GLYCAEMIC CONTROL AMONG WOMEN WITH GESTATIONAL DIABETES MELLITUS IN NORTHERN TERENGGANU: A MIXED METHODS STUDY

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By:

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LIST OF ABBREVIATION

ABBREVIATION	TERMS
AOR	Adjusted Odds Ratio
B40	The bottom 40% of household income categorisation
BSP	Blood sugar profile
CDC	Centers for Disease Control and Prevention
CI	Confidence interval
DOSM	Department of Statistics Malaysia
GDM	Gestational diabetes mellitus
HbA_{1c}	Glycated haemoglobin
IDI	In-depth interview
M40	The middle 40% of household income categorisation
MOH	Ministry of Health
OAD	Oral antidiabetic agents
OR	Odds ratio
SEM	Social-ecological Model
SMBG	Self-monitoring of blood glucose
SPSS	Statistical Package for the Social Sciences
SSB	Sugar-sweetened beverages
T20	The top 20% of household income categorisation
T1DM	Type 1 diabetes mellitus
T2DM	Type 2 diabetes mellitus
WHO	World Health Organization

LIST OF SYMBOLS

SYMBOL	READ AS
%	Per cent
=	Equals to
≤	Less than or equal to
<	Less than
≥	Greater than or equal to
>	Greater than

ABSTRAK

KAWALAN GLISEMIK DALAM KALANGAN WANITA MENGHIDAP DIABETES SEMASA KEHAMILAN DI TERENGGANU UTARA: KAJIAN KAEDAH CAMPURAN

Latar belakang: Diabetes semasa kehamilan merupakan salah satu masalah kesihatan yang sering terjadi dalam kalangan wanita hamil. Penyakit ini dikaitkan dengan komplikasi jangka pendek dan panjang terhadap ibu dan bayi. Namun, maklumat tentang kawalan glisemik yang teruk di Malaysia masih terhad.

Objektif: Kajian ini bertujuan untuk menentukan efikasi kendiri, perilaku penjagaan diri, dan aktiviti fizikal, serta faktor-faktor yang berkaitan dengan kawalan glisemik yang teruk, dan menjelaskan faktor-faktor yang signifikan berdasarkan pengalaman peribadi dalam kalangan wanita menghidap diabetes semasa kehamilan.

Metodologi: Kajian berbentuk kaedah campuran telah dijalankan dalam kalangan wanita menghidap diabetes semasa kehamilan yang mendapatkan perkhidmatan antenatal di klinik-klinik kesihatan di daerah Besut dan Setiu. Pensampelan berstrata telah dilakukan dalam kajian kuantitatif untuk mendapat sampel seramai 235 orang. Analisis regresi logistik telah digunakan untuk menentukan sama ada faktor-faktor sosiodemografik dan obstetrik, efikasi kendiri, perilaku penjagaan diri, dan aktiviti fizikal mempunyai perkaitan dengan kawalan glisemik teruk. Kemudian, pensampelan bertujuan dilakukan dalam kajian kualitatif untuk mendapatkan 12 sampel dalam kalangan mereka yang telah terlibat dalam kajian kuantitatif dan mempunyai kawalan glisemik yang teruk. Analisis tematik telah

digunakan untuk mengenalpasti tema yang berulang. Data daripada kedua-dua kajian kemudiannya diintegrasikan untuk menjawab persoalan kajian.

Keputusan: Min (sisihan piawai; SP) tahap efikasi kendiri keseluruhan adalah 146.89 (24.02). Min (SP) tahap perilaku penjagaan diri untuk diet yang umum, diet yang spesifik, aktiviti fizikal, dan pemeriksaan gula darah adalah masing-masing 4.50 (1.34), 4.77 (1.35), 4.46 (1.58), dan 0.45 (0.44). Median (julat antara kuartil) untuk aktiviti fizikal adalah 137.56 (112.23). Faktor-faktor yang signifikan dengan kawalan glisemik teruk adalah kaunseling dietetik (AOR=2.99; 95% CI: 1.41, 6.35; *p*-value=0.004) dan efikasi kendiri untuk diet (AOR=0.75; 95% CI: 0.57, 0.98; *p*-value=0.033). Enam tema yang dikenalpasti daripada temuramah adalah ketakutan dan kebimbangan, pengetahuan dan motivasi, keutamaan dan kepercayaan terhadap diet, faktor keluarga, faktor pekerjaan, dan kebolehdapatan dan kemampuan. Kebanyakan responden mengakui bahawa sesi kaunseling dietetik memberikan pengetahuan pemakanan yang penting dan praktikal untuk pelaksanaan, sambil turut meningkatkan keyakinan mereka dalam menguruskan GDM dengan lebih berkesan. Selain itu, mereka juga menunjukkan efikasi diri dalam pemakanan dengan mengamalkan tabiat makan sihat, didorong oleh kesedaran peribadi atau termotivasi dengan keluarga mereka.

Kesimpulan: Kajian ini menunjukkan bahawa kawalan glisemik dalam kalangan wanita menghidap diabetes semasa kehamilan tidak hanya dipengaruhi oleh faktor-faktor dalaman, tetapi juga oleh faktor-faktor luaran.

Kata kunci: Diabetes semasa kehamilan, keberkesanan diri, perilaku penjagaan diri, aktiviti fizikal, kawalan glisemik yang teruk

ABSTRACT

GLYCAEMIC CONTROL AMONG WOMEN WITH GESTATIONAL DIABETES MELLITUS IN NORTHERN TERENGGANU: A MIXED METHODS STUDY

Background: Gestational diabetes mellitus (GDM) has become a common medical condition in pregnancy and is associated with short- and long-term complications for mothers and offspring. However, information regarding poor glycaemic control is still limited in Malaysia.

Objectives: This study aims to determine glycaemic control, self-efficacy, self-care, and physical activity levels, as well as factors associated with poor glycaemic control among women with GDM and to explain its significant factors based on individual experiences of women with GDM.

Methodology: An explanatory sequential mixed methods study was conducted among women with GDM who attended health clinics in the Besut and Setiu districts for antenatal care. Stratified sampling proportional to size method was done in quantitative research to obtain 235 samples. Logistic regression was applied to determine associations between sociodemographic and obstetric characteristics, self-efficacy, self-care activity and physical activity with poor glycaemic control. Then, purposive sampling was done in qualitative inquiry to obtain 12 samples among women who were recruited in the quantitative research and had poor glycaemic control. Thematic analysis was applied to identify recurring themes. The data from

both quantitative and qualitative inquiry were then integrated to answer research questions.

Results: The mean (SD) score for overall self-efficacy was 146.89 (24.02). The mean (SD) score for self-care general diet, specific diet, physical activity, and blood glucose testing was 4.50 (1.34), 4.77 (1.35), 4.46 (1.58), and 0.45 (0.44), respectively. The median (IQR) for overall physical activity was 137.56 (112.23). Dietetic counselling (AOR=2.99; 95% CI: 1.41, 6.45; *p*-value=0.004) and diet self-efficacy (AOR=0.75; 95% CI: 0.57, 0.98; *p*-value=0.033) were associated with poor glycaemic control. There were six themes emerged from the interviews, namely: fear and worry, knowledge and motivation, dietary preferences and beliefs, family factors, occupational factors, and availability and affordability. Most of the respondents acknowledged that dietetic counselling sessions offered crucial dietary knowledge and practical integration tips, while also increasing their confidence in managing GDM more effectively. Furthermore, they demonstrated diet self-efficacy by adopting healthy eating habits, driven by personal awareness or their family members.

Conclusion: Our findings showed that glycaemic control among women with GDM was influenced not only by internal factors but also external factors.

Keywords: Gestational diabetes mellitus, self-efficacy, self-care, diet, physical activity, poor glycaemic control

CHAPTER 1

INTRODUCTION

1.1 Background of study

Gestational diabetes mellitus (GDM) has become a common medical condition in pregnancy which could be attributed to the obesity epidemic and increasing maternal age (Ferrara, 2007; Yang *et al.*, 2022). Generally, it reflects the prevalence of type 2 diabetes mellitus (T2DM) in the population (Ferrara, 2007; Hussain *et al.*, 2020). Gestational diabetes mellitus refers to glucose intolerance of varying severity, which is first detected during pregnancy, regardless of whether the condition persists after delivery (American Diabetes Association [ADA], 2009; Ministry of Health [MOH] Malaysia, 2015; Hussain *et al.*, 2020). However, this definition does not rule out the probability that the condition may develop before or simultaneously with the pregnancy (ADA, 2009; Hussain *et al.*, 2020). The definition also does not distinguish whether or not women with GDM are treated with insulin therapy (ADA, 2009; Hussain *et al.*, 2020).

Naturally, pregnant women will experience a state of insulin resistance in the second or third trimester of pregnancy due to hormonal changes such as estrogen, progesterone, leptin, cortisol, placental lactogen, and placental growth hormone (Plows *et al.*, 2018; Burlina *et al.*, 2019; Muche *et al.*, 2019). This situation leads to a slight elevation in blood glucose levels, enabling it to pass through the placenta and

support the growth of the fetus (Colberg *et al.*, 2013; Plows *et al.*, 2018; Burlina *et al.*, 2019). However, in a normal pregnancy, there will be a gradual increase in insulin secretion to control blood glucose levels (Colberg *et al.*, 2013; Burlina *et al.*, 2019). On the other hand, pregnant women whose pancreatic β-cells are unable to keep up with increased insulin demands will develop GDM (Colberg *et al.*, 2013).

The global prevalence of GDM is estimated to be around 14% (Wang *et al.*, 2022a). As for Malaysia, the prevalence of GDM in the country is 22.5% (Kunasegaran *et al.*, 2021). Its prevalence is even higher in Terengganu which is 27.3% (Abd Latif *et al.*, 2022). With the rising prevalence of diabetes mellitus in our country, increasing from 11.2% in 2011 to 13.4% in 2015, and further to 18.3% in 2019 (Institute for Public Health Malaysia [IPH], 2020), it is anticipated that the prevalence of GDM will also increase in the upcoming years.

The increase in the prevalence of GDM would impose additional burdens on the public health system as GDM is associated with short- and long-term complications for both mothers and offspring. Short-term complications of GDM include pregnancy-induced hypertension, pre-eclampsia, increased numbers of caesarean sections, preterm delivery, macrosomia, neonatal hypoglycaemia, congenital anomalies, shoulder dystocia, and other injuries (Parsons *et al.*, 2018; Hussain *et al.*, 2020). One of the long-term complications of GDM is the development of T2DM among women with a history of GDM. A recent systematic review of 20 studies found that women with GDM are ten times more likely to develop T2DM when compared to the general population (Dennison *et al.*, 2021; Yang *et al.*, 2022). There is an increasing body of epidemiological evidence linking adult metabolic disorders to early-life environmental

exposures, known as the Developmental Origins of Health and Disease (DOHaD) hypothesis. In a follow-up study in Denmark, it was found that adult offspring of women with diet-controlled GDM have seven times the odds of developing T2DM or pre-diabetes (Clausen *et al.*, 2008; Burlina *et al.*, 2019).

Previous studies showed that lifestyle changes such as dietary modification and physical activity are crucial in maintaining desired blood glucose levels (Wang *et al.*, 2021), which subsequently reduce the risk of short-term and long-term complications of GDM (Yefet *et al.*, 2019). In a meta-analysis of 18 studies involving 1,151 women with GDM, Yamamoto *et al.* (2018) found that various dietary modifications reduced fasting plasma glucose level (by 0.2 mmol/L), postprandial glucose level (by 0.4 mmol/L), and birth weight (by 171 gram). In a local study involving 166 women with GDM, the authors found that knowledge about GDM had a significant negative association with fasting plasma glucose (Hussain *et al*., 2015). In an intervention study by Coe *et al.*, (2018), the researchers discovered that engaging in moderate-intensity walking for 30 minutes could lower postprandial (after-meal) blood glucose levels for two hours following the activity. Additionally, participants experienced better glucose control for up to three hours after meals on days when they walked compared to sedentary days.

While it is well-established that appropriate dietary changes and increased physical activity can lead to improved glycaemic control in women with GDM, not all women can achieve the target blood glucose levels. Therefore, it is crucial to identify women's perceptions of GDM and explore their experiences in self-managing the condition to adopt a healthier lifestyle to manage GDM effectively.

1.2 Problem statement

Previous studies have predominantly concentrated on T2DM, leaving a significant gap in our understanding of GDM. This oversight is particularly evident in the areas of self-efficacy and self-care behaviours, which are crucial for the effective management of GDM. As a result, there is a need for further study to investigate these aspects in women with GDM. Addressing this gap will enhance our comprehension and provide better support for managing GDM effectively.

Various studies have demonstrated that glycaemic control is influenced by multiple factors including diet, physical activity, medication adherence, self-efficacy, and so on. However, these studies tend to investigate these factors independently, which may result in overlooking the complex interactions between them. By isolating each factor, these studies may miss how these elements work together or counteract each other. This fragmented approach can limit the overall understanding of how these factors collectively impact glycaemic control. Therefore, integrating the investigation of all these factors could provide a more holistic view of their combined effects on glycaemic management.

While numerous studies have investigated the factors that contribute to achieving good glycaemic control, a significant gap remains in research concerning the factors associated with poor glycaemic control. This gap highlights a broader issue of inadequate understanding of the specific challenges that hinder effective glucose management, particularly among women with GDM. The insufficient focus on poor

glycaemic control among women with GDM leads to the failure to address and mitigate the obstacles that lead to suboptimal glucose levels. Consequently, the complexities of poor glycaemic control in GDM remain poorly explored, affecting the overall comprehension of the condition's management.

As dietary modification and physical activity are crucial to managing glycaemic control among women with GDM, it is essential to investigate whether these women are practising the recommended self-management behaviours. Understanding the barriers and enablers that influence their ability to adopt and maintain these healthy lifestyles is crucial for effective management. Currently, there is a lack of qualitative studies, not to mention mixed methods studies, that explore these factors in the context of GDM management. This absence of comprehensive study limits the understanding of how women with GDM manage their condition and the challenges they face. Consequently, more detailed investigations are needed to address these gaps and provide a clearer picture of GDM self-management practices.

1.3 Rationale

Previous studies have highlighted the significant role that self-efficacy and self-care practices play in achieving optimal glycaemic control among women with GDM. Therefore, it is essential to assess the levels of these factors among these populations. Determining these levels will enable the development of targeted health education interventions designed to enhance self-efficacy and self-care practices, which would lead to improved glycaemic outcomes and a reduction in complications associated with GDM.

Investigating all factors simultaneously can provide a more comprehensive understanding of how these factors interact to achieve optimal glycaemic control. This approach allows for a deeper insight into the complex relationships between various influences and how they collectively impact glycaemic management. Exploring the experiences of women with GDM in self-managing their glycaemic control provides valuable insights into their conditions and the challenges they encounter. This in-depth understanding can inform the development of more effective and practical health education programs, tailored to address specific needs and support women in achieving optimal glycaemic levels.

1.4 Research questions

1. What are the self-efficacy, self-care activity, and physical activity levels among women with GDM in Besut and Setiu districts, Terengganu?
2. Are there any association between sociodemographic and obstetric characteristics, self-efficacy, self-care activity, and physical activity levels with poor glycaemic control among women with GDM in Besut and Setiu districts, Terengganu?
3. What are the individual experiences in managing glycaemic control among women with GDM who had poor glycaemic control in Besut and Setiu districts, Terengganu?
4. What are the explanations for the significant factors of poor glycaemic control among women with GDM in Besut and Setiu districts, Terengganu?

1.5 Research objectives

1.5.1 General objective

To study factors (sociodemographic and obstetric characteristics, self-efficacy, self-care activity, and physical activity levels) associated with poor glycaemic control, and further explain its significant factors based on individual experiences of women with GDM in Besut and Setiu districts, Terengganu.

1.5.2 Specific objectives

1. To determine the self-efficacy, self-care activity, and physical activity levels among women with GDM in Besut and Setiu districts, Terengganu.
2. To determine the association between sociodemographic and obstetric characteristics, self-efficacy, self-care activity, and physical activity levels with poor glycaemic control among women with GDM in Besut and Setiu districts, Terengganu.
3. To explore individual experiences in managing glycaemic control among women with GDM who had poor glycaemic control in Besut and Setiu districts, Terengganu.
4. To explain the significant factors of poor glycaemic control based on individual experiences of women with GDM in Besut and Setiu districts, Terengganu

1.6 Research hypothesis

There are significant associations between sociodemographic and obstetric characteristics, self-efficacy, self-care activity, and physical activity levels with poor glycaemic control among women with GDM in Besut and Setiu districts, Terengganu.

CHAPTER 2

LITERATURE REVIEW

The literature search was conducted through three search engines, namely PubMed, Scopus, and Google Scholar. Keywords used in the search were gestational diabetes mellitus, self-efficacy, self-efficacy, physical activity, blood glucose monitoring, glycaemic control, and pregnancy.

2.1 Glycaemic control for gestational diabetes mellitus (GDM)

Glycaemic control is a technique for monitoring the blood glucose levels of individuals with diabetes. According to the local guidelines on GDM, the recommended glycaemic targets are; (1) ≤ 5.3 mmol/L for fasting blood glucose; (2) ≤ 7.8 mmol/L for 1-hour postprandial blood glucose; and (3) ≤ 6.7 mmol/L for 2-hour postprandial (MOH Malaysia, 2017a). Few researchers have suggested glycated haemoglobin A1c (HbA_{1c}) as an indicator for glycaemic control with a value of ≤ 6.5% considered good control (Buhary *et al.*, 2016; Abd Latif *et al.*, 2022). However, despite HbA_{1c} being the gold standard indicator for T2DM, it is not an appropriate indicator for glycaemic control in GDM due to the temporariness of GDM and iron deficiency condition which is common in pregnancy (Hashimoto and Koga, 2015; Hussain *et al.*, 2015a; Li *et al.*, 2016; Gante *et al.*, 2018).

To achieve desired glycaemic control, women with GDM should adhere to dietary modification and regular exercise. If the desired levels are not achieved within 1-2 weeks, it is recommended that women with GDM should be offered metformin (National Institute for Health and Care Excellence [NICE], 2015). Although both metformin and glibenclamide have been used in treating GDM, the latter is less preferred due to limited human data on its safety during pregnancy (MOH Malaysia, 2017a). Should both lifestyle modification and metformin therapy fail to achieve the desired glycaemic control, then, insulin therapy should be initiated (MOH Malaysia, 2017a). Those who are still unable to achieve optimal glycaemic control after dietary modification, regular exercise, and initiation of OAD or insulin, would be considered as having poor glycaemic control (Xu *et al.*, 2022). Poor glycaemic control increases the risk of pre-eclampsia, caesarean delivery, perineal tear, miscarriage, premature birth, premature rupture of membranes (PROM), neonatal hypoglycaemia, macrosomia, and neonatal intensive care unit (NICU) admission (Buhary *et al.*, 2016; Wang *et al.*, 2021).

The prevalence of poor glycaemic control varies greatly from one country to another. A local study by Hussain *et al*. (2015) found that the prevalence of poor glycaemic control among women with GDM was 40.4%. A study in Riyadh involving 177 women with GDM found that 46.9% of the women had $HbA_{1c} > 6.5\%$ (Buhary *et al.*, 2016). Meena *et al.* (2021) reported that the prevalence of poor glycaemic control in India was 38.5%. In a study at the University of Pittsburgh Medical Center, Colicchia *et al*., (2016) discovered that 22.5% of women with GDM had unsatisfactory glycaemic control. A study in China involving 689 women with GDM found that the prevalence of poor glycaemic control was 19.3% (Fan *et al.*, 2006).

2.2 Determinants of poor glycaemic control among women with GDM

2.2.1 Sociodemographic and obstetric characteristics

2.2.1(a) Maternal age

Age has been proven to be one of the determinants of glycaemic control. Previous studies among patients with T2DM showed that older people were more likely to have a controlled glycaemic status (Toh *et al.*, 2011; Woldu *et al.*, 2014; Shamshirgaran *et al.*, 2017; Haghighatpanah *et al.*, 2018; Fekadu *et al.*, 2019). Some authors postulated that older patients were more likely to adhere to medications, thus improving their glycaemic control (Ahmad *et al.*, 2014; Shamshirgaran *et al.*, 2017). On the other hand, younger patients faced more challenges in managing their glycaemic control, for instance, low-fat diet, adherence to medications and dietary suggestions, and glucose monitoring (Fekadu *et al.*, 2019).

A study among women with GDM in China revealed that older maternal age was associated with poor glycaemic control (Xu *et al.*, 2022). The authors attributed the findings to the decline of the sensitivity of tissues towards insulin as maternal age increases. Buhary *et al.* (2016) also found that older maternal age was associated with poor glycaemic control in the GDM group, but not in the type 1 diabetes mellitus (T1DM) or T2DM group.

2.2.1(b) Educational level

Another determinant of glycaemic control is educational level. Wu *et al.* (2018) discovered that patients with T2DM who attained tertiary education (university or above) had better HbA_{1c} control compared to those with low educational levels. Other studies found that patients with T2DM who were illiterate had more than 3 times higher odds of having uncontrolled glycaemic status (Kassahun *et al.*, 2016; Fekadu *et al.*, 2019; Saghir *et al.*, 2019). Yin *et al.* (2016) also found patients with T2DM who were less educated were more likely to be persistent in poor glycaemic control. Interestingly, Sánchez-Hernández *et al.* (2020) discovered that high educational level was associated with compliance to medication, but not with glycaemic control status. Likewise, educational level was found to be significantly associated with diabetes-related knowledge, but not with HbA_{1c} (Islam *et al.*, 2015).

In a local study among women with GDM, Hussain *et al*. (2015) revealed that there was a significant difference in total mean knowledge score between women with primary education and other three educational levels (secondary education, diploma, and degree). Furthermore, the authors also found that maternal educational level was strongly associated with glycaemic control. Generally, low educational levels were correlated with low levels of health literacy and poor understanding towards the disease and its management. In another study involving 4,490 women with GDM, Gante *et al.* (2018) revealed that women who attained lower educational levels were more likely to start insulin therapy, indicating poor glycaemic status among them.

2.2.1(c) Employment status

Employment status was found to be one of the predictors for glycaemic control (Abdissa and Hirpa, 2022). Kassahun *et al.* (2016) discovered that farmers and employed had more than two times (AOR= 2.47 and 2.65 respectively) the odds of having poor glycaemic control than those who were unemployed. Haghighatpanah *et al.* (2018) found that occupation was significantly associated with HbA_{1c} values. In a study among the Chinese population with T2DM by Lin *et al.* (2017), using the Chi-square test, the authors revealed that employment status was significantly associated with glycaemic control. Then, they proceeded to do a correlation analysis and found that employment status was not correlated with HbA_{1c} levels. Instead, employment status was significantly correlated with diabetes self-management, while diabetes self-management was significantly correlated with lower HbA_{1c} values. Unemployed women had higher odds of having poor glycaemic control in univariable analysis, but not in multivariable analysis (Pénager *et al.*, 2020).

2.2.1(d) Parity

Several studies found that multiparous women with GDM had an increased risk of having poor glycaemic control (Scifres *et al.*, 2016; Pénager *et al.*, 2020). In a study by Buhary *et al.* (2016) where pregnant women with diabetes were classified based on types of diabetes in pregnancy (GDM, T1DM, and T2DM), the authors discovered that multiparity was significantly associated with poor glycaemic control ($HbA_{1c} > 6.5\%$) among women with GDM and T2DM. Wang *et al.* (2022b) found that multiparous require a longer duration of physical activity to achieve glycaemic control at a similar level to primiparous women and suggested that this finding might be due to insulin

resistance occurring with each pregnancy, which could lead to a decrease in beta-cell function.

2.2.1(e) Prepregnancy BMI

Several studies involving patients with T2DM discovered an association between BMI and poor glycaemic control. Toh *et al*. (2011) found that those who were overweight and obese had 1.3-1.4 times higher odds of having uncontrolled diabetes (HbA_{1c} > 8%). Haghighatpanah *et al.* (2018) revealed that BMI was significantly associated with HbA_{1c} levels. In a study among 111 women with GDM, Colicchia *et al*. (2016) revealed that prepregnancy BMI was associated with glycaemic control. Buhary *et al.* (2016) found contradicting results between the three groups where prepregnancy BMI was significantly associated with poor glycaemic control only among the GDM group, but not in the T1DM and T2DM groups.

2.2.2 Self-efficacy

Self-efficacy is another important factor that influences one's decision to engage in healthy behaviours apart from proper knowledge and skills (Artino, 2012). According to Bandura (1995), self-efficacy is one's belief in his or her capability to perform certain actions that are required to reach certain outcomes. In his early writings, when he introduced the concept of self-efficacy, Bandura explained that in a behavioural change theory, outcome expectancies (the belief that certain behaviours lead to certain outcomes) should be differentiated from efficacy expectations (the belief that one can successfully perform certain behaviours to obtain certain outcomes). In reality, even if an individual believes that a particular behaviour leads to a favourable outcome, without a good level of confidence that he or she could carry out the behaviour, such

information would not change his or her behaviour (Bandura, 1977). Furthermore, Bandura postulated that people with high self-efficacy tend to engage in particular tasks, while those with low self-efficacy are more likely to avoid them. On top of that, he also hypothesised that people with high self-efficacy are more likely to put more effort and last longer in withstanding hardships (Bandura, 1977).

2.2.2(a) Sources of self-efficacy

Previous studies have proven that self-efficacy is easily influenced (Gerhardt and Brown, 2006). Bandura (1977) proposed four principal sources of information that shape self-efficacy, namely: (1) performance accomplishments; (2) vicarious experience; (3) verbal persuasion; and (4) physiological states. Performance accomplishments (also known as mastery experiences) refer to one's personal experiences in successfully carrying out certain tasks and are considered the most influential source of information for self-efficacy. Bandura (1977) explained that being successful in performing certain tasks enhances mastery experiences, while failure to carry those tasks out weakens them. However, once self-efficacy levels were developed relatively high through repeated successes, the effect of infrequent failure might be lessened. Vicarious experience (or vicarious persuasion) means obtaining information by observing others performing particular tasks successfully (Juwita *et al.*, 2023). The observers are more likely to persuade themselves that if others can perform a particular task, they also could perform it (Bandura, 1977). Verbal persuasion is a common approach used to convince others that they can carry out a particular task successfully (Juwita *et al.*, 2023). However, verbal persuasion is sometimes used to increase outcome expectancies instead of increasing self-efficacy (Bandura, 1977). The final source of efficacy information is emotional arousal which refers to the

emotional sensation that an individual feels during a certain task (Loo and Choy, 2013). According to Bandura (1977), since high arousal weakens self-efficacy, an individual who is worried or bothered is more likely to expect failure in performing a certain task.

2.2.2(b) Self-efficacy among patients with T2DM

Self-efficacy plays an important role in managing patients with T2DM (Bohanny *et al.*, 2013; Walker, Smalls, *et al.*, 2014; Tharek *et al.*, 2018). Previous studies have shown that self-efficacy can have either direct impacts on glycaemic control (Al-Khawaldeh *et al.*, 2012; Walker *et al.*, 2014; Walker *et al.*, 2015; Qteishat and Al-Ghananim, 2016), as well as indirect effects through self-care behaviours (Gao *et al.*, 2013; Lin *et al.*, 2017). In other words, several studies discovered that self-efficacy was not a significant determinant of glycaemic control, but had a positive correlation with self-care behaviours, and at the same time, these self-care behaviours were significantly associated with good glycaemic control.

Several studies among patients with diabetes reported self-efficacy measurement as overall (or general) self-efficacy, such as higher overall self-efficacy scores indicate the respondents are more convinced to perform tasks related to diabetes management and vice versa (Ahmad Sharoni and Wu, 2012; Al-Nadhiri *et al.*, 2023) However, an individual's self-efficacy varies across different diabetes-related behaviours. For instance, a person might have high self-efficacy for blood glucose testing but low self-efficacy for exercise (Al-Khawaldeh *et al.*, 2012). Thus, the analysis of behaviour-specific self-efficacy is beneficial for further improvement in diabetes management.

In a local study among patients with T2DM, Ahmad Sharoni and Wu (2012) revealed that the overall self-efficacy score was moderately high (mean score = 7.57 out of 10). This finding was comparable to another local study by Tharek *et al.* (2018) and a Jordanian study by Al-Khawaldeh *et al.* (2012) with a mean score of 7.33 and 7.26, respectively. However, Alaboudi *et al.* (2016) found that patients with T2DM in Saudi Arabia had a lower level of self-efficacy (mean score = 6.97). In an Iranian study, Dehghan *et al.* (2017) discovered a much lower level of self-efficacy among patients (mean score = 5.49).

Several studies found that their respondents were most efficacious in tasks related to follow-up and taking medication. Alaboudi *et al.* (2016) found that the mean score for the domain was 9.19 out of 10, while studies by Ahmad Sharoni and Wu (2012), Al-Khawaldeh *et al.* (2012), and Tharek *et al.* (2018) discovered that the mean score was 9.04, 8.9, and 8.78, respectively. However, these studies reported different domains as the least efficacious behaviours. For instance, Ahmad Sharoni and Wu (2012) and Alaboudi *et al.* (2016) found that diet self-efficacy had the lowest score (a mean score of 6.57 and 5.85 respectively), while Tharek *et al.* (2018) found that blood glucose testing self-efficacy had the lowest score (mean score = 6.6) and Al-Khawaldeh *et al.* (2012) revealed that exercise-related domain was the least efficacious among the respondents (mean score = 6.2).

2.2.2(c) Self-efficacy among women with GDM

Studies regarding self-efficacy among women with GDM are limited compared to studies among patients with T2DM. In a study in Oman by Al-Hashmi *et al.* (2019), the authors discovered that the overall self-efficacy score was moderate (mean score

= 120.6 out of 190). In another study in Oman by Al-Nadhiri *et al.* (2023), the authors found that the overall self-efficacy score was moderately high (mean score = 121.58 out of 160). Kordi and Banaei Heravan (2020) revealed that women with GDM in Iran had a low self-efficacy level (mean score = 45.87 out of 80). Similar to studies among patients with T2DM, Al-Nadhiri *et al.* (2023) found that the respondents were most efficacious in tasks related to follow-up and taking medication (mean score = 8.74 out of 10). The domain with the lowest score was physical activity self-efficacy (mean score = 6.48).

2.2.3 Self-care activity

In general, self-care behaviours are a set of activities carried out to ensure, maintain, and promote health (Kordi and Banaei Heravan, 2020). Previous studies have shown that the three most crucial self-care activities are dietary modification, regular physical activity, and self-monitoring of blood glucose (Silva-Zolezzi *et al*., 2017; Rasmussen *et al.*, 2020; Su *et al.*, 2023). Adherence to these recommended self-care activities is considered the key element to achieving optimum glycaemic control in GDM (Sarkar *et al*., 2006). Similar to self-efficacy, usually women with GDM engage in different self-care activities unevenly. In other words, certain activities might be done almost every day, while other activities are done once or twice a week. For instance, Al-Hashmi *et al.* (2019) discovered that the most practised self-care behaviour was diet restriction (mean score = 4.0 out of 7 days), followed by blood glucose testing (mean score = 2.5) and physical activity (mean score = 2.1).

2.2.3(a) Dietary modification

Up to now, dietary modification is still considered the standard first-line self-management of GDM (Hernandez and Brand-Miller, 2018). Brown *et al.* (2016) found that adherence to dietary modification was a strong determinant of HbA_{1c}. However, in achieving optimum glycaemic control, dietary modification should not compromise gestational weight gain, proper nutrition for the mother and offspring, and foetal growth and development (Moreno-Castilla *et al.*, 2016; Vasile *et al.*, 2021). Besides, proper dietary modification could be a starting point to promote continuous healthier lifestyles which could prevent or delay the development of T2DM and break the vicious cycle of intergenerational obesity and metabolic diseases (Moreno-Castilla *et al*., 2016; Hernandez and Brand-Miller, 2018). The dietary modification should be individualised based on women's sociodemographic backgrounds, such as BMI status, health status, ethnicity, educational level, household income, cultural aspects, compliance, family support, and so on (Vasile *et al.*, 2021). It also should be a continuous event tailored to women's diet and appetite, blood glucose, weight gain patterns, and physical activity (Rasmussen *et al.*, 2020).

The dietary modification also should emphasise four criteria of a healthy diet, namely: (1) variety; (2) adequate; (3) balanced diet; and (4) moderate. Variety refers to consuming different types of food groups every day, such as vegetables, fruits, cereals, fish, poultry/eggs, meat, legumes, and milk and milk products. Adequate means the food consumed provides sufficient energy, nutrients, and fibre for women with GDM to maintain their health. It should be noted that an adequate diet for a person might not be adequate for others. A balanced diet contains the right proportion of each nutrient needed by women with GDM. Last but not least, moderation ensures the proper

amount of food required to achieve the desired gestational weight gain and optimise the body's metabolic process (National Coordinating Committee on Food and Nutrition [NCCFN], 2021). In other words, all these criteria could be presented in the form of the Malaysian Healthy Plate which is based on the quarter-quarter-half concept which means a quarter of rice or other grain products (noodles, pasta, bread, oats), a quarter of animal or plant protein (chicken, meat, fish, eggs, soya bean, baked beans), and a half of vegetables (leafy green vegetables, coloured vegetables, fruit vegetables, raw vegetables or *ulam*, and edible vegetable stems) and fruits (NCCFN, 2021).

The local guidelines for the management of diabetes in pregnancy suggest dietary modification for women with GDM should be focused on managing carbohydrate intake (MOH Malaysia, 2017). Carbohydrates have been proven to have a huge impact on postprandial blood glucose levels (Ali *et al.*, 2013; Moreno-Castilla *et al.*, 2016; Rasmussen *et al.*, 2020). Both the type and amount of carbohydrates consumed can affect glycaemic control (Ali *et al.*, 2013; MOH Malaysia, 2017; Rasmussen *et al.*, 2020). It is recommended that women with GDM opt for low glycaemic-index (GI) foods (Ali *et al.*, 2013; MOH Malaysia, 2017). The concept of GI refers to the relative increase of plasma glucose 2 hours postprandial (Rasmussen *et al.*, 2020), i.e., low GI foods increase the blood glucose level slowly and steadily. Previous studies have shown that the consumption of low GI foods significantly lowered 2-hour postprandial blood glucose levels and decreased the need for insulin therapy among women with GDM (Rasmussen *et al.*, 2020). As for the amount of carbohydrate intake, it is recommended that carbohydrate consumption should be apportioned throughout the day to prevent an excessive amount of carbohydrates at one particular time (Rasmussen *et al.*, 2020).

Sugar is a type of carbohydrate (NCCFN, 2017). The term ‘added sugars’ or ‘free sugars’ refers to both monosaccharides (glucose or fructose) and disaccharides (sucrose or table sugar) that are added by manufacturers, cooks, or consumers while processing or preparing foods and beverages. Added sugars also include syrups, honey, or fruit juice concentrates. However, sugars which are naturally found in fruits (such as fructose and glucose), vegetables (such as fructose and sucrose), and milk (lactose) are not considered free sugars (World Health Organization [WHO], 2015; NCCFN, 2017). Based on the latest evidence, the WHO recommended that daily free sugar intake should not exceed 10% of total energy consumption, while a further reduction to 5% of total energy intake is considered a conditional recommendation (WHO, 2015; NCCFN, 2017). However, in a study among Malaysian adults and children, sugar consumption was higher than 10% of the calorie intake (NCCFN, 2017). Moreover, Malaysia was found to be the second-highest country with a high availability of sugar and sweeteners (NCCFN, 2017). In the Malaysian Adults Nutrition Survey (MANS), the overall prevalence of daily sugar consumption was 55.9% (58.2% and 53.3% among men and women, respectively). The mean daily servings for men and women were 4.0 and 3.2 teaspoons respectively. The survey also found that sugar was the second most common food consumed every day by adults in the country (Mohamad Kasim *et al.*, 2018).

Several studies have shown that pregnant women tend to improve their dietary behaviours during pregnancy. In a qualitative study conducted in the United States, Lewallen (2004) discovered that the majority of the respondents reported practising healthy dietary behaviours during pregnancy. Smedley *et al.* (2014) compared healthy

behaviours practised by women before and during pregnancy and found that there were significant increases among those who ‘always consume vegetables’ (from 61% to 77%), ‘always consume fruits’ (from 65% to 78%), and ‘always consume fibre’ (from 55% to 76%). The authors also discovered that the proportion of ‘never had fast food’ during pregnancy significantly increased (from 56% to 67%). However, in terms of sugar intake, in a local study by Hasbullah *et al.* (2019), it was revealed that women with GDM consumed high-sugar diets more than the recommended levels (less than 10% of total energy) in the first and second trimesters (18.7% and 18.8% respectively).

2.2.3(b) Physical activity

Commonly, the terms physical activity and exercise are used interchangeably, however, these two terms are different. To be precise, exercise is a subset of physical activity. Physical activity refers to any bodily movements using skeletal muscles that require energy, while exercise is a form of physical activity that is planned, structured, and repetitive movements, and is carried out to improve physical fitness (NCCFN, 2021). Physical activity can be classified based on its type, frequency, duration, and intensity. There are four types of physical activity that should be carried out, namely: (1) endurance activities which are also known as aerobic activities; (2) strength activities; (3) balance activities; and (4) flexibility activities (National Institute on Aging [NIA], 2021). Frequency means the number of times an individual is involved in physical activity over a predetermined period (for example, three times per week), while duration is the time taken to complete a particular physical activity which is usually described in minutes (NCCFN, 2021). Lastly, intensity refers to the degree of overload imposed on the body during performing physical activity compared to resting states. The intensity of physical activity can be categorised into four categories based

on the amount of oxygen consumed during physical activity. Oxygen consumption is expressed in metabolic equivalents or METs (the metabolic equivalent of task). For example, the amount of oxygen consumed while sitting at rest is one MET, which is equal to 3.5 mL of oxygen per kg/minute (NCCFN, 2021). The four categories of intensity are: (1) sedentary behaviour (≤ 1.5 METs); (2) mild- or light-intensity (1.5 METs – ≤ 3.0 METs); (3) moderate-intensity (3.0 METs – < 6.0 METs); and (4) vigorous-intensity (≥ 6.0 METs) (WHO, 2020).

Moderate- and vigorous-intensity aerobic activities are considered safe to be carried out by most pregnant women (Colberg *et al*., 2013; WHO, 2020). These activities include walking, running, jogging, cycling, swimming, water aerobics, and so on. Pregnant women could also safely engage in resistance exercise which is effective in minimising the need for exogenous insulin in managing GDM (De Barros *et al.*, 2010; Colberg *et al.*, 2013).

The World Health Organization published new guidelines in the year 2020, focusing on evidence-updated recommendations regarding the amount of physical activity (frequency, duration, and intensity), as well as addressing sedentary behaviour. These new guidelines provide recommendations for all age groups (children, adolescents, adults, and older adults), and for the first time, include specific recommendations for special groups, such as pregnant and postpartum women, people with chronic conditions, and people with a disability. In general, engaging in some physical activity is better than doing none. Even if they are unable to meet the recommendations, doing some physical activity, even light-intensity physical activity, will benefit them (Bull *et al.*, 2020; WHO, 2020).

Pregnant women without contraindications are recommended to engage in regular physical activity throughout pregnancy and after delivery (NCCFN, 2021). They should carry out at least 150 minutes of moderate-intensity aerobic activities per week. They combine a variety of aerobic, muscle-strengthening, and stretching activities. If they regularly perform vigorous-intensity activities before pregnancy, then they can resume those activities during pregnancy and postpartum periods (Bull *et al.*, 2020; WHO, 2020). However, there are several safety considerations such as: (1) they should avoid performing activities in a supine position after the first trimester; (2) they should avoid performing activities during excessive heat; (3) they should avoid engaging in high-risk activities (such as those activities involving physical contact, risk for fall, and limit oxygenation); (4) they should watch their hydration status; (5) they should learn from healthcare providers on how to identify and deal with red flag during physical activity (Bull *et al.*, 2020; WHO, 2020).

Pregnant women with absolute contraindications are not allowed to participate in activities that are more vigorous than their daily living activities. Examples of absolute contraindications are pre-eclampsia, unexplained vaginal bleeding, placenta previa after 28 weeks of gestation, incompetent cervix, ruptured membrane, uncontrolled T1DM, uncontrolled thyroid disease, uncontrolled hypertension, and more (NCCFN, 2021). As for pregnant women with relative contraindications, they should consult their obstetricians before engaging in physical activities. Examples of relative contraindications are hypertensive disorders of pregnancy, recurrent pregnancy loss, mild or moderate cardiovascular disease, eating disorders, history of spontaneous preterm birth, and so on (NCCFN, 2021).