Prevalence and Risk Factors in Developing Type 2 Diabetes Mellitus after Gestational Diabetes Mellitus and Its Distribution among ABO Blood Groups

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Abstract: - The prevalence of Type 2 diabetes mellitus (T2DM) has recently been elevated due to lifestyle changes and other factors. T2DM is linked to the prevalence of different associated conditions, one of which is gestational diabetes mellitus (GDM). GDM is a common condition of expectant mothers, defined as glucose intolerance, noted to be a predictor of the development of T2DM after pregnancy. In numerous studies regarding GDM, ABO blood groups and other risk factors are being investigated for its correlation in the development of T2DM. In this study, the researchers determined the prevalence and risk factors of T2DM as well as its distribution among ABO blood groups in mothers with a history of GDM in Metro Manila, Philippines. The researchers collected data from mothers within the inclusion criteria using an online survey with a quantitative, non-experimental, cross-sectional approach and non-probability purposive sampling to obtain results. The statistical measures utilized were computation of BMI, Means and Standard Deviations of BMI, One-Way Analysis of Variance of the BMI, prevalence equation, odds ratio, and multivariate logistic regression. The results showed that 49.01% or almost half of the participants that had GDM have developed T2DM. Participants with the B phenotype are discovered to be more likely to develop T2DM, especially those with family history of diabetes and high cholesterol. It is also reported that even with high physical activity, mothers with GDM are still at risk for development of T2DM.

Key Words: — Type 2 Diabetes Mellitus, Gestational Diabetes Mellitus, ABO Blood Groups, Prevalence, Risk Factors, High Blood Cholesterol, Hypertension, Physical Inactivity, Family History, Body Mass Index.

I. INTRODUCTION

1.1. Introduction

Due to the epidemiologic shift of the population towards associated lifestyle changes, among other factors, the global prevalence of Type 2 diabetes mellitus or T2DM has more than doubled and the age of onset of the disease has also become younger (Zhu & Zhang, 2016). T2DM, traditionally known to be an adult-onset diabetes due to causes such as

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Resistance to insulin and insufficient insulin production, has become more common and has shown to be linked with other types of disorders. By 2030, the incidence of diabetes mellitus is anticipated to rocket to 439 million, which represents 7.7% of the global adult population aged 20-79 years old (Chen et al., 2011). In parallel with the emerging rise of T2DM worldwide, the incidence of gestational diabetes mellitus (GDM) has also been increasing (Karagoz et al., 2015).

GDM is a common condition that is defined as glucose intolerance first recognized during pregnancy (Shimodaira et al., 2015). GDM is not only associated with adverse pregnancy complications such as birth trauma, preeclampsia, dystocia, and other metabolic disorders, but GDM also predicts the development of diabetes mellitus postpartum.

GDM also strongly reflects the underlying T2DM epidemic (Karagoz et al., 2015).

In other studies, relationships between GDM and ABO blood groups are also being explored. The ABO blood group system is a classification of blood groups based on the presence or absence of A and B antigens. ABO antigens can have an effect in biomarkers which have been linked to the insulin resistance and development of T2DM. To date, several studies have examined the correlation between diabetes and ABO blood groups, particularly the relationship between GDM and ABO blood groups but the findings among these studies were inconsistent (Sapanont et al., 2019). Likewise, there is an evident lack of studies to date that focus on the Filipino population.

In this study, the researchers determined the prevalence of T2DM in Filipino GDM mothers and investigated if there is an ABO blood group phenotype that is more significantly at risk of developing T2DM from GDM. Data was delimited to T2DM that was associated only with GDM among maternal ABO blood groups, specifically: Blood Group A, Blood Group B, Blood Group AB, and Blood Group O. The researchers focused on gathering information from mothers aged 25 years old to 59 years old who are presently living in Metro Manila, Philippines. The respondents were mothers who have had GDM at least once during their pregnancy period.

1.2. Objectives of the Study

The primary objective of this study was to determine the prevalence of developed T2DM in mothers with a history of GDM, as well as its distribution among ABO blood groups, and associated risk factors.

This study specifically aimed to:

- Determine the prevalence of mothers with T2DM who were diagnosed with GDM during pregnancy;
- List possible risk factors in the development of T2DM from GDM based on participant profiles;
- Determine the prevalence and distribution of GDM mothers who developed T2DM per major Blood Groups A, B, AB, and O; and
- Identify if a certain major blood group is more significantly at risk of developing postpartum T2DM after being diagnosed with GDM compared to other blood groups based on the prevalence, and the associated risk factors.

1.3. Problem Statement

There has been an increase in the development of T2DM in recent years due to shifts in lifestyle and it has become a global burden (Zhu & Zhang, 2016). GDM is known to be a risk factor in developing T2DM (Karagoz et al., 2015); however, there are only limited studies regarding the associated risk factors in developing T2DM among mothers who were previously diagnosed with GDM, especially in the Philippines. The association of diabetes with ABO blood groups and the risk factors for T2DM in mothers previously diagnosed with GDM is still yet to be established.

1.4. Hypotheses of the Study

The following are the hypotheses of this study:

- The development of T2DM was prevalent in mothers who were diagnosed with GDM.
- Excess body weight or high body mass index (BMI), hypertension, high cholesterol, family history of diabetes, and physical inactivity were risk factors in developing T2DM among different ABO blood groups.
- The prevalence and distribution of GDM mothers who developed T2DM varied per major blood groups A, B, AB, and O.
- Based on the gathered data on the distribution and associated risk factors, there existed a major blood group that was more significantly at risk of developing postpartum T2DM after being diagnosed with GDM as compared to other blood groups.

1.5. Research Impediments

The primary goal of this study is centered on identifying the prevalence of having T2DM among mothers diagnosed with GDM and the probability of developing T2DM in relation to their ABO blood groups and risk factors.

The researchers noted the following scope of the study: (a) Only T2DM that is associated with GDM among ABO blood groups was addressed in this study. (b) The blood groups included are Blood Group A, Blood Group B, Blood Group AB, and Blood Group O. (c) The risk factors emphasized were high BMI, family history of diabetes, hypertension, high cholesterol, and physical inactivity only. (d) Mothers aged 25 to 59 years old who have had GDM at least once during their

pregnancy years were the participants of the study. (e) The collected data were provided by the participants assuming that they delivered honest responses. (f) Data was collected from respondents residing in Metro Manila only. (g) As the study was conducted through an online survey, consent was also sought from the participants. (h) Verification of data was only through the respective proofs that were given by the respondents such as identification card, electric/phone/water/internet/cable bills, medical certificates, and recent blood sugar test results.

The researchers established the following delimitations: (a) Mothers who are aged 24 and below were not included in the study since according to the American Diabetes Association or ADA, onset of GDM starts at 25 years old or above. Similarly, mothers 60 years old and above were not included in this study as prescribed to the researchers. (b) Participants who were not willing to provide personal information and medical information were also excluded. (c) Participants who reside outside Metro Manila were rejected for they will be outside the scope of the study. (d) Individuals with Type 1 diabetes mellitus were not eligible to participate since this study focuses solely on T2DM and GDM. (e) Individuals currently diagnosed with other conditions, except for hypertension and high cholesterol, were excluded since other comorbidities not discussed in this study may influence the diagnosis of T2DM. (f) Face-to-face interviews and surveys were not conducted; the need for this type of communication did not arise, so phone calls or online calls/meetings were not done. (g) Due to the restrictions brought about by the pandemic, and for the personal data security of the participants, thorough verification of the data provided was not feasible. (h) Should the participants feel hesitant in participating before the submission of their answers on the survey, they were free to withdraw their involvement in the research. (i) The researchers did not include demographic and perception questions from the Diabetes Questionnaire used for the survey. (j) The risk factors emphasized in this study are based from the reviewed related literature in Chapter 2. (k) This study did not include specific data on when T2DM developed after being diagnosed with GDM during pregnancy. The years between the progressing of T2DM post GDM may be analyzed in a different kind of study.

1.6. Significance of the Study

The study will greatly benefit the following:

*To the Diabetic Community***:**
For people who have experienced or are experiencing GDM, the data presented in this paper can provide awareness regarding the possibilities of developing T2DM based on their blood group, as well as the risk factors associated with it. The findings can help them adjust their ways of living accordingly so that they can reduce the risk of developing T2DM.

To Allied Health Professionals:
The specific aims of this research would aid the present and future physicians, especially the obstetrician-gynecologists. Through this research, they would be able to be more careful and observant on the follow-up of pregnant women, especially GDM mothers, as well as on the provision of a diagnosis early on. They would also be able to monitor women as soon as they are diagnosed, to provide aid immediately.

*To the People of the Academe and Laboratory Sciences field***:**
The scientific findings gathered from this research would supplement the existing knowledge and skills of future medical technologists in the advanced laboratory diagnosis for effective monitoring, risk association, and management of GDM and T2DM. This would further contribute to the previous studies about the two diseases. It would also serve as a foundation for those interested in expanding the available information that would be presented in this research.

*To the General Public***:**
This study is beneficial to society because ABO blood group phenotypes and GDM, among many factors, are associated with different adverse pregnancy outcomes and is also a strong predictor of developing T2DM postpartum. Through the facts and figures shown in this study, people would be educated about the prevalence and risk factors of mothers developing T2DM from GDM. If society is educated about such information, collective efforts to prevent development of T2DM among GDM mothers may be put into action.

1.7. Definition of Terms

The following key terms defined are used in the context of the study:
ABO blood groups. Classification of blood based on the inherited characteristics of red blood cells which are differentiated based on the presence of antigens; the principal

groups of the ABO blood group are the following: Group A, Group B, Group AB, and Group O

ABO gene. Gene responsible for determining a person's blood group.

Antigen. Substance that is not recognized by the body which activates an immune response for the body to produce antibodies.

Antibody. Protein produced by the immune system that responds when there is presence of foreign materials in the body usually called antigens.

Diabetes Mellitus. Group of non-communicable metabolic diseases characterized by hyperglycemia which leads to defects in insulin activity categorized as Type 1 diabetes mellitus, Type 2 diabetes mellitus, other specific types of diabetes, and Gestational diabetes mellitus.

Glucose intolerance. Condition of having an abnormality in the stability of the blood sugar that consists of both prediabetes and diabetes.

Hyperglycemia. Defined as high levels of glucose in the blood

Insulin. Hormone produced by the pancreas that functions by regulating the volume of glucose in a person's blood.

Insulin resistance. Phenomenon wherein the cells of the body are incapable of responding properly to insulin.

Metabolic disorders. Disorders that occur when the metabolism is disrupted due to abnormal chemical reactions which result in an excess or a deficiency of substances in the body such as carbohydrates, lipids, and amino acids.

Polycystic Ovarian Syndrome (PCOS). Condition in which hormonal imbalance is present among women of reproductive age.

Postpartum. Phase after the birth of a baby or after childbirth.

Risk Factors. Any aspect, component, or influence which increases the chance of a person from developing a disease or condition.

II. REVIEW OF RELATED LITERATURE

This chapter contains reviewed related literature that serves as the foundation of this study.

2.1. Gestational Diabetes Mellitus (GDM)

2.1.1. Pathophysiology:

Glucose intolerance with onset or first recognition during pregnancy is termed as gestational diabetes mellitus, also known as GDM. During pregnancy, usually between 24 and 28 weeks of gestation, observable signs and the onset of GDM arise (WHO, 2016). It has been established from various researches that during pregnancy, the placenta produces hormones such as the human placental growth hormone and human chorionic somatomammotropin that make the body resistant to the effect of the insulin. These hormones work together in order for the placenta and uterus to improve vascularization and regulate the body's metabolism and support the fetus with a sufficient amount of glucose. Besides these hormones being altered in levels, estrogen, progesterone, prolactin, cortisol, human chorionic gonadotropin, leptin, TNF-alpha, and oxidative stress biomarkers are also altered. Insulin is a hypoglycemic agent that helps glucose levels in the body to maintain its equilibrium. However, hormones that are elevated during pregnancy to help the fetus grow partially blocks the action of the insulin which is generally secreted by the pancreas. Without enough insulin production, this phenomenon results in building up of glucose in the blood far more than a pregnant body normally needs (ADA, n.d.). This is how it is considered as a category of hyperglycemia or increased plasma glucose levels caused by an imbalance of hormone levels (Diabetes Care, 2015). The thirteenth up until the seventeenth week of pregnancy marks the resistance of insulin which nearly decreased in half of the normal level because of too much glucose production in the body in order to meet the demands of the fetus. This process which involves an increase in the nutritional needs of the fetus can make the pregnant woman at risk for diabetes because of uncontrolled levels of glucose in the body that the insulin cannot handle (Barbour et al., 2018).

In recent years, there is a rising prevalence in patients developing GDM. It has become one of the leading causes of mortality and morbidity worldwide which is a risk for both the mother and the offspring (Li et al., 2020). Despite that, it has been proven that patients diagnosed with GDM can normally return to normal conditions in the postpartum period. However, according to a study made by Barbour, Buschur, & Stetson (2018), about 70% of diagnosed patients develop Type 2 diabetes mellitus or T2DM later in time.

2.1.2. Vulnerable populations:

GDM is a non-communicable disease that can develop due to the production of several hormones as mentioned earlier. The main and root cause of GDM is unknown but it has been

established that it can occur to all expectant women since all can experience the shift in hormone production. Due to its unknown causes, several factors that can increase the risk of GDM were established such as having an unhealthy lifestyle and family history of diabetes.

Excess body weight or high Body Mass index (BMI):
According to the Centers for Disease Control and Prevention or CDC, obesity can underlie several poor health outcomes of individuals. It increases the risk of serious health conditions including diabetes. In a study conducted by Larrabure-Torrealva et al. (2018), obesity along with several factors such as BMI are highly associated with GDM.

According to a study by Heude et al. (2012), women with higher BMI pre-pregnancy are more likely to develop gestational hypertension and GDM. Similarly, a study published by Gaillard et al. (2013) regarding risk factors and outcomes of maternal obesity has shown that excessive gestational weight increases the risk of GDM along with other adverse maternal outcomes.

Family history of diabetes:
Since the cause of GDM is unknown, several studies have claimed that a family history of diabetes is associated with the risk of developing GDM. A meta-analysis of 81 relevant articles in 2017 by Kiani et al., showed that 31% of the articles have claimed that family history of diabetes is a risk factor of GDM. Similarly, a study showed that family history of diabetes could be a distinct predictor of GDM in Taiwanese pregnant women (Lin et al., 2016). Also, according to the aforementioned study by Larrabure-Torrealva et al. (2018), the history of diabetes increases the odds of developing diabetes by 1.5-fold compared to those who have no family history of diabetes.

Advanced maternal age:
The occurrence of GDM is also correlated to age. As stated by the CDC, women who are more than 25 years old during gestation are at risk for developing GDM. One study found that pregnant women at the age of 25 years onwards indicate a relative increase of risk in having GDM (Duman, 2015). In support of this, a meta-analysis of twenty-four studies was conducted by Li et al. (2020), showed that age is directly proportional to GDM, which means that as the age increases, the risk for developing GDM also increases.

Other risk factors:
A notable risk factor mentioned by the CDC in developing GDM is the race. The results from the study by Hedderson, Darbinian, and Ferrara (2010), showed that Asian Indian women have the highest prevalence of GDM. In addition, Asian subgroups namely Chinese, Southeast Asians, especially Filipinos, also have a high prevalence of GDM, along with Mexicans and Pacific Islanders compared to white and black women. CDC also mentioned that having polycystic ovarian syndrome (PCOS) can be a risk factor. This was supported by a study in 2015, stating that women who were diagnosed with PCOS have two-fold increased odds of developing GDM compared to those who do not have nor have symptoms of PCOS (Pan et al., 2015).

2.1.3 Gestational Diabetes Mellitus in the Philippines:
Based on a study by Tan (2015), diabetes has been increasing at an alarming rate within Asian countries and the Philippines is not an exemption. As of 2015, the prevalence of diabetes in the country has been gradually increasing due to factors such as lifestyle and diet. It has been found out that the factors that contributed to this effect is the increasing dependence on electronic devices and also the sedentary lifestyle of most Filipinos (Tan, 2015). The study concluded with the Philippines needing a fundamental and transformative change in diabetes awareness and proper lifestyle to lessen the accumulating numbers.

There are only a few available studies that were conducted in the Philippines pertaining to GDM, so data from other Asian countries were compared. One of the few studies that can be found that has the data of prevalence of GDM in the Philippines is a study by Litonjua et al. in 1996 (Pineda-Cortel et al., 2018). According to that study, it was determined that the prevalence of GDM in the Philippines is at 14%. Another study done by the University of Santo Tomas Hospital-Clinical Division, also known as USTH-CD, identified that the GDM prevalence of the country was 7.5%.

A correlation between GDM and increasing BMI, and family history of diabetes was also found in the study (Pineda-Cortel et al., 2018). Further studies should be conducted about GDM to widen the information and statistics in the Philippines. As of now, studies only pertain to the correlation between the risk factors of GDM and its prevalence in the Philippines.

2.2. Type 2 Diabetes Mellitus (T2DM)

2.2.1. Pathophysiology:

Type 2 diabetes mellitus, also known as T2DM, is a chronic metabolic disorder characterized by insulin sensitivity as a consequence of a decline in insulin secretion, insulin resistance, and pancreatic beta-cell failure (Olokoba et al., 2012).

Initially, there is a sufficient increase in insulin secretion by the pancreatic beta-cells to maintain the body's glucose levels (Goyal & Jialal, 2020). In situations where resistance to insulin is prevalent, the mass of the pancreatic beta-cells undergoes transformation to increase the insulin supply in order to sustain its excessive demand (Baynest, 2015). As these beta-cells change on the onset of T2DM, the insulin secretion is impaired and is unable to meet the glucose homeostasis. This decrease in glucose responsiveness then leads to hyperglycemia (Goyal, 2020). Impaired insulin secretion is progressive. This could be due to the continuous decline in the rate of cellular secretion of the beta-cells, decrease in beta-cell mass, or both, if left untreated (Cantley & Ashcroft, 2015). The progression of impaired insulin secretion is known to affect the long-term blood glucose levels of the body as well as cause complete pancreatic beta-cell dysfunction (Cerf, 2013).

T2DM can also result from insulin resistance (Cerf, 2013). It is a condition wherein there is a deficit in biologic response to insulin stimulation of the major target organs such as the liver and muscles (Freeman et al., 2020). The attention on the molecular mechanism of insulin has elucidated how insulin resistance is related to risk factors such as genetics. Genetic factors that affect insulin signals are: insulin receptor, insulin receptor substrate gene polymorphism, polymorphisms of genes such as beta-3 adrenergic receptor gene, and uncoupling protein gene. These are associated with the promotion of insulin resistance as well as obesity in patients (Kaku, 2010). Recent studies also suggest involvement of adipocyte-derived substances called adipokines, inflammation, incretin resistance, and hyperglucagonemia in insulin resistance (Goyal & Jialal, 2020).

2.2.2. Vulnerable populations:

The development of T2DM has a lot of risk factors; some of which include unhealthy lifestyle, coexisting diseases, and family history. Although T2DM appears later in life as it is adult-onset, the associated risk factors usually start at a younger age and thus, contribute to the development of the disease upon aging.

Overweight and obese populations (high BMI):

According to the WHO, excessive body fat content is the strongest risk factor for T2DM. Therefore, people who are overweight or obese and are physically inactive are at a large risk of developing T2DM. Relatively, from a study done by Kennerly & Kirk (2018), it was shown that diagnosed T2DM adults all have low rates of physical activity and are living a sedentary lifestyle. BMI is directly associated with being obese and overweight, hence, it has widely known that people with higher BMI are more at risk of developing T2DM. The BMI computation is used in determining the classification of the body fat in accordance with their height and weight.

People with family history of diabetes:

Diabetes mellitus is hereditary and people with first-degree relative/s suffering from T2DM have a 40% risk of developing diabetes (Wu et al., 2016). Papazafiropoulou et al. (2017), have established that the risk of developing T2DM significantly increases up to 2-4 times if both or one of the parents also have this disease, and that many of the patients suffering from the disease have family members who have it as well. According to Aasbjerg et al. (2020), even patients with second-degree relatives, even half-siblings sharing a common mother or father, have increased risk of developing diabetes. However, this may also be attributed to other environmental factors.

All age groups:

Although T2DM is otherwise termed as adult-onset diabetes, presently there are also occurrences of cases of this disease in the younger populations (Wu et al., 2014). According to the WHO, evidence suggests that this rising trend of T2DM in the younger generation, particularly children, can be attributed to the increase in consumption of sugars and rampant obesity.

Mothers who had GDM:

Gestational diabetes, according to Rice et al. (2012), "may unmask a predisposition to type 2 diabetes." Studies from Aroda et al. (2015), and Herath, Herath, & Wickremasinghe (2017), have proven that GDM mothers developed T2DM later in life. Aroda et al. (2015) stated that there is a 48% higher chance of developing T2DM, meanwhile Herath, Herath, & Wickremasinghe (2017) claimed that the

development of T2DM is tenfold higher in GDM mothers. In support, Mahzari et al. (2018) stated that "older, multigravid, and multiparous and who have a prior history of GDM" are at risk of developing T2DM. However, proper risk prediction techniques for the development of T2DM in GDM mothers are yet to be established.

People with hypertension:

Diabetes and hypertension have similarities when it comes to risk factors and both conditions often co-exist. High blood pressure along with other factors such as age, ethnicity, obesity, etc. were identified as risk factors for diabetes (American Disease Association, 2014). As evidenced from a study in Korea by Kim, Lim, Choi, and Park (2015), wherein after 8-year follow up, 14.7% of the subjects developed T2DM from subjects that were normotensive, prehypertensive and hypertensive. Thus, the authors claimed that prehypertension and hypertension are considered to be a risk factor for diabetes regardless of baseline glucose status, gender, and BMI. It should be noted, however, that the study had several limitations such as age and the period during the follow-ups. In addition, systemic insulin resistance also manifests in 50% of patients who have high blood pressure (Lastra et al., 2013). On the contrary, another study by Sun et al. (2019) wherein they established that T2DM may be a risk factor for hypertension but such a relationship from hypertension towards T2DM was unlikely.

People with high cholesterol:

Abnormal levels of cholesterol in the blood, specifically serum triglyceride and its lipoprotein carriers – low-density lipoprotein (LDL), intermediate-density lipoprotein (IDL), very low-density lipoprotein (VLDL), and high-density lipoprotein (HDL), are constantly associated with T2DM which is a risk factor of coronary heart disease (Grundy et al., 2019). In a study by Feingold (2020), 30-60% of T2DM patients present a significant increase in serum triglyceride, VLDL, and IDL values while there is a decrease in HDL, the good cholesterol. An increase in small dense LDL, a lipoprotein that promotes buildup of fats and cholesterol, is also noticeable. However, high values of LDL, the bad cholesterol, should not be used as the only indicator of diabetes mellitus or coronary heart disease, as confirmed by the latest guidelines of the American Heart Association (2020). Feingold (2020) also mentioned that the above normal levels of blood cholesterol are especially common since high prevalence of T2DM patients are insulin resistant, obese, and have experienced metabolic syndrome. Furthermore, conclusive results stated by Chehade and colleagues (2013) reported that the blood cholesterol levels of T2DM patients, specifically plasma triglyceride, are markedly increased while the HDL is decreased for about 19% of men and 17% of women compared to 9% and 8% of the nondiabetic controls for men and women respectively.

It is also important to mention that high levels of blood cholesterol and other lipids may be present or absent years before the diagnosis of T2DM as reported by Tan & MacEachern in their 2020 study.

2.2.3. T2DM in the Philippines:

Globally, T2DM has been considered as one of the most difficult issues of public health, especially in developing countries (Ng, 2020). According to the reports of the International Diabetes Federation, the prevalence of diabetes in the Philippines has increased from 3.4 million in 2010 to 3.9 million in 2020.

There are only several recent studies about T2DM in the Philippines that are available and conducted. One of the studies that can be found with the data of the incidence and prevalence of T2DM in the country was conducted by Soria et al. (2009). They have concluded that there is a disturbing growth of diabetes in the Philippines that calls for early vigorous intervention for its prevention and management. They have observed that the incidence of T2DM for 9 years (from 1998 to 2007) was 16.3%, and the prevalence was 28.0%. The study recommends the use of a 2-hour post-glucose load test apart from the fasting blood glucose test for people with diabetes to help in the prevention and management of T2DM in the country.

In a study by Aoto et al. (2019), they made a conceptual model for the quality of life among people with T2DM in the Philippines. In their study, they have observed that there is no direct correlation with social factors and the quality of life of people with T2DM. It indicated that in areas of low-income in the country, the quality of life of people with T2DM has no correlation with their social and economic status. It was observed that Filipinos give importance to understanding their disease and to integrating self-management of their disease into their daily lives.

2.3. T2DM in Relation to GDM

Due to the rising epidemiologic prevalence of diabetes mellitus affecting people at different life stages and populations, there has been an increase in synthesizing data that correlates GDM and T2DM, but they are still limited. GDM has been closely linked and is demonstrated to be correlated to a subsequent development of T2DM. A study published by Herath, Herath, & Wickremasinghe (2017), shows that women who have experienced GDM have a ten-fold higher risk of developing T2DM during a 10-year follow up period, than women who have not experienced GDM. This is further proven by the study conducted by Aroda and colleagues (2015), stating that women experiencing GDM have about 50% likelihood of developing T2DM in the ensuing years, and may also have recurrent GDM in a subsequent pregnancy. The point estimates vary depending on the duration of the women's follow-up and also the population characteristics (Aroda et al., 2015). From the same study, it has also been proven that women who have experienced GDM with pre-existing risk factors can reduce the likelihood of developing T2DM with pre-diabetes intensive lifestyle modification or metformin treatment early on. This would reduce the likelihood of diabetes over the subsequent 10 years by 35–40%. Postnatal advising and check up on women are very much important, most especially to women who have experienced GDM. This is further strengthened by a systematic review and meta-analysis accomplished by Rayanagoudar et al. (2016). The information they have gathered in their study reveals that besides recognizing the risk factors, individualized postnatal counseling would greatly improve pregnancy-specific details such as GTT results, gestational age at GDM diagnosis, use of insulin, and complications such as preeclampsia, preterm birth, and the development of T2DM after GDM. The progression from GDM to T2DM was also very much emphasized in a study published by Mahalakshimi et al. (2014). The results of their study reveal that the development to T2DM occurs within a 5-year period after delivery, and by 10 years, most of the women had already developed T2DM. These rates are possibly dependent on follow-up check-up of the participants.

In a different study published by Eades and colleagues in 2015, it has been discovered that women diagnosed with GDM and then developed T2DM, had a window time of about 8 years between both diagnoses. This time period is important to consider in making decisions about lifestyle changes because that window of time allows women to have an intervention when their child is in an age that makes them less dependent already. Also, based on the findings of this study, overweight women, those with an HbA1c of over 42.1 mg/dL, those who used insulin during their pregnancy and those with FBG of 7.0 mmol/l and over, are to be considered as a priority for intervention because they have a higher risk of developing T2DM after being diagnosed with GDM (Eades et al., 2015). In a separate study conducted by Gunderson et al. (2015), high lactation intensity and lactating for a longer duration were independently associated with lower 2-year incidence of T2DM after GDM.

Besides being correlated with weight and other risk factors, the association between GDM, T2DM, and ABO and Rh blood groups are also being observed for epidemiologic and genetic studies. This further proves the need to take note of patient history and to have regular postpartum check-ups, especially for women who have experienced GDM.

2.4. ABO Blood Groups, Genetics, and Inheritance

The ABO blood group system is a classification of the most basic blood groups based on A and B antigens present or absent on red blood cells (Shimodaira et al., 2016). There are four major blood groups which are the most dealt with in clinical practice, namely Blood Groups A, B, AB, and O (Choate, 2018).

The clinical importance of ABO blood groups goes beyond transfusion medicine (Liumbruno & Franchini, 2013). In recent years, studies have shown great significance of ABO blood group system and its respective phenotypes in association with different diseases such as cancer (Zhang et al., 2014), dementia (Vasan et al., 2015), T2DM (Kamil et al., 2010), and other non-communicable diseases.

As mentioned, the four major blood groups consist of Group A, B, AB, and O. These are inherited from an individual's biological parents just like any other genetic trait. The parents give a total of two ABO genes to their child. The ABO gene which is found in chromosome 9 accounts for the determination of what group of blood an individual would inherit (Kominato et al, 2020). A and B alleles are codominant while O alleles are recessive. This means that the presence of A and B antigens will be expressed on the red blood cell

whichever allele is present. However, the O alleles termed as recessive do not develop any ABO antigens.

Table.1. refers to the possible genes an individual may inherit in accordance with their blood group. In a research study published by Groot and colleagues (2020), it purposely informs about how the ABO blood groups have been proven to play a key role in several inherited diseases like diabetes mellitus, healthy aging, and disease development. Therefore, the determination of ABO blood groups could be of benefit in individualized health maintenance and prevention of diseases. Certain blood groups may pose a lower risk of acquiring or developing a disease. For example, in an article written by Dean, L., MD (2012), it is revealed that in comparison to other blood groups, individuals with Blood Group O have a lower risk of acquiring pancreatic cancer and thromboembolic diseases.

Table.1. ABO Blood Groups Genetic Combinations

Blood Group	Possible Genes
A	AA or AO
B	BB or BO
AB	AB
O	O

2.5. The Role of ABO Blood Groups in the Development of Non-communicable Diseases

The ABO blood group plays a significant role not only in immunohematology but it also extends toward other non-communicable diseases. ABO antigens are commonly known for their expression on red blood cells; however, these expressions are also present in human cells, tissues, platelets, and vascular endothelium. Consequently, Liumbruno and Franchini (2013) claimed that ABO blood group has an involvement in the progress of cardiovascular, oncological, and other diseases. Their study involves different studies providing data regarding ABO blood group's association to several non-communicable diseases. This includes coronary heart disease, since this blood group influences Von Willebrand Factor or VWF and especially factor VIII (FVIII) plasma levels. VWF and FVIII plasma levels are both prothrombotic risk factors that are the focus involving the influence that the ABO blood group system exerts on hemostasis (Franchini & Lippi, 2015). It is also noted that VWF levels are higher for non-O blood groups. This claim is supported by a study by Favaloro, Targher, and Lippi (2012), which also stated that there is a major influence that connects the ABO blood group to the plasma levels of the VWF factor VIII complex and supports the idea that normal Group O individuals have lower levels of VWF and FVIII than non-O individuals. Another study by Franchini and Lippi (2015) claimed that the plasma levels of both VWF and FVIII are approximately 25% higher in individuals of non-O blood group than normal Group O individuals. According to the study, the molecular basis for this claim is due to the identified presence of ABH antigenic structures that are found circulating in VWF that function to regulate the activity with the use of different degrees of glycosylation in this multifunctional protein. The study also claimed that high VWF-FVIII levels is a risk factor for coronary heart disease (Liumbruno and Franchini, 2013). This is supported by the meta-analysis by He, Wolpin, Rexrode, Manson, Rimm, Hu, and Qi (2012), which established that non-O blood groups have an 11% increase in the risk of developing coronary heart disease. In addition, venous thromboembolism also has an association towards ABO blood groups. One review by Welsby and Zhou (2014), conferred for the same findings as Liumbruno and Franchini (2013) stating the ABO blood group's role in determining VWF and FVIII levels which increases the risk of having VTE for non-O blood groups.

Until now, studies have reported several non-communicable diseases' association with non-O blood groups. Cancer risk and ABO blood group are also heavily associated by other studies. Such studies were drawn to the suggested mechanisms which includes intercellular attachment, membrane signaling, inflammation, and immune monitoring of malignant cells are commonly investigated when it comes to correlations of ABO blood group and cancer risk (Fang et al. 2017). According to a study by Franchini and Lippi (2015), pancreatic and gastric cancers have the most consistent connection that has been found in cancers.

Pancreatic cancer is considered to have genetic risk factors; however, the development mechanism of such disease is still yet to be known. Nonetheless, there are several findings with ABO blood group system's genetic variation contributing to the development of pancreatic carcinogenesis explicitly Blood Group A and a lowered risk for Blood Group O (Pelzer et al. 2013).

A study conducted by Yu, Xu, Li, et al. (2019) investigated the relationship between ABO blood groups and gastric cancer. The results showed that individuals with Blood Group A had a higher risk of gastric cancer while individuals with Blood Group AB showed lower risk of having this cancer. For individuals with Blood Group B and Blood Group O, the risk of gastric cancer showed no significant difference.

Different studies still state that further experimental studies need to be conducted to further investigate the relationship between the blood group and non-communicable diseases. As Franchini and Lippi (2015) stated that there is much information to be discovered especially about the molecular mechanisms that link the blood groups and non-communicable diseases, for ABO blood typing can be an important factor in such diseases especially for cancer.

2.6. ABO Blood Groups and Development of T2DM

Due to the inheritable nature of the ABO blood groups, numerous studies are interested in finding out the exact mechanism that might contribute to the role of such blood groups to the development of T2DM. Several studies reported their findings on the possible association of the development of T2DM and ABO blood groups. According to Navabi, Hemmati, Shaahmadi, & Aghaei (2020), these two are connected and "mutually dependent" because of the "immunological and genetic basis" of the ABO blood groups and T2DM. Fagherazzi et al. (2014) stated that the mechanisms are yet to be known; however, it is believed that non-Group O individuals have higher levels of the von Willebrand factor complex. Likewise, there is an association between ABO blood groups and the levels of both the plasma soluble intercellular adhesion molecule 1 (ICAM-1) and tumor necrosis factor receptor 2 or TNF-R2. The aforementioned inflammatory markers are highly associated with the increased risk of the development of T2DM. E-selectin and P-selectin were also identified as markers of increased risk (Legese, Abebe, & Fasil, 2020). These markers are reportedly influenced by the human ABO locus. In addition to these, Legese, Abebe, & Fasil (2020) stated that an increase in the inflammatory endothelial cytokines and C-reactive protein (CRP) production in the liver can promote direct resistance to insulin. Similarly mentioned in the previously cited study is that the imbalances in the gut bacteria, which is influenced by the ABO blood groups, can also be a cause of insulin resistance.

Fagherazzi et al. (2014) have mentioned that based on their cohort study composed of 82,104 women, those with Group A and B blood are more at risk. Studies by Meo, Rouq, Suraya, & Zaidi (2016) and Legese, Abebe, & Fasil (2020) arrived at results where Blood Group B are relatively more at risk. Meanwhile, Blood Group AB was said to be more at risk in the study of Mandal et al. (2018). Blood Group A, on the other hand, was more at risk as stated in the study of Navabi, Navabi, Hemmati, Shaahmadi, & Aghaei (2020). All these four studies have results that indicated Blood Group O as the blood group with the lowest risk. These studies were conducted in France, Saudi Arabia, Ethiopia, India, and Iran respectively.

Based on these reviewed literatures, although it is evident that there is a link between ABO blood groups and the development of T2DM and that having GDM is a risk factor for the development of T2DM, there are still inconsistent results in this field of study, particularly in which blood group is more at risk and what makes the mothers more at risk of developing GDM or T2DM. At present, literature that explores the relation of ABO blood group and development of T2DM from GDM in the Filipino population is very inadequate as papers mostly tackle specifically the prevalence and development of GDM or T2DM and not the development of T2DM after GDM.

2.7. Theoretical Study

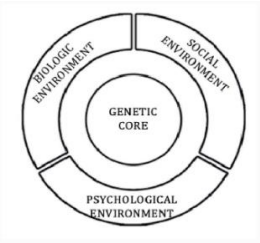

Fig.1. Theoretical Model.

The theory used for this study is the Wheel Theory (Fig. 1). This theory was developed by Mausner and Kramer in 1985. It stipulates that a disease has a central core which involves genetic and peripheral factors such as social, psychological, and biological factors (Green & Johnson, 2013). It can be applied in this research since such factors—behavioral/psychological, social, and genetic factors are all

related to the development of T2DM (Navabi, Navabi, Hemmati, Shaahmadi, & Aghaei, 2020). The researchers are to apply the theory and gather health-related information from the participants, apply statistical analysis, and identify essential factors correlated to the development of T2DM.

2.8. Conceptual Framework

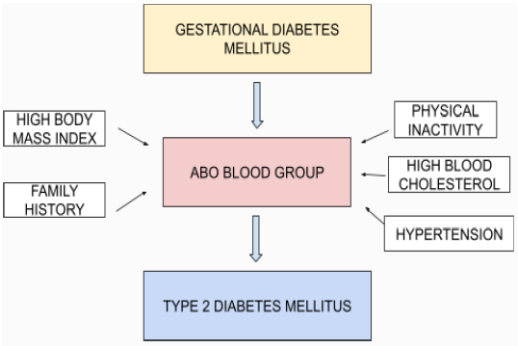

Fig.2. Conceptual Framework

The conceptual framework used for the structure of this paper is presented in Figure 2. Since it has been established, as mentioned in the review of literatures, that blood groups, having a history of GDM, having a family history of T2DM, lack of physical activity, high BMI, high cholesterol, and hypertension can be contributive risk factors to developing T2DM, the researchers wanted to determine the distribution and risk factors associated among the ABO blood groups in mothers who had GDM.

III. RESEARCH METHODS

First and foremost, the research design was limited to a descriptive study with a cross-sectional approach due to the prevailing COVID-19 pandemic situation. Likewise, the process of writing this paper was done through online means in the respective homes of the researchers, and in accordance with the prevailing protocols. This chapter was organized as follows: research design, subject and study site, data measure/instrumentation, data gathering procedure, ethical considerations, and data analysis. The revision did not alter in any way the content of this research work.

3.1. Research Design

In order to gather necessary data, this study used a quantitative, non-experimental, cross-sectional approach which has the capability to provide the following: (a) the prevalence of Type 2 diabetes mellitus (T2DM) among individuals with a history of Gestational diabetes mellitus (GDM), (b) the distribution of the participants in their respective ABO blood groups and (c) the associated risk factors. This study utilized non-probability purposive sampling. The cross-sectional approach involved participants based on an inclusion and exclusion criteria applied to the study and then the exposure and outcomes for the estimation of the prevalence were assessed through odds ratios (Setia, 2016). With the use of a survey, the data from the participants were evaluated and quantified. Thus, the prevalence of T2DM was computed and the participants' blood groups were distributed along with the associated risk factors through odds ratios.

3.2. Subjects and Study Site

The researchers determined the population where they could get suitable and reliable data. According to the study of Duante et al. (2008), there was a higher prevalence of individuals with diabetes located in urban areas (7.0%) as compared to those who are in the rural areas (5.7%). Thus, the study took place in Metro Manila since it was considered as an entirely urban location (Philippine Statistics Authority, 2019). The participants were sourced from Facebook diabetes support groups which were considered as the representative population of Metro Manila since the members of the groups were dispersed throughout the said target location.

From there, an inclusion and exclusion criteria were established in order for the data to be reliable and accurate. The participants accessed the survey and gave consent to provide the needed information for the study. Moreover, the individuals were mothers who are 25 to 59 years old with a history of GDM living in Metro Manila. The participants had to provide a proof of identification and/or residency, as well as their proof of GDM and/or T2DM diagnosis. On the other hand, nulliparous and nulligravid individuals, mothers who did not experience GDM even though they have been diagnosed with T2DM, individuals who are under 25 years of age and over 59 years of age, and participants living outside Metro Manila were excluded from participating in this study. In addition, individuals currently diagnosed with other diseases except hypertension and high cholesterol were excluded in this study. This means individuals such as those who have Type 1 diabetes mellitus were also excluded.

Lastly, face-to-face interviews were avoided due to the restrictions posed by the current public health situation. Participants who were unreachable by the online survey were also excluded. A withdrawal criterion was also established wherein the participants who were hesitant or who had a change of mind were free to withdraw their participation as long as they have not submitted the survey yet.

The steps for recruitment of respondents are as stated. First, the researchers looked into Facebook support groups for diabetes patients where there are members who live in Metro Manila. These support groups are closed groups that have administrators with sufficient knowledge about GDM as well as T2DM. To further ensure the suitability of gathering respondents from such groups, the groups were checked if they are active (the members and administrators are regularly sharing relevant posts about GDM, T2DM, and their own insights and experiences). Through this, the researchers confirmed that the site was suitable enough to gather the needed data for the study. The gathered participants answered the questions asked by the researchers as they were qualified based on the inclusion criteria determined beforehand. In such cases where the responses received were perceived as invalid as per the exclusion criteria, the researchers filtered these out.

In determining the sample size, the researchers used Cochran's formula for getting a representative sample for proportions. It was determined through the desired level of precision, desired level of confidence, and the estimated proportion of the attribute present in the population (Cochran, 1997). It was given by,

$$n_0 = \frac{Z^2 pq}{e^2}$$

Where Z was defined as the z-value derived from the Z table with the provided chosen level of significance, p defined as the estimated proportion, q is 1-p, and e represented the level of precision or the allowed margin of error. In addition, the small population sizes were corrected wherein the given value above was used.

$$n = \frac{n_0}{1 + \frac{n_0 - 1}{N}}$$

In the equation above, the said adjusted formula took the total population into account which was represented by N. The values of the said parameters and the computation of the sample size were provided on Table 2. From there, the needed survey sample size was calculated to be 302.

Table.2. Sample Size Determination using Cochran's Formula with Adjustment

Parameter	Value	Remarks
Z	1.96	Chosen level of confidence is 95%
p	0.5	Chosen for maximum variability and to get a conservatively large sample size
q	0.5	
e	0.05	5% margin of error
N	1,400	Approx. total population
n_0	384.16	
n	302	Rounded up

3.3. Data Measure/Instrumentation

The survey tool used in this study was a questionnaire made accessible through a Google Forms link. The first part consisted of questions which gathered details such as name, age, weight, height, and location or address. By gathering the participants' information regarding height and weight, the researchers calculated the BMI, which was a part of the risk factors related to the development of T2DM. From the calculated BMI, the participants were classified into four groups, namely: below normal weight or underweight, normal weight, overweight, and obese (Hariri et al., 2006). The second part consisted of questions related to whether the participants have been diagnosed with GDM and T2DM. The third part gathered participants' risk factors, such as their blood group, their family history of T2DM, if they have hypertension, if they have high cholesterol, and their physical activity.

The questions regarding physical activity involved estimation of the frequency and duration of activities done by the participants. These questions regarding the physical activity of the participants were adapted from the International Physical Activity Questionnaire and scoring protocol (Di Blasio et al., 2010). The questionnaire, which was verified by authors and made publicly available with open access for researchers, provided an appropriate measure of physical activity. The participants were asked about their vigorous physical activity, moderate physical activity, and the time they spent walking and sitting. Based on the scores, physical activity was measured as MET-minutes/week, and the participants were categorized using the computed scores. This questionnaire was used in different research studies such as the study published by Sibai and colleagues in 2013, among others.

The survey included a part which was adapted from a Diabetes Questionnaire used in the study published by Ferrian in 2011. However, questions such as additional demographics and those about perceptions were not included as they are not applicable to the research design. This questionnaire was already approved and checked for reliability and validity. The survey used in this study consisted of 27 items that were answered by the participants for approximately 10 to 20 minutes.

The researchers used the following: laptops and/or personal computers, Microsoft Office applications (Word, Excel, and Powerpoint), Google Docs, Google Slides, Google Sheets, Google Forms, and R language version 4.0.3.

3.4. Data Gathering Procedure

Crowdsourcing was the type of sourcing model used in this study. The respondents were mothers residing in Metro Manila who were diagnosed with GDM. Through the use of the internet, the researchers found respondents by crowdsourcing and reaching out to Facebook diabetes support groups whose members reside in different parts of Metro Manila. The researchers coordinated with the administrators of the Facebook diabetes support groups.

In this study, the researchers came up with an electronic survey questionnaire which aided in gathering data on the intended respondents. Through the use of social media, the researchers sent out an accessible Google Forms link to the participants for the online survey. In this survey, consent forms were also attached where the participants can read about the purpose and objectives of our study, and give their full consent. The survey was cross-checked to ensure that all the information asked on the survey was appropriate to be answered for the respondents.

The survey also required the respondents to use their personal electronic mail for further verification of their information. An electronic copy of the participants' responses was sent to their respective electronic mail addresses for their own keeping. Lastly, upon hesitance or a change of mind, the respondents had the right to withdraw consent from participating in this research process before they submitted the survey.

The responses collected were subject to the Data Privacy Act of 2012. All identities of the respondents and the data collected from them through the survey questionnaire were not publicly disclosed, rather, they were only internally processed and stored for the sole purpose of this study.

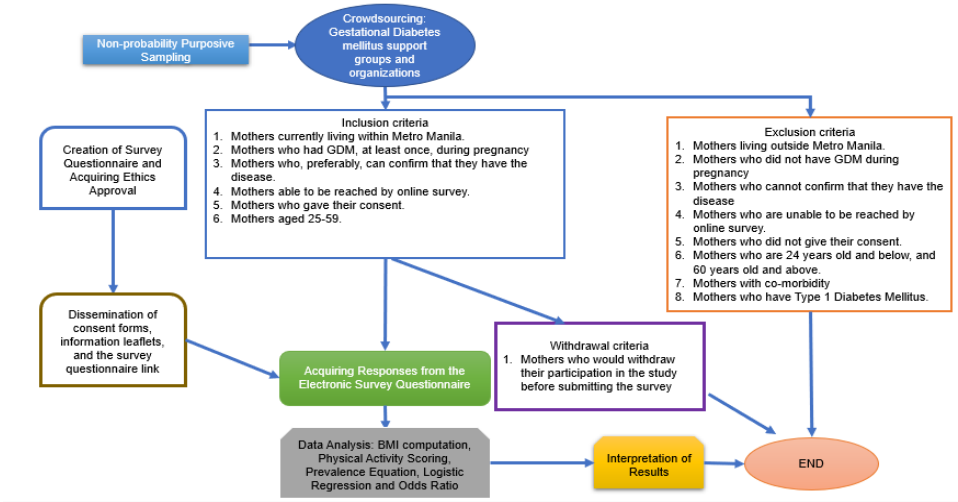

Fig.3. Research Methodology Workflow

3.5 Ethical Considerations

Ethical approval was obtained from the University of Santo Tomas Faculty of Pharmacy Research Ethics Committee (USTFOPREC). Compliance to the USTFOPREC protocol for the assurance of informed consent and respondent confidentiality was guaranteed by the researchers. There was no conflict of interest faced by the researchers while preparing the study. No specific grant was received nor accepted from the University of Santo Tomas, or any agency in public or private sectors.

A brief explanation through online means was given by the researchers to the respondents before the distribution of consent to confirm that they were aware of the purpose of the study, benefits, and risks of participation. The study only yielded minimal psychological risk since basic personal and medical information were asked from the respondents. To counter this risk, confidentiality of information was ensured. Respondents were recruited through crowdsourcing in Facebook diabetes support groups. The researchers coordinated with the group administrators regarding the nature of the study prior to data collection. Consent forms were sought from respondents before they answered the survey questionnaire to ensure their complete voluntary participation. For the benefits, this study serves as another contribution to their community which gave progress to existing studies regarding their condition.

Measures that ensured confidentiality are as follows: names of participants were changed to codes to ensure confidentiality; personal information were not allowed for sharing nor access to third parties; no part of the data was sold to anyone; and no part of the participants' responses were reproduced or stored in any retrieval system. After the data analysis, the raw electronic data were stored and transferred in an encrypted USB device. Only the researchers were able to generate a special code to be used in accessing the data stored in this device. Disposal of the raw data with personal information followed after the entirety of the research by means of deleting files permanently and destroying the encrypted USB device.

Processed data or the data that has been grouped and arranged for analysis were reported and published accordingly in this study. Such data was used for the analysis and for the generation of results. No personal identities of the respondents were disclosed in any part of this paper. However, other researchers may use the processed and analyzed data found in this study, as well as the results, if found helpful for their own respective research studies. The results of this study will be sent to the respective electronic mails of the participants.

3.6. Data Analysis

The statistical techniques utilized by the researchers for the data analysis were the computation of the BMI,

physical activity, prevalence equation, the odds ratio equation, and the logistic regression.

The BMI was computed by dividing the weight in kilograms over the height of the individual in meters squared. The computed value was used to classify them accordingly for the association of the risk of developing T2DM. According to the National Health Service (NHS), the ideal BMI for adults was 18.5 to 24.9. Values below this range were considered underweight. Meanwhile, a result within 25-29.9 was considered overweight, and a result within 30-39.9 was considered obese. The formula for BMI is as stated:

$$BMI = \frac{weight\ (kg)}{height\ (m)^2}$$

Physical activity is a main risk factor measured in this study and it was assessed by the researchers through the use of the International Physical Activity Questionnaire (IPAQ). The questionnaire was inclusive of three different levels of physical activity, mainly vigorous, moderate, and leisure activities such as walking, their frequency per week, and the duration of the activity per day. For this to be measured, the total volume of physical activity was calculated by weighing the type of each activity defined in METs (3.3 for walking, 4.0 for moderate physical activity, and 8.0 for vigorous physical activity). This was multiplied by the duration of the activity in minutes and the frequency of the activity per week (number of days in a week). The formulas are as stated below:

- *Walking MET-minutes/week at work = (3.3)(walking minutes) (walking days at work)*
- *Moderate MET-minutes/week at work = (4.0)(moderate-intensity activity minutes)(moderate-intensity days at work)*
- *Vigorous MET-minutes/week at work = (8.0)(vigorous-intensity activity minutes)(vigorous-intensity days at work)*

Total Work MET-minutes/week = sum of Walking + Moderate + Vigorous MET-minutes/week scores

After each individual's scores were computed, the population was categorized into three groups: inactive or low physical activity, moderately active or moderate, and highly active or HEPA (Health Enhancing Physical Activity). A participant was categorized as highly active or HEPA, if they have done vigorous-intensity activity on >3 days/week while accumulating at least 1500 MET-minutes/week; or >7 days of any combination of walking, moderate-intensity, or vigorous-intensity intensity activities achieving at least 3000 MET-minutes per week. The moderate level of activity corresponded to ≥3 days of vigorous-intensity activity of at least 20 minutes per day; or ≥5 days of moderate-intensity activity and/or walking of at least 30 minutes per day; or ≥5 days of any combination of walking, moderate-intensity or vigorous intensity activities achieving a minimum Total physical activity of at least 600 MET-minutes/week. Any participant who did not meet the criteria mentioned above for both moderate and high categories, were classified as having low level of physical activity.

The prevalence computation involved the prediction of the percentage of the population who have the specific characteristic in a given time period. In this report, the prevalence equation was used to calculate the prevalence of diagnosed T2DM among mothers who have been diagnosed with GDM during their pregnancy. The prevalence equation used is as stated:

$$Prevalence = \frac{All\ new\ and\ existing\ cases\ of\ Type\ 2\ DM}{Total\ population\ during\ the\ same\ time\ period}\ x\ 100$$

Logistic Regression involved the prediction of a binary response variable wherein the prediction equation was framed in terms of the probability of an event occurring. That is, the link function used, or the function that related the expected value of the probability distribution of the response to the linear function of the explanatory variables, connecting the systematic and random components of a Generalized Linear Model (Agresti, 2018), was the logit link. The responses were usually coded as 1 and 0. The equation for logistic equation is as stated:

$$logit(\pi(x)) = log(\frac{\pi(x)}{1-\pi(x)}) = \alpha + \beta_1 x_1 + \beta_2 x_2 + \ldots + \beta_p x_p$$

From the above equation, the estimated probability of success was derived as:

$$\pi(x) = \frac{exp\{\alpha + \beta_1 x_1 + \beta_2 x_2 + \ldots + \beta_p x_p\}}{1 + exp\{\alpha + \beta_1 x_1 + \beta_2 x_2 + \ldots + \beta_p x_p\}}$$

The odds ratio was given by the exponential transformation of β where a unit increase in x corresponds to a multiplicative effect, eβ, to the odds of success. The results of the final logistic regression model were used to characterize the significant relationships between the risk factors and blood groups, and the probability of developing T2DM. The odds ratio measured the association between the risk factors and the outcome in that the effect of the presence or absence of a factor to that presence or absence of T2DM was quantified. These results were put into the context of subsets of the population (i.e., in terms of the different blood groups). Results were also subjected to hypothesis testing.

IV. PRESENTATION, ANALYSIS, AND INTERPRETATION OF DATA

Descriptive statistical methods were used to present the demographic and overall profile of the respondents in terms of the variables measured. This included computing for summary statistics with measures of variability for continuous variables, as well as frequency and percentage distributions for categorical variables. For this study, Body Mass Index (BMI) was the only continuous data collected; since it was normally-distributed, Means and Standard Deviations (SDs) were shown.

Prevalence rates were taken by dividing the number of cases with T2DM by the total sample size under consideration. A multivariate logistic regression model was fitted to identify significant associations between the variables and T2DM incidence, and to estimate their effects using Odds Ratios (ORs). Two-sided p-values < 0.05 were considered statistically significant, and 95% confidence intervals (CIs) were calculated for the estimates (sometimes presented as estimate ± Margin of Error or MOE = 1.96 * Standard Error or SE). Computations were done using version 4.0.3 of the R language for statistical computing.

4.1 Results

4.1.1. Summary of Respondent Characteristics:

Survey responses from a total of 302 respondents with GDM were collected between April 8, 2021 to June 6, 2021 after filtering those that met the inclusion/exclusion criteria of the study. A total of 148 or 49.01% (95% CI: 43.25% - 54.79%) were diagnosed with T2DM.

The mean BMI was 26.31 kg/m^2 (95% CI: 25.77 - 26.85) which is considered overweight by the NHS. The BMI of the 302 participants ranged from 15.03 kg/m^2 to 40.9 kg/m^2. Table 3 presents the characteristics of the T2DM and non-T2DM groups, as well as of the overall sample. Comparisons between the two groups made use of Student's t-test for (normally-distributed) continuous variables, and Pearson's chi-squared test and Fisher's Exact test (for small frequencies) for hypothesis tests for categorical variables.

Majority of the total sample (58.6%) were either Overweight (36.4%) or Obese (22.2%). Respondents between the T2DM and non-T2DM groups did not have significantly different BMIs ($p = 0.1605$) even when stratified into weight status categories. Within the T2DM group, most (37.2%) were in the Overweight category, while most (42.9%) were in the Normal category for the non-T2DM group.

Almost three-fourths (73.8%) reported having a family history of T2DM, while about one-fourth were diagnosed with hypertension (26.2%), or were diagnosed with high cholesterol (23.5%). Most of the respondents (58.3%) were classified as having a low level of physical activity. The sample was not symmetrically-distributed across blood groups; almost half (45.4%) belonged in Blood Group O, Groups A and B equally took about 22%, and Group AB had the smallest frequency (11.3%). For these characteristics, all hypothesis tests between the T2DM and non-T2DM groups were statistically significant ($p < 0.05$) except for physical activity which was only marginally significant ($p < 0.10$). Mothers who developed T2DM were more likely to report a family history of the disease ($p = 0.0014$), and had more instances of hypertension ($p = 0.0104$) and high cholesterol ($p = 0.0015$). The T2DM group also indicated relatively higher physical activity levels (High: 14.9% versus 7.1%; overall $p = 0.0799$). As with the overall sample, both groups of respondents most frequently belonged in Blood Group O and least in Group AB, but the non-T2DM group relatively had more from Group A (26.0% versus 17.6%); while the T2DM group had more from Group B (27.7% versus 15.6%) and Blood Group B is the second most frequent phenotype ($p = 0.0402$) for this sub-group.

Table.3. Characteristics of Respondents in the T2DM and non-T2DM groups, and Overall

Characteristic	**Overall (N = 302)**	**T2DM Group (N = 148, 49.01%)**	**Non-T2DM Group (N = 154, 50.99%)**	**p-value**
BMI in kg/m^2 - Mean ± MOE (SD)	26.31 ± 0.53 (4.73)	26.70 ± 0.76 (4.74)	25.94 ± 0.74 (4.71)	
Underweight - N (%)	5 (1.7%)	2 (1.4%)	3 (1.9%)	
Normal - N (%)	120 (39.7%)	54 (36.5%)	66 (42.9%)	
Overweight - N (%)	110 (36.4%)	55 (37.2%)	55 (35.7%)	
Obese - N (%)	67 (22.2%)	37 (25.0%)	30 (19.5%)	
With Family History - N (%)	223 (73.8%)	122 (82.4%)	101 (65.6%)	***
With High Blood Pressure or Hypertension - N (%)	79 (26.2%)	49 (33.1%)	30 (19.5%)	***
With High Cholesterol - N (%)	71 (23.5%)	47 (31.8%)	24 (15.6%)	***
Physical Activity - N (%)				
Low	176 (58.3%)	85 (57.4%)	91 (59.1%)	**
Moderate	93 (30.8%)	41 (27.7%)	52 (33.8%)	
High	33 (10.9%)	22 (14.9%)	11 (7.1%)	
Blood Group - N (%)				
A	66 (21.9%)	26 (17.6%)	40 (26.0%)	***
B	65 (21.5%)	41 (27.7%)	24 (15.6%)	
AB	34 (11.3%)	18 (12.2%)	16 (10.4%)	
O	137 (45.4%)	63 (42.6%)	74 (48.1%)	
*** p-value < 0.05 ** p-value < 0.10				

The characteristics of the respondents according to ABO blood groups are shown in Table 4. The same statistical tests were done for comparisons across the phenotypes except for respondents' BMIs where One-Way Analysis of Variance (ANOVA) was done to compare the means. Among the blood groups, the risk factors for samples were similar for almost all characteristics with largely non-significant p-values and distributions that followed the overall trend. A significant difference (p = 0.0217) was found, however, in the frequency of reported diagnoses of hypertension where Blood Group AB had relatively the highest proportion (44.1%) followed by groups B (32.3%), O (21.9%), and A (19.7%).

Table.4. Characteristics of Respondents by ABO Blood Group

Characteristic	**A (N = 66, 21.9%)**	**B (N =65, 21.5%)**	**AB (N = 34, 11.3%)**	**O (N = 137, 45.5%)**	**p-value**
BMI in kg/m^2 - Mean ± MOE (SD)	26.26 ± 1.12 (4.62)	26.22 ± 1.19 (4.91)	26.16 ± 1.56 (4.65)	26.42 ± 0.80 (4.76)	
Underweight - N (%)	1 (1.5%)	2 (3.1%)	0 (0.0%)	2 (1.5%)	
Normal - N (%)	29 (43.9%)	21 (32.3%)	13 (38.2%)	57 (41.6%)	
Overweight - N (%)	24 (36.4%)	26 (40.0%)	14 (41.2%)	46 (33.6%)	
Obese - N (%)	12 (18.2%)	16 (24.6%)	7 (20.6%)	32 (23.4%)	
With Family History - N (%)	48 (72.7%)	47 (72.3%)	27 (79.4%)	101 (73.7%)	
With High Blood Pressure or Hypertension - N (%)	13 (19.7%)	21 (32.3%)	15 (44.1%)	30 (21.9%)	***
With High Cholesterol - N (%)	16 (24.2%)	13 (38.2%)	12 (18.5%)	30 (21.9%)	
Physical Activity - N (%)					
Low	41 (62.1%)	35 (53.8%)	19 (55.9%)	81 (59.1%)	
Moderate	20 (30.3%)	22 (33.8%)	10 (29.4%)	41 (29.9%)	
High	5 (7.6%)	8 (12.3%)	5 (14.7%)	15 (10.9%)	
*** p-value < 0.05					

4.1.2 T2DM Prevalence across Blood Groups:

T2DM prevalence rates with 95% CIs across blood groups are shown in Table 5. Blood Group B had the highest prevalence rate (63.1%) followed by Groups AB (52.9%), O (46.0%), and A (39.4%). As shown in Table 3, the Chi-squared test was significant (p = 0.0402) and indicated that there was an association between blood group and T2DM incidence. Thus, for the subsequent multivariate regression analyses, Blood Group B will be used as the reference category for computing the adjusted ORs.

Table.5. T2DM Prevalence Rates across Blood Groups

Blood Group	**# of with T2DM**	**Prevalence Rate of T2DM (%)**	**95% Confidence Intervals**	
			Lower	**Upper**
A	26	39.4%	38.3%	40.5%
B	41	63.1%	61.9%	64.2%
AB	18	52.9%	50.9%	54.9%
O	63	46.0%	45.4%	46.6%

4.1.3 Risk Factor Associations with T2DM

The multivariate logistic regression model was fitted with T2DM diagnosis as the binary dependent variable, and six categorical independent variables namely: BMI group, blood group, and diagnosis of hypertension, diagnosis of high cholesterol, physical activity level, and family history of T2DM.

A Likelihood-Ratio Test (LRT) was conducted to see if the difference between the models' residual deviances provided sufficient evidence to consider the simpler model over the complex one (Table 6). Upon conducting this test, M1 (Model with significant variables only) was found to be a better fit with the development of T2DM. A model containing all of the predictors (M_0) was first fitted, followed by a model containing only the significant variables (M_1).

The multivariate logistic regression model performed in this study was also done in a related study by Kugishima et al. (2018) to test for the independent relationships between the risk factors in the development of diabetes in mothers diagnosed with GDM and the development of diabetes itself.

Table.6. Goodness of Fit of Candidate Models - LRT

Model	**Residual Deviance**	**p-value**
M_0 (Full Model)	381.27	
M_1 (Model with significant variables only)	384.34	
The LRT tests the null hypothesis that the nested model (M_1) provides a better fit. With non-significant p-values (p = 0.5459), we do not reject the null hypothesis and have no sufficient evidence that the full model (M_0) has significantly better fit than the simpler model.		

The estimates of M_1 were chosen to interpret the effects of the risk factors to T2DM incidence. To ensure that the inferences made were valid, diagnostic checks on this model were done, along with additional assessments of model adequacy. These can be found in Appendix 8. The Hosmer-Lemeshow goodness of fit test was not significant (p = 0.7690) and was unable to detect indications of poor fit. Based on the Chi Square statistics where the p-value must be >0.05 for the model fit of the data to be acceptable. This test was also used for confirmation of a fit model in a cross-sectional study about the progression of T2DM and its associated risk factors after hyperglycemia first detected in pregnancy (Chivese, Levit, & Norris, 2019). The model is considered to be correctly specified, and is interpreted.

The regression coefficients and the computed ORs are shown in Table 7. BMI group and diagnosis of hypertension were both not significant and were excluded from the final model. All other predictors had categories that were significant at least 0.10 level.

The reference categories were "Low" for physical activity level, "Normal" for BMI group, "No" for the indicators on family history of T2DM, diagnosed hypertension or high cholesterol, and "B" for blood group. Mothers with a family history of T2DM were more than twice as likely to develop T2DM (OR 2.31, p = 0.0036) than those without family history. Progression to T2DM varies widely from being diagnosed with GDM during pregnancy. Results have shown that diagnosis of high cholesterol increases the odds of developing T2DM by almost three times (OR 2.51, p = 0.0019). Having a high level of physical activity had marginally significant association with T2DM wherein odds were twice as likely than having low physical activity levels (OR 2.03, p = 0.0845). Blood Groups A and O showed significantly reduced odds of T2DM incidence compared to Group B where ORs showed a lower risk as they are 66% and 55% less likely to develop T2DM, respectively (Group A: OR 0.34, p = 0.0087; Group O OR 0.45, p = 0.0202).

Table.7. Summary of Logistic Regression Models for Risk Factors associated with T2DM

Variable	**M_0**			**M_1**		
	Coefficients	**OR (95% CI)**	**p-value**	**Coefficients**	**OR (95% CI)**	**p-value**
BMI in kg/m^2						
Underweight	-0.177	0.83 (0.09-6.23)		—	—	—
Normal		(reference)		—	—	—
Overweight	0.003	1.00 (0.57-1.76)		—	—	—
Obese	0.388	1.47 (0.77-2.83)		—	—	—
With Family History ('Yes')	0.809	2.25 (1.28-4.02)	***	0.837	2.31 (1.32-4.10)	***
With High Blood Pressure or Hypertension ('Yes')	0.333	1.39 (0.77-2.55)		—	—	—

With High Cholesterol ('Yes')	0.814	2.26 (1.23-4.23)	***	0.919	2.51 (1.42-4.53)	***
Physical Activity						
Low		(reference)			(reference)	
Moderate	-0.183	0.83 (0.48-1.43)		-0.165	0.85 (0.50-1.45)	
High	0.791	2.21 (0.99-5.17)	**	0.709	2.03 (0.92-4.69)	**
Blood Group						
A	-1.000	0.37 (0.17-0.77)	***	-1.07	0.34 (0.16-0.71)	***
B		(reference)			(reference)	
AB	-0.724	0.49 (0.20-1.19)		-0.719	0.49 (0.20-1.18)	
O	-0.760	0.47 (0.24-0.88)	***	-0.797	0.45 (0.24-0.84)	***

*** p-value < 0.05
** p-value < 0.10
M_o: Full Model
M_1: Model with significant variables only (rows with '—' indicate excluded variables)

In Table 8, comparisons between Group B and non-B blood groups were also done. Non-B blood group was chosen as the reference group because Blood Groups A, AB, and O had all decreased risks compared to Blood Group B. Thus, Table 8 serves as a comparison of the odds of developing T2DM between the two blood groups. Mothers in Group B had significantly increased odds of developing T2DM, being 2.37 times as likely as those in non-B groups (p = 0.0044).

Table.8. Summary of Logistic Regression Model for ABO Blood Group Associations with T2DM

Blood Group	**M_{1b}**		
	Coefficients	**OR (95% CI)**	**p-value**
Non-B		(reference)	
B	0.863	2.37 (1.32-4.35)	***

*** p-value < 0.05

M_{1b}: Model with significant variables only, refitted with new grouping for blood groups (B vs. Non-B) to get adjusted ORs.

4.2. Discussion

In this study, a total of 302 respondents with GDM were collected, and 148 or 49.01% (95% CI: 43.25% - 54.79%) were diagnosed with T2DM (*refer to Table 3*). This is aligned with the study conducted by Aroda and colleagues (2015), stating that women experiencing GDM have about 50% likelihood of developing T2DM in the ensuing years, and may also have recurrent GDM in a subsequent pregnancy.

The associated risk factors of the respondents *(refer to Table 4)* presented were chosen based on the literature found in relation to GDM and T2DM. Since, both diseases share characteristics with regards to its risk factors and mechanisms. In this study, such risk factors were associated with ABO blood groups. Groot and colleagues mentioned in their 2020 study that ABO blood groups, as well as aging, have a role in inheriting and developing diseases.

The results *(refer to Table 4)* revealed that the blood groups and most of the risk factors are not statistically associated with each other. However, a significant difference was found in the frequency of mothers with a history of GDM that was diagnosed with hypertension, especially those that belong in Blood Group AB with a proportion of 44.1% followed by groups B (32.3%), O (21.9%), and A (19.7%).

Legese, Abebe, and Fasil (2020) also had similar findings with the relation of such characteristics wherein family history, physical exercise, BMI, Diastolic Blood Pressure, TRG, and HDL are not correlated to ABO blood groups *(refer to Table 4)*. However, in exception, hypertension was found out to be associated with Blood Group AB which has the highest proportion of the said condition. This aligned to the findings of the aforementioned published study by Legese and colleagues wherein hypertension was said to be associated with the blood groups. The only difference is that in this study, Blood Group AB has the highest proportion of diagnosed hypertension. This is in contrast with the study of Legese, Abebe, and Fasil (2020) where Blood Group A was the most associated blood group with diagnosed hypertension. The possible reason for this is the difference in sample size and participant criterion, as well as other additional risk factors.

The yielded results *(refer to Table 5)* were consistent with the results of a study by Fagherazzi et al. (2014), that indicated that individuals with the Blood Group B had the highest risk of developing T2DM compared to other blood groups. The same findings were found with the results of the study by Legese, Abebe, & Fasil (2020), stating that individuals with Blood Group B had the highest risk of developing T2DM. The difference in the results from other studies not mentioned may be the result of different populations and criteria in both studies.

The regression coefficients and the computed ORs are shown *(refer to Table 7)*. The BMI group and diagnosis of hypertension were both not significant and were excluded from the final model in the Likelihood-Ratio Test (LRT). This may be because of the limitations brought about by the sample size due to the sampling method done. The data gathered from the respondents might not be enough to represent the whole population of people diagnosed with T2DM with regards to BMI and hypertension as its contributing risk factors.

A reference group was needed for the logistic regression model in order to compare it from the other groups. In other words, the other groups are compared to the reference group. A reference group can be chosen from any of the variables that are found in the data and no matter what variable is chosen, the yielded results will be the same except for the resulting p-value. This is usually chosen as the group that comes first or last alphabetically, the normative group, has the largest group, or the group whose mean is in the middle, or conversely, at one of the ends. It does not really matter what group is chosen as the reference group as long as it makes the most logical sense and makes interpretation of results easier.

In the physical activity level, “Low” was chosen to be the reference group to further point out and see the interesting comparison of how people differ in terms of level of their physical activity since the majority of the respondents (58.3%) answered “Low.” Thus, the majority group can be a

better option to compare with the minority group levels such as the "Moderate" and "High." For the BMI group, the "Normal" category was used because apart from it having the highest percentage result, this category pertains to the normative group which makes it easier to compare with the extremes of the category namely the underweight, overweight, and lastly the obese. Indicators on family history of T2DM and those diagnosed with hypertension or high cholesterol used "No" as the reference category to be able to compare it to the one who answered "Yes." Finally, for the blood group, Blood Group B was used as the reference group since it had the highest prevalence rate (63.1%) compared to the other blood groups. One of the objectives of this study is to identify if a certain major blood group is more significantly at risk of developing T2DM after being diagnosed with GDM during their pregnancy. Thus, the researchers chose Blood Group B that had the highest prevalence rate compared to the other blood groups to make the interpretation of the results of this study easier. These specific reference groups per category were chosen to provide a better understanding on the comparison of the yielded data and will not vary if the reference groups were changed in terms of interpreting the results.

Progression to T2DM varies widely from being diagnosed with GDM during pregnancy. Risk factors include race, elevated BMI, and family history of T2DM (Rayanagoudar et al., 2016). According to Wu et al. (2016), people with first-degree relatives diagnosed with T2DM have 40% risk of inheriting the chronic disease. In addition, the probability of having the disease may increase if both or either of the parents suffer from the disease. A 2020 study conducted by Feingold found that approximately 30-60% of T2DM patients exhibited a significant increase in their serum triglyceride, VLDL, and IDL cholesterol levels. These observations were found to be common since there is a high prevalence and distribution of T2DM patients who are normally obese, insulin resistant, and have experienced metabolic syndrome. A similar study by Kugishima et al. (2018) suggested that women who were more obese or with higher BMI ($p = 0.0044$) had higher risks of developing diabetes after pregnancy. The result (*refer to Table 7)* showed that a high level of physical activity had marginally significant association with T2DM wherein odds were twice as likely than having low physical activity levels (OR 2.03, $p = 0.0845$). This result contradicts most of the results of similar studies pertaining to the association between physical activity and T2DM. Physically inactive individuals are at risk of developing T2DM as proved by a study conducted among T2DM patients and non-diabetic patients (Ahmad et al., 2020). IPAQ or the International Physical Activity Questionnaire is a standardized self-reported measure of habitual physical activity. Despite having a standardized habitual physical activity questionnaire, the researchers were not able to closely monitor and instruct how the respondents answer the IPAQ. This could be another limitation due to the sampling method done in this study. The survey conducted was completely done through online means so there may be limitations such as having response bias which is a tendency for the participants to respond inaccurately. However, this just implies that even the mothers with high physical activity, as long as there are other risk factors present, are still at risk of developing T2DM from GDM.

The comparisons of the odds in developing T2DM between Group B and non-Group B are presented (*refer to Table 8)*. It shows that Mothers in Group B had significantly increased odds of developing T2DM, being 2.37 times as likely as those in non-B groups ($p = 0.0044$). The same model is also used by Legese, Abebe, & Fasil (2020) which yielded results that are aligned with the study. The authors concluded that individuals that belong in Blood Group B were 2.12 times more at risk in developing T2DM and Blood Group O individuals have the least risk in developing the disease. However, the aforementioned study included men in their participants contrary to this study that only involved women with a history of GDM. Another study by Fagherazzi et al. (2014) also stated that group Blood Group B showed the highest risk of developing T2DM with results of 1.23 (1.09, 1.38) using the same model compared to the other blood groups. The difference was that the reference group of the aforementioned study was only Blood Group O while this study used all non-B blood groups.

V. SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS

This chapter presents the summary, conclusions drawn from the study, and recommendations for further research.

5.1. Summary

This study aimed to determine the prevalence of developing Type 2 diabetes mellitus (T2DM) in mothers previously diagnosed with Gestational diabetes mellitus (GDM). This also discussed the prevalence and distribution of T2DM among the different ABO blood groups and its associated risk factors.

With these objectives, a descriptive study with a quantitative, non-experimental, cross-sectional approach was conducted. The sample size was computed using 95% confidence interval with a margin of error of 5-10%, and 0.8 power. Three hundred and two (302) participants were involved in this study. This number was established by using Cochran's formula to derive a representative sample for proportions. The participants were then selected using a non-probability purposive sampling. The participants were from Facebook diabetes support groups and were filtered based on the inclusion and exclusion criteria found in Chapter 3. An online survey was disseminated to the participants through Google Forms along with a consent form to ensure that they understood the details of the study. The survey consisted of three parts: 1) basic personal information used to calculate the Body Mass Index (BMI), 2) questions on whether the participants were diagnosed with GDM and T2DM, and 3) questions about the risk factors in relation to being diagnosed with GDM or T2DM. The data collection was done from April 8, 2021 to June 6, 2021.

After the data was acquired from the online survey, the researchers used statistical measures namely computation of BMI, Means and Standard Deviations of BMI, One-Way Analysis of Variance of the BMI, prevalence equation, odds ratio, and multivariate logistic regression to analyze data. Additionally, statistical tests such as Student's t-test, Pearson's chi-squared test, and Fisher's Exact test were also performed to test the hypotheses. The collected data was coded and computed using the R language version 4.0.3 for statistical computing. In-depth findings were presented and discussed in Chapter 4.

The results of this study revealed that a total of 148 out of 302, or 49.01% of mothers who have experienced GDM, have developed T2DM. The respondents were characterized based on profiles such as BMI, family history of diabetes, having high cholesterol or hypertension, blood group, and level of physical activity.

For the BMI, the mean was 26.31 which was interpreted as overweight based on the criteria established by the NHS. Majority of the respondents (58.6%) were either overweight (36.4%) or obese (22.2%). Although there is no significant difference between the BMIs of mothers with and without T2DM, it is worth noting that the T2DM group were mostly overweight (37.2%) while those without T2DM (42.9%) were in the normal BMI category. In terms of other risk factors, almost three-fourths (73.8%) disclosed having a family history of T2DM while almost a quarter (23.5%) revealed to have been diagnosed with high cholesterol.

More than a quarter (26.2%) were also revealed to be hypertensive or have high blood pressure. Subsequently, the blood groups were not equally-distributed with Blood Group O dominating almost half (45.4%) of the research population. The second most frequent blood group differs between the T2DM and non-T2DM groups. In the T2DM group, Blood Group B is the second most common phenotype meanwhile in non-T2DM group, Blood Group A is the second most common phenotype after Blood Group O. With regards to physical activity, more than half of the overall sample (58.3%) were classified as having low physical activity.

Based on the findings, only family history of diabetes, high cholesterol, high physical activity, and blood group were significant risk factors in developing T2DM among different ABO blood groups. For physical activity, however, it must be noted that this risk factor only had a marginal significance in association with being diagnosed with T2DM, although it was mentioned that the odds of developing T2DM were twice as likely in mothers with high physical activity. On the contrary, high BMI category, hypertension, and physical inactivity were found to be not significant in terms of the development of T2DM in mothers who had GDM in relation to the different ABO blood groups.

A logistic regression model specifically comparing Blood Group B and non-Blood Group B presented in Chapter 4 showed that Blood Group B can significantly increase the odds of developing T2DM. As stated in Chapter 4, mothers who are Blood Group B are 2.37 times more likely to have T2DM than those who do not belong to the group. Furthermore, it has been proven that among different blood groups there is a significant variation in the prevalence of the development of T2DM. Blood Group B had the highest

prevalence rate (63.1%), then Blood Group AB (52.9%), followed by Blood Group O (46.0%), and Blood Group A (39.4%).

Mothers in Blood Group B are more at risk of developing T2DM especially if they have a family history of T2DM and high cholesterol, and even if they have high levels of physical activity. This high level of physical activity risk factor is only marginally significant as aforementioned. Thus, it does not denote that the mothers are automatically at risk if they are physically active. The researchers suggest that this finding means that even those with high physical activity could also be at risk especially if the other two risk factors are present; noting that the other two are truly significant. It is also worth noting that Blood Group AB, being the second T2DM-prevalent blood group, had a relatively higher proportion of T2DM mothers with hypertension.

5.2. Conclusions

In conclusion, the researchers were able to find out that there are Filipino mothers that develop T2DM after being diagnosed with GDM during pregnancy. Likewise, the researchers also arrived at results that show how there are different possible risk factors in the development of T2DM in mothers after having GDM during pregnancy.

The results of this study along with further research studies are beneficial to the diabetic community, allied health professionals, people of the academe, and general public, as it can raise awareness of the possibilities of developing T2DM based on their blood group, as well as the risk factors associated with it. The findings can also help health professionals to provide monitoring, screening, and interventions for patients which is a need during and after pregnancy to reduce the risk of progression to T2DM.

5.3. Recommendations

Based on the findings and conclusions that the researchers have arrived at, the following are the suggested recommendations: firstly, due to the pandemic, the researchers were limited to only using online surveys and online interviews to collect data for a limited time - it is recommended that future similar studies use a different method of sampling which could be through acquisition of patient data from actual in and/or out-patients in hospitals or clinics, or through big data sourcing from the said institutions. For this reason, it is also recommended to have a bigger sampling size that would better represent the population. Next, it can also be recommended to gather participant information from different data points, such as before, during, and after pregnancy, to further determine which risk factors contribute to the development of T2DM. Regarding such recommendations, it is further advised to gather information such as BMI, hypertensive status, and other risk factors during the recommended different data points. This is a long-term research study. Lastly, a different type of tool may also be formulated or used to assess the physical activity of the respondents.

REFERENCES

[1]. American Diabetes Association. (n.d.). Hyperglycemia (High Blood Glucose). Retrieved September 19, 2020.

[2]. NHS. What is the body mass index?

[3]. World Health Organization. (n.d.). GLOBAL REPORT ON DIABETES [Catalog]. Retrieved September 18, 2020.

[4]. Cochran, W. G. (1997). Sampling Techniques. New York: John Wiley & Sons, Inc.

[5]. Hariri, S., Yoon, P., Moonesinghe, R., Valdez, R., & Khoury, M. (2006). Evaluation of family history as a risk factor and screening tool for detecting undiagnosed diabetes in a nationally representative survey population. Retrieved November 28, 2020.

[6]. Metzger, B.E., Buchanan, T.A., Coustan, D.R., de Leiva, A., Dunger, D.B., Hadden, D.R., Hod, M., Kitzmiller, J.L., Kjos, S.L., Oats, J.N., Pettitt, D.J., Sacks, D.A., & Zoupas, C. (2007). Summary and recommendations of the Fifth International Workshop-Conference on Gestational Diabetes Mellitus. Diabetes Care. 30(suppl 2):S251–S260.

[7]. Narayan, K.M., Boyle, J.P., Thompson, T.J., Gregg, E.W., & Williamson, D.F. (2007) Effect of BMI on lifetime risk for diabetes in the U.S. Diabetes Care. 30:1562–1566.

[8]. Soria, M. L., Sy, R. G., Vega, B. S., Ty-Willing, T., Abenir-Gallardo, A., Velandria, F., & Punzalan, F. E. (2009). The incidence of type 2 diabetes mellitus in the Philippines: A 9-year cohort study. Diabetes Research and Clinical Practice, 86(2), 130-133.

[9]. Di Blasio, A., Ph.D., M.Sc., B.Sc., Izzicupo, P., Ph.D., M.Sc., B.Sc., Di Donato, F., B. Sc, & Mazzocco, C. (2010). IPAQ-Automatic Report [PDF]. IPAQ.

[10]. Hedderson, M. M., Darbinian, J. A., & Ferrara, A. (2010). Disparities in the risk of gestational diabetes by race-ethnicity and country of birth. Paediatric and perinatal epidemiology, 24(5), 441–448.

[11]. Kaku, K. (2010). Pathophysiology of type 2 diabetes and its treatment policy. Japan Medical Association Journal. 53. 41-46.

[12]. Kamil, M., Ali Nagi Al-Jamal, H., & Mohd Yusoff, N. (2010). Association of ABO blood types with diabetes mellitus. Libyan Journal of Medicine, 5(1), 4847.

[13]. Chen, L., Magliano, D. J., & Zimmet, P. Z. (2011). The worldwide epidemiology of type 2 diabetes mellitus—present and future perspectives. Nature Reviews Endocrinology, 8(4), 228–236.

[14]. Ferrian, N. D. (2011). Assessing students' risk factors for type II diabetes at a Midwest public university. [Master's thesis, Minnesota State University, Mankato]. Cornerstone: A Collection of Scholarly and Creative Works for Minnesota State University, Mankato.

[15]. He, M., Wolpin, B., Rexrode, K., Manson, J. E., Rimm, E., Hu, F. B., & Qi, L. (2012). ABO blood type and Risk of Coronary Heart Disease in Two Prospective Cohort Studies. Arteriosclerosis, Thrombosis, and Vascular Biology, 32(9), 2314–2320.

[16]. Heude, B., Thiébaugeorges, O., Goua, V., Forhan, A., Kaminski, M., Foliguet, B., Schweitzer, M., Magnin, G., Charles, M. A., & EDEN Mother-Child Cohort Study Group (2012). Pre-pregnancy body mass index and weight gain during pregnancy: relations with gestational diabetes and hypertension, and birth outcomes. Maternal and child health journal, 16(2), 355–363.

[17]. Olokoba, A. B., Obateru, O. A., & Olokoba, L. B. (2012). Type 2 diabetes mellitus: a review of current trends. Oman medical journal, 27(4), 269–273.

[18]. Rice, G. E., Illanes, S. E., & Mitchell, M. D. (2012). Gestational Diabetes Mellitus: A Positive Predictor of Type 2 Diabetes? International Journal of Endocrinology, 2012, 1-10.

[19]. Cerf M. E. (2013). Beta cell dysfunction and insulin resistance. Frontiers in endocrinology, 4, 37.

[20]. Chehade, J. M., Gladysz, M., & Mooradian, A. D. (2013). Dyslipidemia in Type 2 Diabetes: Prevalence, Pathophysiology, and Management. Drugs, 73(4), 327-339.

[21]. Gaillard, R., Durmuş, B., Hofman, A., Mackenbach, J., Steegers, E., & Jaddoe, V. (2013). Risk factors and outcomes of maternal obesity and excessive weight gain during pregnancy. Retrieved September 19 2020.

[22]. Green, B. N., & Johnson, C. D. (2013). Establishing a theoretical basis for research in musculoskeletal epidemiology: a proposal for the use of biopsychosocial theory in investigations of back pain and smoking. Journal of chiropractic humanities, 20(1), 1–8.

[23]. Liumbruno, G. M., & Franchini, M. (2013). Beyond immunohaematology: the role of the ABO blood type in human diseases. Blood transfusion = Trasfusione del sangue, 11(4), 491–499.

[24]. Pelzer, U., Klein, F., Bahra, M., Sinn, M., Dörken, B., Neuhaus, P., Meyer, O., & Riess, H. (2013). Blood group determinates incidence for pancreatic cancer in Germany. Frontiers in physiology, 4, 118.

[25]. Sibai, A.M., Costanian, C., Tohme, R., Assaad S., & Hwalla, N. (2013) Physical activity in adults with and without diabetes: from the 'high-risk' approach to the 'population-based' approach of prevention. BMC Public Health 13, 1002 (2013).

[26]. American Disease Association. (2014). Standards of Medical Care in Diabetes. Diabetes Care, 37(supp 1), S14–S80.

[27]. Büyükkayacı Duman, N. (2014). Frequency of Gestational Diabetes Mellitus and the Associated Risk Factors in Turkish Women. Pakistan Journal of Medical Sciences, 31(1).

[28]. Fagherazzi, G., Gusto, G., Clavel-Chapelon, F. et al. ABO and Rhesus blood groups and risk of type 2 diabetes: evidence from the large E3N cohort study. (2014). Diabetologia 58, 519–522 (2015).

[29]. Lastra, G., Syed, S., Kurukulasuriya, L. R., Manrique, C., & Sowers, J. R. (2014). Type 2 diabetes mellitus and hypertension: an update. Endocrinology and metabolism clinics of North America, 43(1), 103–122.

[30]. Mahalakshmi, M.M., Bhavadharini, B., Kumar, M., Anjana, R.M., Shah, S.S., Bridgette, A., Choudhury, M., Henderson M., Desborough, L., Viswanathan, M., & Ranjani, H. (2014). Clinical profile, outcomes, and progression to type 2 diabetes among Indian women with gestational diabetes mellitus seen at a diabetes center in south India. Indian Journal of Endocrinology and Metabolism, 18(3), 400.

[31]. Wu, Y., Ding, Y., Tanaka, Y., & Zhang, W. (2014). Risk Factors Contributing to Type 2 Diabetes and Recent Advances in the Treatment and Prevention. International Journal of Medical Sciences, 11(11), 1185-1200.

[32]. Zhang, B., He, N., Huang, Y., Song, F., & Chen, K. (2014). ABO blood types and Risk of Cancer: A Systematic Review and Meta-analysis. Asian Pacific Journal of Cancer Prevention, 15(11), 4643-4650.

[33]. Zhou, S., & Welsby, I. (2014). Is ABO blood type truly a risk factor for thrombosis and adverse outcomes? World journal of cardiology. 6(9), 985–992.

[34]. Classification and Diagnosis of Diabetes. (2015). Diabetes Care. 38(Supplement_1).

[35]. Aroda, V.R., Christophi, C.A., Edelstein, S.L., Zhang, P., Herman, W.H., Barrett-Connor, E., Delahanty, L.M., Montez, M.G., Ackermann, R.T., Zhuo, X., Knowler, W.C., Ratner, R.E.; Diabetes Prevention Program Research Group. The effect of lifestyle intervention and metformin on preventing or delaying diabetes among women with and

without gestational diabetes: the Diabetes Prevention Program outcomes study 10-year follow-up. J. Clin. Endocrinol. Metab. 100, 1646–1653 (2015)

[36]. Baynest, H. W. (2015). Classification, Pathophysiology, Diagnosis and Management of Diabetes Mellitus. Journal of Diabetes & Metabolism, 06(05).

[37]. Cantley, J., & Ashcroft, F. M. (2015). Q&A: insulin secretion and type 2 diabetes: why do β-cells fail?. BMC biology, 13, 33.

[38]. Cecilia, J. A., Sjoberg, K. A., Bien, M. J., Charmaine, D. A., & Gabriel, J. V. (2015). Prevalence of Diabetes Mellitus and Pre-Diabetes in the Philippines: A Sub-study of the 7th National Nutrition and Health Survey (2008). Retrieved September 12, 2020.

[39]. Dean, L. (2015). ABO blood type.

[40]. Duman N. B. (2015). Frequency of gestational diabetes mellitus and the associated risk factors. Pakistan journal of medical sciences, 31(1), 194–197.

[41]. Eades, C. E., Styles, M., Leese, G. P., Cheyne, H., & Evans, J. M. (2015). Progression from gestational diabetes to type 2 diabetes in one region of Scotland: an observational follow-up study. BMC Pregnancy and Childbirth, 15(1).

[42]. Gunderson, E. P., Hurston, S. R., Ning, X., Lo, J. C., Crites, Y., Walton, D., Dewey, K. G., Azevedo, R. A., Young, S., Fox, G., Elmasian, C. C., Salvador, N., Lum, M., Sternfeld, B., & Quesenberry, C. P., Jr. (2015). Lactation and Progression to Type 2 Diabetes Mellitus after Gestational Diabetes Mellitus. Annals of Internal Medicine, 163(12), 889.

[43]. Karagoz, H., Erden, A., Ozer, O., Esmeray, K., Cetinkaya, A., Avci, D., Karahan, S., Basak, M., Bulut, K., Mutlu, H., & Simsek Y. (2015). The role of blood groups in the development of diabetes mellitus after gestational diabetes mellitus. Therapeutics and Clinical Risk Management, 1613.

[44]. Kim, M. J., Lim, N. K., Choi, S. J., & Park, H. Y. (2015). Hypertension is an independent risk factor for type 2 diabetes: the Korean genome and epidemiology study. Hypertension research: official journal of the Japanese Society of Hypertension, 38(11), 783–789.

[45]. Pan, M., Chen, L., Tsao, H., & Chen, K. (2015). Relationship between Polycystic Ovarian Syndrome and Subsequent Gestational Diabetes Mellitus: A Nationwide Population-Based Study. Plos One, 10(10).

[46]. Vasan, S. K., Rostgaard, K., Ullum, H., Melbye, M., Hjalgrim, H., & Edgren, G. (2015). ABO blood type and Dementia Risk – A Scandinavian Record-Linkage Study. PLOS ONE, 10(6).

[47]. Cholesterol Abnormalities and Diabetes. (2016). Retrieved February 02, 2021.

[48]. Coustan, D. R. (2016). Recurrent GDM and the development of type 2 diabetes have similar risk factors. Endocrine, 53(3), 624–625.

[49]. Lin, P., Hung, C., Chan, T., Lin, K., Hsu, Y., & Tzeng, Y. (2016). The risk factors for gestational diabetes mellitus: A retrospective study. Midwifery, 42, 16-20.

[50]. Meo, S.A., Rouq, F.A., Suraya, F., & Zaidi, S.Z. (2016) Association of ABO and Rh blood groups with type 2 diabetes mellitus. Eur Rev Med Pharmacol Sci. 2016; 20(2):237-42. PMID: 26875891.

[51]. Papazafiropoulou, A., Papanas, N., Melidonis, A., & Maltezos, E. (2016). Family History of Type 2 Diabetes: Does Having a Diabetic Parent Increase the Risk? Current Diabetes Reviews, 13(1), 19-25.

[52]. Rayanagoudar, G., Hashi, A. A., Zamora, J., Khan, K. S., Hitman, G. A., & Thangaratinam, S. (2016). Quantification of the type 2 diabetes risk in women with gestational diabetes: a systematic review and meta-analysis of 95,750 women. Diabetologia, 59(7), 1403–1411.

[53]. Setia, M. (2016). Methodology series module 3: Cross-sectional studies. Indian Journal of Dermatology,61(3), 261.

[54]. Shimodaira, M., Yamasaki, T., & Nakayama, T. (2016). The association of maternal ABO blood group with gestational diabetes mellitus in Japanese pregnant women. Diabetes & Metabolic Syndrome: Clinical Research & Reviews, 10(2), S102–S105.

[55]. Tan, G. (2016, April 22). Diabetes Care in the Philippines. Retrieved September 19, 2020.

[56]. WHO Reproductive Health Library. WHO recommendation on the diagnosis of gestational diabetes in pregnancy. (December 2016). The WHO Reproductive Health Library; Geneva: World Health Organization.

[57]. Zhu, Y., & Zhang, C. (2016). Prevalence of Gestational Diabetes and Risk of Progression to Type 2 Diabetes: a Global Perspective. Current Diabetes Reports, 16(1).

[58]. Herath, H., Herath, R., & Wickremasinghe, R. (2017). Gestational diabetes mellitus and risk of type 2 diabetes 10 years after the index pregnancy in Sri Lankan women—A community based retrospective cohort study. PLOS ONE, 12(6), e0179647.

[59]. Kiani, F., Naz, M. S., Sayehmiri, F., Sayehmiri, K., & Zali, H. (2017). The Risk Factors of Gestational Diabetes Mellitus: A Systematic Review and Meta-Analysis Study. International Journal of Women's Health and Reproduction Sciences, 5(4), 253-263.

[60]. Wang, F.M., Zhang, Y., Zhang, G.-M., Liu, Y.-N., Sun, L.-J., & Liu, Y. (2017). Association of ABO Blood Types and Clinicopathological Features of Prostate Cancer. Disease Markers, 2017, 1–6.

[61]. Agresti, A. (2018). An introduction to categorical data analysis. John Wiley & Sons.

[62]. Barbour, L., Buschur, E., & Stetson, B. (2018). Diabetes In Pregnancy. Endotext.

[63]. Choate, J. D. (2018). ABO and Rh Blood Groups. Clinical Principles of Transfusion Medicine, 15-24.

[64]. Kennerly, A., & Kirk, A. (2018). Physical activity and sedentary behaviour of adults with type 2 diabetes: A systematic review. Practical Diabetes, 35(3).

[65]. Kugishima, Y., Yasuhi, I., Yamashita, H., Sugimi, S., Umezaki, Y., Suga, S., Fukuda, M., & Kusuda, N. (2018). Risk factors associated with the development of postpartum diabetes in Japanese women with gestational diabetes. BMC Pregnancy and Childbirth, 18(1).

[66]. Larrabure-Torrealva, G. T., Martinez, S., Luque-Fernandez, M. A., Sanchez, S. E., Mascaro, P. A., Ingar, H., Williams, M. A. (2018). Prevalence and risk factors of gestational diabetes mellitus: Findings from a universal screening feasibility program in Lima, Peru. BMC Pregnancy and Childbirth, 18(1).

[67]. Mandal, B., Shukla, R., Basu, A.K., Sinha, A., Maiti, A., & Bhattacharjee, K. Association of ABO blood types with type-2 diabetes mellitus and its complications. (2018). J Diabetes Metab Disord Control. 2018; 5(1):1-7.

[68]. Pineda-Cortel, M.R.B., Manalo, M.E.M., Canivel, R.R.C., Matias, III R.S., Dizon, A.J.B., Bacani, M.N.S., & Dalmacio, J.S.B. (2018). Screening and Diagnosis of Gestational Diabetes Mellitus Using 75-g Oral Glucose Tolerance Test Following the WHO, ADA, and IADPSG Criteria. J Diabetes Metab 9: 799.

[69]. Aoto, H., Tanimura, C., Majbauddin, A., Kobayashi, N., Morita, T., Inoue, K., Otani, S., Fukada, M., & Hanaki, K. (2019). A Conceptual Model for Quality of Life among People with Type 2 Diabetes in the Philippines. Yonago Acta Medica, 62(1), 053-061.

[70]. Chivese, T., Norris, S. A., & Levitt, N. S. (2019). Progression to type 2 diabetes mellitus and associated risk factors after hyperglycemia first detected in pregnancy: A cross-sectional study in Cape Town, South Africa. PLOS Medicine, 16(9), e1002865.

[71]. Grundy, S. M., Stone, N. J., Bailey, A. L., Beam, C., Birtcher, K. K., Blumenthal, R. S., Yeboah, J. (2019). 2018 AHA/ACC/AACVPR/AAPA/ABC/ACPM/ADA/AGS/APhA/ASPC/NLA/PCNA Guideline on the Management of Blood Cholesterol. Journal of the American College of Cardiology, 73(24).

[72]. Philippine Statistics Authority. (2019). Urban Population in the Philippines (Results of the 2015 Census of Population). Retrieved September 12, 2020.

[73]. Sapanont, K., Sunsaneevithayakul, P., & Boriboonhirunsarn, D. (2019). Relationship between ABO blood type and gestational diabetes mellitus. The Journal of Maternal-Fetal & Neonatal Medicine, 1–151.

[74]. Sun, D., Zhou, T., Heianza, Y., Li, X., Fan, M., Fonseca,V., & Qi, L. (2019). Type 2 Diabetes and Hypertension: A Study on Bidirectional Causality. Circulation Research. CIRCRESAHA.118.314487.

[75]. Aasbjerg, K., Holm Nørgaard, C., Vestergaard, N., Søgaard, P., Køber, L., Weeke, P., Gislason, P., & Torp-Pedersen, C. (2020). Risk of diabetes among related and unrelated family members. Diabetes Research and Clinical Practice, 160, 107997.

[76]. Freeman A.M., & Pennings N. Insulin Resistance. [Updated 2020 Jul 10]. In: StatPearls [Internet]. Treasure Island (FL): StatPearls Publishing; 2020.

[77]. Goyal R., Jialal I. Diabetes Mellitus Type 2. [Updated 2020 May 28]. In: StatPearls [Internet]. Treasure Island (FL): StatPearls Publishing; 2020.

[78]. Groot, H. E., Villegas Sierra, L. E., Said, M. A., Lipsic, E., Karper, J. C., & van der Harst, P. (2020). Genetically Determined ABO blood type and its Associations with Health and Disease. Arteriosclerosis, Thrombosis, and Vascular Biology.

[79]. International Diabetes Federation - Members - Western Pacific. (2020).

[80]. Kominato, Y., Sano, R., Takahashi, Y., Hayakawa, A., & Ogasawara, K. (2020). Human ABO gene transcriptional regulation. Transfusion, 60(4), 860–869.

[81]. Li, F., Hu, Y., Zeng, J., Zheng, L., Ye, P., Wei, D., & Chen, D. (2020). Analysis of risk factors related to gestational diabetes mellitus. Taiwanese Journal of Obstetrics and Gynecology, 59(5), 718-722.

[82]. Li, Y., Ren, X., He, L., Li, J., Zhang, S., & Chen, W. (2020). Maternal age and the risk of gestational diabetes mellitus: A systematic review and meta-analysis of over 120 million participants. Diabetes Research and Clinical Practice, 162, 108044.

[83]. Legese, B., Abebe, M., & Fasil, A. (2020). Association of ABO and Rh Blood Group Phenotypes with Type 2 Diabetes Mellitus at Felege Hiwot Comprehensive Referral Hospital

Bahir Dar, Northwest Ethiopia. International Journal of Chronic Diseases, 2020, 1-9.

[84]. Navabi, J., Navabi, S., Hemmati, N., Shaahmadi, Z., & Aghaei, A. (2020). Higher Odds of Type 2 Diabetes for Some Blood Groups. Public Health Genomics, 23(1-2), 37-41.

[85]. Ng, J. Y., Clement, I. J., Jimeno, C., Sy, R. A., Mirasol, R., Pena, P. D., Wiebols, E. (2020). Estimating direct medical costs of type 2 diabetes mellitus in the Philippines: A protocol. BMJ Open, 10(7).

[86]. Olaogun, I., Farag, M., & Hamid, P. (2020). The Pathophysiology of Type 2 Diabetes Mellitus in Non-obese Individuals: An Overview of the Current Understanding. Cureus, 12(4), e7614.

[87]. Tan, M., & MacEachern, M. P. (2020). Treating Dyslipidemias in the Primary Prevention of Atherosclerotic Cardiovascular Disease in Older Adults with Diabetes Mellitus. Clinics in Geriatric Medicine, 36(3), 457-476.

[88]. Ahmad, I., Aung, M. N., Ueno, S., Khin, E. T., Latt, T. S., Moolphate, S. & Yuasa, M. (2021). Physical Activity of Type 2 Diabetes Mellitus Patients and Non-Diabetes Participants in Yangon, Myanmar: A Case-Control Study Applying the International Physical Activity Questionnaires (IPAQ-S). Diabetes, Metabolic Syndrome and Obesity: Targets and Therapy, Volume 14, 1729–1739.