THE ASSOCIATION BETWEEN DIET QUALITY AND GLYCAEMIC CONTROL AMONG TYPE 2 DIABETES MELLITUS PATIENT IN HOSPITAL PAKAR UNIVERSITI SAINS MALAYSIA (HPUSM)

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SCHOOL OF HEALTH SCIENCES
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By

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Dissertation submitted in partial fulfilment
of the requirements for the degree
of Bachelor of Health Science (Honours) (Dietetics)

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DECLARATION

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

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LIST OF ABBREVIATION

T2DM	Type 2 Diabetes Mellitus
HbA1c	Glycated Haemoglobin
HEI	Healthy Eating Index
MHEI	Malaysian Healthy Eating Index
S-MHEI	Standardized Malaysian Healthy Eating Index
MDG	Malaysian Dietary Guidelines
RNI	Recommended Nutrient Intake
WHO	World Health Organization
NDR	National Diabetes Registry
MANS	Malaysian Adult Nutrition Survey
ANS	Adolescent Nutrition Survey
NCDs	Non-Communicable Diseases
OGTT	Oral Glucose Tolerance Test
HPUSM	Hospital Pakar Universiti Sains Malaysia
KPP	Klinik Pakar Perubatan
KRK	Klinik Rawatan Keluarga
SPSS	Statistical Package for the Social Sciences
JEPeM	Jawatankuasa Etika Penyelidikan Manusia
TEI	Total Energy Intake
OA	Orang Asli
ADA	American Diabetes Association
OGLD	Oral Glucose-Lowering Drugs

HUBUNGKAIT ANTARA KUALITI DIET DAN KAWALAN GLISEMIK DALAM KALANGAN PESAKIT DIABETES MELITUS JENIS 2 DI HOSPITAL PAKAR UNIVERSITI SAINS MALAYSIA (HPUSM)

ABSTRAK

Diabetes mellitus jenis 2 (T2DM) merupakan masalah kesihatan yang semakin membimbangkan di Malaysia, di mana kualiti diet yang rendah menyumbang kepada kawalan glisemik yang tidak terkawal dan meningkatkan risiko komplikasi. Kajian ini bertujuan untuk menilai kualiti diet dan kawalan glisemik dalam kalangan pesakit T2DM serta mengenalpasti hubungkait antara kedua-dua pemboleh ubah tersebut. Kajian keratan rentas ini melibatkan 91 pesakit luar T2DM di Hospital Pakar Universiti Sains Malaysia (HPUSM). Majoriti responden adalah lelaki (51.6%), berumur ≥60 tahun (67.0%), Melayu (96.7%), berkahwin (85.7%), dan mempunyai sejarah keluarga T2DM (67%). Sebanyak 89% telah menghidap diabetes ≥5 tahun dan 84.6% menerima rawatan ubat oral penurunan glukosa (OGLD). Kualiti diet dinilai menggunakan Indeks Pemakanan Sihat Malaysia (M-HEI) manakala kawalan glisemik berdasarkan tahap HbA1c dalam tempoh 3 hingga 6 bulan lepas. Majoriti responden (79.1%) menunjukkan kualiti diet sederhana (skor M-HEI 51–80%), manakala 20.9% menunjukkan kualiti diet rendah (<51%), dan tiada yang mencapai skor tinggi (>80%). Dari segi kawalan glisemik, hanya 19.8% mempunyai HbA1c terkawal (≤7.0%) dan selebihnya tidak terkawal (>7.0%). Ujian Pearson menunjukkan tiada kolerasi signifikan antara kualiti diet dan kawalan glisemik (p= 0.586, r= -0.058). Kesimpulannya, ini menunjukkan keperluan untuk pendekatan pengurusan diabetes yang lebih menyeluruh, merangkumi aspek selain pemakanan seperti kepatuhan ubat, aktiviti fizikal, dan sokongan psikososial.

THE ASSOCIATION BETWEEN DIET QUALITY AND GLYCAEMIC CONTROL AMONG TYPE 2 DIABETES MELLITUES IN HOSPITAL PAKAR UNIVERSITI SAINS MALAYSIA (HPUSM)

ABSTRACT

Type 2 diabetes mellitus (T2DM) is an increasingly concerning health issue in Malaysia, where poor diet quality contributes to uncontrolled glycaemic levels and elevates the risk of complications. This study aimed to assess diet quality and glycaemic control among patients with T2DM and to determine the association between these two variables. A cross-sectional study was conducted involving 91 T2DM outpatients at Hospital Pakar Universiti Sains Malaysia (HPUSM). The majority of respondents were male (51.6%), aged ≥60 years (67.0%), Malay (96.7%), married (85.7%), and had a family history of T2DM (67%). Most had diabetes for ≥5 years (89%), were on oral glucose-lowering drugs (OGLDs) (84.6%). Diet quality was assessed using the Malaysian Healthy Eating Index (M-HEI), while glycaemic control was based on HbA1c levels recorded within the past 3 to 6 months. Most respondents (79.1%) had moderate diet quality (M-HEI score 51–80%), while 20.9% had poor diet quality (<51%), and none achieved high scores (>80%). Regarding glycaemic control, only 19.8% had controlled HbA1c (≤7.0%), whereas the remaining 80.2% had uncontrolled levels (>7.0%). Pearson's correlation test revealed no significant correlation between diet quality and glycaemic control (p= 0.586, r= -0.058). In conclusion, this highlights the need for a more comprehensive diabetes management approach that includes not only dietary aspects but also medication adherence, physical activity, and psychosocial support.

CHAPTER 1

INTRODUCTION

1.1 Background of Study

Type 2 Diabetes Mellitus (T2DM) is a chronic metabolic disorder which is characterized by elevated blood glucose level due to damage to the organ systems such as heart, vasculature, eyes, kidneys and nerves (Galicia-Garcia et al., 2020). Most cases of T2DM arise as a consequence of the insufficient insulin secretion from pancreatic islet β-cells, body tissues' resistance to insulin, and the eventual decline in capacity to produce sufficient insulin to gainsay these (Galicia-Garcia et al., 2020).

Glycaemic control is simply defined as maintaining glucose levels to the recommendable levels (Rakhis Sr et al., 2022). Its measurement is usually done in terms of the levels of glycated haemoglobin (HbA1c), which also measure the long-term blood glucose control in individuals with T2DM besides it is also as an important biomarker for glycaemic monitoring (Wang et al., 2021). In reality, many patients could not reach these optimal levels due to bad dietary habits, minimal exercise and lack of awareness and knowledge about T2DM self-management.

Diet is an important aspect of controlling T2DM. High-whole grains, fruits, vegetables, legumes and nuts and moderate alcohol with refined grains, processed meats and sugar-sweetened beverages in the diet reduce the diabetic risk and improve glycaemic control among T2DM patients (Jing et al., 2023).

1.2 Problem Statement

Many individuals are reported to suffer from type 2 diabetes mellitus (T2DM) in Malaysia, making it the most severe public health problem among countries in the world. The fight towards the management of T2DM is very complicated regarding the genetic, lifestyle, and environmental factors attached to it (Akhtar et al., 2022). One of the most pivotal modifiable factors in the management of diabetes is that of dietary quality and its effects on glycaemic control (Akhtar et al., 2022).

For example, in Malaysia, much of the high-caloric and low-nutrition foods are preferred, thereby contributing to poor-quality diet (Nik et al., 2019). Further, although all intakes of fruits, vegetables, and whole grains are identified as insufficient, intake of sugar, salt, and fats has been excessive (Kee et al., 2023) Despite providing dietary guidelines, most persons with T2DM are said not to follow such guidelines, poor glycaemic outcome results from such noncompliance and could lead to increased risk for diabetes-related complications such as nephropathy, retinopathy, and cardiovascular diseases (Hiong et al, 2020).

Key factors of dietary nonadherence are socio-economic status, duration of disease, limited knowledge on diabetes, cost of diet, which is healthy, and inadequate communication with health care providers (Tirfie et al., 2020). Besides, people with T2DM have problems regarding changing their eating habits, which are very much ingrained in their daily lives and social practices (Saito et. al, 2025). These obstacles are added with the insufficient dietary counselling and education tailored to individual needs, leaving many patients without the necessary tools to make informed food choices (Deshmane et. al, 2022). As a result, a poor-quality diet not only worsens hyperglycaemia but also reduces the effectiveness of other treatments (Premagowri, 2020). Addressing

these issues requires a deeper understanding of how diet quality influences glycaemic outcomes and identifying key determinants that hinder adherence to healthy eating practices among individuals with T2DM.

1.3 Research Objectives

General objective:

To assess the diet quality status and and glycaemic control among status among type 2 diabetes mellitus in Hospital Pakar Universiti Sains Malaysia (HPUSM)

Specific objectives:

1. To determine the diet quality status among type 2 diabetes mellitus in Hospital Pakar Universiti Sains Malaysia (HPUSM)
2. To determine the glycaemic control status among type 2 diabetes mellitus in Hospital Pakar Universiti Sains Malaysia (HPUSM)
3. To determine the association between diet quality and glycaemic control status among type 2 diabetes mellitus in Hospital Pakar Universiti Sains Malaysia (HPUSM).

1.4 Research Questions

1. What is the diet quality status among type 2 diabetes mellitus in Hospital Pakar Universiti Sains Malaysia (HPUSM)
2. What is the glycaemic control status among type 2 diabetes mellitus in Hospital Pakar Universiti Sains Malaysia (HPUSM)
3. Is there an association between diet quality and glycaemic control status among type 2 diabetes mellitus in Hospital Pakar Universiti Sains Malaysia (HPUSM).

1.5 Research Hypothesis

Null Hypothesis (H0): There is no association between diet quality and glycaemic control status among type 2 diabetes mellitus in Hospital Pakar Universiti Sains Malaysia (HPUSM).

Alternative Hypothesis (HA): There is an association between diet quality and glycaemic control status among type 2 diabetes mellitus in Hospital Pakar Universiti Sains Malaysia (HPUSM).

1.6 Significance of Study

It is essential to develop appropriate management strategies for coping with individuals' and the health system's burdens resulting from increasing prevalence of T2DM and its complications. It is a modifiable factor that influences the effectiveness of blood glucose control, thereby promoting a reduced risk of complications (Antonio et al., 2019).

This will add further knowledge to already known areas by citing evidence for the quality of diet in glycaemic control, especially in HbA1c levels, between Malaysian T2DM patients. The information will be useful for reference by dietetics students and other health professionals in the future. T2DM patients can spur greater awareness in their effort to motivate themselves to improve the quality of their diets. Better control will then improve their quality of life outcomes by reducing the complications of nephropathy, retinopathy and cardiovascular diseases.

Conceptual Framework

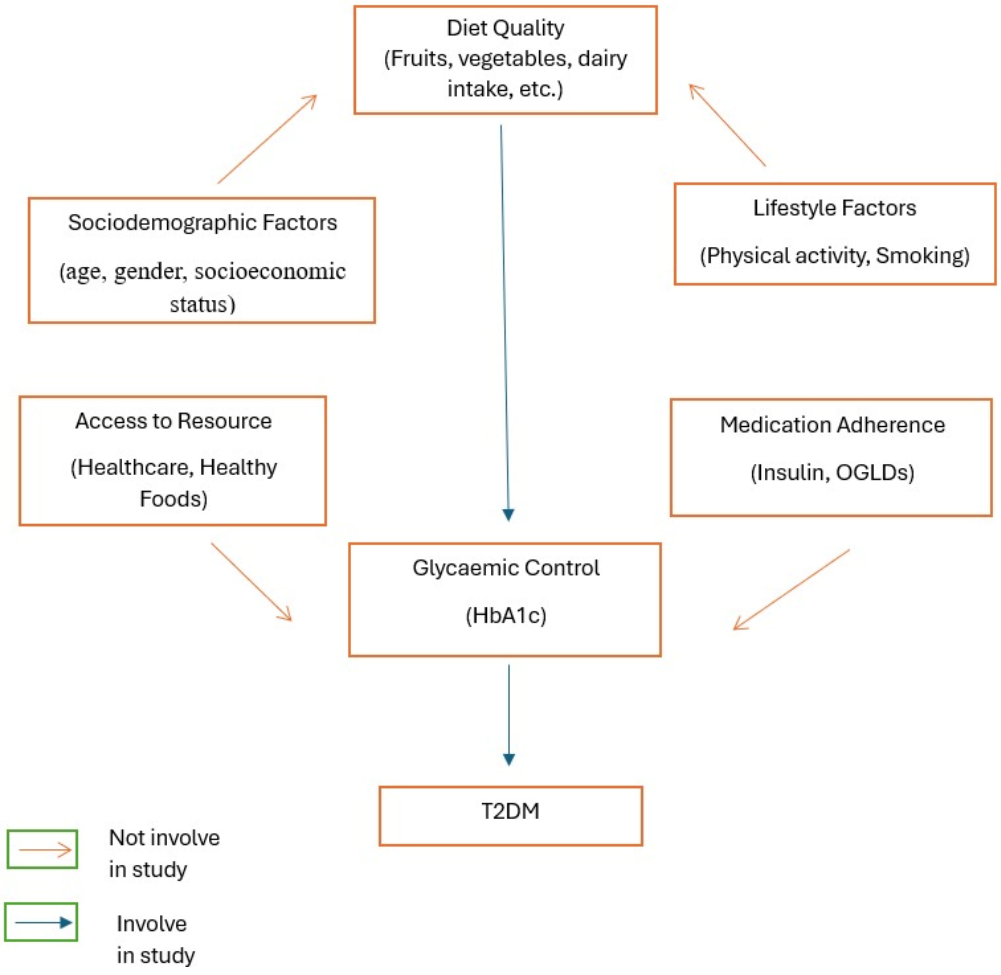

Figure 1: Conceptual Framework

Figure 1 shows the conceptual framework of the association between diet quality and glycaemic control in T2DM patients. A balanced diet that includes whole grains, fruits, vegetables, proteins and healthy fats that follow the recommended portion will indicates good diet quality and it leads to better glycaemic control and lower HbA1c levels due to stable blood sugar level (Nik et al., 2019). Therefore, diet quality is the independent variable and glycaemic control is the dependent variable. Other factor that is not included in the study are sociodemographic factors and lifestyle factors that can also impact diet quality of individuals (Rondhianto et al., 2024) (Karatzi et al., 2021). On than that, glycaemic control also can get affected by access to resource and medication adherence that contributes to T2DM and its complications (Sendekie et al., 2022) (Shaheen et al., 2021).

CHAPTER 2

LITERATURE REVIEW

2.1 Latest T2DM prevalence in Malaysia

In Malaysia, the prevalence of diabetes has increase intensely, as evidenced by the National Diabetes Registry (NDR) 2023 report, which documented 870,771 individuals diagnosed with diabetes, 99.48% of patients are discovered having T2DM. Malay ethnic group (60.13%) and females (57.08%) are the highest prevalence observed. Among the age group, 65 to 69 years old (16.10%) patients show the highest one, which indicates the elderly are susceptible to T2DM (NDR, 2023). Despite efforts to improve management, achieving glycaemic control remains a challenge in Malaysia because only 34.38% of patients met the glycosylated haemoglobin (HbA1c) target of ≤6.5% in 2023 (NDR, 2023).

2.2 Overview of Diet Quality

The Healthy Eating Index (HEI) is a measure of diet quality that reflects how well a person's diet comply with established dietary guidelines. HEI was made public for the first time in 1995, is a way of evaluating how good an overall diet is for the American population by synthesizing the dietary guidelines with nutrient requirements into one measure (Jailani et al., (2021). This has since undergone some changes and improvements, which went on to become the favourite adaptation of several other countries for evaluating how good the diet of its populace is in compliance with that of the nation itself (Jailani et al., 2021).

In Malaysia, it seems that the diet quality measure has limitations regarding application and relevance. The development of a new standardized Malaysian Healthy

Eating Index (S-MHEI), an instrument in measuring the quality of diet for all Malaysians, irrespective of their energy requirement level (Jailani et al., 2021). The Malaysia Dietary Guideline (MDG) 2010 and MDG for Children and Adolescents 2013 are the main references for the components developed in the index (Jailani et al., 2021). Additionally, the latest Adult Malaysian Nutrition Survey (MANS) and Adolescent Nutrition Survey (ANS) were also referred to ensure that the components selected are relevant (Jailani et al., 2021). The least restrictive approach was employed for adequacy components (total grains, whole grains, fruits, vegetables, fish, meat, poultry and eggs, legumes and nuts, milk and milk products) in establishing the standard for scoring system (Jailani et al., 2021). However, the scoring system for moderation components (sodium and added sugar) was built according to the Recommended Nutrient Intake (RNI) 2017 (Jailani et al., 2021). The S-MHEI now consists of 11 components with a maximum total score of 100 (Jailani et al., 2021). The least restrictive method could use the index across energy requirement levels. It would, however, forwardly not concern with adhering to the specific recommended amount of intake, thus making that the index focuses on measuring diet quality rather than diet quantity (Jailani et al., 2021).

The newly reformed standard MHEI (S-MHEI) becomes very essential instrument in judging at various times and population consistency among Malaysian people toward MDG by the Ministry of Health (Jailani et al., 2021). This information will facilitate in planning the intervention program, monitoring population, and strategy to reduce the incidence of malnutrition among Malaysian people per specific food groups. Also, that score can be effective in a broader area of research for more comprehensively understanding diet related diseases and demographic factors affecting poor dietary intake (Jailani et al., 2021).

2.3 Glycaemic Control in T2DM

The greater part of the time, glycaemic control measured through glycated haemoglobin or HbA1c levels in T2DM patients remains one of the greatest determinants of long-run outcomes. The poor glycaemic control exposes the patient to complications from nephropathy, retinopathy, and cardiovascular disease, which have been reported to be 12.70%, 11.12%, and 5.11% among patients with T2DM, respectively, in NDR 2023 (Ramakrishnan et al, 2023).

Since 1988, when the American Diabetes Association (ADA) recommended its use for assessment of glycaemic control in patients with diabetes, HbA1c has been accepted as a gold standard (Wang et al., 2021). For years, diabetes diagnosis rested on glucose measures-only fasting glucose or random glucose or the 75 g OGTT (Wang et al., 2021). At first, American Diabetes Association did not approve the use of HbA1c for diabetes diagnosis until in the year 2010, where improvements in assays spurred ADA's validation with diagnostic criteria for diabetes at cutoff ≥6.3%, pre-diabetic among those between the range of 5.7-<6.3%, and normal <5.7% (Wang et al., 2021). The MBS allowed HbA1c test to be subsidized for diabetes diagnosis once every 12 months in high-risk patients but maximum of 4 times a year for monitoring of established diabetes (Wang et al., 2021).

A result in measurement for HbA1c of 48 mmol/mol (6.5%) or higher is seen as diagnostic of diabetes through laboratory testing via a validated method (Wang et al., 2021). It should be encouraged, however, for use in measuring those who are potential diabetics. Advantage HbA1c is that it is easy to collect; no preparation for testing is required. Sample stability and greater reliability from day-to-day score better in comparison (Wang et al., 2021).

Test for HbA1c measures the percentage of glycosylated haemoglobin (i.e., has glucose attached to haemoglobin). This occurs because blood glucose bound to haemoglobin is contained in red blood cells (Sherwani et al., 2016). Red blood cells survive for about three months, therefore-associated HbA1c concentrations represent average blood glucose levels during this period (Sherwani et al., 2016). In summary, HbA1c is a reliable test in diagnosing and monitoring diabetes because it reflects the average blood glucose level over three months without the need for fasting.

2.4 Diet Quality Status in Malaysia

Malaysia is undergoing a nutrition transition propelled by rapid urbanization, changing lifestyles, and a growing prevalence of diet-related NCDs such as T2DM. Management is highly dependent on optimal glycaemic control, which, in turn, is highly dependent on diet quality. Evidence suggests that diet quality is suboptimal across Malaysia, across all age groups, socio-economic strata, and geographical settings. This is further compounded by a double burden of malnutrition, where obesity exists alongside undernutrition with major implications for public health. Poor dietary habits have been linked to deteriorating glycaemic control in T2DM patients, and hence this subject urgently warrants investigation.

For example, over 55% of adults in Malaysia were estimated to have diet quality ranked as "needs improvement" with a mean M-HEI score of 61.3 ± 10. Dietary imbalances among the urban populations, despite an increased exposure to all kinds of foods, include high intake of salt, sugar, and fats and low intake of recommended food groups like fruits, vegetables, legumes, and dairy products (Ramadas et al., 2021). Indian women, in particular, have the lowest HEI score (75.7 ± 8.1) among ethnic groups,

indicating disparities in dietary habits and quality among Malaysia's multi-ethnic population (Ramadas et al., 2021)

Rural and indigenous communities have inadequate diet quality. For example, in populations of Orang Asli (OA), diet quality is inadequate among 73.8% males and 59.1% females (Ramadas et al., 2021). The dietary diversity scores of children from rural regions were found to be relatively low while vegetables, milk, and fruits had been significantly deficit. Moreover, food insecurity-which has plagued 81 percent of the households in these communities-exacerbates dietary deficiencies and lack of access to nutrient-rich foods, leading to poor growth and health outcomes. On the other hand, the urban poor households often rely on calorie-dense, low-cost foods, contributing to a combination of obesity and micronutrient deficiencies. This has been consistent in pregnant women and women of childbearing age, with M-HEI scores ranging between 52.7–56.1% throughout pregnancy. These findings raise concern over possible long-term health implications both for mothers and their children.

Nutritional deficiencies and excessive intake of unhealthy foods are extremely high in Malaysia. The diets are uniformly insufficient to meet not only the national dietary recommendations but also those globally because of widespread deficits in fruit, vegetable, legume, and dairy intakes, added to an over-reliance on energy-dense, nutrient-poor foods, especially in urban areas where diets have become westernized. This has far-reaching health consequences, especially for the patient with T2DM, where poor diet quality translates into poor glycaemic control and disease progression. Poor M-HEI scores are associated with higher body mass index, abdominal obesity, and poor postprandial glucose regulation (Ziaee et al., 2021). This has a further complicating impact on the glycaemic control of the patients with T2DM and is a reason why so many patients end up needing insulin due to suboptimal dietary management.

The disparities in diet quality across communities are concerning. Although older adults have a slightly better diet quality score of 70.2 ± 12.0 compared to younger populations, the scores are far from optimal, especially in urban settings where Western dietary influences are more pronounced. Younger age groups, particularly adolescents, were more likely to adhere to Westernized dietary patterns characterized by high intakes of fast food, sweetened beverages, and processed snacks, placing them at an increased risk of developing T2DM and other chronic diseases at younger ages. Ethnic and gender disparities further exacerbate the problem, with males and Indian females consistently scoring lower in diet quality assessments; the disparities in diet quality across communities are a cause for concern. Although the diet quality scores for the older adults were slightly higher 70.2 ± 12.0, when compared with younger populations, they were still far from optimum, especially in urban centres where Western dietary influences are commanding. Younger generations, especially adolescents, are more likely to adhere to a Westernized dietary pattern characterized by high consumption of fast foods, sweetened beverages, and processed snacks, leading to an increased risk of T2DM and other diet-related chronic diseases at younger ages. Ethnicity and gender further complicate this issue, since men and Indian women always have the lowest scores when it comes to the assessment of diet quality. In addition, it may reduce the influence of poor dietary quality on glycaemic control in patients with T2DM and overall NCD burden in Malaysia by addressing the relevant issues.

2.4 Association between Diet Quality and Glycaemic Control in T2DM

A quality diet comprises diversification with a balance of quantities and nutrition sufficient to meet the calorie and nutritional requirements for growth and health maintenance. This quality diet comprises all those food groups, including fruits and

vegetables, whole grains, lean proteins, and healthy fats that are good for wellbeing and keeping diseases away (Wong et al.,2021). Health and nutrition include all these food components ranging from fruits and vegetables to select whole grains as well as lean protein with little-or-no contribution from unhealthy fats.

Diet quality ties directly to glycaemic control in individuals with T2DM (Santos et al., 2024). Higher diet quality, derived from dietary indices, indicates better glycaemic outcomes, primarily lower HbA1c levels. These indicate the critical role of dietary choices in blood glucose management (Santos et al., 2024). Dietary indices like the Healthy Eating Index indicate that diet quality has an impact on clinical outcomes in T2DM patients. According to studies, patients who had lesser diet quality were about thrice as likely to have poor glycaemic control compared to those with decent diet qualities (Antonio et al., 2019). Hence, diet quality has a major influence on diabetes management. These dietary patterns have proven efficacy in improving glycaemic control and are characterized by increased intake of whole grains, fruits, and vegetables, and low intakes of processed food and sugar. One study has indicated that patients consuming healthier dietary patterns had better glycaemic control compared with patients who consumed more red meat and processed foods (Qiang et al., 2025).

Adopting a high-quality diet, however, has other impediments such as playing to plan meals, access to healthy viable yet affordable foods, and, in addition, resistance to the availability of unhealthy options (Gillingham et al., 2024). Such barriers may thwart and keep an individual from consistently adopting dietary patterns that are favourable for glycaemic control (Gillingham et al., 2024).

CHAPTER 3

RESEARCH METHODOLOGY

3.1 Study Design

This study used a cross-sectional study design to investigate the association between diet quality and glycaemic control in patients with Type 2 Diabetes Mellitus (T2DM). In a cross-sectional design, data was collected from participants at a single point in time, providing a snapshot of the variables under investigation (Capili, 2021). This study design was appropriate for identifying the associations between diet quality and glycaemic outcomes in T2DM patients.

3.2 Study Area

The study was conducted at Hospital Pakar Universiti Sains Malaysia (HPUSM), with data collected from outpatients Dietetic Clinic, *Klinik Pakar Perubatan* (KPP), *Klinik Rawatan Keluarga* (KRK) or *Klinik warga.*

3.3 Study Population

The target population for this study consisted of adult patients with Type 2 Diabetes Mellitus (T2DM), who are from outpatients Dietetic Clinic, *Klinik Pakar Perubatan* (KPP), Klinik Rawatan Keluarga (KRK) or *Klinik warga.*

3.4 Selection Criteria

3.4.1 Inclusion criteria

i. Aged 19 and older

ii. Patients who diagnosed with T2DM

iii. T2DM patient in outpatient Dietetic Clinic, KPP, KRK or *klinik warga* in HPUSM

iv. Have HbA1c records for between 3-6 previous months

3.4.2 Exclusion Criteria

i. Patients with severe comorbidities or acute conditions (e.g., cancer, chronic liver disease, end-stage renal disease)

ii. Patients with cognitive impairments, psychiatric disorders, or other conditions affecting their ability to provide accurate dietary information.

3.5 Sample Size Calculation

95% - Z score = 1.96

$\Delta = 0.1$

No.	Objectives	Anticipated Population Proportion	Minimal Sample Size
1	To determine the poor glycaemic control status among type 2 diabetes mellitus. (Awang et al., 2020)	P: the population proportion that represents poor glycaemic control status among T2DM patients is 0.796 $n = (\frac{1.96}{0.1})^2 \ x\ 0.796\ x\ (1 - 0.796)$ n = 62.4 ~ 62	10% dropout rate (d = 0.10) 62+ (62x0.1) = 68.2 ~ 68
2	To determine diet quality among T2DM patients (Shaheen et al., 2021)	P: the population proportion that represents poor diet quality among T2DM is 0.683 $n=(\frac{1.96}{0.1})^2$ x 0.683 x (1-0.683) = 83.2 ~ 83	10% dropout rate (d = 0.10) 83+ (83x0.1) = 91.3 ~ 91
3	To determine the association between poor glycaemic control and poor diet quality among T2DM	Zα= 1.96 (α=0.05) Zβ= 0.84 (80% power) P1: the population proportion that represents poor glycaemic control is 0.918 (A Kakade et al., 2018) P2: the population proportion that represents poor diet quality among T2DM is 0.683 (Shaheen et al., 2021) $\frac{[0.918\ (1\text{-}0.918) + 0.683(1\text{-}0.683)]\ x\ (1.96 + 0.84)^2}{(0.918 - 0.683)^2}$ = 41.4 ~ 41 = 41 x 2 = 82	10% dropout rate (d = 0.10) 82+ (82x0.1) = 90.2 ~ 90

Therefore, the highest number of participants that was included in the research is about 91 participants.

3.6 Sampling Method and Subject Recruitment

For this study, the non-probability purposive sampling method was used to investigate the association between diet quality and glycaemic control among patients with Type 2 Diabetes Mellitus (T2DM) attending Hospital Pakar Universiti Sains Malaysia (HPUSM). Purposive sampling is a technique where researchers choose participants based on specific characteristics they need (Campbell et al.,2020)

3.7 Research Tool and Instrument for Data Collection

The data for this study was collected through interview-administered for questionnaire of demographic, diet history, nutritionist pro and M-HEI.

3.7.1 Questionnaire of demographic

Demographic information from the participants included questions related to age, ethnicity, gender, family history of diabetes and status duration of diabetes and treatment used.

3.7.2 Diet history

Diet history provided a comprehensive and detailed food intake of the participant's typical dietary habits over the past week or month (Shahar et al., 2015). The diet history questionnaire used in the study was an open-access tool, available in book Atlas of Food Exchanges and Portion Sizes Third Edition, 2015. Diet history was collected through

face-to-face interview and participants were asked to describe their portion intake using educational tools or visual image using Dietetic Teaching Tools book.

3.7.1 Nutritionist Pro Software

The collected data were then analysed using the Nutritionist Pro to obtain the serving size of foods that will used in the formula of M-HEI.

3.7.2 Malaysian Healthy Eating Index (M-HEI)

Diet quality was measured using M-HEI that consists of 11 components which divided into adequacy, optimal and moderation categories (Jailani et al., 2021). The total score was obtained by summing scores from 11 components, which maximum score is 100%, where above 80% is considered good diet quality, 51-80% is moderate diet quality and below 51% is poor diet quality (Jailani et al., 2021).

No	Component	Type	Max Score	Criteria for Min Score (0)	Criteria for Max Score
1	Total grains	A	5	0 servings/1000 kcal	1.4 servings/1000 kcal
2	Whole grains	A	5	0 servings/1000 kcal	0.7 servings/1000 kcal
3	Fruits	A	10	0 servings/1000 kcal	0.9 servings/1000 kcal
4	Vegetables	A	10	0 servings/1000 kcal	1.2 servings/1000 kcal
5	Fish	A	10	0 servings/1000 kcal	0.4 servings/1000 kcal
6	Meat, poultry and eggs	A	10	0 servings/1000 kcal	0.4 servings/1000 kcal
7	Legumes and nuts	A	10	0 servings/1000 kcal	0.4 servings/1000 kcal
8	Milk and milk products	A	10	0 servings/1000 kcal	0.9 servings/1000 kcal
9	Total Fat	O	10	0 or ≥55% of TEI	25–30% of TEI
10	Added Sugar	M	10	≥25% of TEI	≤5% of TEI
11	Sodium	M	10	≥2300 mg	≤1925.0 mg

Table 1: New standardized Malaysia Healthy Eating Index (S-MHEI)

- Type A: Adequacy component – total grains, whole grains, fruits, vegetables, fish, meat, poultry and eggs, legumes and nuts, milk and milk products
- Type O: Optimal component- total fats
- Type M: Moderation component- added sugar and sodium

a. Scoring method for adequacy component (Type A)

For adequacy components, a score of zero was assigned when a component is not consumed at all, the maximum score was be given when consumption is equal to or exceeds the cut-off value (Jailani et al., 2021). For example, in Table 1, if the consumption of total grains is 1.4 servings or more, it is considered to meet the maximum score criteria, with 1.4 servings set as the cut-off value for total grains. Similarly, the same approach applied to other adequacy components using its own specific cut-off value. The maximum score for most adequacy components is set at 10 except for total grain and whole grain with maximum score are 5 each. The scores for intakes between zero and the cut-off value are prorated linearly and calculated using Formula 1 as below (Jailani et al., 2021):

$$Score = \frac{The\ reported\ intake}{The\ cut\ off\ value} \times The\ maximum\ score$$

b. Scoring method for Type M

For moderate component which are added sugar and sodium, a zero of score was given when the consumption is above the threshold value and maximum score was be given when intake is equal to or lower than the cut off value (Jailani et al., 2021). For sodium, in Table 1, 2300 mg was set as threshold value and 1925 mg was mark for cut-off value with maximum score of 10, which align to the WHO recommendations (Jailani et al., 2021). While for added sugar, 25% of total energy intake (TEI) was set as threshold value and the cut-off value for maximum score is less than 5% of TEI with maximum score of

10 (Jailani et al., 2021). The score for each intake was calculated using the Formula 2 as below (Jailani et al., 2021):

$$Score = \frac{(The\ threshold\ value - The\ reported\ intake)}{(The\ threshold\ value - The\ cutoff\ value)} \times The\ maximum\ score$$

c. Scoring method Type O

For total fat, zero was given in two conditions, when there is no intake of total fat, or when intake was higher than the threshold (Jailani et al., 2021). While maximum points were given if the intake is between the lower and upper cut-off values (25-30% of TEI) (Jailani et al., 2021). The score between zero to the lower cut-off value, which was set at 25% of TEI, is calculated using Formula 1, the same formula to calculate scoring for adequacy component while the score between the upper cut-off value (30% TEI) to the threshold value (55% of TEI) is calculated using the Formula 2, which is the same formula to calculate the scoring of moderate components (Jailani et al., 2021).

3.8 Data Collection Method

After research proposal had been approved by Human Research Ethics Committee (JEPeM) with code number USM/JEPeM/KK/25010143, the data collection was started by visiting the outpatient clinics such as Dietetic Clinic, klinik warga, Klinik Rawatan Keluarga (KRK) and Klinik Pakar Perubatan (KPP) at Hospital Pakar Universiti Sains Malaysia (HPUSM). The attendance list of was reviewed to identify the participants that meet the inclusion criteria. Patients aged 19 above with T2DM and have medical record of hbA1c of 3-6 months previous will become the potential participant.

The participant was approached and requested to join the study. Once received the consent form, the participant filled in the demographic questionnaire and interview of diet history started with overall approximate time is 30 minutes. The data collection was repeated until achieve the targeted sample size. The duration given for data collection was 2 months.

3.9 Study flowchart

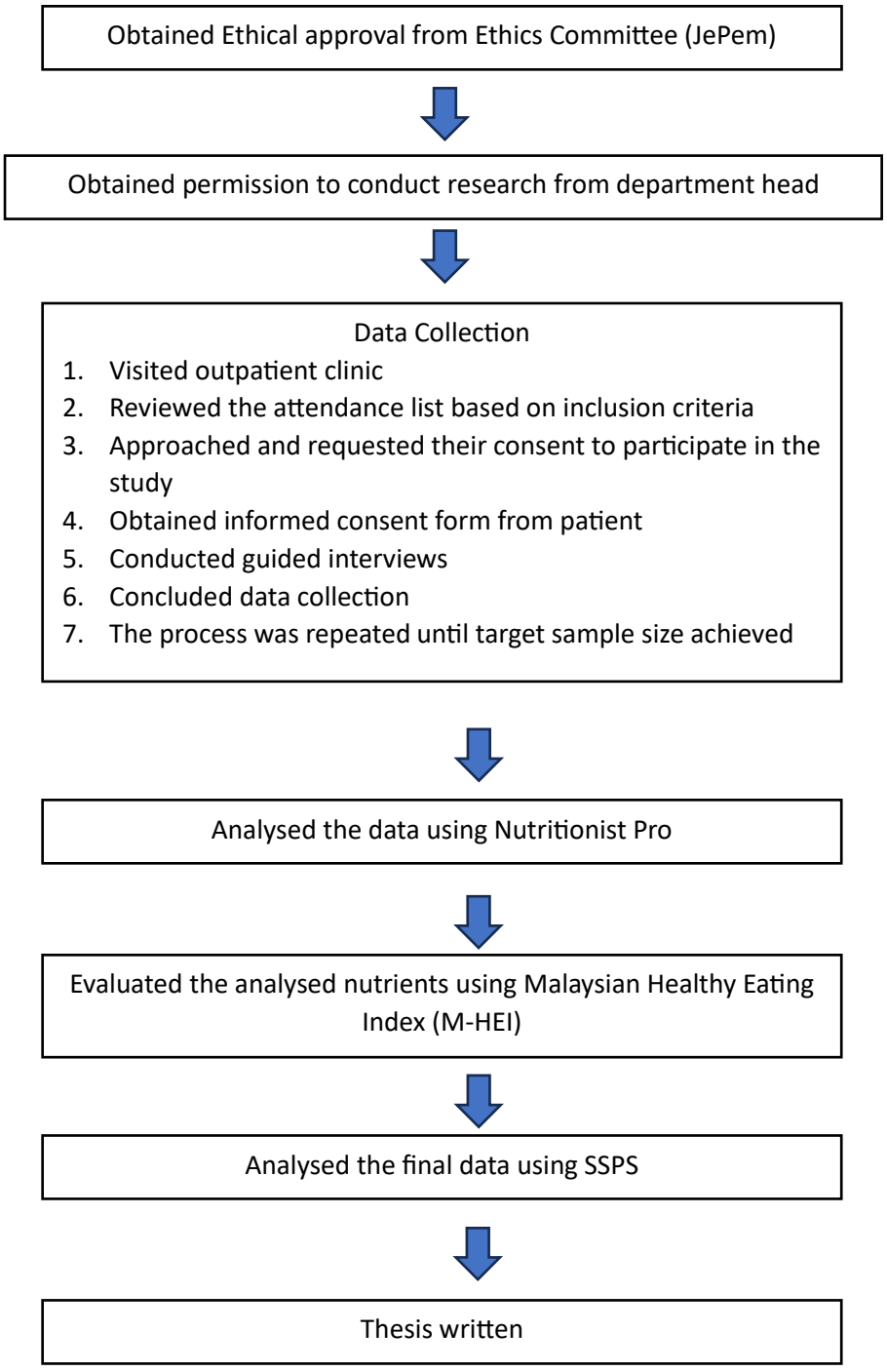

Figure 2: Study flowchart

Figure 2 demonstrated about the flow of conducting research study, began with the preparation of the research proposal, outlining the research study design, objectives and methodology. Followed with the ethical approval that was obtained from the relevant Ethnic Committee (JePem) to ensure the compliance of ethical standards.

The data collection was started by visiting outpatient clinics and reviewing attendance lists to identify patients that aligned to the inclusion criteria. The patient was approached and was asked for their consent to participate in the study. Informed consent forms were obtained, guided interviews of diet history were conducted to gather the food intake. This process continued until the target sample size was achieved, ensuring adequate representation for the study.

Once data collection was completed, the collected data was analysed using Nutritionist Pro software to determine dietary intake and nutrient profiles. The nutrient data was then evaluated using the M-HEI to assess the diet quality of the participants. Following this, the final data was analysed using SPSS software to identify associations between diet quality and glycaemic control in individuals with type 2 diabetes mellitus. Finally, the findings were compiled and thesis writing was started.