PREVALENCE OF GESTATIONAL DIABETES MELLITUS AND SELECTED RISK FACTORS AMONG PREGNANT WOMEN IN HOSPITAL UNIVERSITI SAINS MALAYSIA

ONG MING FONG

BACHELOR OF NURSING
SCHOOL OF HEALTH SCIENCES
UNIVERSITI SAINS MALAYSIA

2021

PREVALENCE OF GESTATIONAL DIABETES MELLITUS AND SELECTED RISK FACTORS AMONG PREGNANT WOMEN IN HOSPITAL UNIVERSITI SAINS MALAYSIA

by

ONG MING FONG

Dissertation submitted in partial fulfillment of the requirement for the Bachelor of Nursing (Honours)

July 2021

ACKNOWLEDGEMENT

First of all, I would like to dedicate my dissertation to my lovely supervisor, Madam Duangta A/P Shet and co-supervisor, Dr. Norhasmah Mohd Zain for always spending their invaluable times and giving full support in guiding, supervising and encouragement throughout the process of proposal preparation to completion of the dissertation. The dissertation would not be able to accomplish without their assistance and dedicated involvement throughout the process.

I would like to thanks my family who encouraging me during moments of despair and giving me endless support throughout my study at Universiti Sains Malaysia. Moreover, I would like to take this opportunity to thank Mr. Belonwu M. Onyenekwe for the approval to use this questionnaire in this study. This questionnaire is an important aspect in this study.

Finally, I would like to appreciate for persons involved in this study, either directly or indirectly, which included respondents that involved in this study, my friends that always supporting me during handling difficult times in my journey and also those who helped and guided me in every step to complete this dissertation especially in data analysis. I would like to give the highest appreciation to them for their patience in providing a clear suggestion for my data analysis and SPSS guidance.

TABLE OF CONTENT

LIST OF TABLES

LIST OF FIGURES

LIST OF ABBREVIATION

BMI- Body Mass Index

GDM- Gestational Diabetes Mellitus

HUSM- Hospital Universiti Sains Malaysia

IDM- Infant of Diabetic Mother

O&G- Obstetrics and Gynecology

OGTT- Oral Glucose Tolerance Test

RDS- Respiratory Distress Syndrome

KELAZIMAN GDM DAN FAKTOR RISIKO TERPILIH DI KALANGAN WANITA YANG MENGANDUNG DI HOSPITAL UNIVERSITI SAINS MALAYSIA

ABSTRAK

Kelaziman semasa *Gestational Diabetes Mellitus* (GDM) meningkat di seluruh dunia termasuk di Malaysia, dan faktor risiko yang berkaitan tidak diteroka secara mendalam. Hal ini penting untuk merancang langkah-langkah pencegahan GDM secara berkesan, oleh itu, menurunkan kelaziman GDM di Malaysia. Kajian keratan rentas dilakukan di Klinik Obstetrik dan Ginekologi sepanjang Disember 2020 hingga Februari 2021. Seramai 89 responden dipilih melalui kaedah persampelan bertujuan dan data dikumpulkan menggunakan borang soal selidik. Umur purata responden adalah 32 ± 5.8, berumur antara 21 hingga 46 tahun. Ujian Person's Chi Square atau Fisher's Exact digunakan untuk menentukan hubungan antara faktor risiko terpilih dengan kelaziman GDM. Hasil kajian menunjukkan bahawa kelaziman GDM adalah 33.7% dan majoritinya di bawah kawalan diet. Hasil kajian juga menunjukkan bahawa ciri sosiodemografi tidak mempunyai statistik yang signifikan dengan kelaziman GDM. Kajian ini juga menunjukkan tiada hubungan signifikan antara Indeks Jisim Badan, status kehamilan, sejarah keluarga diabetes mellitus, pengetahuan wanita mengenai faktor risiko GDM, pola diet dan aktiviti fizikal dengan kelaziman GDM kecuali sejarah GDM yang lalu (p=0.016) antara wanita di Klinik Obstetrik dan Ginekologi, Hospital Universiti Sains Malaysia. Kesimpulannya, kelaziman GDM adalah tinggi dan sejarah GDM yang lalu berkait dengan GDM. Faktor risiko yang berkemungkinan menyebabkan GDM harus dikenal pasti supaya intervensi pencegahan awal dapat dilakukan untuk mengurangkan kelaziman dan komplikasi GDM.

PREVALENCE OF GESTATIONAL DIABETES MELLITUS AND SELECTED RISK FACTORS AMONG PREGNANT WOMEN IN HOSPITAL UNIVERSITI SAINS MALAYSIA

ABSTRACT

The current prevalence of Gestational Diabetes Mellitus (GDM) was globally increasing included in Malaysia, and its associated risk factors were not adequately studied. It is important in the planning of preventive measures of GDM effectively thus, lowering the prevalence of GDM in Malaysia. A cross-sectional study was conducted in Obstetrics and Gynecology Clinic, Hospital Universiti Sains Malaysia from December 2020 to February 2021. A total of 89 respondents was purposively selected and the data was collected using a structured self-administered questionnaire. The mean age of respondents was 32 years old (SD= 5.8), with age ranging between 21 to 46 years old. Pearson's Chi-Square or Fisher's exact test was used to determine the association of selected risk factors to the prevalence of GDM. Results showed that the prevalence of GDM was 33.7% and majority of them were on diet control. The results also showed sociodemographic characteristics were not statistically significant associated with the prevalence of GDM. The study also revealed there was no significant association between BMI, gestational status, family history of diabetes mellitus, knowledge of women about risk factors of GDM, dietary pattern and physical activities with the prevalence of GDM except the past history of GDM (p=0.016) among the women in Obstetrics and Gynecology Clinic, Hospital Universiti Sains Malaysia. The conclusion is that the prevalence of GDM is high and past history of GDM is associated with GDM. Risk factors that may cause GDM should be recognized to allow early prevention interventions to decrease the prevalence and complications of GDM.

CHAPTER 1

INTRODUCTION

This study was carried out to identify the prevalence of gestational diabetes mellitus (GDM) and to assess selected risk factors of GDM. Chapter 1 details the background of the study, problem statement, research objectives, research questions, research hypothesis, the significance of this study and the definitions of the conceptual and operational terms.

1.1 Background of Study

Globally, the prevalence of diabetes mellitus is increasing especially GDM. GDM is defined as a state of hyperglycemia and glucose intolerance which first recognized or the first onset during pregnancy (DeFronzo, Ferrannini, Zimmet & Alberti, 2015; Erem, Kuzu, Deger & Can, 2015). Currently, the prevalence of GDM is still under investigation, that the true prevalence of GDM remains unknown (Egbe, Tsaku, Tchounzou & Ngowe, 2018). The cause of GDM is currently unknown, however, GDM may happen due to maternal adaptation to pregnancy (DeFronzo et al., 2015). The most common risk factors that cause GDM globally included high maternal age, women who have a family history of diabetes, women who have previous GDM history during previous pregnancy and mothers with pre-pregnancy obesity (Erem et al., 2015).

GDM may cause complications to both mother and the infant. The GDM mother may develop hypertension, polyhydramnios, infections and pre-eclampsia (Buchanan, Xiang &

Page, 2012; Erem et al., 2015). While the infant of diabetes mother may develop macrosomia, hypoglycemia, Respiratory Distress Syndrome (RDS) and birth trauma (Buchanan et al., 2012; Erem et al., 2015). Children of GDM mothers have a higher prevalence to develop obesity and impaired glucose tolerance during their childhood and adolescence (Erem et al., 2015). Moreover, pregnant women tend to ingest more glucose during late pregnancy, results in a higher and sustained level of glucose compared to non-pregnant conditions, as well as suppressed level of glucagon, causing further insulin resistance (DeFronzo et al., 2015). GDM happens because, during early pregnancy, maternal glucose supplies cross the placenta through diffusion to supply glucose requirements of the fetus which may cause maternal fasting hypoglycemia in addition to elevated secretion and synthesis of after-meal insulin (DeFronzo et al., 2015). However, during the second half of pregnancy, insulin resistance developed due to the elevation of hormones such as human placental lactogen, glucocorticoids and progesterone (DeFronzo et al., 2015). Hence, the women with GDM have 6 to 7 times higher risk to develop type II diabetes in the year following the pregnancy than the women with normal glucose tolerance even though the women return to normoglycemia state after delivery (Erem et al., 2015; Gracelyn & N., 2016; Zhu & Zhang, 2016).

The prevalence of GDM should be identified to indicate the affected level among pregnant women in Malaysia. Due to the threatening and life-long complications of GDM towards both mother and infant, it is important to study the possible risk factors that may be associated with GDM. By identifying the possible risk factors, preventive measures of these risk factors can be taken, and hence lowering the prevalence of GDM among Malaysia women.

1.2 Problem Statement

The current prevalence of GDM remains unknown although many pieces of research conducted. This is maybe due to the results of research conducted is not applicable to generalize population or the GDM prevalence trends are not yet stable. The unsure global trends should not be comparable due to the methodological issue of research conducted, which is not standardized or lacks uniformity to obtain accurate comparison (dos Santos, Madi, da Silva, Rodrigues Vergani, de Araujo & Garcia, 2020; Zhu & Zhang, 2016). The current prevalence of GDM varies between 1% to 28% in all pregnancies depending on factors such as genetic history, the population being studied and the environment the population are in (Egbe et al., 2018; Erem et al., 2015; Onyenekwe, Young, Nwatu, Okafor, Ugwueze & Chukwu, 2019). However, according to the research conducted by Logakodie, Azahadi, Fuziah, Norizzati, Tan, Zienna et al. (2017), Egbe et al. (2018) and Versteegen (2019), the prevalence of GDM among Malaysia, African and United States are increasing. The prevalence of GDM globally should be determined as GDM may cause many complications, for both mother and infant.

In past researches, higher maternal age, high Body Mass Index (BMI) or being obese, high parity count, family history of diabetes, and having a history of GDM during previous pregnancy are among the most common risk factors that cause GDM among pregnant women (Ali, Mehrass, Al-Adhroey, Al-Shammakh & Amran, 2016; Erem et al., 2015; Logakodie et al., 2017). Besides these risk factors, there are also other risk factors to be studied as stated from the research done by Ali et al. (2016), Erem et al. (2015) and Logakodie et al.(2017) such as low or high birth weight, smoking, physical inactivity, excess weight gain during

pregnancy as well as socioeconomic factors such as education level, occupation and household income.

However, the association between the prevalence of GDM and risk factors was not adequately studied regionally and globally. In Malaysia, the research conducted to study GDM was still in few numbers and this is not adequate to confirm the prevalence of GDM and its association between risk factors of GDM stated. Hence, these risk factors need further investigation and research to prove the association of these risk factors to the prevalence of GDM. This is important to plan preventive measures of GDM effectively to lower the prevalence of GDM in Malaysia.

This study will help in identifying the current prevalence of gestational diabetes of pregnant women who visit the Obstetrics and Gynaecology (O&G) clinic in Hospital Universiti Sains Malaysia (HUSM). This study aims to determine the prevalence of GDM among pregnant women in HUSM and its selected associated factors.

1.3 Research Question

The research questions for this study are as follows:

i. What is the prevalence of gestational diabetes mellitus among pregnant women in Hospital Universiti Sains Malaysia (HUSM)?

ii. What are the associated risk factors of GDM among pregnant women in Hospital Universiti Sains Malaysia (HUSM)?

iii. What is the association between the prevalence of GDM and selected risk factors among pregnant women in Hospital Universiti Sains Malaysia (HUSM)?

1.4 Research Objective

Research objectives are divided into general objective and specific objectives.

1.4.1 General Objective

The general objective is to study the prevalence of gestational diabetes mellitus among pregnant women in Hospital Universiti Sains Malaysia (HUSM) and its associated factors.

1.4.2 Specific Objectives

i. To determine the prevalence of gestational diabetes mellitus (GDM) among women in Hospital Universiti Sains Malaysia (HUSM).

ii. To determine the associated risk factors of GDM among pregnant women in Hospital Universiti Sains Malaysia (HUSM).

iii. To determine the association between the prevalence of GDM and selected risk factors among pregnant women in Hospital Universiti Sains Malaysia (HUSM).

1.5 Research Hypotheses

The research hypothesis for this study are as follow:

Null Hypothesis (H_o): There is no significant association between the prevalence of GDM and selected risk factors among pregnant women in Hospital Universiti Sains Malaysia (HUSM).

Alternative Hypothesis (H_1): There is a significant association between the prevalence of GDM and selected risk factors among pregnant women in Hospital Universiti Sains Malaysia (HUSM).

1.6 Significance of the Study

A woman with GDM may have complications from GDM for herself as well as her newborn. The common complications of GDM for mother included higher risk to develop high blood pressure, pre-eclampsia and any type of diabetes after delivery especially Type II diabetes. The woman with GDM may also have higher possibility to deliver her baby through Cesarean section. While the complications of GDM for the infant are macrosomia or large for gestational age, hypoglycemia, RDS during or shortly after birth, obesity and type II diabetes later in childhood or adolescence. Some complications are irreversible and may be fatal to mother and infant as the complication may cause secondary complications. Hence, it is essential for early recognition of GDM prevalence to assist healthcare workers in considering the size of GDM and provide necessary treatment and management and revert this growing disease.

This study concerns the research gap about the prevalence and risk factors associated with GDM which may influence the way and effectiveness of delivering care and management towards GDM mother and their infant. Significantly, the effectiveness of care and management of GDM will influence the development of complications for mother and infant as well as the growth and development process of the children in later life. With this concern, the purpose of this research is to determine the prevalence and associated risk factors of GDM among pregnant women in HUSM. This will lead to better health outcomes for both mothers with GDM and their children.

GDM affected not only the patient and her baby but her family members as well. This is because family members are anxious about the serious complications from GDM and its long-term health effect, especially severe hypoglycemia for the baby, which is one of the

most serious effects for an infant of diabetes patient due to insulin prescription for the diabetic mother. Severe hypoglycemia may cause an infant to experience seizures, which may cause them to be unresponsive or lead to irrational behavior or even lead to fatal conditions, which will further distressing family members. With holistic and individualized effective management of GDM, prevention of GDM among pregnant women was monitored and further minimizes the risk of GDM during pregnancy, hence, minimize the risk of complications from GDM.

Prevention is better than cure. GDM was preventable through healthy lifestyles, balance nutrition and regular monitoring of blood sugar level. This study contributes to the understanding of trends of GDM and associated risk factors that may cause GDM, hence help in creating awareness of the society about GDM and improve their knowledge regarding GDM. In this way, trends of GDM may become stable and even decreasing as society are more aware to prevent GDM.

This research was also providing a guideline to other researchers that study similar issue about GDM. Researchers can refer to and modify the strength and weaknesses of this study to develop more uniform and holistic tools to determine the real regional trends of GDM. This play a role in improving healthcare delivery system to the patient with GDM, their infants and family members so that complications from this growing disease can minimize. Hence, this research was necessary for global benefits.

1.7 Definition of Conceptual and Operational Terms

Definitions for the operational terms used in this research proposal are as follow:

Gestational Diabetes Mellitus (GDM) : Any degree of glucose or carbohydrates intolerance which lead to several severities of hyperglycemic in patient and first detected or the first onset is during pregnancy (Egbe et al., 2018; Lee, Ching, Ramachandran, Yee, Hoo, Chia et al., 2018). In this study, GDM refers to glucose during gestation, diagnosed through Oral Glucose Tolerance Test (OGTT) during 24- weeks of gestation.

Prevalence : Number of existing cases of the disease in a population at a specific time (Lo & Tanner, 2014). In this study, prevalence refers to the number of GDM cases among pregnant women who visit the O&G clinic in HUSM.

Risk factor	: Risk factor is a type of correlate associated with an increased probability of an outcome, that occurs before the outcome (Offord & Kraemer, 2000). In this study, risk factor refers to determinants that cause GDM among pregnant women in HUSM.
Women	: Women refers to all females of the human species, more restricted sense, it means all females who have arrived at the age of puberty (Bouvier, 1856). In this study, women refer to all pregnant women in HUSM.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

This chapter discusses about gestational diabetes, its prevalence, associated risk factors and complications of this disease to the mother and infant. This chapter also described the conceptual framework used in this study in detail.

2.2 Pathophysiology of Gestational Diabetes Mellitus (GDM)

There are changes in body physiology and hormone changes during pregnancy. Insulin resistance in pregnancy may due to maternal obesity. Obesity may cause changes in adipocytokine production or increasing the production of diabetogenic placental hormones (Mirghani Dirar & Doupis, 2017; Molęda, Fronczyk, Safranow & Majkowska, 2015). This is because obesity is recognized by the body as a chronic inflammatory state, which then produced excessive inflammatory markers, and causes insulin resistance (Abell, De Courten, Boyle & Teede, 2015; Mirghani Dirar & Doupis, 2017). Adipocytokines influence glucose tolerance during pregnancy through interfering regulation mechanism of insulin secretion and insulin receptor, hence, developing insulin resistance (Mirghani Dirar & Doupis, 2017). A low maternal level of adiponectin was also associated with insulin resistance (Mirghani Dirar & Doupis, 2017). Tumor necrosis factor-α (TNF-α) also interferes the insulin receptor signaling and β-cell dysfunction, hence, influence states of hyperglycemia in pregnant women (Mirghani Dirar & Doupis, 2017). In the study by Mirghani Dirar & Doupis (2017) and Mmorisset, Dubé, Côté, Robitaille, Weisnagel & Tchernof (2011), Interleukin-6, an

inflammatory marker, is found significantly high in GDM women than women that do not have GDM.

Besides inflammatory markers, diabetogenic placental hormones played role in the induction of insulin resistance such as human placental lactogen, placental insulinase, cortisol, estrogens and progesterone (Mirghani Dirar & Doupis, 2017; Ngala, Fondjo, Gmagna, Ghartey & Awe, 2017). These placental hormones may cause the enlargement of islets of Langerhans cells, or also known as pancreatic β-cell hyperplasia (Ngala et al., 2017). Another pathophysiology of GDM is related to pancreatic β-cell dysfunction (Mirghani Dirar & Doupis, 2017). This condition is best explained by insulin resistance that caused by the physiological effects of placental hormones (Molęda et al., 2015).

2.3 Prevalence of Gestational Diabetes Mellitus (GDM)

Based on the worldwide studies done before, the prevalence of GDM in many countries are increasing, this included African (Egbe et al., 2018), United States (Versteegen, 2019) and Malaysia (Logakodie et al., 2017), and the rate of GDM in the general population is parallel to the rate in pregnancy (Meharry, Tengera, Rulisa, Byambu, Nietert, Byiringiro et al., 2019). Many studies conducted also concluded that the prevalence of GDM is increasing globally (Debnath, Talukder, Islam, Khan, Sabuj & Jhorna, 2018; Egbe et al., 2018; Gracelyn & N., 2016; Leng, Shao, Zhang, Tian, Zhang, Zhang et al., 2015), however there was no evidence to support the statement, although there are few studies that claimed the prevalence of GDM in their country increasing. Besides, the prevalence of GDM globally had a wide variation, which varied from 1% to 28% (Ali et al., 2016; Debnath et al., 2018;

Onyenekwe et al., 2019), depending on the populations and diagnostic technique taken, hence the researcher was concerned of the trend of GDM globally.

For example, the prevalence of GDM in some African countries reported 9.5% in Tanzania and 8.2% in Nigeria (Zhu & Zhang, 2016). However, there are variations reported in the same area by another study conducted by Egbe et al. (2018), which is ranged from 0% in Tanzania to 13.9% in Nigeria. Systemic review done in six countries of Africa reported that the overall prevalence rate of GDM in Africa is 5% to 6.3% (Egbe et al., 2018; Meharry et al., 2019). Another systemic review done in Sub-Saharan Africa in 2011 reported the prevalence of GDM ranged from 0% to 9% based on studies published (Mwanri, Kinabo, Ramaiya & Feskens, 2015). Recent studies done stated that the prevalence rate of GDM in Kenya is 2.9% (Pastakia, Njuguna, Onyango, Washington, Christoffersen-Deb, Kosgei et al., 2017) and 9.1% in South Africa (Farrar, Duley, Dowswell & Lawlor, 2017).

Central and South America reported 16.6% and 5.7% in Cuba and Brazil respectively (Zhu & Zhang, 2016), however, another study conducted by Larrabure-Torrealva, Martinez, Luque-Fernandez, Sanchez, Mascaro, Ingar et al. (2018) in Peru stated that the overall estimated prevalence of GDM in Central and South America is approximately 11%. A study by dos Santos et al. (2020) shows that the prevalence of GDM in a city in Brazil during 2016 is approximately 5.4%. This prevalence is approximately similar to the prevalence conducted by Zhu & Zhang (2016) in 2016 which is 5.7%. Hence, the prevalence of GDM in Brazil had no significant changes from 2016 to 2020. United States recorded 3.74% to 7.15% variation of prevalence during a study conducted in 23 states of United States during 2013 (Bardenheier, Elixhauser, Imperatore, Devlin, Kuklina, Geiss et al., 2013). However, a study conducted by (Zhang, Tobias, Chavarro, Bao, Wang, Ley et al., 2014) recorded 1.1% to

25.5% in Unites States, which is wider variation of prevalence than prevalence by Bardenheier et al. (2013) in 2013. In contrast, general prevalence of GDM in United States is reported at 7% to 9% as stated by Larrabure-Torrealva et al. (2018), Maqbali (2018) and Yong, Mohd Shariff, Rejali, Mohd Yusof, Yasmin & Palaniveloo (2018).

The prevalence of GDM in Asia is higher than in European countries (5.4%) but lower than in African (14.0%) (Lee et al., 2018). Besides African, published report shows the variation of GDM prevalence in most Arabian countries, which is between 4.2% to 24.9% in United Arab Emirates, Oman, Qatar, Bahrain, Kuwait and Arabia (Ali et al., 2016). A meta-analysis done in 20 Asian countries reported that the prevalence in Saudi Arabia is 22.9%, which is the third-highest among the Asian countries studied (Lee et al., 2018). Malaysia recorded the highest prevalence of GDM among Southeast Asian countries, which is 18.3%, followed by India (13.6%), Bangladesh (9.7%) and Sri Lanka (8.1%) (Zhu & Zhang, 2016). Another study done by Debnath et al. (2018) shows that the prevalence of GDM in Bangladesh (9.7%) is higher than in India which ranged from 3.8% to 8.3%. However, in 2018, Malaysia recorded the second highest prevalence of GDM among Southeast Asian country which is 18.3%, followed by Singapore (17.6%) and Thailand (17.1%) (Lee et al., 2018). Besides, a study conducted in Malaysia in 2019 stated that Malaysia's prevalence of GDM is relatively higher than most of the western countries, which recorded 11.4% to 18.3% in a Selangor university hospital and a public health clinic (Hassan, Ching, Ling, Jaffar & Lee, 2019).

The wide range of variation of prevalence of GDM worldwide may be affected by geographical region and lack of uniformity of international guidelines in diagnosing GDM

(Onyenekwe et al., 2019). Hence, it is important to set uniform international guidelines in diagnosing GDM to ensure the validity and accuracy of each study done.

2.4 Diagnostic Criteria of Gestational Diabetes Mellitus (GDM)

There are two criteria for diagnosing GDM used by most institutions, which are World Health Organization (WHO) criteria, American Diabetes Association (ADA) criteria or International Association of Diabetes and Pregnancy Study Groups (IADPSG). WHO 2013 criteria recommended one-step method. WHO defines criteria for diagnosis of GDM as in any stage of pregnancy, fasting glucose in plasma is over 126 mg/dl (7.0 mmol/L), reading in 75g OGTT of plasma glucose reading more than 180 mg/dl (10.0 mmol/L) after an hour and 200 mg/dl (11.1 mmol/L) after two hours (Karaçam & ÇelİK, 2019; World Health Organization (WHO), 2016).

ADA recommended one-step method as WHO, which OGTT should be performed after fasting at least 8 hours (Gracelyn & N., 2016; Karaçam & ÇelİK, 2019). ADA or IADPSG recommend the diagnostic criteria of GDM that women with fasting plasma glucose values exceeded 92 mg/dl (5.1 mmol/L), exceeded 180 mg/dl (10.0 mmol/L) of plasma glucose values after an hour of OGTT and exceeded 153 mg/dl (8.5 mmol/L) of plasma glucose values after two hours of OGTT (Gracelyn & N., 2016; Karaçam & ÇelİK, 2019; Metzger, 2010; Muche et al., 2020). ADA also recommended using 2-step approach for those having positive testing for 1 hour OGTT (Alsaedi, Altalhi, Nabrawi, Aldainy & Wali, 2020).

2.5 Risk factors of Gestational Diabetes Mellitus (GDM)

Previous study recognizes a few risk factors that lead to GDM such as advanced maternal age, positive family history of diabetes mellitus, previous history of GDM, parity status, low economic status, increasing maternal BMI, socioeconomic status of pregnant mother and lifestyles of the pregnant women. In this subtitle, these risk factors will be discussed in detail.

2.5.1 Demographic status of pregnant women

One of the risk factors of developing GDM is maternal age (Adam & Rheeder, 2017; Bardenheier et al., 2013; Debnath et al., 2018; Larrabure-Torrealva et al., 2018; Price, Lock, Archer & Ahmed, 2017). According to studies, the prevalence of GDM among women with age group 35 years old to 45 years old is 45% (Bener, Saleh & Al-Hamaq, 2011). 31.7% of pregnant women with GDM are within this age group in another study (Teh, Teede, Paul, Harrison, Wallace & Allan, 2011). Based on these studies, advanced maternal age group, which is between 35 years old to 45 years old, was significant risk factor of GDM.

Women with positive family history of diabetes mellitus are also at higher risk to develop GDM (Adam & Rheeder, 2017; Debnath et al., 2018; Price et al., 2017). In Bener et al. (2011) study, 31.7% of the respondent with GDM had positive family history of diabetes mellitus, compared to 12.8% in normal women. In Teh et al. (2011) study, the women with GDM and had positive family history of diabetes mellitus are two-fold compared to women with GDM but with negative family history of diabetes mellitus. The highest proportion of recognizing family history of diabetes mellitus as one of the risk factors of GDM is 49% in

Price et al. (2017) study. The high percentage from these studies is determining the usefulness of investigating this risk factor of GDM.

There are studies shows that 30% to 60% of women with history of GDM in previous gestation will develop GDM in the next gestations (Padayachee, 2015; Price et al., 2017; Reece, 2010; Zhu & Zhang, 2016). Besides, most GDM mothers are multigravida (71.6%) as shown in the study conducted in Malaysia (Parhofer, Hasbargen, Ulugberdiyewa, Abdullayewa, Melebayewa, Annamuhammedov et al., 2014). Similar finding was found in previous studies in Asia, GDM women with multigravida were 63.1% to 87.6% (Parhofer et al., 2014; Reece, 2010).

Some studies reported socioeconomic status influence the prevalence of GDM (Bener et al., 2011; Teh et al., 2011). Most GDM women had lower economic status although there was no significant relationship between the level of education and occupation with GDM, however, these can be risk factors of GDM as women in lower socioeconomic status more likely to have poorer understanding and controlling of diabetes (Bener et al., 2011). This can be shown using the study by Larrabure-Torrealva et al. (2018) that women that had lower socioeconomic status are 48.8% to 86.8% develop GDM.

2.5.2 Lifestyles

Lifestyle factors that included in this study included body weight, dietary pattern, exercise and smoking habit, which are modifiable. In the study conducted by Meltzer (2014) and Zhang et al. (2014), there was strong evidence to support that these four lifestyle factors are playing role in the development of GDM. Women with healthy body weight, adherence

to healthy dietary pattern, having regular exercise and do not smoke are in the category of low-risk lifestyle factors and have 41% lower risk to develop GDM compared to other pregnant women (Meltzer, 2014; Zhang et al., 2014).

Healthy body weight is when a women's BMI is less than 25, which the woman is not being overweight or obese (Meltzer, 2014; Zhang et al., 2014). Women with GDM were significantly more overweight or being obese compared to those without diabetes (Bener et al., 2011; Meharry et al., 2019). It is significantly affected the risk to develop GDM if pregnant women have higher BMI or being obese (BMI more than 30) (Egbe et al., 2018; Farrar et al., 2017; Pastakia et al., 2017; Price et al., 2017; Yong et al., 2018). 59.2% of pregnant women with significant overweight or obesity is developed GDM (Bener et al., 2011). Women who start their pregnancy with a healthy body weight and healthy lifestyle are 52% lower risk to develop GDM (Meltzer, 2014; Zhang et al., 2014). However, BMI of a person may be affected by the sedentary lifestyles and their dietary habit which are in calorie-rich and nutrient-poor diet (Price et al., 2017).

Good dietary intake during pregnancy will also reduce the risk of developing GDM among pregnant women. Intake of nutritional-rich and energized food is relatively more important than offering a large amount of food (Yong, Shariff, Yusof, Rejali, Appannah, Bindels et al., 2020). Assessment of dietary intake during pregnancy is by assessing the intakes of energy, macro-nutrients and micro-nutrients of food groups (Yong et al., 2020). A prudent diet which is fat and cholesterol controlling diet, rich in vegetables, fruits, legumes, fish, whole grains and low-fat dairy products, rather than processed foods, red meats, high concentrated sweets and butter, are higher in nutrient contents and hence, provide a lower risk of developing GDM (Du, Jiang, Karmin, Chen, Xu, Liu et al., 2017; He, Yuan, Chen,

Lu, Hu, Mai et al., 2015; Tryggvadottir, Medek, Birgisdottir, Geirsson & Gunnarsdottir, 2016).

Physical activity had known direct and indirect impacts on insulin sensitivity and glucose homeostasis (Padmapriya, Bernard, Liang, Loy, Cai, Zhe et al., 2017). Women that have regular exercise or physical activities are at 50% lower risk to develop GDM (Meharry et al., 2019; Padmapriya et al., 2017). Based on the study done by Padayachee (2015), pregnant women that having sedentary lifestyles are two-fold higher risk to develop GDM compare to active pregnant women. Low-risk usual exercise is defined as an exercise at least one and a half-hour of vigorous or moderate physical activity a day for at least five days a week, which equates to 150 minutes per week such as brisk walking, strengthening exercises, dancing, swimming and chair exercises (Meltzer, 2014; Padayachee, 2015; Padmapriya et al., 2017; Zhang et al., 2014). However, pregnant women in second and third trimester should avoid activities that involved lying on their back as well as weight-bearing exercises (Padayachee, 2015).

Currently, smoking is a significant risk factor to develop GDM, which is associated with hyperinsulinism and insulin resistance in some studies (Erem et al., 2015; Leng et al., 2015). Some study shows that there is an association between cigarette smoking and the prevalence of GDM, in contrast, the study by Erem et al. (2015) shows an inverse association between smoking and GDM. This condition may due to alteration of body metabolism due to cessation of smoking (Erem et al., 2015), hence it required more investigations.

2.6 Management of Women with Gestational Diabetes Mellitus (GDM)

Management of women with GDM during pregnancy and after pregnancy will be discussed in this section. GDM management during pregnancy included self-monitoring of blood glucose level, physical activities and insulin treatment. GDM management after pregnancy involved screening of diabetes six weeks after delivery and lifestyle modification.

2.6.1 GDM Management during Pregnancy

Early management and diabetes control in pregnancy are important to reducing complications to both mother and infant (Alkassheh, 2014). The best way of maintaining normal glucose levels during pregnancy is self-monitoring of blood glucose level, sufficient and tolerance exercise and insulin treatment (Alkassheh, 2014; Hod, Kapur, Sacks, Hadar, Agarwal, Di Renzo et al., 2015). Women should understand the importance of self-monitoring of glucose level to reduce complications to themselves and their infant. Some studies stated that self-monitoring of blood glucose is effective in reducing pregnancy complications (Alkassheh, 2014; Wendland, Torloni, Falavigna, Trujillo, Dode, Campos et al., 2012). Pregnant women with GDM should regularly have tolerated physical activity to reduce blood glucose levels (Alkassheh, 2014). Insulin therapy is required when blood glucose cannot be controlled through diet modifying and oral anti-diabetic drug and should be individualized to prevent complications from the treatment itself (Hod et al., 2015).

2.6.2 GDM Management after delivery

Women with GDM are at high risk to develop type 2 diabetes after delivery, hence, women with GDM should be screened for diabetes six weeks post-delivery (Alkassheh, 2014). Besides, life style modification should be planned for women with GDM after delivery especially those who obese or overweight for dietary modification and physical activity after delivery aims to reduce blood glucose level to normal range and minimize the risk of diabetes in the future (Alkassheh, 2014; Murakami, Shionoya, Komenoi, Suzuki & Sakane, 2016; Nalliah, 2017; New Zealand Ministry of Health, 2014).

2.7 Complication of Gestational Diabetes Mellitus to mother and infant

GDM may cause many complications to both mother and infant, which some complications are lifelong effects for the mother and the infant. The main complications of GDM to mother including 8-fold of risk to develop eclampsia or pre-eclampsia, birth canal injuries and cesarean section (86%) due to large fetus, polyhydramnios and cardiovascular problems such as hypertension and hyperlipidemia (Badakhsh, Balouchi, Amirshahi & Hashemi, 2016; Begum, Dey & Fatema, 2018; Domanski, Lange, Ittermann, Allenberg, Spoo, Zygmunt et al., 2018; Padmapriya et al., 2017). Women with GDM are 50% higher risk to develop type II diabetes in their later life (Badakhsh et al., 2016; Padmapriya et al., 2017). According to the study, one-third of mothers who had GDM develop type II diabetes as soon as they deliver their baby (Badakhsh et al., 2016; Ferrara, Hedderson, Brown, Albright, Ehrlich, Tsai et al., 2016). Another study stated that there are more than 50% of women with GDM progress toward type I or type II diabetes after 5 to 10 years with higher prevalence

(Badakhsh et al., 2016; Bener et al., 2011; Finer, Mathews, Lowe, Smart, Hillman, Foo et al., 2014).

An infant of diabetic mother (IDM) is at higher risk (11.1% versus 6.96%) for preterm birth (Domanski et al., 2018; Maqbali, 2018). Macrosomia (about 28%), neonatal hypoglycemia (ranged from 25% to 48%) and embryonic jaundice (20%) are common in IDM (Badakhsh et al., 2016; Begum et al., 2018; Malhotra & Stewart, 2015; Padmapriya et al., 2017). There are some studies reported that severe GDM is related to increased risk of stillbirth in the last two months of gestation and GDM causes the risk of pre-eclampsia twofold (Badakhsh et al., 2016; Hogg, Price & Robinson, 2014). IDM also are in 17-fold to develop type II diabetes in their later life (Bener et al., 2011; Malhotra & Stewart, 2015; Padmapriya et al., 2017).

2.8 Conceptual framework of the study

Risk is a probability of an individual develops a specific disease over a specific period of time, given that the individual is alive and disease-free at the start of period of time (Monson Cleaver, Abrams, Bingham, Buffler, Cardis et al., 2006). Risk assessment is important especially in healthcare to identify the hazard and individuals at risk for a specific disease. Once the risk is identified, it is vital to score and rank based on their occurrence and its impact to promote effective interventions to prevent the risk (NEJM Catalyst, 2018). To gather health information, health risk assessment or also known as health risk appraisal is used to assess an individual's health status, risks and habits (Schillling, 2005).

Krist and Woolf (2011) described a five-phase health assessment process, which included patient information collection through health risk assessment tools, integration of patient information from medical records, counseling of patient, provide individualized clinical and risk-reduction interventions to the patient and decision making of the patient regarding his or her health. Hence, the important elements of health risk assessment are their content, mode of administration, provider capacity, quality assurance, monitoring and evaluation (Goetzel, Staley, Ogden, Stange, Fox, Spangler et al., 2011).

A health risk assessment usually in a questionnaire form, which contains questions about demographic characteristics, lifestyles, physical health and preventive screening (Bregendahl, Orlando & Palaniappan, 2017). Family history is the strongest predictor of most chronic diseases such as diabetes mellitus because most chronic diseases have a genetic origin (Bregendahl et al., 2017). A holistic risk assessment model helps reduce healthcare costs as well as reduce disability and mortality through effective prevention interventions such as follow-up planning and modifying lifestyle behaviors (Goetzel et al., 2011).

Risk appraisal model of GDM is not fully developed. However, some studies summarized possible risk factors and complications of GDM in a flow chart which is shown in Figure 2.1 (Nahavandi, Price, Sumithran & Ekinci, 2019). The model shows that the pathophysiology of diabetes mellitus, which is insulin resistance caused by many factors such as pregnancy and change in pregnancy hormones level. The model then connects the maternal risk factors that possibly cause GDM such as obesity, advanced age, gestational weight gain and ethnicity. From those risk factors, the model then rules out what are the possible long-term and short-term complications for the mother and IDM. For example, higher risk to develop type 2 diabetes for the mother in later life and neonatal hypoglycemia for her baby.

Figure 2.2 shows the adapted risk appraisal model of GDM that used in this study to guide the process of research. Overall, the prevalence of GDM is a dependent variable that is affected by independent variables, which are the risk factors that may cause GDM, as shown in Figure 2.2. The complications of GDM to both mother and infant were expressed in the figure to shows the importance of risk assessment of GDM in reducing morbidity and mortality caused by GDM.