increased homocysteine concentrations associated with brain atrophy, cognitive decline, and dementia.

Out of nutrition, anthropometric variables including Body Mass Index (BMI) and Waist-Hip Ratio (WHR) were also linked to dementia risk. BMI, which indicates overall body fat, has a relationship with cognitive decline (Liu et al., 2019). However, longitudinal studies have indicated that increased weight, obesity and excessive weight gain at midlife are associated with higher risk of dementia in later life (Singh-Manoux et al., 2018, Whitmer et al., 2005).

Currently, studies regarding the relationship of dietary vitamin B12, BMI, WHR with dementia risk are still limited especially in the Malaysian population. The health behaviours and dietary patterns practiced in Kelantan are not similar with other regions, thus it is imperative to determine this association in this region to formulate a culturally appropriate intervention for the population. Hospital Pakar Universiti Sains Malaysia (HPUSM) in Kelantan, is an ideal setting for this study because it serves a diverse group of older adults in the area. This study aimed to examine the relationship of dietary vitamin B12 intake, BMI, and WHR with the risk of dementia among older adult in HPUSM, Kelantan. The findings from this research may serve as a guide for public health and clinical guidelines, in the role of diet and lifestyle style in the prevention of dementia. By

identifying key modifiable risk factors, this study hopes to contribute to the growing body of evidence on the prevention of dementia and improve the cognitive health and quality of life of older adults in Kelantan and beyond.

1.2 Problem Statement

The rise in prevalence due to an aging population poses a major public health challenge, especially among older adults. Dementia is currently the seventh leading cause of death and one of the leading causes of disability and dependency among older adults globally, according to the World Health Organization 2025. This condition is not only giving a high burden on patients, families, and society, but at the same time, it significantly burdens healthcare systems and long-term care services (Cloak et al., 2024). According to Wati Nikmat et al., (2011), Malaysians have very low levels of knowledge and awareness about dementia and most people in Asian countries, including Malaysia, think that dementia is a normal condition that caused by the aging. Thus, it is crucial to discover and understand modifiable risk factors for dementia in order to develop effective prevention and intervention strategies.

Several risk factors contribute to dementia, are nutritional deficiency especially vitamin B12. Vitamin B12 deficiency has been associated with a number of neurological disorders and data suggests that very low serum levels of vitamin B12 can cause severe cognitive impairment (Umekar et al., 2025). Vitamin B12 plays a vital role in the methylation of myelin, neurotransmitters, and membrane phospholipids, whose deficiency may lead to neurological impairments such as loss of memory and cognitive dysfunction (Baik, 2024). In addition, older adults are more likely to experience vitamin B12 deficiency as the body becomes less adapt at taking in this vital vitamin with age,

and thus the cognitive effects may be most pronounced in this population (Beaudry-Richard et al., 2025.,Leigh, 2025). Other metabolic parameters such as vitamin B12 intake, BMI and WHR, are critical components of metabolic health and have all been associated with increased dementia risk. Obesity, characterized by higher BMI, is linked with systemic inflammation and vascular health degradation, which also has adverse effects on cognitive ability. WHR, a metric used to evaluate excess body fat, especially abdominal fat, has also been associated with health risks (Cheng et al., 2025., Liu et al., 2019., Zeng et al., 2024).

There is, however, limited data on elderly population in Malaysia, particularly the relationship between dietary vitamin B12 intake, BMI and WHR with dementia risk among older adults in HPUSM, Kelantan and the present study aims to explore this apparent deficit. The main question to answer is how these elements correlate and together influence cognitive health. This research aims to clarify these relationships as a first step toward informing future dietary recommendations and health interventions that may reduce dementia risk in this at risk population.

1.3 Research Question
The following questions are sought to be answered at the end of the study:

I.   What is the mean WHR and BMI of older adults by gender in Hospital Pakar Universiti Sains Malaysia, Kelantan?

II. What is the propotion of dementia risk among older adults by gender in Hospital Pakar Universiti Sains Malaysia, Kelantan?

III. What is the dietary vitamin B12 intake among older adults by gender identified as being at risk for dementia?

IV. Is there a relationship between WHR and the risk of dementia among older adults in Hospital Pakar Universiti Sains Malaysia, Kelantan?

V. Is there a relationship between BMI and the risk of dementia among older adults in Hospital Pakar Universiti Sains Malaysia, Kelantan?

VI. What is the relationship between vitamin B12 intake and the risk of dementia among older adults in Hospital Pakar Universiti Sains Malaysia, Kelantan?

1.4 Research Objective

1.4.1 General Objectives

To determine the relationship between dietary Vitamin B12 intake, Body Mass Index (BMI) and Waist-to-hip ratio (WHR), with the risk of Dementia among older adults in Hospital Pakar Universiti Sains Malaysia, Kelantan (HPUSM).

1.4.2 Specific Objectives

I. To determine the mean WHR and BMI of older adults by gender in Hospital Pakar Universiti Sains Malaysia, Kelantan.

II. To assess the propotion of dementia risk among older adults by gender in Hospital Pakar Universiti Sains Malaysia, Kelantan.

III. To determine the dietary vitamin B12 intake among older adults by gender with risk of dementia.

IV. To determine the relationship between WHR and the risk of dementia among older adults in Hospital Pakar Universiti Sains Malaysia, Kelantan.

V. To determine the relationship between BMI and the risk of dementia among older adults in Hospital Pakar Universiti Sains Malaysia, Kelantan.

VI. To determine the relationship between vitamin B12 intake and the risk of dementia among older adults in Hospital Pakar Universiti Sains Malaysia, Kelantan.

1.5 Research Hypothesis

1.5.1 Null hypothesis (Ho)

I. There is no relationship between WHR and the risk of dementia among older adults in Hospital Pakar Universiti Sains Malaysia, Kelantan.

II. There is no relationship between BMI and the risk of dementia among older adults in Hospital Pakar Universiti Sains Malaysia, Kelantan.

III. There is no relationship between vitamin B12 intake and the risk of dementia among older adults in Hospital Pakar Universiti Sains Malaysia, Kelantan.

1.5.2 Alternative hypothesis (HA)

I. There is a relationship between WHR and the risk of dementia among older adults in Hospital Pakar Universiti Sains Malaysia, Kelantan.

II. There is a relationship between BMI and the risk of dementia among older adults in Hospital Pakar Universiti Sains Malaysia, Kelantan.

III. There is a relationship between Vitamin B12 and the risk of dementia among older adults in Hospital Pakar Universiti Sains Malaysia, Kelantan.

1.6 Justification of study

These results will provide information on potentially modifiable dementia risk factors, and we can compare it to the vitamin B12 intake, BMI, and how fat is distributed in the body (WHR) to understand the impact on dementia risk. Vitamin B12 is necessary for brain function but many elderly individuals do not get enough of it. On the other hand, high BMI and adverse fat distribution measured by WHR are related to metabolic syndrome and cardiovascular diseases that are both risk factors for developing dementia (Czernichow et al., 2011.,Z. Liu et al., 2019). This is a particularly important point

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considering the limited research currently undertaken in Malaysia with regards to the interaction and contribution of all three of these variables in influencing dementia risk, which this research aims to address. The findings may give rise to specific nutritional and weight management strategies for this population and have implications for better health in older adults and potentially lower the social and economic burden of dementia. In the end, such research may result in strategies to prevent or delay dementia, improving older people's quality of life.

1.7 Conceptual Framework
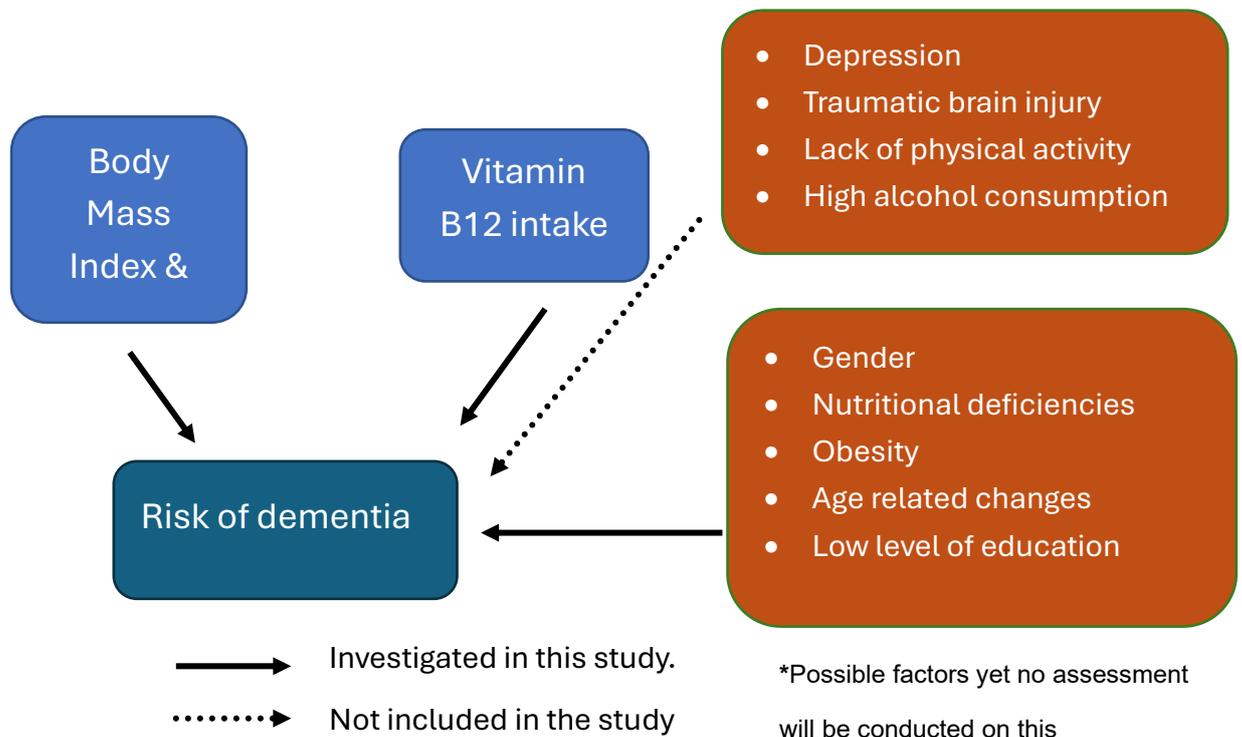
Figure 1.7 Conceptual framework of cause and effect related to Body Mass Index (BMI), Waist-to-hip ratio (WHR) and vitamin B12 intake with the risk of dementia among older adults in Hospital Pakar Universiti Sains Malaysia, Kelantan.

Dementia is a progressive neurodegenerative syndrome resulting in memory, cognitive, and instrumental impairment (World Health Organization, 2025). BMI and WHR are well-established measures of body composition and fat distribution. Excess body fat,

especially abdominal fat, can increase the risk of metabolic diseases that may lead to cognitive impairment (Fauziana et al., 2016.,T. Zhang et al., 2018). On the other hand, vitamin B12 deficiency is known to lead cognitive decline since vitamin B12 is an important part for normal brain functioning and nerve maintenance (Rosenberg, 2024).

Given that the three factors listed have the most obvious potential to change the risk of dementia, especially the aging populations which specifically focused on BMI, WHR and vitamin B12 intake. However, there are other factors that very likely impact dementia risk, which are not even in the scope of this study. These factors include depression, traumatic brain injury, lack of physical activity, high alcohol consumption and low level of education.

This framework underscores the need to investigate whether modifiable factors such as BMI, WHR, and vitamin B12 intake relate to dementia risk. It also acknowledges there are other things that can cause dementia but are beyond the scope of this study. Therefore, this study highlights the relationship between cognitive decline among older adults' patients and BMI, WHR and vitamin B12 intake among older adults in the HPUSM in the state of Kelantan.

CHAPTER 2

LITERATURE REVIEW

2.1 Prevalence of dementia among older adults in Malaysia

Dementia is a term describing a group of cognitive dysfunctions that disrupts daily living where it is impacting memory, thinking and social abilities (Cipriani et al., 2020). It includes a variety of forms, such as Alzheimer's disease, vascular dementia, and Lewy body dementia which all give a challenge to individuals and families that impacted. According to Alzheimer's Association, stated that when people have a memory loss, they can have trouble with language, experience impaired judgment, mood changes, and a decrease in ability to complete everyday tasks, and these symptoms usually worsen over time which it is severely affecting quality of life and independence. Global population aging has increasingly focused public health attention on dementia, because of its devastating effects on quality of life and on the health care system. Dementia is a growing issue in Malaysia, as in many other countries. As recorded by the Department of Statistics Malaysia (DOSM), the age group of 65 years and above as a proportion of the total population increased from 7.2% to 7.4% during a certain period, which is a signal that Malaysia is entering into population ageing. This demographic change is reinforced by a Malaysia's growing total population which was estimated at 33.4 million in 2023, up from 32.7 million in 2022, with an annual population growth rate of 2.1%. According to a report by DOSM, the proportion of older adults in Malaysia is expected to be almost at a similar level as the younger population (14.5% vs 18.6%) by 2040, with more than 6 million people aged 60 and above. With this transition, Malaysia will officially be

classified as an aged society. Therefore, the increasing aging population will contribute to the increasing number of people suffering from dementia disease in Malaysia.

2.2 Risk factors of cognitive impairment

With time, an age-related decline in cognition occurs, especially in memory and executive functions, primarily as a result of neuronal loss, decreased synaptic plasticity and changes in brain structure (Murman, 2015).

The next non-modifiable risk factor for cognitive impairment is gender. The gender difference in cognitive impairment also has been consistently reported, as women in general are more at risk than men to develop dementia, especially to develop Alzheimer's disease (Beam et al., 2018). This gender difference might be related to hormonal changes, especially to the decline of estrogen during the menopausal period that possess neuroprotective effects (Levine et al., 2021; Mielke et al., 2014).

Then, sedentarily is an important modifiable risk factor for cognitive impairment. It has been well documented that regular physical activity has protective effects on brain health, as it supports hippocampal integrity (neurogenesis), increases cerebral blood flow and reduces vascular inflammation (Barnes & Corkery, 2018). Conversely, physical inactivity has been associated with a heightening in the risk of both cognitive decline and dementia (Blondell et al., 2014). Exercise, particularly aerobics, is known to enhance blood flow and alleviate arterial stiffness as well as improve cognitive performance, in part by promoting healthy blood flow in the brain. Even though substantial evidence indicates that exercise promotes vascular and brain health (Erickson et al., 2011).

Another high-risk factor for cognitive impairment is high consumption of alcohol. Repeated long-term alcohol abuse can lead to drinking-related damage to the brain and can also increase the risk for dementias such as Wernickes-Korsakoff syndrome which is the result of thiamine deficiency from prolonged consumption of alcohol (Ridley et al., 2013). Heavy drinking has been linked to an atrophy of brain regions essential for memory and cognitive expertise, specifically hippocampus. Older adults who consume moderate amounts of alcohol have cognition adversely affected, especially considering other risk factors such as age and nutritional deficiencies (Topiwala et al., 2017).

Education has been seen as a protective factor against cognitive decline, and those who are more educated are at a lower risk of cognitive impairment. This would be consistent with the use of the "cognitive reserve" hypothesis where education builds a buffer of cognitive skills and a cognitive "resource" of functional neural networks with which to compensate for brain aging or damage (Meng & D'Arcy, 2012; Stern, 2012). Low education is a risk factor for cognitive impairment and dementia possibly due to the fact that low education correlates with low cognitive reserve, which has poorer reserve for aging (Meng & D'Arcy, 2012; Stern, 2012). Educational interventions and lifelong learning may mitigate this risk.

2.3 Relationship between Waist-to-Hip ratio (WHR) and the risk of dementia

The WHR is increasingly recognized as a significant predictor of various health risks, including cardiovascular diseases, type 2 diabetes, and more recently, dementia (Fauziana et al., 2016). A higher WHR reflects a greater concentration of visceral fat,

which has been correlated with elevated levels of inflammation throughout the body. The progression of chronic inflammation to neuroinflammation has been observed, which is harmful for the health of the brain and linked to the survey of neurodegenerative diseases, including dementia (Ambikairajah et al., 2020; Anstey et al., 2011; Tang et al., 2021). WHR is an even more reliable predictor of dementia risk than BMI because it considers where fat is deposited on the body rather than just how much there is (Karlsson et al., 2022). For an example, postmenopausal women are doubly vulnerable to this phenomenon, as their hormones shift to promote abdominal obesity just as they have an increase in dementia risk (Kerwin et al., 2010; Shang et al., 2023). Too much fat in the abdominal area has been associated with alterations in the brain structure and function. It is known to hinder blood flow to the brain, which limits delivery of oxygen and nutrients that support cognitive health (Raji et al., 2024). Over time, this can cause neuronal damage and raise the risk of cognitive decline, including dementia. This may, in turn, affect the brain's ability to clear waste products, including beta-amyloid, a factor linked to Alzheimer's disease (Solis, et al., 2020).

2.4 Relationship between body mass index (BMI) and risk of dementia

BMI is a widely used metric for determining if someone is underweight, healthy, overweight or obese using body weight and height, and the role of BMI in the development of dementia has been investigated recently (Kang et al., 2021). Study demonstrating that have led to the identification of therapeutic targets identified as obesity-related metabolic disorders like insulin resistance and chronic inflammation lead to neurodegeneration (Dhurandhar et al., 2025; Zeng et al., 2025). A study found that those with obesity had a higher likelihood of developing dementia when compared to

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those with normal BMI, even after correcting for confounding risk factors like smoking and hypertension (Ma et al., 2020), the effect of weight change across the life span has also been studied in association with dementia which weight gain in mid-life was found to be a strong predictor of dementia in old age, while weight loss in late life is likewise strongly predictive of cognitive decline, particularly when it occurs after midlife obesity (Albanese et al., 2017; Xu et al., 2011). The mechanisms through which obesity affects brain health are associated with inflammation and insulin resistance where both increased in the presence of excess body fat. Moreover, insulin resistance has been shown to affect the metabolism of glucose in the brain, an effect that contributes to cognitive dysfunction and the evolution of dementia (Ghowsi et al., 2021).

2.5 Role of Vitamin B12 in cognitive function

Vitamin B12 is a water-soluble vitamin which is essential as a cofactor for Deoxyribonucleic Acid (DNA) synthesis and vital for the metabolism of every cell in the human body (Whitbourne, 2025). Deficiencies in vitamin B12 can lead to peripheral neuropathy, pernicious anemia, or cognitive disorders (Soh et al., 2020). Research conducted by Selhub et al (2000) has found a correlation between vitamin B12 deficiency and cognitive complications including memory loss, diminished attention span, and mental confusion. Deficiency can lead to dementia-like symptoms, particularly in older adults. Elevated serum levels of methylmalonic acid and homocysteine are known markers of a specific type of myelin impairment because of low levels of vitamin B12 (Jatoi et al., 2020; Selhub et al., 2000; Umekar et al., 2025). Beyond myelination, vitamin B12 is also involved in the production of neurotransmitters, the chemicals that carry signals between brain cells. Vitamin B12 is linked to the production of serotonin and

dopamine, which help to regulate mood, and can suppress depression and improve your overall mood, including memory and mental clarity. Elevated homocysteine is also linked to Alzheimer's, cardiovascular disease and stroke (Ganguly & Alam, 2015; Jatoi et al., 2020). Abnormal levels of the vitamin B12, which is being too high or too low may lead to the apoptosis or usually called as brain cell death, abnormal calcium flow in cells (calcium spillage), which can cause silent brain injury. This is likely due to oxidative stress and buildup of toxic homocysteine compounds, which are usually common when there are deficiency of vitamin B12 (Jatoi et al., 2020; Umekar et al., 2025). Several studies have reported that the increasing risk for cognitive decline in older healthy adults are due to the lower concentrations of vitamin B12. For example, a longitudinal study conducted by Smith et al.,(2010) found that older adults with low B vitamins (folate, B6 and B12) levels have a faster rate of brain atrophy, which is a major contributor to cognitive decline. In addition, Moore et al.,(2012), suggested that supplementation with vitamin B12 in people with low levels of that vitamin could delay the progression of cognitive impairment.

2.6 Interaction between vitamin B12 intake, BMI and WHR with the risk of dementia

Dementia can be significantly affected by the relationship between vitamin B12 levels, BMI and WHR. Vitamin B12 is crucial for healthy brain function. Facilitating the formation of myelin which protects neurons and synthesizing neurotransmitters, it supports cognitive processes (Umekar et al., 2025). Low B12 levels result in high homocysteine, leading to higher neuroinflammation and oxidative stress, known dementia risk factors (Ueno et al., 2022; Umekar et al., 2025). It is demonstrated that

those who do not consume sufficient vitamin B12 are at a greater risk of cognitive impairment and dementia also when combined with other metabolic risk factors, for example obesity. Having a high BMI, which is an indicator for obesity, is a known risk factor for dementia. Obesity in midlife is an important risk factor for metabolic disturbances such as insulin resistance, chronic systemic inflammation, and vascular dysfunction, which further leads to rapid cognitive decline (Baltaci et al., 2014). WHR is the most relevant indicator of central obesity than BMI (Khan et al., 2023). Elevated of WHR reflects and increased amount of visceral fat, suggesting that fat is being stored deep within the abdominal cavity around vital organs. Unlike subcutaneous fat, this visceral fat is very metabolically and hormonally active where it contribute to the release of proinflammatory cytokines (Olsthoorn et al., 2021; Salas-Venegas et al., 2022). These inflammatory molecules cross the blood-brain barrier to worsen neuroinflammation and accelerate the neurodegenerative processes associated with dementia (Janelidze et al., 2017; Olsthoorn et al., 2021; Salas-Venegas et al., 2022). Therefore, the interaction of low intake of vitamin B12, increased in BMI and WHR may dramatically increase the risk of developing diseases like dementia. Vitamin B12 deficiency may impair the defense mechanism of the body against inflammation and oxidative stress, while high BMI is linked with metabolic disturbances and high WHR is a reality reflecting high visceral fat and chronic systemic inflammation. These risk factors that overlap could also have an interactive effect that accelerates the decline of cognitive function.

2.7 Methods of measuring dietary vitamin B12 intake

For understanding on how vitamin B12 affects our health, it is important to understand how to evaluate the dietary intake accurately. Therefore, 24-hour diet recall is one of the dietary assessment tools that are used to help in estimating the nutrient intake, including vitamin B12. Using 24-hour diet recall, participants are asked to report all food

and drink consumed in the previous 24-hour diet recall, which enables detailed and specific collection of dietary data. The main advantage for this method is less burdensome for participants compared to other methods, such as food frequency questionnaires (FFQs) or weighed food records (Shim et al., 2014). However, this method also has limitations where it relies heavily on the participant's memory, making it prone to recall bias, especially among certain populations such as the elderly or those with cognitive impairments (Shim et al., 2014). Underreporting or overreporting food items and portion sizes can also lead to inaccuracies. To address this, researchers recommend collecting multiple 24HRs on non-consecutive days to improve reliability and provide a more comprehensive dietary assessment (Bailey, 2021). In this approach, food consumed is not simply counted, but instead, analysed using software like Nutritionist Pro to quantify specific nutrient intakes including those of vitamin B12, which is vital for both cognitive health and neurological function.

CHAPTER 3
METHODOLOGY

3.1 Research Design

A cross-sectional study design was used in this research to investigate the relationship between dietary vitamin B12 intake, body mass index (BMI) and waist-to-hip ratio (WHR), with the risk of dementia among older adults in Hospital Pakar Universiti Sains Malaysia, Kelantan since this cross-sectional study design is easy to conduct and cheap (Wang & Cheng, 2020). It also analyzes the data at a single point in time and gives useful evidence or clear view of the relationship among these variables within the target population (Wang & Cheng, 2020). It includes a survey with standardized questions and questionnaires for data collection. Dietary vitamin B12 intake was assessed using a detailed 24-hour diet recall, while anthropometric measurements of BMI and WHR were taken using standardized tools to ensure accuracy. Additionally, cognitive assessments were performed to evaluate the risk of dementia.

3.2 Study Location

The study was conducted at Hospital Pakar Universiti Sains Malaysia (HPUSM) in Kelantan, where focusing on several areas including Klink Dietetik Pesakit Luar, Klinik Warga, Klinik Rawatan Keluarga (KRK), Klinik Pakar Perubatan, Klinik Ortopedik, Klinik Radiologi, Wad Perubatan (7 Utara dan 7 Selatan), Wad Isomedikal, Wad Ortopedik (4 Utara, 4 Selatan dan 2 Zamrud), and Wad Surgeri (3 Utara, 2 Intan). These locations were selected due to the high number of older adults receiving treatment there, which provides an effective setting for data collection.

3.3 Study Population

References population

Older adults aged 60 years and above in Hospital Pakar Universiti Sains Malaysia, Kelantan including both inpatient and outpatient settings.

Target population

Older adults aged 60 years and above who are either attending the outpatient clinics or have been admitted to the wards at HPUSM, Kelantan.

Source population

Older adults aged 60 years and above who are admitted to HPUSM, covering both outpatient and inpatient settings.

Sampling frame

Registration list of older adults in the selected wards and other specific clinics in HPUSM.

3.4 Research Subjects

3.4.1 Inclusion and Exclusion Criteria

Inclusion Criteria

I.   Older adults aged 60 years and above

II. Female and male

III. Understand Malay and English language

IV. Patients who are present at the outpatient clinics or admitted to the wards at HPUSM

V.   Agree to participate in this study

Exclusion Criteria

I.   Those who are in intensive care unit (ICU) setting

II.   Severe hearing or visual impairment

III. Those who have infectious diseases

3.5 Sample Size Calculation

The sample size required for research was calculated according to the objectives of the study based on the use of the population variance of the given outcome variable.

<u>Sample size for first objective:</u>

For the first objective which is to assess the proportion of dementia risk among older adults by gender in HPUSM, Kelantan, one proportion calculation was used to estimate the sample size (Arifin, 2013). The formula for one proportion calculation is as shown below:

$$n = \left[\frac{Z}{\Delta}\right]^2 p (1 - p)$$

n   = sample size

Z   = value representing the desired confidence level.

Δ = absolute precision

p   = anticipated population proportion

Using Δ value of 0.05 and confidence level of 95% for the study, the Z-score will be 1.96. According to the first objective, proportion of dementia risk among older adults

by gender in Hospital Pakar Universiti Sains Malaysia, Kelantan is used as the anticipated population proportion. Ganapathy et al., (2020) reported that prevalence of dementia among older adults aged ≥60 years in Malaysia was found to be 8.5%. Thus, the anticipated population proportion is 0.085.

$$n = \left[\frac{1.96}{0.05}\right]^2 0.085\,(1-0.085)$$

$$= 119.51 \sim 120 \text{ subjects}$$

To account for potential non-response rate, extra respondents are required to be enrolled in the study. A higher non-response rate is chosen because the study population is a high-risk population due to health issues. Therefore, 10% dropout rate is applied to the sample size:

$$n = \left[\frac{1.96}{0.05}\right]^2 0.085\,(1-0.085) + 10\,\%$$

$$= 120 + 12$$

$$= 132 \text{ subjects}$$

Sample size for second objective:

Using Δ value of 0.1 and confidence level of 90% for the study, the Z-score will be 1.65. The second objective in this study is to determine the vitamin B12 intake among older adults by gender with the risk of dementia. The sample size calculation for this study will be based on the total B vitamins intake and its association with cognitive status of

the older adults in agricultural settlements (FELDA) in Kuantan, Pahang, as reported in the study conducted by Lokman et al., (2019). Researchers stated that most of the subjects have inadequate total vitamin B12 intake which is 63% out of 78 subjects. Thus, the anticipated population proportion is 0.63. The sample size calculation also will be performed using the one proportion formula, as demonstrated in a previous study conducted by (Arifin, 2013)

$$n= \left[\frac{1.65}{0.1}\right]^2 0.630 \, (1- 0.630)$$

$$= 63.46 \sim 63 \text{ subjects}$$

To account for potential dropouts, 10% dropout rate is applied to the sample size:

$$n = \left[\frac{1.65}{0.1}\right]^2 0.630 \, (1- 0.630) + 10\,\%$$

$$= 63 + 6.3$$

$$= 69.3 \sim 69 \text{ subjects}$$

3.6 Sampling Method

This study employs a convenience sampling method to recruit participants among the older adults in HPUSM, Kelantan. It has also been used because this approached provides easy access to participants, who were easily available at their hospital visits, making for efficient and cost-effective data collection (Nikolopoulou, 2022). Sociodemographic data is used to assess the eligibility of participants and those meeting

the inclusion criteria will be enrolled. This sampling method is suitable for the research because of numerous practical considerations and limitations. Despite some disadvantages likes potential biases and the inability to generalize, convenience sampling is still acceptable for the initial search for correlation (Nikolopoulou, 2022).

3.7 Research Instrument

3.7.1: Data Collection Form

The data collection for this study was conducted using a questionnaire and the participants were interviewed to obtain accurate and comprehensive responses. The data collection form was structured into five distinct sections: A, B, C, D, and E with each section was designed to gather specific types of information relevant to the study's objectives.

Part A focused on sociodemographic data and was designed to collect basic background information on the research subjects. Age, sex, ethnicity, marital status, level of education, occupation, and household income were included. Next for Part B focuses on the medical history domain, such as personal medical history, medication, polypharmacy, smoking history, fall history (12-month period), hospitalization history (12-month period), past surgeries, sleeping difficulty and nocturnal awakenings. Then Part C focused on anthropometric data in which weight, height, BMI, waist circumference, hip circumference, and WHR will be collected. Meanwhile for Part D consisted of an open ended questionnaire involving a 24-hours diet recall where this questionnaire was designed to assess an individual's dietary intake by asking them to recall and report all the foods and beverages they consumed in the previous 24 hours and the last component, which is part E, involved the administration of Malay version of Addenbrooke's Cognitive Examination III (ACEIII) to determine the cognitive status of

the participants. Permission to use this Malay version of ACE III questionnaire had already been obtained from the authors.

3.7.2: Anthropometric Measurement

Anthropometric measurements helped with assessing an individual health, nutritional status and risk for future diseases (Kobel et al., 2022). They also provided information regarding body composition, which could be useful for estimating nutritional deficiencies or identifying disorders like obesity (Gavriilidou et al., 2015; Kobel et al., 2022). In this study, height, waist and hip circumference and weight provided the main components used for calculation of BMI and WHR.

For height, the measurement was taken using bodymeter in brand SECA 206. Participants were required to remove shoes, slippers, sandals, hair accessories, jewellery, buns, or braids from the head, before measuring the height. The participants stood barefoot with the shoulders in relaxed and the scapula, buttocks and the heels must be in contact with the walls with arms by the side of body, legs straight and together. The head was held straight on, with the Frankfort horizontal plane of the subject such that a line from the ear to the eye was horizontal. The measuring rod was then lowered and stopped at a point where it reached the crown of the participant's head. The participant sat up tall but was relaxed, not standing on tip toes or slumping. Having the participant take a deep breath assisted with spine alignment, resulting in a more accurate and reproducible heights. The bodymeter (SECA 206) was calibrated and adjusted perpendicular to the surface of the floor before measurement. Height was measured in cm and recorded in the nearest 0.1 cm. After measuring the height and weight, BMI was determined by weight in kilograms divided by the square of height in meters (kg/m^2) and according to the Asian Pacific classification, BMI was divided into four categories; underweight ($\leq 18.5\ kg/m^2$),

normal (18.5-22.9 kg/m^2), overweight (23-24.9 kg/m^2)and obese ($\geq$ 25 kg/m^2) and this for both men and women. The cutoff for overweight and obese is lower for Asian population compared to other population because of increased risks of cardiovascular diseases and diabetes have been shown to be higher at BMI's lower than 25 kg/m^2 suggested for other ethnic groups (Lim et al., 2017; Nishida et al., 2004). BMI is a common measurement of body fat based on height and weight and is one of the main variables in assessing obesity, which has also been associated with a range of health risks, including cognition decline. For older adults though, different cut-off points were used because they have the natural occurrence of muscle loss (sarcopenia), increased abdominal fat and decrease in height. These changes in body composition render the standard BMI criteria less accurate for them (Singh & Chattopadhyay, 2024). Thus, according to the Malaysian Dietary Guidelines for Older Adults (2023), cut-off points for older adults were divided into three categories as underweight ($<$24 kg/m^2), normal weight (24-27 kg/m^2), and overweight/obese ($>$ 27 kg/m^2).

Then, for waist and hip circumference measurements, all procedures adhered to the WHO STEPwise Approach to Surveillance (STEPS) standards for accuracy. The measurement sites directly followed the WHO recommendations and used a SECA measuring tape calibrated with the accuracy of 0.1 cm. For waist circumference, the tape was held horizontally around the participant's waist, halfway between the lower margin of the last observable rib and the top of the iliac crest. For hip circumference, the measuring tape was at the widest part of the buttocks. These measurements were also only as accurate as the tightness of the measuring tape, and the location of the measuring tape should always be parallel to the floor at the level of measurement. The tape should fit around the body snugly, but not tightly enough to constrict and according to the WHO STEPS protocol, which prescribed the same instructions for waist and hip measurements.