Translation, Cultural Adaptation and Validation of Perceived Nutrition Environment Measures Survey (NEMS-P) and Its Relationship With the Glycaemic Values (Hba1c) Among Diabetic Patients in Kuala Terengganu District

AHMAD SYAIFY BIN BERAHIM

UNIVERSITI SAINS MALAYSIA

2024

Translation, Cultural Adaptation and Validation of Perceived Nutrition Environment Measures Survey (NEMS-P) and Its Relationship With the Glycaemic Values (Hba1c) Among Diabetic Patients in Kuala Terengganu District

By

AHMAD SYAIFY BIN BERAHIM

Thesis submitted in fulfilment of the requirements for the degree of Doctor of Public Health (Family Health)

UNIVERSITI SAINS MALAYSIA

2024

ACKNOWLEDGEMENT

I extend my gratitude to Allah, the Lord of the Worlds, for blessing me throughout my academic journey and guiding me in completing my Doctor of Public Health (DrPH) dissertation.

I would like to express my sincere appreciation to my esteemed main supervisor, Associate Professor Dr. Rohana Abdul Jalil, for her invaluable guidance, encouragement, and expertise in public health nutrition. I am also thankful to my co-supervisor, Associate Professor Dr. Najib Majdi bin Yaacob, for his unwavering support, and to my co-researcher, Dr. Ruslina binti Yeop, for her assistance, particularly during the data collection process. I would like to express highest gratitude to Pn Fadlina, Dr Rujhan, Pn Nadirah and Dr Adli for their kind assistance in the translation process of my project.

I sincerely thank the family medicine specialists, medical officers, and diabetic educators at all health clinics in the Kuala Terengganu district for their exceptional cooperation during my data collection process. Although there are too many to name individually, please know that your contributions are deeply appreciated.

I would like to express my sincere gratitude to the School of Medical Sciences, Universiti Sains Malaysia, for the financial support to facilitate this project.

My thanks go to my lecturers and colleagues from the Department of Community Medicine who have supported and assisted in completing this research project, whether

directly or indirectly.

To my beloved parents, Haji Berahim bin Awang and Hajah Khalipah binti Jantan, I offer my heartfelt thanks for their continuous support, encouragement, and sacrifices. Their love, guidance, and prayers have been crucial to my success. I also would like to extend my gratitude to my parent-in-laws, Haji Harun bin Ngah and Hajah Saadiah binti Awang Kechik, as well as my siblings, for their unwavering support and encouragement.

To my wonderful wife, Dr. Nur Al-Kamaliah binti Harun, and our four children, I am deeply grateful for your patience, understanding, and unconditional love throughout my journey. Your support has been my driving force, and I could not have accomplished this without you.

TABLE OF CONTENT

LIST OF TABLES

LIST OF FIGURES

LIST OF APPENDICES

LIST OF SYMBOLS

%	Percent
=	Equal to
≥	More than and equal to
≤	Less than and equal to
>	More than
<	Less than

LIST OF ABBREVIATIONS

Abbreviation	Full term
NEMS-P	Perceived Nutrition Environment Measure Survey
HbA1c	Haemoglobin A1c
CFA	Confirmatory factor analysis
SLR	Simple Linear Regression
MLR	Multiple Linear Regression
CVR	Content validity ratio
CVI	Content validity index
FVI	Face validity index
MOH	Ministry of Health
WHO	World Health Organisation
PCNE	Perceived Community Nutrition Environment
PSCE	Perceived Store Consumer Environment
PRCE	Perceived Restaurant Consumer Environment
PHFE	Perceived Home Food Environment

ABSTRAK

Penterjemahan, Adaptasi Budaya dan Kesahan Soal selidik Mengukur Persepsi Persekitaran Pemakanan Serta Perkaitannya Dengan Nilai Glisemik (HbA1c) Dalam Kalangan Pesakit Kencing Manis di Daerah Kuala Terengganu

Pengenalan: Persepsi pesakit diabetes terhadap persekitaran makanan boleh mempengaruhi pemilihan makanan dan memberi kesan kepada kawalan gula di dalam darah mereka. Soal selidik *Perceived Nutrition Environment Measures Surveys (NEMS-P)* adalah satu instrumen yang sah dan boleh dipercayai untuk menilai persepsi persekitaran pemakanan. Buat masa ini, tiada instrumen yang boleh digunakan untuk mengukur persepsi persekitaran pemakanan di Malaysia dan perkaitannya dengan tahap kawalan gula di dalam darah (kawalan glisemik) dalam kalangan pesakit diabetes. **Objektif:** Objektif kajian ini dalah bertujuan untuk menterjemah soal selidik *Perceived Nutrition Environment Measures Survey (NEMS-P)* ke Bahasa Melayu, adaptasi budaya, dan menilai kesahannya, serta mengkaji perkaitan antara persepsi persekitaran pemakanan dengan nilai glisemik dalam kalangan pesakit diabetis yang mendapatkan rawatan di klinik-klinik kesihatan di daerah Kuala Terengganu. **Metodologi:** Fasa 1 melibatkan terjemahan, adaptasi budaya dan pengesahan *NEMS-P* dalam konteks setempat. Analisis faktor pengesahan melibatkan 200 pesakit diabetes di daerah Kuala Terengganu di mana para responden telah dipilih secara rawak melalui pensampelan berperingkat dan ditemu bual menggunakan NEMS-P versi bahasa Melayu. Fasa 2 merupakan kajian keratan rentas melibatkan 304 pesakit diabetes yang menggunakan soal selidik yang disahkan tersebut untuk menilai persepsi persekitaran pemakanan di daerah Kuala Terengganu. Para responden dipilih daripada semua tiga

klinik kesihatan di Kuala Terengganu dengan menggunakan kaedah pensampelan berstrata mengikut saiz dan responden yang terpilih akan ditemu bual. Regresi Linear digunakan untuk analisis. **Keputusan:** Purata Nisbah Kesahan Kandungan (CVR) adalah 0.90, Indeks Kesahan Kandungan Skala (S-CVI) untuk relevan adalah 0.81 dan S-CVI untuk kejelasan adalah 0.96, kedua-dua indeks kesahan muka (S-FVI) untuk kejelasan dan kefahaman adalah 0.97 dan nilainya boleh diterima. Konstruk yang disertakan dalam Analisis Faktor Pengesahan (CFA) adalah persepsi persekitaran pengguna di kedai, persepsi persekitaran pengguna di restoran, dan persepsi persekitaran makanan di rumah, manakala persepsi persekitaran pemakanan komuniti tidak disertakan dalam fasa ini kerana tidak memerlukan analisis konstruk. Pemuatan faktor *(factor loadings)* adalah dari 0.3 hingga 0.9 dan model tersebut mempunyai nilai kesesuaian *(model fitness)* yang boleh diterima. Nilai kebolehpercayaan konstruk *(Construct Reliability)* berkisar dari 0.614 hingga 0.778 tetapi purata varians yang diekstrak (*AVE*) adalah rendah, berkisar dari 0.171 hingga 0.469. Satu nilai korelasi antara faktor lebih tinggi daripada punca kuasa dua purata varians yang diekstrak (*AVE*). Untuk fasa 2, 68.8% responden adalah wanita dengan umur purata 58.77 tahun (SD 10.57). Kebanyakan responden telah menamatkan sekolah menengah (57.9%), sudah berkahwin (69.7%) dan berlebihan berat badan atau obes (72.0%). Peratus perokok adalah rendah (7.6%). Tempoh purata (tahun) diabetes adalah 6.71 tahun (SD 5.78) dengan purata HbA1c (%) sebanyak 8.09 (SD 2.14). Keempat-empat konstruk dimasukkan untuk penilaian persepsi persekitaran makanan. Skor purata untuk persekitaran pemakanan komuniti adalah 9.70 (SD 2.71), persekitaran pemakanan pengguna di kedai adalah 37.60 (SD 3.82), persekitaran pemakanan pengguna di restoran adalah 4.28 (SD 3.11), dan persekitaran makanan di rumah adalah 19.53 (SD 4.95). Walaupun begitu, tiada hubungan yang signifikan antara persekitaran makanan

yang dirasai dan nilai gula di dalam darah. Terdapat faktor-faktor lain yang signifikan; umur [-0.05% (95% CI: -0.075, -0.025 *p*-value: 0.001)], berkahwin [1.42% (95% CI: 0.407, 2.429 *p*-value: 0.006)], bercerai [1.20% (95% CI: 0.063, 2.331 *p*-value: 0.039)], merokok [1.25% (95% CI: 0.377, 2.128 *p*-value: 0.005)] dan tempoh diabetes [0.10% (95% CI: 0.052, 0.137 *p*-value: 0.001)]. **Kesimpulan:** Soal selidik versi NEMS-P Melayu adalah alat yang sah dan boleh dipercayai untuk mengukur persepsi persekitaran pemakanan di Kuala Terengganu. Tiada perkaitan yang signifikan secara statistik antara persepsi persekitaran makanan dengan nilai HbA1c, menunjukkan keperluan untuk mempelbagaikan populasi kajian pada masa hadapan.

Kata kunci: persepsi, persekitaran makanan, diabetes, pemakanan

ABSTRACT

Translation, Cultural Adaptation and Validation of Perceived Nutrition Environment Measures Survey (NEMS-P) and its Relationship With the Glycaemic Values (HbA1c) Among Diabetic Patients in Kuala Terengganu

Introduction: The perceptions of diabetic patients on their food environment influence their dietary choices and may impact glycaemic control. The Perceived Nutrition Environment Measures Surveys (NEMS-P) questionnaire is a valid and reliable measure to access perceived food environment. To date, there is no available instrument to measure the perceived food environment in Malaysia and its association with the level of glycaemic control among diabetic patients. **Objectives:** This study aimed to translate, culturally adapt and validate Malay version of NEMS-P, and to study the relationship between the perceived food environments and the glycaemic values among diabetic patients attending health clinics in Kuala Terengganu district. **Methodology:** Phase 1 study involved translation, cultural adaptation and validation of the NEMS-P within Malay context. Confirmatory factor analysis (CFA) was conducted involving 200 diabetic patients in Kuala Terengganu and were randomly selected by multi-staged sampling and interviewed using the NEMS-P (Malay). Phase 2 was a cross-sectional study involving 304 diabetic patients and were selected from all three health clinics in Kuala Terengganu by applying the stratified sampling proportional to size method and utilising the validated NEMS-P (Malay). Linear Regression was used for the analysis. **Results:** The average Content Validity Ratio (CVR) was 0.90, the Scale Content Validity Index (S-CVI) for relevance was 0.81 and the S-CVI for clarity was 0.96, both scale face validity index (S-FVI) for clarity and comprehension were 0.97 and all were acceptable. The constructs which were included

in CFA were perceived store consumer environment (PSCE), perceived restaurant consumer environment (PRCE) and perceived home food environment (PHFE) but perceived community nutrition environment (PCNE) was excluded as it did not require construct analysis. The factor loading ranged from 0.3 to 0.9 and the model had acceptable fit. The construct reliability (CR) values ranged from 0.614 to 0.778, the average variance extracted (AVE) 0.171 to 0.469. One inter-factor correlation value was higher than the square root of average variance extracted (AVE). For phase 2, 68.8% of respondents were females with the mean age of 58.77 (SD 10.57). Most respondents entered secondary school (57.9%), married individuals (69.7%) and overweight or obese (72.0%). The proportion of smokers was low (7.6%). All four perceived food environment constructs were included for scoring. The mean score for the PCNE was 9.70 (SD 2.71), PSCE was 37.60 (SD 3.82), PRCE was 4.28 (SD 3.11) and PHFE was 19.53 (SD 4.95). The mean duration (years) of diabetes was 6.71 (SD 5.78) with the mean HbA1c (%) of 8.09 (SD 2.14). There was no significant association between perceived food environments and glycaemic values. Instead, there were other statistically significant factors; age [-0.05% (95% CI: -0.075, -0.025 *p*-value: 0.001)], married [1.42% (95% CI: 0.407, 2.429 *p*-value: 0.006)], divorced/separated [1.20% (95% CI: 0.063, 2.331 *p*-value: 0.039)], smoking [1.25% (95% CI: 0.377, 2.128 *p*-value: 0.005)] and duration of diabetes [0.10% (95% CI: 0.052, 0.137 *p*-value: 0.001)]. **Conclusion:** Malay version of NEMS-P questionnaire is a valid and reliable tool to measure perceived food environment in Kuala Terengganu. There was no statistically significant relationship between perceived food environments and HbA1c values, indicating the need for future research with a more heterogeneous and diverse population.

Keywords: perception, food environment, diabetes, nutrition

CHAPTER 1

INTRODUCTION

1.1 Background

Diabetes is a worldwide public health issues and contributes a major burden to public health and socioeconomic development. The increasing trend of diabetes is not limited to the developing countries but also includes developed countries, despite of having more advanced preventive and curative health facilities (Akhtar *et al.*, 2022). Diabetes is a chronic disease that occurs due to either when the pancreas does not produce enough insulin, or when the body is not able to use the produced insulin effectively. It is estimated to reduce the individual's average lifespan by around 10 years (WHO, 2022). The prevalence of diabetes is expected to increase from 9.3% in year 2019 to 10.9% by the year 2045 with 50.7% of people with diabetes were found to be undiagnosed in 2017 (IDF, 2021). As a matter of fact, a total of 970 billion USD was spent in year 2021 to provide the health care to the diabetic patients alone (Gordon, 2022).

The findings from a systemic review discovered that there were different cut-off between studies in term of poor glycaemic control. Two studies set poor glycaemic control as HbA1c more than 7.0%, seven studies set it as poor control with HbA1c equals or more than 7.0% and one study set it as poor control at HbA1c equal to 7.0%. Due to the variation of the cut off in which resulted in the different prevalence of poor glycaemic control, therefore it was calculated to be between 45.2% and 93.0%, indicating of high prevalence of diabetes (Bin Rakhis *et al.*, 2022a). Even with

different cut-off point, the prevalence was still high and increasing, hence, it is a need to consistently find solutions to improve glycaemic control among the diabetic patients in reducing the morbidity and mortality due to the complications. Due to the high prevalence, more complications are expected from the disease if better solutions are not found, beyond relying heavily on medications, where poor compliance remains a significant issue. As the mean age of diagnosing diabetes become younger, patients need to take medications earlier of their age. They will find it difficult to comply after routinely taking medications for a longer period of time compared to those diagnosed at the later age in which they will take medications for a relative shorter period before they passed-away (Barker *et al.*, 2022). Subsequently, the effect of poor compliance to medications will lead to poor glycaemic control and increase the risk of developing complications from the disease.

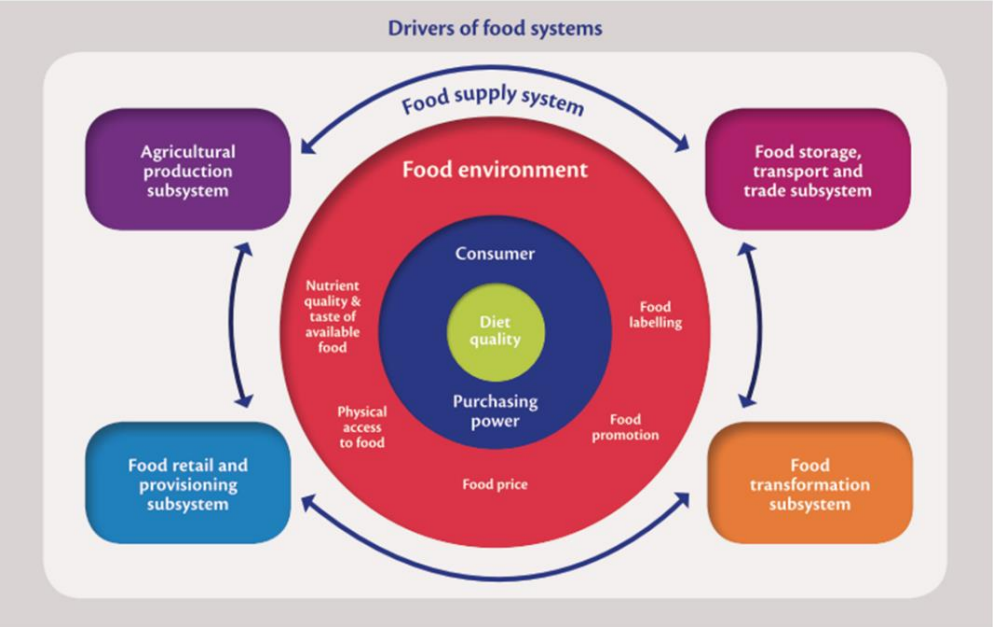
In Malaysia, the national prevalence of diabetes increased from 9.4% in 2019 to 15.6% in year 2023 (Institute for Public Health, 2024). The states with highest prevalence of diabetes include Negeri Sembilan, Perlis and Pahang with the prevalence of 33.2%, 32.6% and 25.7% respectively (Institute for Public Health (IPH), National Institutes of Health, 2019). Terengganu is also among the state with the prevalence of diabetes of more than 20% which equals to 70,127 of diabetes patients being registered in the National Diabetes Registry in the year 2020 (MOH, 2020). Even with a significant proportion of properly diagnosed diabetic patients, the effectiveness of maintaining or controlling blood glucose is still very poor (Yeemard *et al.*, 2022). In year 2019, 27.6% of diabetic patients in Malaysia had achieved target HbA1c of 6.5% and below and had improved to 30.7% in year 2020. Whereas in Terengganu state, the prevalence of good glycaemic control was 28.3% in year 2019 and improved to 32.1% in year 2020 (MOH, 2020). Despite of slight improvement, more than two-third of the

diabetic patients still did not achieve good glycaemic control in which could increase the risk of developing diabetes-related complications such as retinopathy, nephropathy and cardiomyopathy (Awang *et al.*, 2022).

In addition to pharmacotherapy and exercise, nutrition also plays vital roles in managing glucose level among diabetic patients (Usman Malik, Furqan Hashmi, 2020). Other study also found that dietary modification is effective in controlling blood glucose level to achieve good glycaemic control among diabetic patients (Brown *et al.*, 2022). Mediterranean diet, for example, has favourable impacts on glycaemic control and metabolic health (Rein *et al.*, 2022). However, dietary modifications are influenced by the taste of the food, social factors, employment status and acculturation process. Environmental factors such as food prices, access to food outlets in obtaining wide range of foods, disparities in access, particularly in transportation also factors that affecting food choices (IOM (Institute of Medicine) & NRC (National Research Council), 2013).

Food environments are usually defined as the settings with all the different types of food made available and accessible to people as they go about their daily lives (FAO, 2016). It is also defined as collective physical, economic, policy and sociocultural surroundings, opportunities and conditions that influence people's food and beverage choices and nutritional status (Hawkesworth *et al.*, 2017). Figure 1.1 shows how the food environments are influenced by the food systems which supply them, and vice versa. Four food supply subsystems comprise the entire food chain, namely agricultural production; food storage, transportation, and trade; food transformation; and food retail and provisioning and these subsystems influence the food environments in which people make their dietary choices (FAO, 2016). Food environments mitigate the impact of these subsystems on the choice and quality of diets of the individual through a variety

of factors, including food labelling, promotion, pricing, physical access, and nutrient quality and taste of food (FAO, 2016).



(Source: Global Panel on Agriculture and Food Systems for Nutrition (GLOPAN) 2016 (FAO, 2016, p. ix)
Figure 1.1: Theoretical framework for the links between food systems, food environment and diet quality

The dimension of food environment also can be viewed as availability, accessibility, affordability, acceptability, and accommodation. Availability refers to the adequacy of the supply of healthy food; accessibility refers to the location of the food supply and ease of getting to that location (travel time and distance); affordability refers to food prices and people's perceptions of worth relative to the cost; acceptability refers to people's attitudes about attributes of their local food environment, and whether or not the given supply of products meets their personal standards; accommodation refers to how well local food sources accept and adapt to local residents' needs (Turner *et al.*, 2021).

In addition, the people's perception on food environment can also influence their

dietary choices. Diabetic patients did not comply to the dietary guidance given by the dieticians at the health clinics due to their perceived food environment around their neighbourhood, hence the prevalence of poorly controlled diabetes is still high. A study showed that unhealthy food environment (fast-food outlets) in the neighbourhood may have detrimental impact on the risk of type 2 diabetes, thus it would affect their diabetic outcomes (Kusuma *et al.*, 2022). In Malaysia, research on perceived food environment is still lacking, particularly its relationship with diabetic prevalence and glycaemic control. Therefore, the study on food environment should be conducted to identify its relationship with glycaemic control among diabetic patients.

Majority of previous studies focus on the objective measures of food environment instead of perceived food environment. Objective measure of food environment is a method of assessing the food environment by using the trained individuals to assess the availability of healthy and unhealthy food in the market, however, perceived food environment is assessing the perception of the individuals on their food environment (Green & Glanz, 2015). Few studies found that individuals' perceived food environment is strongly related to their dietary intake and thus further study should be conducted to explore on how perceived food environment influence the dietary options (Menezes, Diez Roux & Souza Lopes, 2018). Based on the "Model of Community Nutrition Environments", it was suggested that the perceived and observed food environment interact with each other to influence the food behaviours either directly or indirectly through food purchasing behaviour, the frequency of restaurant visit and the home food environment (Martínez-García *et al.*, 2020). By integrating this information can enhance glycaemic control in diabetic patients by not only offering healthy food options but also effectively promoting their accessibility

and availability within the patients' local communities.

1.2 Problem statement & Study rationale

The prevalence of diabetes mellitus in Malaysia is among the highest in Western Pacific region (IDF, 2021). In term of control, only 30.0% of diabetic patients in the country have a good control of the glycaemic values (MOH, 2020). Nowadays, processed food is readily available and affordable which make healthy eating is no longer an individual choice but rather largely influenced by the perceived food environment. Unfortunately, as for diabetic patients, they will face difficulties to control their blood glucose level (Martin & McCormack, 2022). Recent research evaluating the perceived food environment have been subjective or only focused on a small number of items which limit the interpretation (Green & Glanz, 2015).

In Malaysia, to our concern, there is lack of instrument available to assess the perceived food environment and its association with diabetes prevalence. Therefore, it is a need to identify the appropriate tool or measurement to assess the perceived food environment in our local context. One of the perceived food environment questionnaires available worldwide is the Perceived Nutrition Environment Measure Survey (NEMS-P) which assesses the perception of different types of food environment (stores food environment, restaurant food environment, home food environment) (Martínez-García *et al.*, 2020). However, there is no Malay version available to date in assessing perceived food environment in Malaysia.

Translation and cultural adaptation of perceived food environment questionnaire allows assessment of the perceived local food environment as food habits and consumption patterns vary between countries and not comparable (Martínez-García *et al.*, 2020). Hence, it is a need to conduct this study due to the lack of data on perceived

food environment and its association with glycaemic control among diabetic patients. Availability of validated instrument to measure the perceived food environment allows epidemiological data for food environment intervention and food policy in Malaysia. Through the translation and validation process, the Malay translated instrument can be used to determine the association of perceived food environment with the glycaemic control among diabetic patients.

1.3 Research Question(s)

1. Is Malay version of Perceived Nutrition Environment Measures Survey (NEMS-P) a valid and a reliable tool to measure perceived food environment among diabetic patients in Kuala Terengganu district?
2. What is the proportion of perceived unhealthy food environment among diabetic patients in Kuala Terengganu district?
3. Is there a relationship between the perceived food environment and glycaemic values (HbA1c) among diabetic patients in the Kuala Terengganu district?

1.4 Objectives

1.4.1 General objective

To translate, culturally adapt and validate Malay version of Perceived Nutrition Environment Measures Survey (NEMS-P), and to study the relationship between the perceived food environment with the glycaemic values (HbA1c) among patients attending health clinics in Kuala Terengganu district.

1.4.2 Specific objectives

Phase 1

1. To translate the Perceived Nutrition Environment Measures Survey (NEMS-P) questionnaire into Malay language, culturally adapt and determine its validity (content validity, face validity, construct validity) and reliability (construct reliability).

Phase 2

1. To describe the proportions of individual with perceived unhealthy food environment among diabetic patients in Kuala Terengganu district using validated Malay version of Perceived Nutrition Environment Measures Survey (NEMS-P).
2. To determine the relationship between the perceived unhealthy food environment with the glycaemic values (HbA1c) among diabetic patients Kuala Terengganu.

1.5 Research hypothesis

1. Malay version of Perceived Nutrition Environment Measures Survey (NEMS-P) is a valid tool to measure the perceived food environment among diabetic patients in Kuala Terengganu district.
2. There is significant relationship between perceived food environment and the glycaemic values (HbA1c) among diabetic patients in Kuala Terengganu.

CHAPTER 2

LITERATURE REVIEW

2.1 Diabetes overview

Diabetes is a chronic condition characterized by insufficient insulin production or ineffective utilization of insulin by the body, leading to hyperglycaemia, which can progressively cause extensive damage to multiple system in the body especially the nervous and vascular systems (WHO, 2019). In 2014, 8.5% of adults aged 18 and over were diagnosed with diabetes, and by 2019, the disease was directly responsible for 1.5 million deaths, with 48.0% occurred before the age of 70 years old, alongside an additional 460,000 deaths from kidney disease and approximately 20.0% of cardiovascular deaths attributed to uncontrolled blood glucose levels (WHO, 2023a).

There were many studies related to diabetes in terms of factors affecting the glycaemic level as more than half of diabetic patients did not achieve the recommended target (Bin Rakhis *et al.*, 2022b). Nevertheless, majority of the studies focused on the individual factors or the medical personnels' factors who treat the patients (Bitew *et al.*, 2023). Studies on the perceived food environment which can influence the dietary choices were mainly conducted in US and still lacking in many parts of the world including Malaysia and this led to difficulties in comparing the perceived food environment factors and their impact to the glycaemic level among diabetic patients (Yamaguchi *et al.*, 2022).

2.2 Perceived unhealthy food environments and its prevalence

The perceived aspect of the neighbourhood environment is essential because the

perception of individuals can be different for the same objective neighbourhood environment such as the availability of fast-food restaurants. Therefore, the assessment of the people's perception on their food environment is important as it strongly influence their food choices compared to objective measurement of the environment alone (Cerin *et al.*, 2021). In a study to investigate the effect of perceived food environment on fruit and vegetable intake, it was found that individuals who perceived the affordability of fruit and vegetables at their neighbourhood associated with higher daily servings of fruits and vegetables compared to those who did not afford for fruits and vegetables (Oladele *et al.*, 2022a). This study suggested that instead of looking objectively into the availability of food in the neighbourhood environment only, perception of the individual toward food environment should also be considered. This will put the responsibilities on the government to enhanced health promotion on neighbourhood food environment so that they can make informed decisions on their dietary intake (WHO, 2024).

In term of perceived unhealthy food environment proportion, the Japanese individuals with poor perceived access to fruits and vegetables was 25.3% and this group had significantly lower intake frequency of vegetables and fruits (Yamaguchi *et al.*, 2019). This finding showed that poor perceived accessibility towards healthy food led to poor intake of healthy food. In a review involving Australia, Canada, Mexico, the United Kingdom (UK) and USA, it was found that, across the countries, around 50.0% of participants perceived that junk food and sugary drinks were available for purchase; meanwhile only 30.0–40.0% perceived that fruits and vegetables and other healthy snacks were available for purchase (Contreras-Manzano *et al.*, 2022). Another study in US showed that 55.0% of the students who lived in campus strongly agreed that it was easy to purchase fresh fruits and vegetables as the products were readily

accessible in-campus (Martin & McCormack, 2022). It was also found that majority of the respondents among pre-diabetes and at risk of pre-diabetes in Malaysia were not able to meet the recommended serving size for vegetables, fruits, fish, legumes milk and dairy products (Siddiqui *et al.*, 2020). However, study associated the food environment is very scarce in Malaysia. The high proportion of perceived unhealthy food environments increases the likelihood of unhealthy food consumption which increases the risk of diabetes and poor glycaemic control.

Food labelling on the other hand also play a role in perceived food environment through informed choices of food. Lack of knowledge in food labelling led to perceived unhealthy food choices. Data from the complementary market survey in Malaysia revealed that 9.1% of food manufacturers made less action towards food labelling to facilitate informed choices (Ng *et al.*, 2020). About 55.0% of respondents said they never read food labels, 22.0% occasionally read and only 23.0% always read the labels and it was found that being male, low education level, single (not married, divorced, widowed, or living alone) and people who are normal weight were significantly less likely to read food labels (Ambak *et al.*, 2018). It shows that more than half of Malaysian do not practice reading food labels and thus, lack of information in term of food consumption.

2.3 Food environment and diabetes

2.3.1 Home food environment

People who had a regular consumption of meal that was prepared at home during work hours was associated with lower HbA1c level for patients with type 2 diabetes (R^2 = 0.146, F(14, 170) = 2.075, p=0.015; adjusted R^2 = 0.076) (Hung *et al.*, 2022).

Another study found that frequent consumption of meal that was prepared at home was associated with lower risk of type 2 diabetes partly contributed by less weight gain among the participants who consumed meals that was prepared at home (HR: 0.95, 95% CI 0.89,1.01; $p = 0.13$) (Zong *et al.*, 2016). In a study involving prediabetes, the participants were found to have lower availability of healthy foods and higher availability of unhealthy foods at home compared to non-diabetes individuals (McAtee *et al.*, 2020). It showed that the consumption of home prepared meal or reduce intake of outside food can improve glycaemic level of an individual.

Eating out exposed the consumers to imbalanced portion of food groups and led to weight gain. Increase in fat storage in the body reduce insulin sensitivity and in longer term affect the glycaemic control increase the risk of diabetes (Gesteiro *et al.*, 2022). These give some evidence that preparing own meals at home allow better adjustments of glucose intake in accordance with the suitability of the individual glycaemic control.

2.3.2 Store food environment

A study involving gestational diabetes patients found that there was spatial overlap between regions with food retailers selling poor-quality food and areas with a high prevalence of gestational diabetes, posing challenges for managing their blood glucose levels (Fonge *et al.*, 2020). Another study corroborated these findings by demonstrating that neighbourhoods experiencing a decrease in the availability of fruits and vegetables store density and a concurrent increase in the chain convenience stores density have higher odds of diabetes compared to adults residing in neighbourhoods where there was no change in fruit and vegetable store density or chain convenience store density (OR: 3.90, 95% CI 1.61, 9.48) (Pérez-Ferrer *et al.*, 2020).

Even though these findings could not become a causal relationship as there were multiple factors that can affect the diabetes incidence, nevertheless, the relationship of food consumption derived from the food stores in neighbourhood with diabetic occurrence has been established. While a relationship between environmental characteristics and type 2 diabetes has been identified, although remains a gap in knowledge, this phenomenon has only been observed in a restricted number of high-quality studies (Public Health Ontario, 2023). With the absence of healthy fresh food source and availability of more unhealthy food sources, it will become evident that food environment does play a big role in the increase of diabetes prevalence, eventually led to poorly glycaemic control among the diabetic patients.

2.3.3 Restaurant food environment

In a 20 year longitudinal study, the prevalence of fast-food and pizza restaurants, grocery stores, and full-service restaurants were linked to the prevalence of type 2 diabetes mellitus (Zick *et al.*, 2023). This was supported by another study in which the higher ratio of fast-food restaurants compared to all restaurants was associated with increased risk of type 2 diabetes mellitus (aHR: 1.01, 95% CI: 1.00,1.02) (Kanchi *et al.*, 2021). In addition to these studies, a study conducted among the UK citizens also found that access to ready-to-eat food environments was positively associated with type 2 diabetes (Sarkar, Webster & Gallacher, 2018a). A study found that those who rarely eating out became a protective factor by 65.0% toward diabetes mellitus (Choi *et al.*, 2019)

The availability of easy access to ready food increases the risk of diabetes as people tend to neglect the nutrition values of the food in favour for the good taste and fast to eat food as they do not need to prepare the food by themselves. Worst case

scenario is when the restaurant or food outlets do not offer healthier food but instead focusing on taste rather than nutrition value offered to the consumers with affordable rice. Factors such as price, service quality, and food quality, including taste of the food, impact customers' purchasing decisions and price stands out as the primary factor influencing the purchase behaviour of young Malaysian customers towards fast food (Salleh *et al.*, 2023).

2.3.4 Eating habit

A study conducted in Kenya found that the increase in the burden of non-communicable diseases including diabetes in urban areas has been attributed to changing social and physical environments, food habits, and a proliferation of energy-dense nutrient poor foods and beverages entering the diet, often high in trans fats, salt, and sugar (Asiki *et al.*, 2020). Whereas in the United Arab Emirates (UAE), the consumption of fizzy drinks and fast food at least one time a week increased the odds of poor glycaemic control by 2.05 (95%CI 1.16,3.68; p =0.01) and 1.83 (95% CI 1.02,3.3 p=0.04) respectively while fresh food consumption decrease the odds of poor glycaemic control (OR=0.65, 95% CI 0.23,1.79; p=0.04) (Sadiya & Mnla, 2019). Poor eating habit led to poor nutrition such as consumption of food high in carbohydrate which contribute to poor glycaemic control. Another study supported the findings whereby poor eating habits among diabetic Japanese employers were significantly associated with poor glycaemic and body weight control (Gouda, Matsukawa & Iijima, 2018).

2.3.5 Food shopping behaviour

In a qualitative study among diabetic patients, the participants revealed that limited availability of healthy food make them difficult to control their diet and glucose level (Han *et al.*, 2020). The finding showed that health promotion without provision of healthy food did not guarantee that the patients able to empower themselves to control the blood glucose level.

Furthermore, in a large study conducted in United Kingdom, it showed that the exposure to ready-to-eat food environments was associated with higher odds of Type 2 Diabetes Mellitus (OR: 1.129, 95% CI 1.05,1.21; p=0.0007) (Sarkar, Webster & Gallacher, 2018b). This was supported by another study which showed that the environments with one-third of the health-harming food outlets were associated with the highest risk for Type 2 Diabetes (OR: 3.67, 95% CI: 2.14,6.30) (Mezuk *et al.*, 2016). From these studies, it showed that the relationship of food environment with diabetes mellitus is plausible.

Nevertheless, another study found that perceived healthy food accessibility was not correlated with glycaemic control, but it was strongly correlated with the real healthy food access at shorter distances from home (Sadler *et al.*, 2021). In another study it was found that community with a higher density of fast-food outlets at the neighbourhood was associated with a 9.21 mg/dl blood glucose increase (Kusuma *et al.*, 2022).

2.4 Other factors associated with glycaemic control among diabetic patients

2.4.1 Age and sex

Globally, it was found that factors such as age, gender, duration of diabetes, type

of treatment, body mass index (BMI), fasting plasma glucose, lipid profile, education level, occupation, medication compliance, presence of comorbidities, self-care practice, and mental and psychosocial health problems were associated with glycaemic control (Dinavari *et al.*, 2023). Similarly, in Southeast Asia, poor glycaemic control was associated with age, BMI, hypertension, smoking, education, physical activity, and dyslipidaemia (Nova & Virginia, 2023).

In a local study conducted in Kedah, it was found that good glycaemic control among diabetic patients were associated with young age (aOR: 0.972, 95% CI: 0.969,0.974) and male gender (aOR: 0.930, 95% CI 0.876,0.988) (Hassan *et al.*, 2021). In contrast, another study found that variables which were associated with good glycaemic control were older age (OR: 1.033, 95%CI: 1.008,1.059) and shorter duration of diabetes mellitus (OR: 0.948, 95%CI: 0.909,0.989) (Ahmad, Islahudin & Paraidathathu, 2014; Sadler *et al.*, 2021). Patients who were diagnosed with diabetes at the early age believed that they were able to manage diabetes solely by controlling their diet, however, lack knowledge about the disease itself resulting in poor glycaemic control and diabetic complications (Amsah, Md Isa & Kassim, 2022). These mixed findings could be due to different socioeconomic, rurality or food environment which might influenced their dietary intake.

2.4.2 Duration of diabetes

A study conducted in Johor showed that the duration of diabetes of more than 10 years and early onset of diabetes were also associated with poor glycaemic control and was postulated due to the continuous loss of function of pancreatic beta cells and reluctant to visit the hospital respectively (Amsah, Md Isa & Kassim, 2022). Those with longer duration of diabetes commonly comprised of elderly. For this age group,

due to their relatively lesser consumption of food compared to the younger age group, the medical practitioner tend to be less stringent with their glycaemic control to avoid the patient's becoming hypoglycaemia (low in blood glucose level) which cause more harm to them (de Souto Barreto *et al.*, 2022). Diabetics patients who suffered the disease for more than five year were associated with increased risk of death despite strict glycaemic control was practiced, whereas strict glycaemic control among those shorter duration of diabetes associated with lowest risk of death (Ghouse *et al.*, 2020).

2.4.3 Smoking habit

A lot of evidences shows that smoking cigarettes increases the likelihood of developing type 2 diabetes up to 40.0% compared to non-smokers, as nicotine, a toxic substance in tobacco smoke, adversely affects β cell functions, thereby impairing insulin production and glucose regulation (WHO, 2023b). In a cohort study involving 10,551 men and 15,297 Chinese women with diabetes, smoking was linked to a higher odds ratio (OR) of 1.49 in men and 1.56 in women for poor glycaemic control, with this association being particularly notable in elderly patients but in another study involving 25 diabetic patients found that those who quit smoking exhibited poorer glycaemic control compared to those who continued smoking which indicated possible confounding effects (Campagna *et al.*, 2019).

2.4.4 Body mass index (BMI)

In a retrospective cohort analysis, it was found that the diabetic patients with obesity had notably lower odds of having baseline HbA1c below target compared to their counterparts without obesity, ranging from 12.2% in Germany (OR: 0.878, 95%CI:

0.795,0.970, $p = 0.0103$) to 29.9% in France (OR: 0.701, 95%CI: 0.500,0.984, $p = 0.0399$) and proved that higher BMI was associated with poorer glycaemic control (Mount *et al.*, 2023). In a study in US, among individuals who lost at least 15.0% of their initial weight, average HbA1c reductions were 1.2% in the 1-year follow-up group and 0.5% in the 5-year follow-up group (Shinde *et al.*, 2024). This showed that BMI had a significant relationship with HbA1c level whereby changes in BMI can influence the Hba1c level and this gave evidence the importance of a good weight management among diabetic patients.

2.4.5 Physical activity

Aerobic exercise improves insulin sensitivity and vascular function for up to 48 hours and reduce fasting plasma glucose up to 18.58 mg/dl, while a meta-analysis of over 8,500 type 2 diabetes patients showed that structured resistance training significantly reduces HbA1c levels by 0.57% compared to non-exercising controls (Syeda *et al.*, 2023). A systematic review also found that a structured exercise regimen consisting of 40- to 60-minute sessions, 3–5 days per week, or totalling 150 minutes weekly, significantly enhances glycaemic control, BMI, and waist circumference while even less frequent exercise, such as 1–2 days per week and general physical activities like walking can also contribute to reducing blood glucose levels (Shah *et al.*, 2021). This evidence proved that physical activities could benefit the diabetic patients even if it is a low intensity exercise.

2.4.6 Food consumption

A study in Selangor suggested that poor glycaemic control is associated with

high consumption of carbohydrates, lack of physical activity and lack of knowledge about diabetes and its treatment (Ahmad, Islahudin & Paraidathathu, 2014; Fekadu *et al.*, 2019). However, further enquiry may suggest that the root cause of poor glycaemic control is due to the unhealthy food environment which lead to poor diet control among diabetic patients.

In a qualitative study, most individuals with Type 2 Diabetes appear to have a negative perception about the quality of meals served at food outlets but compelled to dine out due to the nature of their work and the size of the family unit (Swarna Nantha *et al.*, 2021). There is possibility that if the market provides healthier and affordable meal, there will be significant number of people will select this diet compared to unhealthy diet.

2.4.7 Socioeconomic status

A study found that each additional convenience store per 1000 residents in high poverty/high-minority counties was associated with 1.8 percentage point increase in diabetes prevalence compared to only a 0.3 percentage point increase in low poverty/low-minority counties (Haynes-Maslow and Leone, 2017). The study also stated that among the low income individuals, the availability of healthy food will not result in much different of intake among the population since it is still unaffordable to many (Haynes-Maslow & Leone, 2017). Therefore, to increase the availability of healthy food, it must also be affordable to the consumers to encourage the populations to consume healthy food.

Similar study conducted showed that individuals residing in the most privileged residential areas were 2.59 times more likely to achieve glycaemic control compared to those living in the least privileged residential areas (95% CI: 2.43, 2.77) (Tabaei *et*

al., 2018). Advantaged residential areas are usually better equipped and provided with more food variations for the residents.

Other than cultural and social factors, people's eating patterns and choices were also influenced by the different ethnic glycaemic response to a standard food, highlighting the importance of ethnic consideration when making dietary advice (Sadiya & Mnla, 2019). Different ethnic has different food culture, thus glycaemic control recommendations should not be generalised to all patients. In addition, some ethnic groups buy different type of food as their perception towards the food are different. For example, Chinese may prefer porridge as their breakfast while other ethnics may prefer higher protein diet such as omelettes as their breakfast.

2.5 Food environment measurement tools

As a measurement tool in food environment study, there is a need for cultural adaptation in addition to linguistic translation as poorly translated instruments threaten the validity of research data (Wild *et al.*, 2005). For example, if the new culture has a different way of approaching a task that makes it inherently more or less difficult compared with other items, it would change the validity, certainly in terms of item-level analyses (Beaton *et al.*, 1999). Therefore, it is important to conduct a cultural adaptation for food environment tool due to different food culture based on locality and country.

2.5.1 Perceived Neighbourhood Food Environment Scale (PNFE)

The Perceived Neighbourhood Food Environment Scale (PNFE) by Komatsu *et al.*, 2020 consists of eight items selected by the food education committee organized

by the Cabinet Office of Japan to assess participants' perceptions of the present condition of their food environment. It is comprised of two factors: "regional food culture" (5 items) and "physical availability of food" (3 items). The "regional food culture" subscale evaluates food-related regional linkages and includes resources of social capital (SC) related to food, such as social support and participation in neighbourhood organizations. The "physical availability of food" subscale includes items used for the observational or geographical measurement of the conventional food environment, such as availability of food and access to grocery stores. The model fitness indices for the questionnaire were good (GFI = 0.97, AGFI = 0.95, CFI = 0.96, RMSEA = 0.073) and Cronbach's α was 0.77 for the whole scale indicating higher reliability of the instrument.

2.5.2 Built Food Environment (NEM-CS/BTG-COMP) tools

Another study proposed the measurement of the built food environment which included objective observations of food stores in the study area and self-reported perceptions of healthy food availability (Freedman *et al.*, 2019). An objective retail choice block score was calculated for all study area census blocks and then assigned to participants based on their home address. The block scores were based on two components. First, for the convenience stores, the objective measures of the food environment will be measured using an adapted Nutrition Environment Measures Survey in Convenience Stores (NEMS-CS), a standardized tool for evaluating availability, price, and quality of healthy food options. Second, to evaluate healthy and unhealthy advertising on store exteriors, an adapted Food Store Observation Form from the Bridging the Gap Community Obesity Measures Project (BTG-COMP) will be used. Two trained auditors will complete each store observation with high interrater

reliability (97% agreement). Using both the NEMS-CS and the BTG-COMP tools, a score for each store will be calculated.

2.5.3 Perceived Food Environment Questionnaire

In the Perceived Food Environment Questionnaire, the items generated were relevant to be used for both high and low socio-economic groups. This instrument was developed and chosen by a team of three nutrition researchers and one health behaviour researcher to ensure the face validity of the questionnaire (Carbonneau *et al.*, 2017).

The questionnaire consisted of fourteen items grouped into two distinct sections. The first section includes twelve items assessing accessibility to healthy (nine items) and unhealthy foods (three items) and was developed to evaluate participants' perceptions of the food environment in their daily life. The items were rated on a five-point scale, from 'strongly disagree' to 'strongly agree', with the addition of a 'not applicable' option for the items pertaining to the work environment.

The second section included two complementary questions documenting the self-reported travel time from home to the main food retailer by car and on foot. These two items did not assess food environment perceptions but were included in the questionnaire because they would be useful for the interpretation of the results obtained in the previous section, allowing the integration of subjective (perceived food environment) and more objective (travel time) measures, as it was proposed that the two types of measures can bring complementary information. The subscales demonstrated adequate internal consistency (Cronbach's a=0.77 for healthy foods and 0.62 for unhealthy foods) and test-retest reliability (r=0.59 and 0-60, respectively; both $P<0.0001$).

2.5.4 EURO-PREVOB Community Questionnaire

The EURO-PREVOB Community Questionnaire is an observational audit tool designed to measure objectively important aspects of the food and built environments in urban areas of varying levels of affluence, in different countries (Pomerleau *et al.*, 2012). The literature on environmental determinants of physical activity and diet and their indicators informed the content of the questionnaire. The questionnaire consists of two section which are food environment and built environment. Food environment section includes census of shops selling foods and beverages in the selected areas and food environment in the stores. Built environment section includes assessment of selected aspects of neighbourhood 'walkability' and 'bikeability' in the selected areas. The overall reliability of the EURO-PREVOB Community Questionnaire was excellent (inter-observer agreement (IOA) > 0.87; intraclass correlation coefficients (ICC)s > 0.91 and kappa statistics > 0.7.

2.5.5 Business Impact assessment (BIA)-Obesity questionnaire

This questionnaire is developed by the International Network for Food and Obesity/Non-Communicable Diseases Research, Monitoring and Action Support (INFORMAS) group (Karupaiah & Hoe, 2019). The BIA-Obesity instrument covers domains related to: (1) corporate strategy; (2) product formulation; (3) nutrition labelling; (4) promotion practices; (5) product accessibility; and (6) relationships with external organisations. This instrument is based on the Access to Nutrition Index (ATNI) method, WHO recommendations, in which also included public health literature and being adapted for Malaysia use.

However, this questionnaire is used to measure the commitment by the food

industry players and the compliant to the food policy and does not measure the food environment among the individuals in the population and its association with chronic diseases.

2.5.6 Perceived Nutritional Environmental Measure Survey (NEMS-P)

2.5.6(a) Overview of NEMS-P

NEMS-P was developed to measure individuals' perceived food environment unlike other instrument which used trained raters to measure the neighbourhood food environment. This questionnaire had been used worldwide and had been translated to other languages as well. Ironically, the NEMS-P items cover the following constructs:

i. Sociodemographic factors
ii. Perceived community nutrition environment (6 items)
iii. Perceived consumer nutrition environment (24 items)
    a. Perceived store consumer nutrition environment
    b. Perceived restaurant consumer nutrition environment
iv. Perceived home food environment (30 items)
v. Perceived food shopping behaviours (11 items)
vi. Perceived eating behaviours (10 items)

The NEMS-P tool is a survey to be answered or completed by the person who does most of the food shopping in a household to learn about his/her perceptions of the nutrition environments (where food is consumed or purchased and at home). It was developed as a tool to compliment the observational data collected using the other NEMS tools provided by the team at the University of Pennsylvania led by Dr Glanz which record a trained rater's direct observations of the nutrition environments of specific food outlets in a defined area. The conceptual model for the questionnaire is