Hanoi – 2026

Vietnam National University, Hanoi

International School

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M.A Thesis Proposal

CURRENT STATUS OF GESTATIONAL DIABETES MELLITUS AND SOME RELATED FACTORS IN PREGNANT WOMEN AT NATIONAL HOSPITAL OF OBSTETRICS AND GYNECOLOGY

DANG HA LE

Field **Biomedical Engineering Technology**

Supervisor **Assoc. Prof. Dr. Chu Dinh Toi**

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CERTIFICATE OF ORIGINALITY

I, the undersigned, hereby certify my authority of the study project report entitled **"Current status of gestational diabetes mellitus and some related factors in pregnant women at National Hospital of Obstetrics and Gynecology"** submitted in partial fulfillment of the requirements for the degree of Master in Biomedical Engineering and Technology. Except where the reference is indicated, no other person's work has been used without due acknowledgement in the text of the thesis.

Hanoi, 2026

Dang Ha Le

Approved by

SUPERVISOR 1 **SUPERVISOR 2**

Date: Date:

ACKNOWLEDGEMENTS

After a period of study and skill development at the VNU – International School, with sincere gratitude and respect, I would like to express my heartfelt thanks to the Board of Directors, the Graduate Office, and all the lecturers for their dedicated teaching and guidance throughout my course.

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Despite my best efforts, due to certain limitations in time and capability, this thesis may still have shortcomings. I sincerely welcome any comments and suggestions from esteemed teachers, experts, colleagues, and friends to help improve the study further.

Hanoi, 2026

Author

Ha Le Dang

ABSTRACT

Background: Gestational diabetes mellitus (GDM) is a common community health issue, causing long-term impacts on pregnant women and infants. In the context of changing dietary patterns, reduced physical activity, GDM has become a challenge for developing countries, including Vietnam. Although many risk factors for GDM have been identified, evidence regarding the distribution and impact of these factors across different populations remains limited. In Vietnam, domestic studies have focused on common risk factors, while data on less reported factors, such as an abnormal obstetric history or hypertension , are still lacking, indicating gaps that require more research.

Objective: This study was conducted with two objectives: (1) To describe the current status of GDM among pregnant women attending and delivering at the National Hospital of Obstetrics and Gynecology in 2025; and (2) To compare clinical, demographic, personal and family medical history characteristics and to identify selected factors associated with GDM in pregnant women.

Methods: A cross-sectional descriptive design was performed. Descriptive statistics were frequency, percentage, and mean ± standard deviation. Logistic regression was performed to determine independent predictor factors; odds ratios (OR) and 95% confidence intervals (95% CI) were computed.

Results: The prevalence of GDM was 18.3%. The mean maternal age was 31.0 ± 5.7 years; the mean pre-pregnancy BMI was 21.4 ± 4.3 kg/m². The independent risk factors for GDM were the following: first-degree family history of type 2 diabetes (aOR = 3.625; $p < 0.01$), maternal age ≥ 35 years (aOR = 1.716; $p = 0.03$), pre-pregnancy BMI ≥ 25 kg/m² (aOR = 2.293; $p = 0.002$).No statistically significant associations in stillbirth history, macrosomia, ART intervention, hypertension, multiple pregnancy, urinary glucose or fetal sex.

Recommendation: Early screening should be strengthened for high-risk pregnant women, and larger-scale studies as well as more research on pathophysiological mechanisms are needed to improve prevention and management of GDM.

Keywords: *Gestational diabetes mellitus; risk factors; pregnancy; BMI; maternal age; family history; Vietnam.*

LIST OF ABBREVIATIONS

Abbreviations	Full term
GDM	Gestational Diabetes Mellitus
WHO	World Health Organization
IDF	International Diabetes Federation
BMI	Body Mass Index
FFA	Free Fatty Acid
TNF-α	Tumor Necrosis Factor alpha
IL – 1,6	Interleukin – 1,6
IRS – 1	Insulin Receptor Substrate-1
ACOG	American College of Obstetricians and Gynecologists
IADPSG	International Association of Diabetes and Pregnancy Study Groups
USPSTF	United States Preventive Services Task Force
OGTT	Oral Glucose Tolerance Test
NDDG	National Diabetes Data Group
CC Criteria	Carpenter and Counstan Criteria
PCOS	Polycystic Ovary Syndrome
CDC	Centers for Disease Control and Prevention
PFOA	Perfluorooctanoic Acid
ART	Assisted Reproductive Technology

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CHAPTER 1. INTRODUCTION

Gestational diabetes mellitus (GDM) is a condition that not only affects the health and quality of life of women and their children, but also places a notable burden on healthcare systems in many countries. During pregnancy, GDM is associated with several adverse outcomes, including fetal macrosomia, a higher rate of cesarean section, and an increased risk of pregnancy complications such as preeclampsia. These complications may negatively influence both maternal and neonatal outcomes and complicate clinical management during pregnancy and delivery. Importantly, the impact of GDM does not end after childbirth. Women with a history of GDM have a substantially higher risk of developing type 2 diabetes later in life. In addition, offspring exposed to hyperglycemia in utero are more likely to experience metabolic disorders as they grow older. Taken together, these findings indicate that GDM is not only a short-term obstetric issue, but also a condition with long-term implications for maternal and child health [1-4].

Estimates from the World Health Organization (WHO) and the International Diabetes Federation (IDF) indicate that tens of millions of women worldwide develop GDM each year, accounting for approximately 14% of all pregnancies [5]. However, the prevalence of the disease varies considerably across different regions all over the world, as well as among areas within the same country. This heterogeneity reflects variations in risk factors, demographic characteristics, and healthcare conditions specific to each locality [1, 6].

In the context of increasing lifestyle changes, dietary imbalances, and the increasing prevalence of overweight and obesity, the incidence of GDM continues to rise and has become a major challenge for developing countries, including Vietnam. Therefore, early detection, risk factor–based screening, and timely treatment play a crucial role in protecting the health of both mother and fetus [6-8].

A range of factors has been associated with GDM, including advanced maternal age, pre-pregnancy body mass index (BMI), and a family history of type 2 diabetes. In addition, other factors such as fetal sex, history of abnormal pregnancy, polycystic ovary syndrome, and maternal smoking habits have been reported, though the results remain inconsistent [7, 9-11]. In Vietnam, these aspects have been less frequently addressed in previous studies, indicating that many gaps still need to be further clarified.

The National Hospital of Obstetrics and Gynecology is a leading medical institution in the field of obstetrics and gynecology, receiving a large number of pregnant women for examination, antenatal care, and delivery each year. Conducting research at this hospital not only contributes to updating the practical picture of the current situation of GDM but also provides valuable information to help clinicians perform early screening, accurate diagnosis, and timely intervention for pregnant women. At the same time, comparing domestic data with international reports will establish an important foundation for advancing more in-depth studies on epidemiology, pathogenesis, and intervention strategies.

Based on the above context, the research team conducted the study entitled: ***"Current status of gestational diabetes mellitus and associated factors among pregnant women attending and delivering at National Hospital of Obstetrics and Gynecology."***

Research Objectives

(1) To describe the current status of gestational diabetes mellitus among pregnant women attending and delivering at the National Hospital of Obstetrics and Gynecology in 2025.

(2) To compare clinical, demographic, personal and family medical history characteristics and to identify selected factors associated with gestational diabetes mellitus in pregnant women.

CHAPTER 2. LITERATURE REVIEW

2.1. Definition

For decades, GDM has been understood as glucose intolerance initially diagnosed during pregnancy, regardless of whether the condition appeared before or persisted after delivery. This definition established a unified standard for screening and diagnosis; however, certain limitations still remain [12-14]. Owing now to increasing prevalence of obesity and diabetes, there is a rise in the number of women of reproductive age with undiagnosed type 2 diabetes. Pregnant women who are diagnosed with diabetes during the first trimester based on the diagnostic criteria for the nonpregnant population are categorized as having preexisting diabetes, most commonly type 2. In contrast, GDM refers to diabetes that develops for the first time during the second or third trimester, according to current guidelines [12, 14]. The distinction between preexisting diabetes and GDM is illustrate in Figure 2.1.

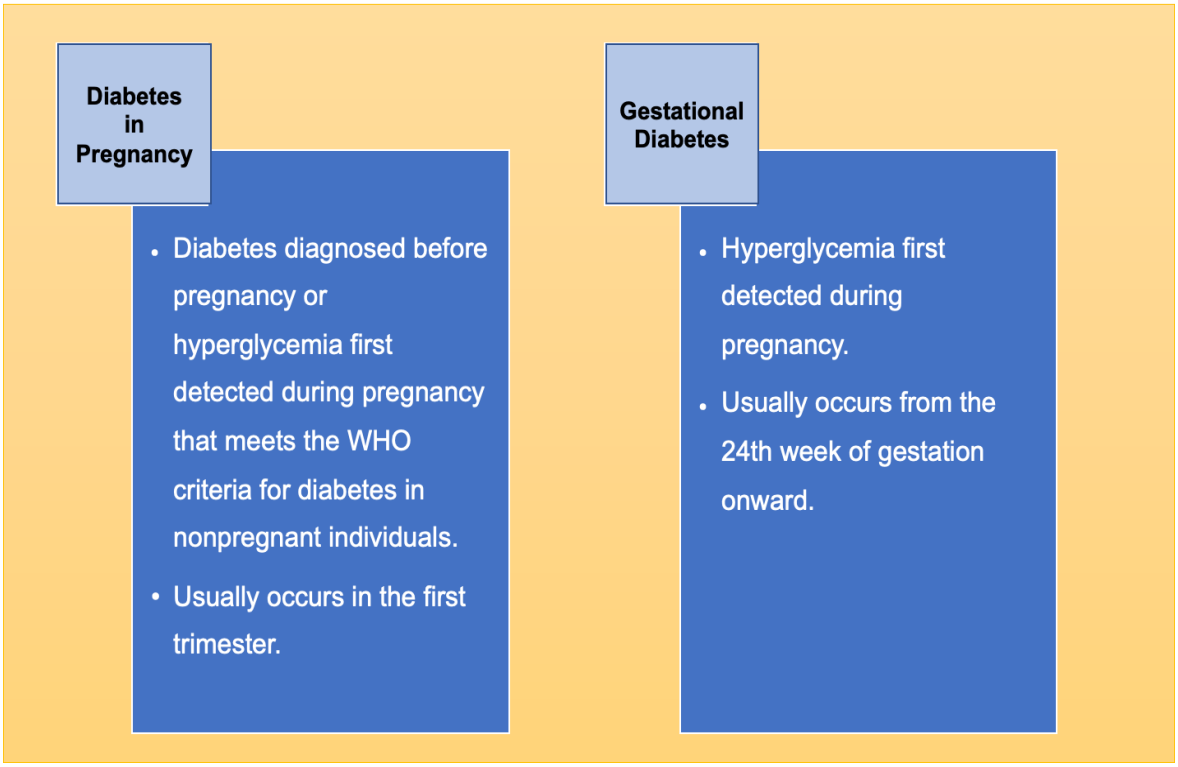


Figure 2.1. Distinction between two types of diabetes during pregnancy [12, 14]

2.2. Pathophysiology

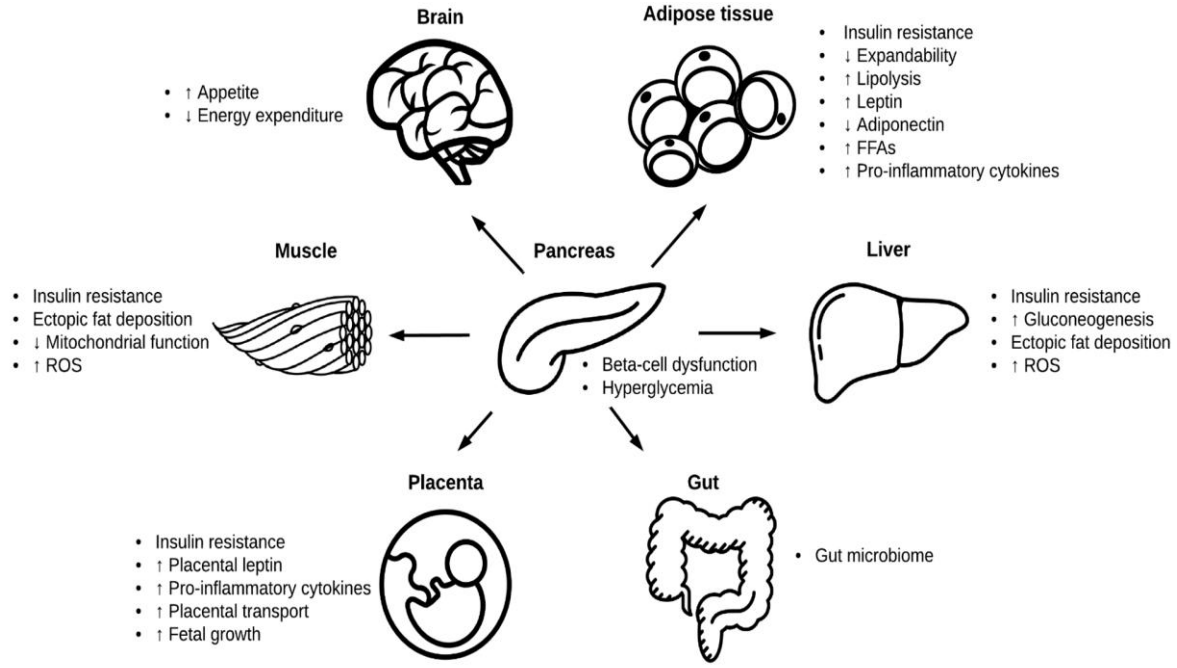


Figure 2.2. Key organs involved in the pathophysiology of GDM [15]

Figure 2.2 illustrates the organs of the body that undergo changes and are involved in the pathophysiological process of GDM.

During pregnancy, the maternal body undergoes numerous physiological changes aimed at creating optimal conditions for fetal growth and development. These adjustments affect multiple organ systems, including the cardiovascular, renal, hematologic, respiratory, and particularly the metabolic systems involving glucose, lipid, and protein metabolism [13, 16]. This metabolic adaptation is achieved through the coordinated interaction of three main components—the mother, the placenta, and the fetus—collectively known as the maternal–placental–fetal unit [16].

The secretion of hormones and metabolic regulators, such as estrogen, cortisol, leptin, and progesterone, along with placental lactogen and placental growth hormone, are involved in driving the biological process. These hormones work in synchrony to change maternal metabolism across pregnancy. Together, they contribute to physiological insulin resistance, stimulate endogenous glucose production, and mobilize stored fat, leading to elevated circulating glucose and free fatty acids (FFA) concentrations [16, 17]. This physiological resistance to insulin is a useful and important adaptive mechanism during pregnancy. By augmenting maternal glucose and FFA availability, it keeps a sufficient and constant supply of energy substrates to the developing fetus, particularly during periods of rapid fetal growth. This metabolic adaptation is compensated for appropriately during normal pregnancy by

upregulation of insulin secretion from maternal pancreatic β-cells, allowing glucose homeostasis to be maintained while satisfying fetal nutritional requirements [18].

In response to an increase in plasma glucose levels, the maternal pancreas adapts by expanding pancreatic islet mass through β-cell hypertrophy and hyperplasia. This adaptation increases insulin synthesis and secretion in response to glucose stimulation while lowering the glucose threshold for insulin release [16, 18]. Consequently, pregnant women typically exhibit hyperinsulinemia and lower fasting glucose levels compared with nonpregnant women.

Insulin resistance in pregnant women gradually increases with gestational age and usually peaks around the 24th week of pregnancy. As long as the maternal pancreas is capable of compensatory hyperinsulinemia sufficient to counteract this resistance, blood glucose levels remain within the normal range. However, when insulin resistance exceeds pancreatic compensatory capacity, or when β-cell function becomes impaired, the pancreas fails to produce adequate insulin [18]. And this imbalance damages glucose homeostasis leading to hyperglycemia. Additionally, pro-inflammatory cytokines like interleukin-1 (IL-1), interleukin-6 (IL-6), and tumor necrosis factor-α (TNF-α) inhibit insulin signaling by inducing serine phosphorylation of IRS-1, thus advancing insulin resistance through inflammation

Consequently, during pregnancy, the maternal pancreas faces significant stress, making individuals with pre-existing insulin resistance or limited insulin secretory capacity—such as those who are underweight or of smaller stature—more susceptible to GDM [13]. After delivery, β-cell mass, blood glucose levels, and insulin sensitivity may return to normal. However, in some cases, these abnormalities persist, increasing the long-term risk of metabolic disorders such as obesity, chronic insulin resistance, and dyslipidemia [18].

These metabolic changes are illustrated in Figure 2.3.

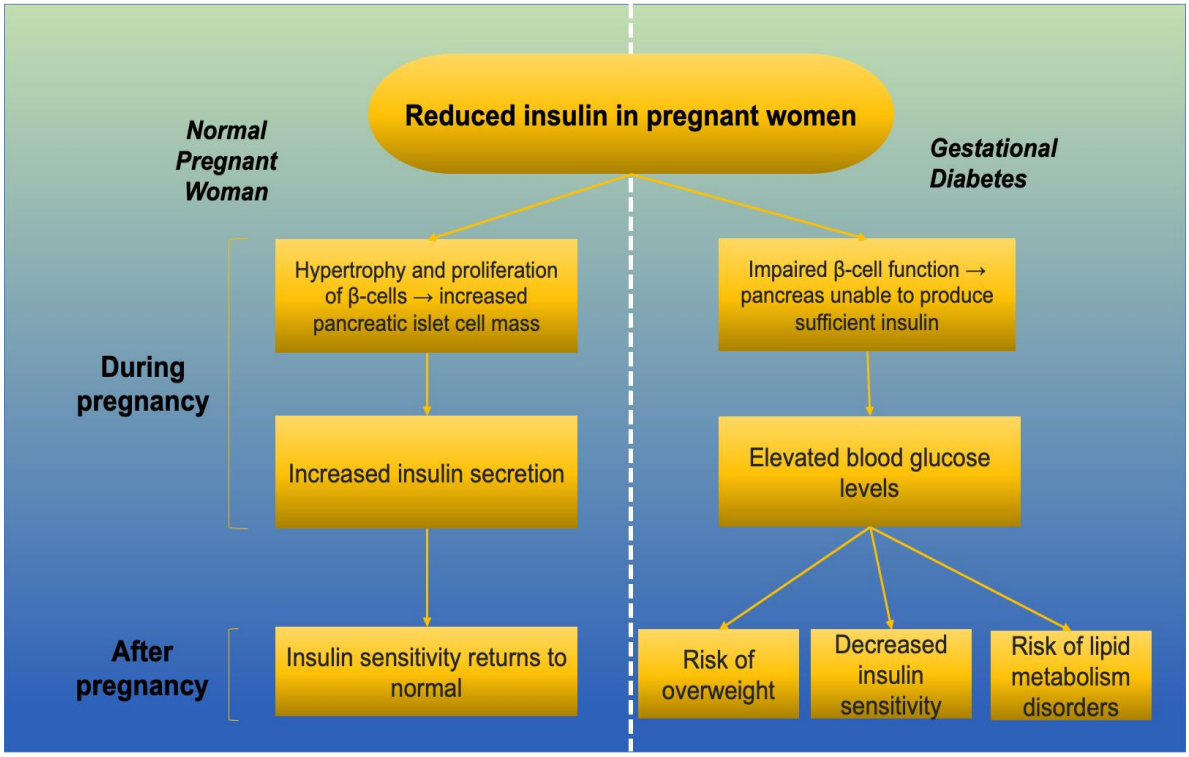


Figure 2.3. Metabolic changes in GDM [16, 18]

2.3. Diagnostic criteria

According to the U.S. Preventive Services Task Force (USPSTF) and several other reputable professional organizations, it is recommended that pregnant women who are between 24 and 28 weeks of gestation should undergo screening for GDM. This screening is considered crucial, as it helps identify women who may be at risk for developing complications related to GDM, both for themselves and for their developing babies. Currently, screening before 24 weeks of gestation remains controversial, with conflicting evidence regarding its effectiveness [19]. However, each organization recommends different screening approaches, among which the two most commonly used are the one-step and two-step methods.

2.3.1. One-step approach

This method is recommended in the 2021 guidelines of the Vietnamese Ministry of Health, the World Health Organization (WHO), and the International Association for the Study of Diabetes and Gestational Diabetes (IADPSG) for pregnant women between 24 and 28 weeks of gestation without high-risk factors. This method ensures regular screening for this group, ensures timely detection of glucose release within a defined timeframe, and maintains determinations and consistency in clinical practice across different healthcare settings [20, 21].

Glucose loading is typically performed in the morning after at least eight hours of

overnight excretion, during which time fluid intake is permitted. Plasma venous glucose is assessed at three time points: before glucose administration (fasting), and 1 hour and 2 hours after ingesting 75 grams of glucose solution. Gestational diabetes can be expected when one or more plasma values reach or exceed established limits [20].

The expected thresholds for diagnosing gestational diabetes mellitus (GDM) are as follows: 92 mg/dL (5.1 mmol/L) at fasting, 180 mg/dL (10.0 mmol/L) one hour after oral glucose administration, and 153 mg/dL (8.5 mmol/L) two hours after oral glucose administration. GDM can be predicted when one or more of these thresholds are met or exceeded during testing. For women identified with high risk factors for GDM, it is recommended to conduct a fasting venous glucose test at the first prenatal visit, provided that the woman has fasted for at least eight hours. This proactive approach enables early detection of any unexpected blood glucose spikes and allows for timely clinical intervention

2.3.2. Two-step approach

The ACOG recommends the two-step approach for screening gestational diabetes [8]. Initial venous plasma glucose levels are assessed by a 50-gram oral glucose tolerance test, performed without eating in the first step. A blood sample is taken shortly after glucose ingestion to assess postprandial plasma glucose levels, allowing for the identification of women at higher risk for GDM. Pregnant women with glucose values exceeding the screening threshold of 130–140 mg/dL are then referred to for confirmatory expectation testing.

The predictive assessment is performed by a 100-gram oral glucose tolerance test (OGTT) after overnight flushing. In this experiment, venous plasma glucose levels were measured at four time points: fasting and 1, 2, and 3 hours after glucose ingestion. Preeclampsia is expected when two or more plasma glucose values reach or exceed established thresholds according to the Carpenter and Coustan criteria or the National Diabetes Data Group (NDDG) criteria, ensuring a standardized and widely accepted expectation framework (shown in figure 2.4).

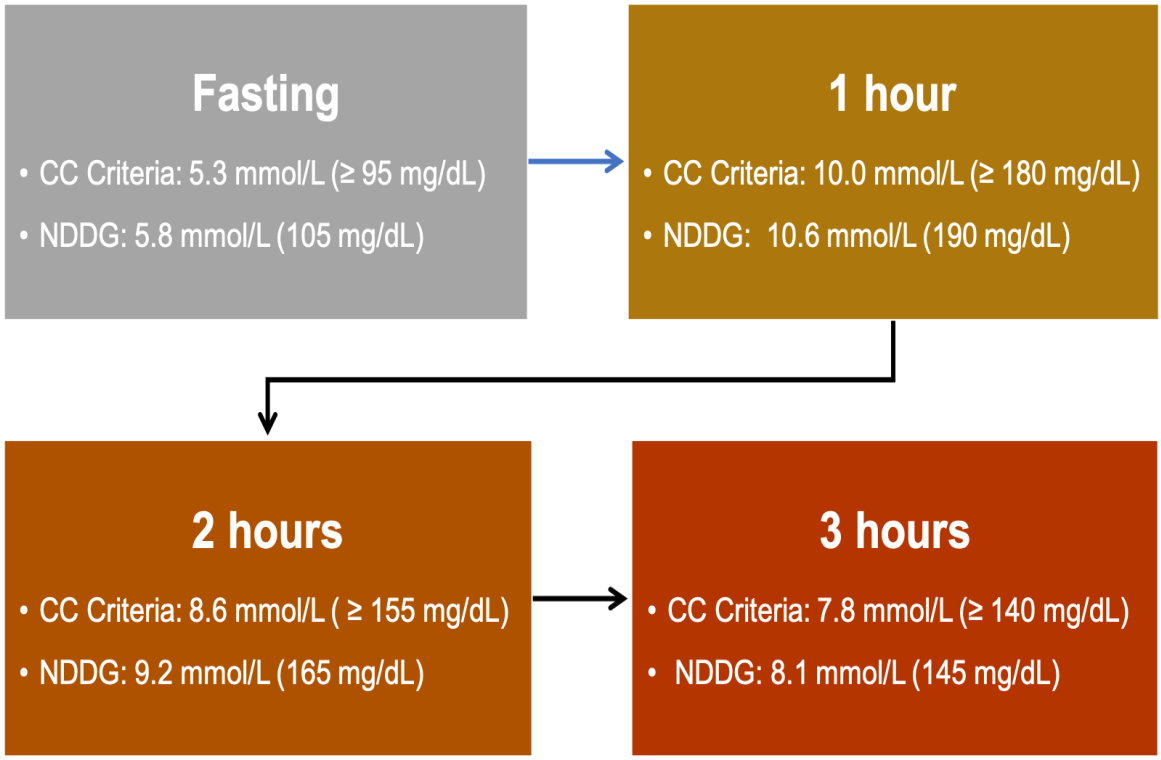


Figure 2.4. Two sets of diagnostic criteria for serum glucose concentrations in the 100-gram OGTT [8, 22]

This method does not require fasting and can be integrated into routine antenatal care. The majority of pregnant women undergoing this screening test have normal results and do not require further testing. Approximately 20% of women have glucose levels exceeding the threshold and are subsequently required to undergo a 3-hour OGTT with 100 grams of glucose after fasting, to confirm the diagnosis of gestational diabetes [13, 23].

There is still ongoing debate regarding the optimal method for screening and diagnosing gestational diabetes. The one-step approach generally yields a significantly higher rate of diagnosis compared with the two-step approach. Fuller KP et al. reported that the one-step procedure did not result in significant differences in maternal or neonatal outcomes compared with the two-step protocol [24]. Large-scale community-based trials conducted in China and Iran have also reached similar conclusions [25, 26]. However, since incomplete follow-up among patients in the two-step approach may lead to missed diagnostic testing, the one-step method is often considered more appropriate [27].

2.4. Risk factors

2.4.1. Major risk factors

One of the strongest risk factors for gestational diabetes is maternal age. The older

the mother, the higher the likelihood of developing the condition, with the incidence increasing by 7.90% per year among Asian women and 12.74% among European women [28]. In Asian and sub-Saharan African populations, women over 25 years old are at higher risk, while in Europe, the Middle East, and North Africa, the risk increases significantly after the age of 30 [29, 30]. A study conducted in China reported that women aged 36–45 years had a fourfold higher risk of developing the disease compared with those aged 18–25 years [31]. The underlying mechanism linking gestational diabetes and maternal age remains unclear but is thought to be associated with higher insulin resistance, inflammatory markers, and elevated circulating adipokine levels [32].

A high body mass index (BMI) is another independent risk factor associated with gestational diabetes. Shin Y. Kim et al. demonstrated that more than 70% of affected pregnant women had a pre-pregnancy BMI of at least 25 kg/m² [33]. Women who were obese (BMI ≥ 30 kg/m²) prior to pregnancy face a heightened risk of developing not only gestational diabetes but also gestational hypertension, regardless of their weight gain during pregnancy [32]. The prevalence of gestational diabetes is highest among women aged 30–34 years with a pre-pregnancy BMI of 30 kg/m² [3].

A family history of type 2 diabetes is critically important to consider. Numerous studies have demonstrated a significant link between gestational diabetes and a positive family history of the condition. Women with one or both parents diagnosed with type 2 diabetes face a fourfold increased risk of developing gestational diabetes compared to those without such a family history [34]. Moreover, even women whose grandmothers had type 2 diabetes were found to have a 2.34-fold higher risk compared with those with no family history of diabetes [35].

Previous studies have demonstrated that pregnant women with a history of polycystic ovary syndrome (PCOS) are at a higher risk of developing gestational diabetes. It has been reported in some previous studies that the prevalence of the condition in women with PCOS is from 4% to as much as 16% more than in women who do not have this syndrome [36].

In addition, ethnicity has been identified as a contributing factor. Women of Arab, South Asian, Southeast Asian, or Latin American origin have been identified as having a higher likelihood of developing not only gestational diabetes but also type 2 diabetes later in life , according to the Centers for Disease Control and Prevention (CDC).

Based on the 2021 guidelines issued by the Vietnamese Ministry of Health, pregnant women classified as high-risk (Table 2.1) require assessment from the first prenatal visit [37].

Table 2.1. High-risk group according to Vietnamese Ministry of Health (2021)

No.	Characteristics
1	Overweight BMI with at least one additional risk factor, including first-degree family history of diabetes, high-risk ethnicity, cardiovascular disease, hypertension, HDL < 0.9 mmol/L, triglycerides > 2.82 mmol/L, PCOS, physical inactivity, or acanthosis nigricans
2	HbA1c > 5.7% or prediabetes
3	History of GDM
4	Maternal age > 35
5	Immunodeficiency, including HIV infection

2.4.2. Other risk factors

Emerging studies have suggested that certain genetic factors may influence the development of gestational diabetes, although current data remain limited [10]. Exposure to specific environmental chemicals—such as perfluorooctanoic acid (PFOA), commonly found in cleaning agents and nonstick cookware—has also been associated with an increased risk of the disease [11].

In their study on the association between GDM and smoking during pregnancy, Zhang et al. identified maternal smoking and a history of parental smoking as potential risk factors for the condition. However, a subsequent meta-analysis found that smoking did not have a significant overall impact on the incidence of gestational diabetes [38, 39].

Furthermore, multiparous women have been observed to have a higher risk of developing gestational diabetes compared with primiparous women, suggesting a correlation between parity and disease risk [40]. Finally, although most studies have found no significant association between fetal sex and the incidence of gestational diabetes, a few statistical analyses have indicated that carrying a male fetus may be linked to an increased risk of the condition [41-44].

Figure 2.4 illustrates the major and other risk factors associated with GDM.

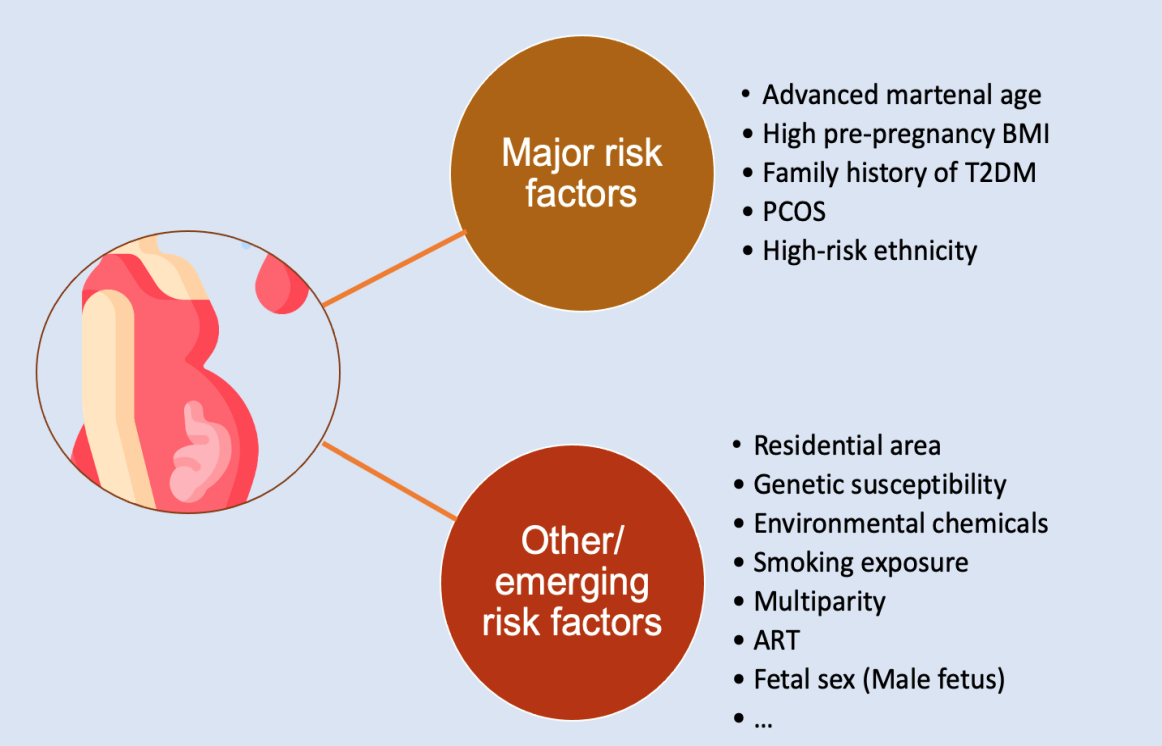
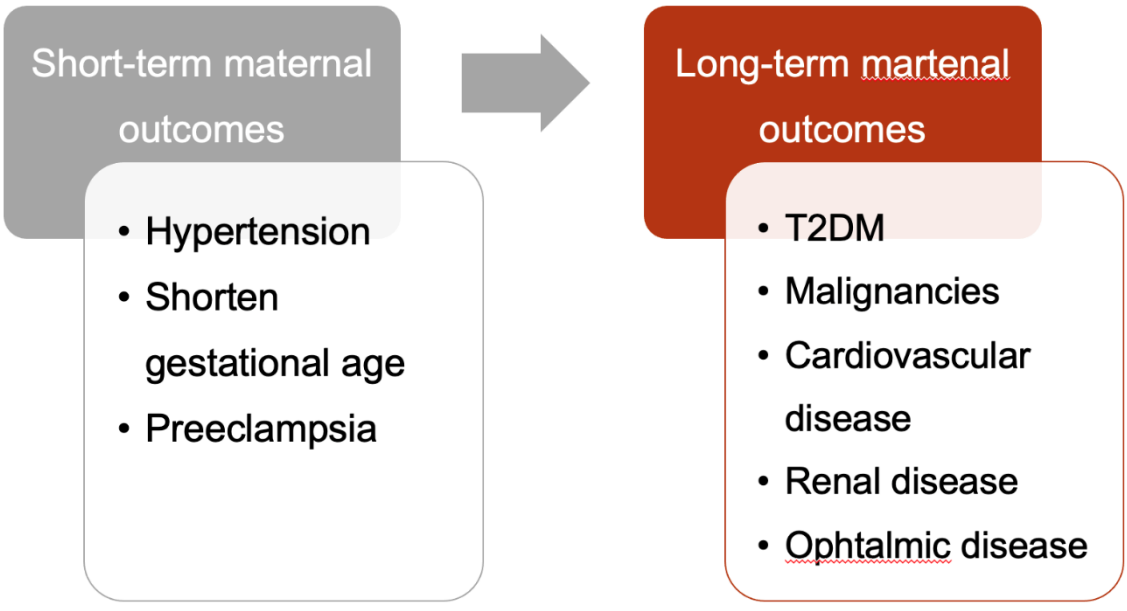


Figure 2.5. Major and other/emerging factors associated with GDM

2.5. Consequences and complications

2.5.1. Maternal consequences and complications



. **Figure 2.6. Adverse outcomes of maternal with GDM**

Figure 2.6 illustrates main consequences of pregnant women having GDM.

The complications caused by GDM may occur in both the mother and the fetus.

Women with the condition are more likely to develop hypertension, which is explained by prolonged hyperglycemia leading to endothelial cell damage and vascular dysfunction, thereby increasing blood pressure [3, 45]. Elevated blood glucose levels are associated with a two- to threefold higher risk of hypertensive disorders [46]. In addition to hypertension, women with GDM also have an increased risk of other cardiovascular diseases such as coronary artery disease, venous thromboembolism, angina pectoris, and heart failure, particularly within the first 10 years after pregnancy [4, 47].

Hypertension and proteinuria are the two main causes of preeclampsia—a serious pregnancy complication [48]. There is a positive association between the incidence of preeclampsia and GDM, with the prevalence reaching up to 20.8% [45, 49]. Moreover, women who develop GDM during their first pregnancy have a 48% risk of recurrence in subsequent pregnancies, accompanied by significantly higher rates of hypertensive disorders, preeclampsia, and cesarean delivery [50, 51]. Patients with GDM also have a higher incidence of preterm birth compared with non-diabetic pregnant women [52]. Simmons D. and colleagues conducted a comprehensive study and found a key finding related to the reduced use of ectopic pregnancy management GDM. They found that even when therapeutic GDM treatment was initiated between weeks 24 and 28 of gestation, women with GDM generally had shorter gestational ages compared to those without GDM. This is an important observation, as it highlights the potential implications of GDM not only for the immediate health of the mother but also for the outcome of the pregnancy itself [53].

Furthermore, the long-term consequences of suspected GDM are quite alarming. Women predicted to have GDM are ten times more likely to develop prediabetes or progress to type 2 diabetes compared to women without the condition. This increased risk is particularly pronounced in the years following childbirth, especially in the first five years after delivery [54-56]. This complication is more common among women with a family history of diabetes and those living in Europe or Southeast Asia [57]. Diabetes is often accompanied by cardiovascular and metabolic complications, and this risk is twice as high among women with a history of GDM [58]. GDM can be considered the strongest predictive factor for the development of type 2 diabetes mellitus (T2DM) in women [59].

Moreover, the long-term consequences of GDM also include an increased risk of cancer, most commonly ovarian cancer, breast cancer, and pancreatic cancer. In

addition, the incidence of eye-related diseases is increased by approximately 20%. One of the most common conditions with the highest risk is renal failure, including hypertension-related kidney disease and end-stage renal disease [60].

Adverse outcomes in women with GDM are three times higher when comparing treated and untreated groups, and six times higher when comparing untreated women with GDM to women without the condition [61].

2.5.2. Fetal/Neonatal consequences and complications

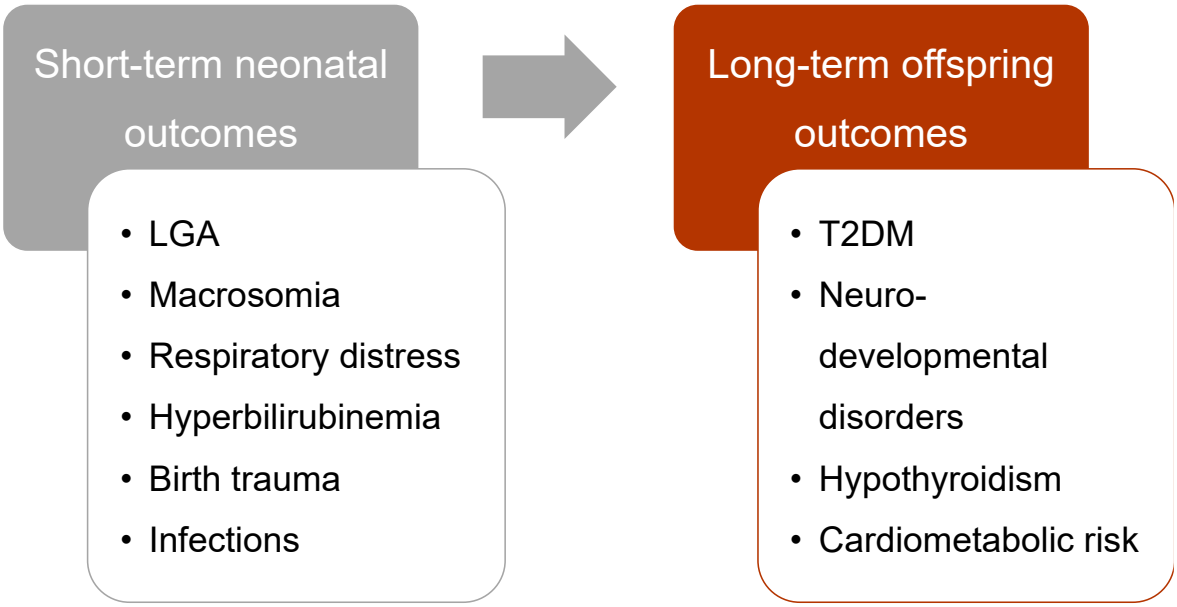


Figure 2.7. Adverse outcomes in offspring of mother having GDM

Similar to mothers with GDM, their offspring may experience both short-term and long-term outcomes, as summarized in Figure 2.7.

In the context of infant development, research has shown that babies born to mothers diagnosed with GDM tend to be larger than what is typically expected for their gestational age [62, 63]. This phenomenon has been documented in numerous studies, with findings indicating that the incidence of larger-than-average infants—often referred to as being 'large for gestational age' (LGA)—is approximately 1.42 times higher when compared to infants born to mothers who do not have diabetes [64]. The underlying mechanisms contributing to this increased size are primarily related to the high concentrations of certain substances in the blood of mothers with gestational diabetes. Specifically, there are high concentrations of circulating amino acids and free fatty acids in the blood of these mothers. These high concentrations facilitate the excessive transfer of nutrients across the placenta to the developing fetus. This excess of nutrients can stimulate rapid fetal growth, ultimately leading to a larger birth size.

Furthermore, this situation is exacerbated in obese women, as they face an even higher risk. Studies show that these women are three to four times more likely to give birth to babies with higher than normal birth weight (macrosomia) [65, 66].

The prevalence of respiratory distress, jaundice, and the necessity for admission to the neonatal intensive care unit is significantly higher among newborns who are born to mothers diagnosed with GDM when compared to those infants born to mothers who are considered healthy and free from any metabolic disorders [62]. This alarming trend highlights the potential risks and complications that can arise during the perinatal period for infants whose mothers experience GDM. In addition to the aforementioned conditions, a range of other neonatal complications has been identified, including hypoglycemia, hyperbilirubinemia, birth trauma, and various neonatal infections, which can all contribute to increased morbidity in this vulnerable population [63, 67]. Notably, certain risks for neonatal complications persist even when maternal GDM is adequately treated. Recent evidence also indicates that male infants have a higher rate of adverse outcomes compared with female infants [68, 69].

In addition, children born to mothers with GDM are also at risk of experiencing adverse long-term outcomes. The incidence of impaired glucose tolerance in offspring is five times higher compared with children born to mothers without GDM [60]. A large cohort study involving 200,000 births identified increased risks of neurological disorders, including autism spectrum disorder, cerebral palsy, and eating disorders [70]. Among mothers with GDM who do not adequately control their diet, the risk of hypothyroidism in their children is increased by 2.1 times [71].

2.6. Therapeutic goals and management strategies

As soon as a pregnant woman is diagnosed with GDM, treatment should be initiated and adjusted flexibly throughout pregnancy. Early intervention from the time of diagnosis is important to limit the progression of glucose intolerance and to reduce the need for more intensive treatment in later stages of pregnancy [72]. With the aim of preventing potential perinatal and long-term complications, the main therapeutic goal of GDM is to maintain blood glucose levels comparable to those of pregnant women without the disease, while ensuring normal fetal growth and development [72].

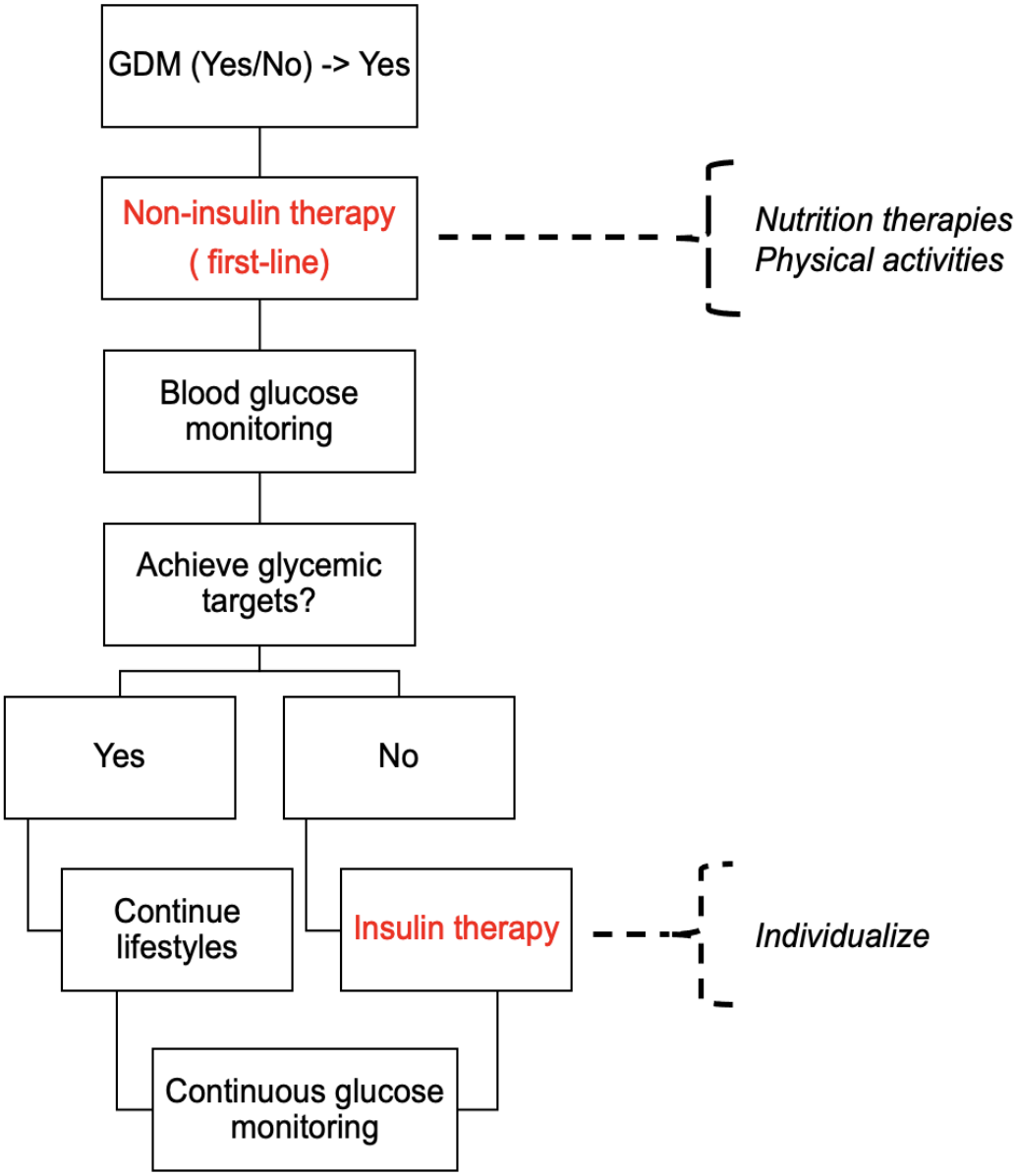


Figure 2.8. Management strategy for GDM

Figure 2.8 illustrates the management strategy for GDM based on international recommendations and national guidelines [37, 72, 73].

The treatment of GDM includes non-insulin therapies and insulin therapy. Non-insulin therapy is the key first-line treatment in most GDM and is the cornerstone of management. This approach includes appropriate nutritional therapy, with balanced energy intake according to metabolic demands during pregnancy, as well as suitable and safe physical activities for pregnant women. When lifestyle modification fails to achieve target blood glucose levels, insulin therapy will be indicated to obtain better

glycemic control [72]. The choice of insulin regimen should be individualized based on blood glucose levels, gestational age, and patient compliance. Therefore, each patient may have a different treatment plan depending on individual glycemic response. Continuous monitoring of blood glucose is mandatory to evaluate treatment effectiveness and to allow timely adjustment of therapy.

Most international guidelines recommend that pregnant women with GDM monitor blood glucose levels at fasting and postprandial time points. This approach helps ensure effective disease management. Blood glucose monitoring is necessary to evaluate the effectiveness of nutritional therapy. It also supports decisions on initiating or adjusting insulin therapy. In addition, it is used to monitor glycemic control throughout pregnancy [72, 73].

Studies have shown that fasting blood glucose is useful in predicting increased neonatal fat mass. It is also associated with a higher long-term risk of obesity and type 2 diabetes in offspring.

Postprandial glucose is commonly measured at two time points. These include one hour and two hours after meals. However, current evidence does not indicate that either time point is superior in terms of clinical benefit [72, 73]. From a physiological perspective, peak blood glucose typically occurs at approximately 90 minutes after meals. This peak lies between the two measurement time points.

At present, there is no evidence defining the optimal frequency of blood glucose monitoring in women with GDM. In clinical practice, the general recommendation is to monitor blood glucose approximately four times per day. This usually includes one fasting measurement and postprandial measurements taken one hour or two hours after meals [72].

When blood glucose levels are stably controlled with dietary management, the monitoring frequency may be reduced. This adjustment depends on gestational age, treatment adherence, and the risk of requiring changes in therapy. However, in clinical practice, monitoring blood glucose fewer than two times per day is rarely recommended [72].

Based on available evidence, the IDF, ACOG, and the Vietnamese Ministry of Health provide consistent recommendations for glycemic targets. Blood glucose levels should be <95 mg/dL at fasting. The target is <140 mg/dL at one hour after meals. At two hours after meals, the recommended level is <120 mg/dL [72, 73].

A comprehensive blood glucose diary is advisable for pregnant women to check and follow up the efficacy of the treatment. This diary is usually reviewed regularly during antenatal visits, commonly on a weekly basis, depending on the severity of GDM. Reviewing the glucose diary helps healthcare providers identify early trends of hyperglycemia as well as factors related to diet and daily activities. For pregnant women with stable blood glucose levels within target ranges, the frequency of diary review may be reduced; however, it should not be discontinued completely. In contrast, women whose blood glucose levels do not meet treatment targets will require more frequent assessment and timely adjustment of therapeutic strategies.In general, maintaining blood glucose levels within recommended targets is the goal of all treatment strategies for GDM [8, 72, 73].

Effective glycemic control helps reduce short-term and long-term risks for both the mother and the fetus. These risks include macrosomia, increased rates of cesarean delivery, adverse perinatal outcomes, as well as long-term metabolic disorders in both the mother and the child [8, 72, 73].

2.7. Current status and research on gestational diabetes mellitus worldwide and in Vietnam

2.7.1. Worldwide

GDM represents a common medical complication occurring during pregnancy. Although the prevalence of the disease varies significantly across regions due to differences in ethnicity, lifestyle, and healthcare systems, the overall trend shows a continuous increase worldwide. This rising prevalence poses not only a challenge for healthcare systems but also a substantial burden on society and individual families, given its long-term affects the health of both mothers and their infants. The prevalence in Asian countries, including Vietnam, is relatively higher compared with other regions [74]. In addition to regional variations, when classified by national income levels (high, middle, and low), the average prevalence of GDM is higher in high-income countries than in those with middle or low income [5].

To date, numerous studies have been carried out worldwide GDM. These studies have primarily focused on several important aspects, including the prevalence, its associated risk factors, potential complications for both mothers and infants, and the outcomes of various treatment approaches. Understanding these dimensions is crucial for healthcare providers and policymakers aiming to mitigate the impact of this condition. In particular, Table 2.2 provides a comprehensive summary of the reported incidence of GDM across selected regions worldwide. This table not only highlights

the variations in prevalence between different countries but also emphasizes the differences in diagnostic criteria employed in various healthcare systems. Additionally, it includes a detailed overview of the commonly reported risk factors associated with GDM.

Table 2.1. Prevalence of GDM in selected regions worldwide

Author	Region	Year	Diagnostic Criteria	Ratio (%)	Risk Factors
Veronika Lappe (2023) [75]	Germany	2010	Two-step Approach	9.4	Not mentioned
		2020		15.1	Not mentioned
Teresa A Hillier (2021) [23]	The USA		One-step Approach	16.5	Not mentioned
			Two-step Approach	8.5	Not mentioned
M Orós [76]	Spain	2012 – 2018	Two-step Approach	6.5	Maternal age Overweight Ethnicity
Bruono Basil (2023)	North – Mid Nigieria	2018 – 2019	One-step Approach	16.7	Maternal age Overweigh

Yashdeep Gupta (2023) [77]	South Asia		One-step Approach	17.1	Maternal age Number of pregnancies (gravidity/parity) History of GDM Family history of diabetes
Fang Li [78]	China	2018	One-step Approach	19.2	Maternal age Pre-pregnancy BMI First-degree family history of diabetes

2.7.2. In Vietnam

According to IDF, the prevalence of GDM in Vietnam has seen a dramatic increase, rising fivefold in 2023 when compared to the rates observed between 2001 and 2004. This significant rise raises important public health concerns and underscores the need for targeted interventions.

Available data, as presented in Table 2.3, compiles findings from various studies conducted across different localities and hospitals throughout Vietnam. These studies contribute to a growing body of evidence regarding the current state of GDM in the country, reflecting not only the alarming trends but also the diverse landscape of healthcare experiences that women face in different regions.

Moreover, these results are noteworthy as they highlight existing regional disparities in GDM prevalence, showing that socioeconomic conditions, access to healthcare, and levels of public awareness can differ considerably between localities. This variability underscores the importance of tailoring healthcare protocols and interventions to address the specific needs of different populations.

The study by Hua Thanh Nhan et al. at Phuong Chau International Hospital in Can Tho, conducted on 271 pregnant women aged over 25 years, reported a GDM prevalence of 25.8%. Significant related factors included maternal age, pre-pregnancy BMI ≥ 23, and living in urban areas, which was associated with a higher risk than living in rural areas [79].

The prevalence of GDM was found to be notably high at 26.9% in a comprehensive study conducted by Bui Thi Kieu Diem at the Kien Giang Obstetrics and Pediatrics Hospital. This research involved a diverse group of 275 participants, providing a solid foundation for the findings. Specifically, women in the age group of 25 to 34 years exhibited a striking 3.5 times greater likelihood of being diagnosed with GDM compared to their younger counterparts who were under the age of 25. In addition to maternal age, the study also identified a first-degree family history of type 2 diabetes as a critical and prominent associated factor influencing the likelihood of developing GDM [80].

Another study by Hoang Thi Lan Huong at Hue Central Hospital in 2022 identified several factors related with GDM, including maternal age over 35, history of delivering a baby weighing more than 3,500 grams, BMI, and a family history of diabetes. The prevalence based on the ADA 2015 diagnostic criteria was 20.9% [81].

The study by Bui Chung Thuy et al. at Da Nang Obstetrics and Pediatrics Hospital reported similar risk factors to those found in the Hue Central Hospital study, with additional factors including a history of miscarriage and stillbirth [82].

A prospective study by Bui Van Huy et al. at the Department of Obstetrics, University of Medicine and Pharmacy Hospital, Hue, conducted in 2017, found a GDM prevalence of 8.9%. Identified risk factors included maternal age, pre-pregnancy overweight or obesity, family history of diabetes, and a history of delivering a macrosomic infant (≥ 3,500 grams) [83].

In a comprehensive cross-sectional analysis conducted by Le Minh Hieu in the region of Thai Binh, a significant study involving 1,106 pregnant women was undertaken to explore the prevalence of GDM. The findings revealed a concerning prevalence rate of 27.1% among the participants, indicating that over a quarter of the women in this study were affected by this condition. The researchers identified several key risk factors associated with the development of GDM, which included maternal age being equal to or greater than 35 years, a BMI of 23 or higher, a family history of diabetes, a previous diagnosis of GDM in earlier pregnancies, and a history of infertility treatment [84].

In a related study conducted at An Binh Hospital, located in the bustling city of Ho Chi Minh City, researchers examined a different cohort of 465 pregnant women to assess the prevalence of GDM. The results revealed a lower prevalence of 13.5% in this population, suggesting variations in GDM rates that may be influenced by

geographical, socioeconomic, or healthcare access factors. The independent risk factors identified in this particular study included a history of unexplained late stillbirth, a family history of diabetes, and a previous diagnosis of impaired glucose tolerance [85].

A study by Nguyen Thuy Trang et al. conducted at the National Hospital of Obstetrics and Gynecology in 2012 included 210 pregnant women and reported a GDM prevalence of 18.6%. The analysis identified several key risk factors for GDM, including maternal age, a pre-pregnancy body mass index (BMI) of 23 or higher, and parity . The study also showed that the risk of GDM increased with advancing maternal age [86].

Table 2.3. Prevalence of GDM in selected provinces and cities of Vietnam

Author	Location	Year	Diagnostic Criteria	Ratio (%)
Hua Thanh Nhan [79]	Phuong Chau International Hospital, Can Tho	2022- 2023	One-step Approach	25.9
Bui Thi Kieu Diem [80]	Kien Giang Obstetrics and Pediatrics Hospital	2022	One-step Approach	26,9
Hoang Thi Lan Huong [81]	Hue Central Hospital	2022	One-step Approach	20,9
Bui Chung Thuy [82]	Da Nang Obstetrics and Pediatrics Hospital	2023	One-step Approach	15,8
Le Minh Hieu [84]	Thai Binh – Vietnam	2023 – 2024	One-step Approach	27.1

Nguyen Thi Le Hang [85]	An Bình Hospital – Ho Chi Minh City	2015 -2016	One-step Approach	13.5
Nguyen Thuy Trang [86]	National Hospital of Obstetrics and Gynecology	2012	One-step Approach	18.6

CHAPTER 3. METHODOLOGY

3.1. Study subjects

Inclusion criteria

Medical records of pregnant women who:

- Received antenatal care and delivered at the National Hospital of Obstetrics and Gynecology in March 2025
- Complete data on maternal demographic characteristics, obstetric history and and relevant clinical variables and outcome related to GDM.
- GDM status determined according to current diagnostic guidelines, based on glucose testing performed from the 24th week of gestation onward, and documented in the medical records.

Based on the diagnostic of GDM, the study population was divided into two groups: "With GDM" and "Without GDM".

Exclusion criteria

Medical records of pregnant women who:

- Currently using medications that affect glucose metabolism, including beta-blockers, thiazide diuretics, corticosteriods, and salbutamol.
- Currently having medical conditions that may effect glucose metabolism, including hypothyroidism, hyperthyroidism, or renal impairment.
- Having malignant diseases, psychiatric disorders.
- Delivered before 24 weeks of gestation.

3.2. Study design

Study design: Cross-sectional descriptive study

3.3. Study setting and duration

Study setting: National Hospital of Obstetrics and Gynecology

Study duration: March 1, 2025 to March 31, 2025

3.4. Study sample

3.4.1. Sampling method

Convenient sampling. All medical records of pregnant women who delivered at the National Hospital of Obstetrics and Gynecology in March 2025 and met the inclusion criteria were selected.

3.4.2. Sample size calculation for Objective 1

Based on the prevalence of GDM among pregnant women reported in a prior study by Nguyen Thuy Trang et al. (2013) at the National Hospital of Obstetrics and Gynecology, the sample size for Objective 1—determining the prevalence of GDM—was calculated using a single-proportion sample size formula [86]:

$$n = Z^2_{1-\alpha/2} \frac{p \times (1-p)}{d^2}$$

Where:

- Z represents the standard normal deviate associated with the desired confidence level, with a value of $Z = 1.96$;
- d is the margin of error, $d = 0.05$;
- p indicates the prevalence of gestational diabetes mellitus among pregnant women at the National Hospital of Obstetrics and Gynecology, based on previous studies, with a value of $p = 0.186$.

The minimum required sample size for Objective 1 was calculated to be 233 medical records of pregnant women (include " With GDM" group and "Without GDM" group)

3.4.3. Sample size calculation for Objective 2

With Objective 2, when performing multivariable logistic regression analysis with 12 independent variables (as detailed below), the minimum required sample size was calculated using the following formula:

$$N = \frac{10 \times k}{p}$$

Where:

- N is the minimum sample size
- k is the number of independent variables, $k = 12$
- p indicates the prevalence of gestational diabetes mellitus among pregnant women at the National Hospital of Obstetrics and Gynecology, based on previous studies, with a value of $p = 0.186$

The minimum sample size required for Objective 2 was calculated to be 646. When comparing the sample size requirements for the two research objectives, the

calculated minimum sample size for Objective 2 is larger than for Objective 1. Therefore, the minimum sample size required for the entire study is determined based on Objective 2, resulting in a final minimum sample size of 646.

In practice, the actual sample size included in the study may be larger than the minimum required, depending on the available data. Including a larger sample size can help improve the reliability and stability of the statistical analysis.

3.5. Research variables

Dependent variable: Gestational diabetes mellitus status of the pregnant women (yes/no).

The independent variables were selected based on established clinical guidelines, international studies, and data availability, including demographic characteristics, personal and family medical history, and clinical features (Table 3.1).

Table 3.1. Selected independent variables

Variable group	Variable definition
Demographic characteristics	Place of residence (urban/rural residence)
	Martenal age: calculated in calendar years
Personal and family medical history	History of type 2 diabetes mellitus in first-degree relatives, including the parents, brothers, and sisters.
	History of stillbirth
	History of macrosomia (birth weight ≥4,000 g)
Obstetric characteristics	Gravidity (number of pregnancies)
	Singleton or multiple pregnancy
	Assisted reproductive technology (ART) intervention (yes/no)

	Sex of the newborn
Clinical features	Pre-pregnancy Body Mass Index (BMI)
	Hypertension
Paraclinical features	Urinary glucose

3.6. Some criteria used in the study

3.6.1. Gestational diabetes mellitus diagnostic criteria

Blood glucose levels measured at any of the three time points equal to or exceeding following thresholds were diagnosed as GDM.

Table 3.2. Blood glucose thresholds of GDM

Fasting	After 1 hour	After 2 hours
92 mg/dL (5.1 mmol/L)	180 mg/dL (10 mmol/L)	153 mg/dL (8,5 mmol/L)

3.6.2. BMI and classification

Body Mass Index (BMI) was determind using the formula presented below:

$$\text{BMI} = \frac{\text{Weight (kg)}}{[\text{Height(m)}]^2}$$

BMI classification was based on the criteria of the International Diabetes Institute and the World Health Organization Regional Office for the Western Pacific (IDI & WPRO) (Figure 3.1).

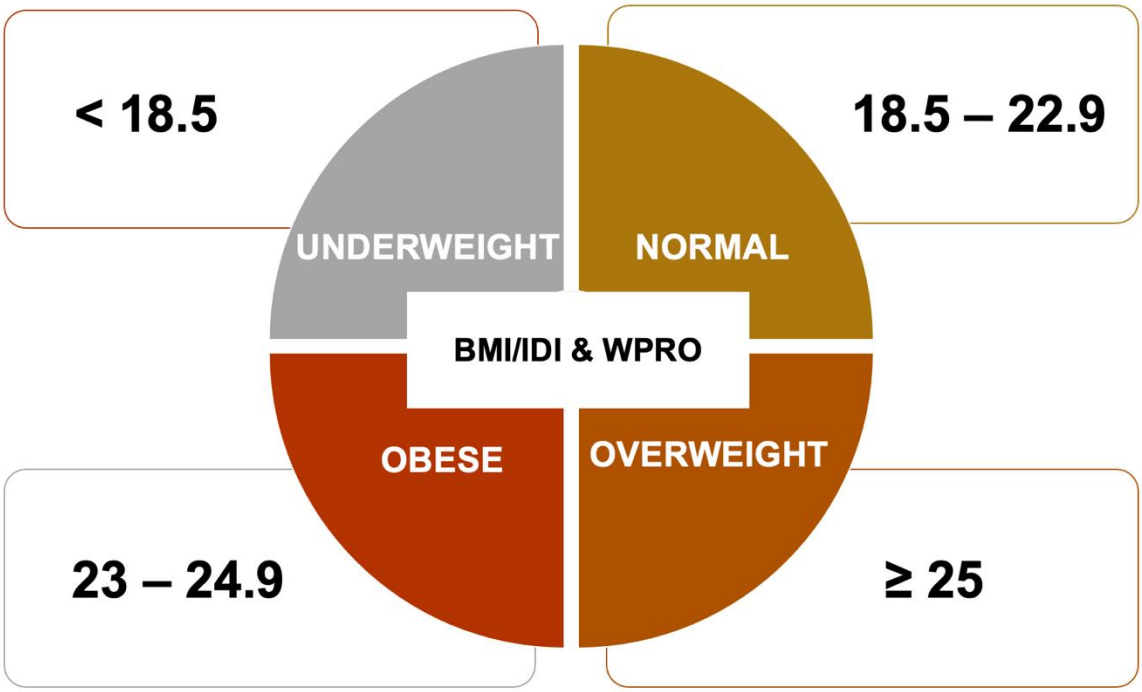


Figure 3.1. BMI Classification

3.6.3. Fetal macrosomia

Newborns with a birth weight of ≥ 4000 grams were classified as macrosomic according to the WHO criteria.

3.6.4. Hypertension

Hypertension criteria:

- Systolic blood pressure ≥ 140 mmHg; or
- Diastolic blood pressure ≥ 90 mmHg.

3.6.5. Urinary glucose:

The presence of glucose in urine is determined based on the results of a urine test. A result is considered positive when glucose is detected in the urine at a level greater than 0 mg/dL. Conversely, a result is considered negative when no glucose is detected in the urine.

3.7. Research instruments and data analysis methods

3.7.1. Data collection methods

Data were directly collected from paper-based medical records at the hospital. All the required information was recorded in the "Data collection form", which included all study variables corresponding to the stated objective. The forms were subsequently reviewed to verify completeness and accuracy before data entry.

3.7.2. Data Analysis Methods

Figure 3.2 illustrates the data analysis process for each statistical objective of the study, including descriptive statistics, univariate logistic regression analysis, and multivariable logistic regression analysis.

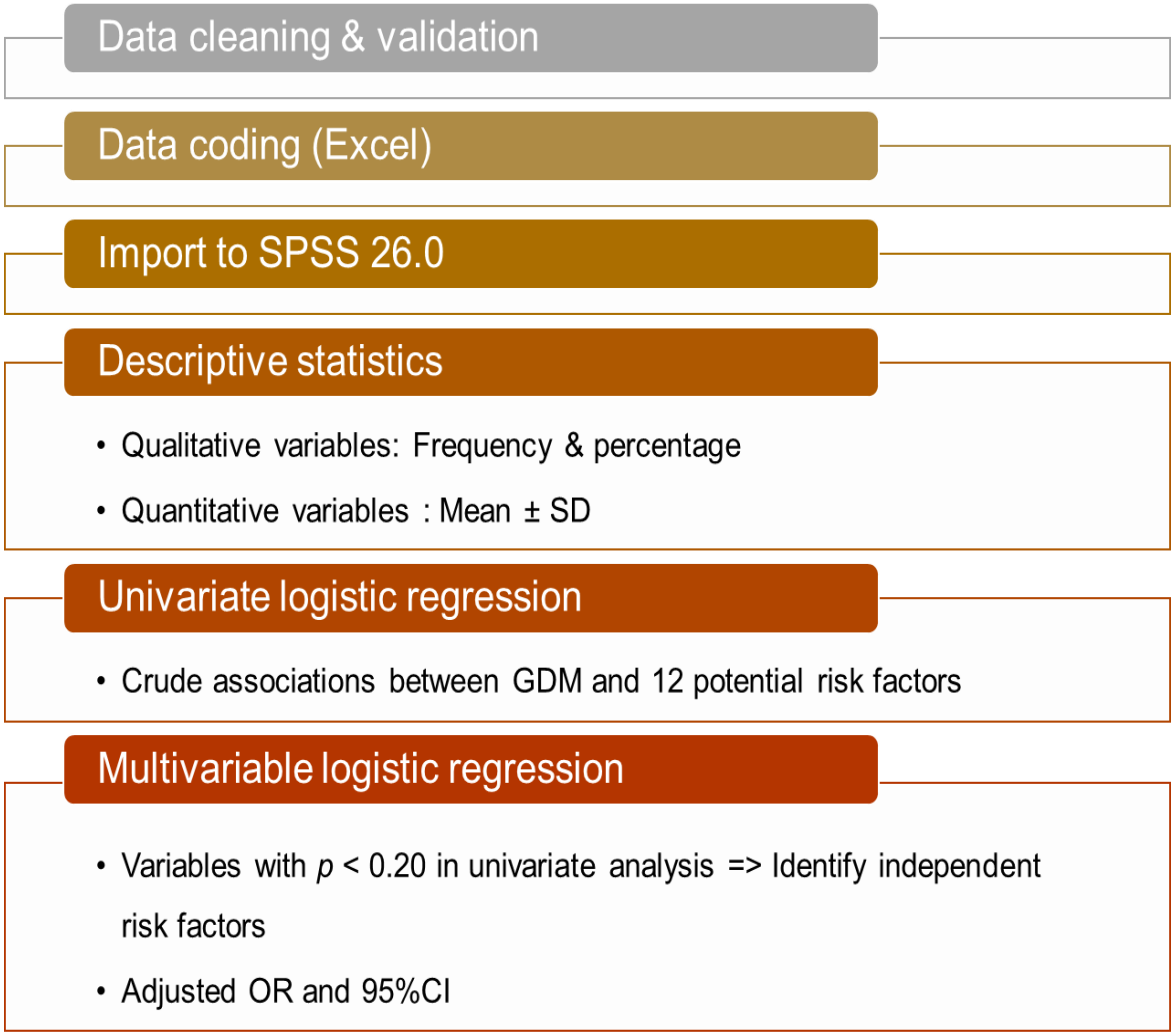


Figure 3.2. Data analysis workflow and statistical methods

After being cleaned and checked for validity, the data were coded and managed using Microsoft Excel software, then transferred to SPSS software version 26.0 for statistical analysis.

Descriptive statistics

- For qualitative variables, frequencies and percentages were calculated;
- For quantitative variables, the mean ± standard deviation was calculated for normally distributed quantitative variables.

Analysis of related factors of GDM

- Univariate logistic regression was used to identify crude odds ratios (cORs).

- Variables with a p-value < 0.20 were subsequently entered into the multivariable model.

Analysis of independent risk factors

- Multivariable logistic regression was used to identify adjusted odds ratios (adjusted ORs).
- Odds ratios (ORs) and confidence intervals were calculated.
- A p-value < 0.05 was considered statistically significant.

3.8. Ethical consideration

The study employed a robust methodology by utilizing secondary data that was meticulously extracted from existing medical records. This approach ensured that there was no direct intervention in the care or treatment of pregnant women participating in the research, thereby maintaining the integrity of their medical care. The research team focused exclusively on collecting variables that were directly relevant to the objectives of the study, ensuring that the data gathered was pertinent and useful for the analysis. Importantly, no personally identifiable information was obtained during this process, which underscores the commitment to protecting the privacy of the individuals whose records were reviewed.

At the time of data entry, a comprehensive coding and anonymization process was implemented to further safeguard the identities of the participants. The data was securely stored in a manner that restricted access solely to the members of the research team, thereby enhancing confidentiality and minimizing the risk of unauthorized access. The ethical considerations of this study were paramount, and as such, the hospital ethics committee conducted a thorough review and subsequently approved both the use of medical records and the overall implementation of the study. This approval was granted in accordance with the institutional regulations that govern research practices, emphasizing the commitment to ethical standards.

Throughout the research process, privacy and confidentiality were meticulously maintained, adhering strictly to the regulatory guidelines established by the Ministry of Health of Vietnam. This adherence ensured that all aspects of the study were compliant with national health regulations designed to protect individuals' rights. Furthermore, it is crucial to highlight that all data collected during this research was utilized exclusively for research purposes. The study's design and execution were carefully crafted to ensure that they did not adversely affect the rights, care, or interests of any individual involved, thus reinforcing the ethical foundation on which

the research was built. Overall, the study exemplified a conscientious approach to research that prioritized the welfare of participants while contributing valuable insights to the field.

CHAPTER 4. RESULTS AND DISCUSSION

4.1. Prevalence of gestational diabetes mellitus

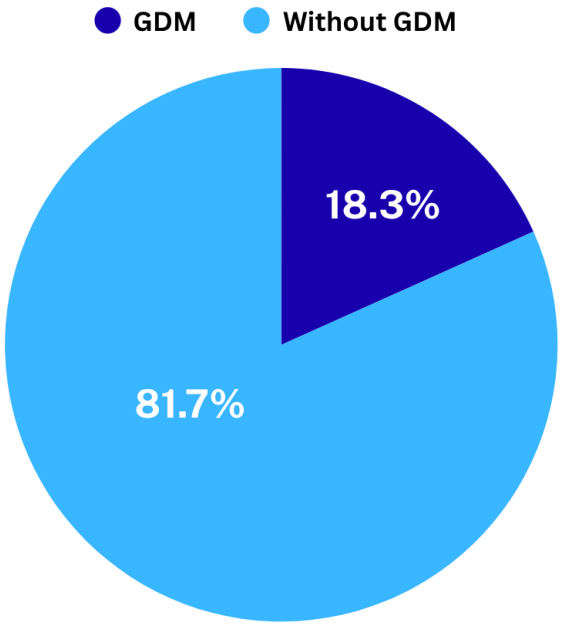


Figure 4.1. Prevalence of GDM

Among a total of 1033 pregnant women surveyed and diagnosed GDM using the one-step screening method), the prevalence was 18.3% (Figure 4.1).

This rate is consistent with the previous study conducted at the same hospital in 2013 by Nguyen Thuy Trang and Do Quan Ha (18.6%) and higher than that reported in 2012 at the same site (11.4%) [86, 87]. The similarity to the 2013 study indicates stable results over time, which may be explained by the same research location, the use of a single-step screening method during 24–28 weeks of gestation, and similar population characteristics (women giving birth at a central-level hospital).

The difference compared with the 2012 study may be because that research was conducted only in the Service Department, and more than 60% of participants were tested after 28 weeks of gestation, when the peak of insulin resistance had passed.

Compared with recent studies, our findings are consistent with those conducted in Ca Mau Province (18%) during 2023–2024 and in several provinces of the Mekong Delta region (2024) [88, 89]. However, the prevalence of GDM in the present study was considerably lower than that reported in Ho Chi Minh City (27.7%) and Thai Binh (27.1%) in 2024 and 2025, respectively [84, 90]. This discrepancy may be attributed to regional population characteristics and differences in screening or diagnostic procedures.

This finding also aligns with a systematic review reporting an average GDM prevalence of approximately 17% in Vietnam [91], demonstrating good representativeness of the study sample and reflecting the current national trend. The slight difference may be explained by variations in data collection periods (2025 in the present study versus 2010–2022 in previous studies), in the context of an increasing prevalence of risk factors for the disease.

4.2. Description of some characteristics of the pregnant women

Maternal age and pre-pregnancy BMI were calculated and presented as the mean ± standard deviation (Mean ± SD), together with the minimum and maximum values. Percentages were calculated for occupation and number of births.

4.2.1. Age characteristics

Table 4.1. Maternal age characteristics between " With GDM" and "Without GDM" groups

Group	n	Min	Max	Mean ± SD	p-value
Total	1033	18	47	31.0 ± 5.7	<0.001
GDM	189	20	47	33.6 ± 5.5	
Without GDM	844	18	45	30.5 ± 5.6	

Table 4.1 showed that the mean age of women with GDM (33.6 ± 5.5 years) was significantly higher than that of those without the disease (30.5 ± 5.6 years; $p < 0.001$). The overall mean age of pregnant women attending and delivering at the National Hospital of Obstetrics and Gynecology was 31.0 ± 5.7 years.

The mean age of pregnant women in the present study was higher than that reported in a previous study conducted at the same hospital — the National Hospital of Obstetrics and Gynecology — in 2012 (29.7 ± 4.8 years) [87]. This result was also higher compared to the study by Le Minh Hieu in Thai Binh Province in 2024 (27 years), reflecting demographic differences between regions [84]. In large urban cities such as Hanoi, higher socio-economic development levels, together with changing perspectives on marriage and career, have led women to marry and give birth at a

later age. When compared with a study conducted in Ho Chi Minh City — another major urban center in the same period — the mean maternal age was similar (30.8 ± 5.7 years) [90].

4.2.2. Pre-pregnancy BMI characteristics

Table 4.2. Pre-pregnancy BMI characteristics between " With GDM" and "Without GDM" groups

Group	n	Min	Max	Mean ± SD	p-value
Total	1033	16.0	33.3	21.4 ± 4.3	
GDM	189	17.0	30.0	22.35 ± 2.91	<0.001
Without GDM	844	16.0	33.0	21.25 ± 4.46	

The mean BMI of women with GDM (22.35 ± 2.91) was significantly higher than that of those without the disease (21.25 ± 4.46; $p < 0.001$). The overall mean BMI of all participants was 21.4 ± 4.3, which falls within the normal weight range according to the WHO classification for Asian populations (Table 4.2).

Although the difference in BMI between the two groups was relatively small, it was still significantly associated with the risk of GDM. This may be explained by metabolic characteristics typical of Asian women, who tend to be more susceptible to insulin resistance even with minor increases in visceral fat accumulation.

The mean BMI observed in our study was higher than that reported in a study conducted in Thai Binh Province (20.4; range 18.9–22.1), possibly reflecting lifestyle differences between urban and rural areas [84]. Women living in urban environments such as Hanoi often have more energy-dense diets, lower physical activity levels, and tend to conceive at older ages. Our findings are also comparable to the mean BMI of pregnant women in China (2016), indicating similar body composition and lifestyle patterns among East Asian populations [92].

4.2.3. Occupation characteristics

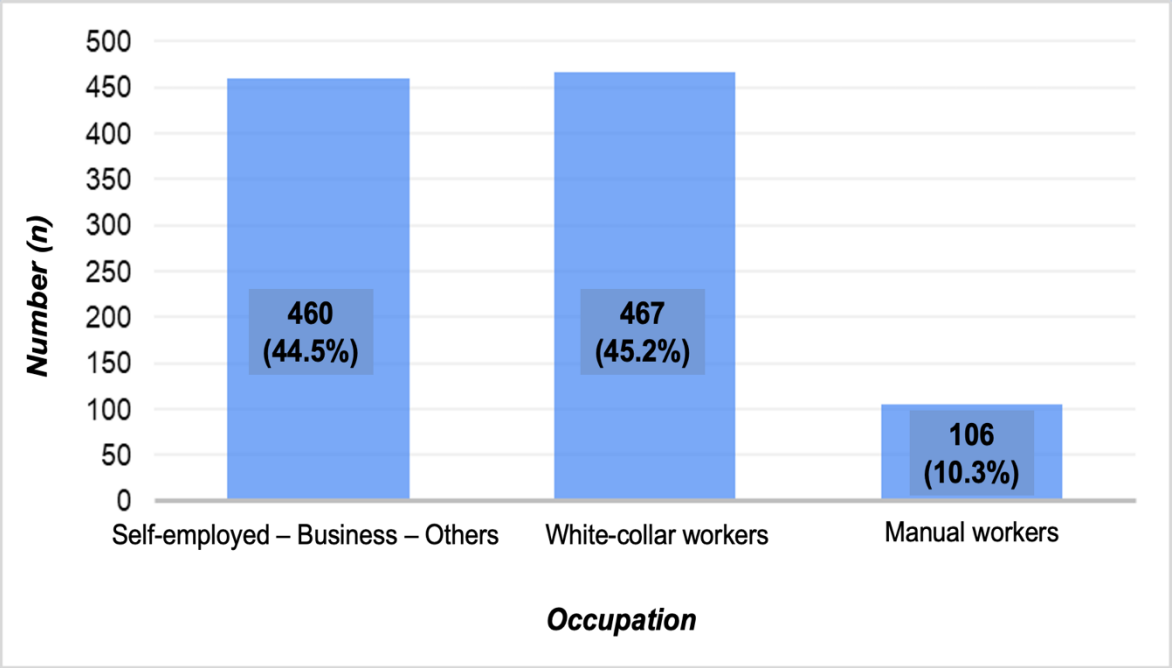


Figure 4.2. Distribution of occupation in the study population

Figure 4.2 shows that the white-collar workes group accounted for the highest proportion, at 45.2% (n = 467). The group of self-employed workers, business owners, and other occupations also accounted for a considerable proportion, at 44.5% of the total number of pregnant women in the study. In contrast, the manual labor group accounted for a lower proportion, comprising only 10.3% of the entire study sample.

Compared with studies conducted in Thai Binh (2025) and Can Tho City (2019), the occupational structure of pregnant women in this study shows clear differences [89, 93, 94]. While studies in those locations reported a predominance of manual workers, the occupational distribution in our study reflects different socio-economic characteristics. This difference may be related to the study setting in Hanoi—one of the largest cities in Vietnam—which has a higher proportion of intellectual and office workers compared with rural areas or other provinces and cities.

Previous studies have shown that socio-economic conditions and occupation have a notable influence on access to health information, healthcare services, and antenatal screening programs. Women in occupational groups with more limited socio-economic conditions often face barriers in accessing appropriate healthcare, which may increase the risk of GDM. Therefore, considering differences in occupation and socio-economic context across study settings is important for developing more appropriate strategies for pregnancy care.

4.2.4. Gravidity characteristics

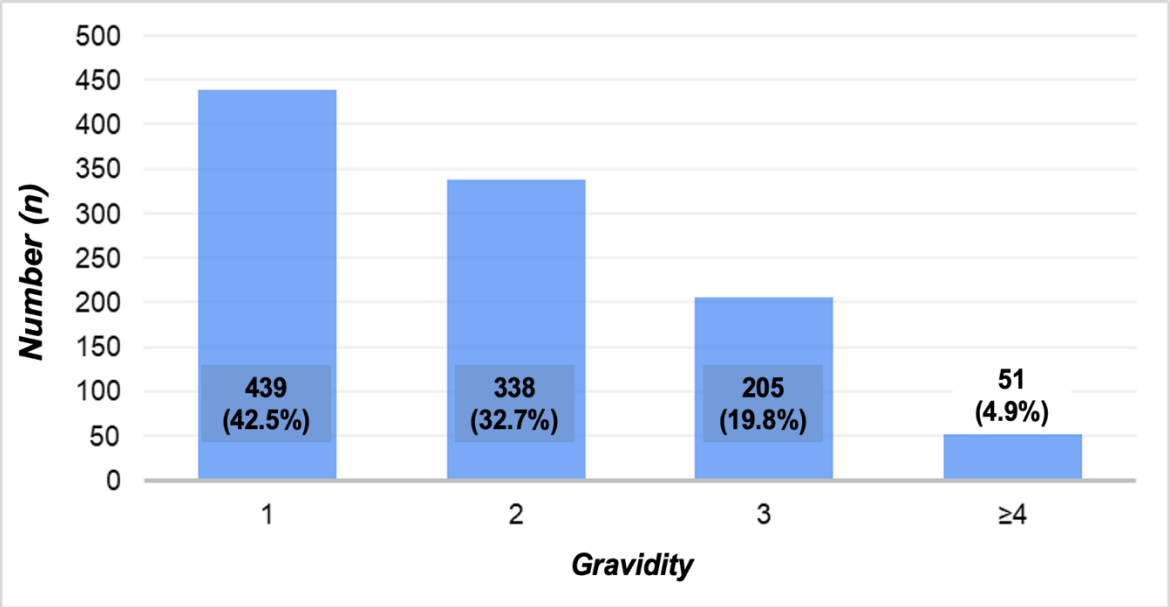


Figure 4.3. Distribution of gravidity in the study population

According to Figure 4.3, women experiencing their first pregnancy accounted for the highest proportion, at 42.5% (n = 439) of the total study population. Women in their second pregnancy also accounted for a considerable proportion, at 32.7% (n = 338). The proportion of women in their third pregnancy was lower, at 19.8% (n = 205). Meanwhile, women with four or more pregnancies accounted for the lowest proportion in the study sample, at only 4.9% (n = 51).

In our study, the proportion of primiparous women accounted for 42.5%, which is consistent with the study conducted in Can Tho [94]; herefore, women with two or more previous births still accounted for a higher proportion in the study sample. Several studies conducted in large populations have reported a trend of increasing risk of GDM with a higher number of pregnancies or births, suggesting a potential role of this factor in disease risk. However, other studies, such as those conducted in China, have described a higher risk mainly among women with three or more births, while the strength of this association tended to decrease or lose statistical significance after multivariable adjustment [95, 96].

Therefore, parity remains a variable of interest in studies on GDM and should be considered and included in models analyzing associated factors, particularly when evaluated together with maternal age and BMI.

4.3. Screening of potential factors related to GDM (univariate analysis)

Univariate logistic regression analysis was conducted to evaluate the relationship

between GDM status and each potential related variable. For every variable, crude odds ratios (cORs) and 95% confidence intervals (95% CI) were computed. A p-value of less than 0.05 was deemed statistically significant.

4.3.1. Maternal age factor

Table 4.3. Univariate analysis of maternal age associated GDM

Age group	GDM n(%)	Without GDM n(%)	Total	Crude OR (95%CI)	p-value
18 – 24	7 (3.7%)	122 (14.5%)	129 (12.5%)	0.303 (0.137 – 0.668)	0.003
25 – 34	99 (52.4%)	522 (61.8%)	621 (60.1%)	1.00	-
35	83 (43.9%)	200 (23.7%)	283 (27.4%)	2.188 (1.567 – 3.056)	<0 .001
Total	189	844	1033	-	-

According to Table 4.3, maternal age was significantly associated with the risk of GDM; the older the mother, the higher the risk of developing the disease. Specifically, women aged 18–24 had the lowest GDM prevalence at 3.7% (OR = 0.303, 95% CI: 0.137–0.668, p = 0.003), indicating a 70% lower risk compared with women aged 25–34 (reference group). Women aged ≥ 35 years had a 2.188-fold higher risk of GDM compared with the 25–34-year group (OR = 2.188, 95% CI: 1.567–3.056, p < 0.001).

These findings are supported by several studies done domestically and worldwide that repeatedly demonstrate the heightened risk for GDM associated with increasing maternal age. Chung Thuy Bui et al. at Da Nang Women and Children's Hospital reported prevalence of GDM to be 7.6%, 15.8%, and 26% among women aged < 25, 25–34, and ≥ 35 years, respectively (p < 0.05), indicating a clear age pattern [82]. Similarly, Minh Hieu Le et al. in Thai Binh estimated that the risks of GDM were approximately two-fold and three-fold among women aged 25–34 and ≥ 35 years, respectively, with respect to women aged < 25 years in adjusted odds ratios [84]. Likewise, Thanh Nhan Hua in Can Tho reported a 2.37-fold higher risk among

women older than 35 years (95% CI: 1.32–2.46, p = 0.003). Likewise consistent trends emerge in a Malaysian review in 2022, which also confirms the robustness of this association across various populations [79, 97].

These consistent findings align with national and international guidelines, highlighting the need for early detection and management of GDM among older pregnant women.

4.3.2. Pre-pregnancy BMI factor (according to IDI&WPRO classification)

Table 4.4. Univariate analysis of pre-pregnancy BMI associated with GDM

BMI	GDM n(%)	Without GDM n(%)	Total	Crude OR (95%CI)	p-value
<18.5 Underweight	11 (5.9%)	127 (15%)	138 (13.4%)	0.406 (0.212 – 0.777)	0.006
18.5 – 22.9 Normal	113 (59.8%)	530 (62.8%)	643 (62.2%)	1.00	-
23 – 24.9 Overweight	35 (18.5%)	123 (14.6%)	158 (15.3%)	1.335 (0.871 – 2.045)	0.185
≥ 25 Obese	30 (15.9%)	64 (7.6%)	94 (9.1%)	2.199 (1.362–3.549)	0.001
Total	189	844	1033 (100%)	-	-

Table 4.4 shows that pre-pregnancy BMI is associated with the risk of GDM. Overall, women with higher pre-pregnancy BMI were considered to have a higher risk of GDM. Especially, obese women (BMI ≥ 25) had a significantly higher risk of GDM than women with normal BMI. The risk in this group was more than double (OR = 2.199, 95% CI: 1.362–3.549), and this association was significantly significant (p = 0.001).

Contrary, underweight women before pregnancy showed a lower risk of GDM, indicating a protective effect in this group (OR = 0.406, 95% CI: 0.212–0.777). For women classified as overweight (BMI 23–24.9), the risk of GDM was slightly higher

than for women with a normal BMI. However, this increase was not significantly significant (OR = 1.335, 95% CI: 0.871–2.045; p = 0.185).

Higher pre-pregnancy BMI was associated with an increased risk of GDM as shown by the findings in our study which is consistent with an existing study at Da Nang Women and Children's Hospital (2019–2020) [82]. Likewise, a systematic review in Asia demonstrated that this relationship was statistically significant given that BMI ≥ 25 [7]. In comparison, a number of other studies conducted at Hanoi Obstetrics and Gynecology Hospital (2020), Hue University of Medicine and Pharmacy Hospital (2017), and Ca Mau Obstetrics and Pediatrics Hospital (2020) established statistically significant associations at the lower cutoff of BMI ≥ 23 [88, 98, 99].

The relatively small n size of our overweight group (n = 158) may have contributed to these differences in our sample size, leading to wider confidence intervals and less power of statistical analysis. Meanwhile, maternal age, family history of type 2 diabetes mellitus and other obstetric factors are likely all factors that have an impact on our link between BMI and GDM. Nevertheless, the increased BMI before pregnancy was always linked to an increased risk of GDM—confirming the fact that BMI will serve as an important risk factor according to suggestions made by WHO, IADPSG, and Vietnamese Ministry of Health.

4.3.3. Residential area factor

Table 4.5. Univariate analysis of residential area associated with GDM

Residential area	GDM n (%)	Without GDM n (%)	Total	Crude OR (95%CI)	p-value
Rural	92 (48.6%)	432 (50.1%)	524 (50.7%)	1	0.533
Urban	97 (51.3%)	412 (48.8%)	509 (49.3%)	0.905 (0.660 – 1.240)	
Total	189	844	1033	-	-

As shown in Table 4.5, place of residence (urban or rural) was not a statistically significant factor associated with the risk of GDM (p = 0.533; OR = 0.905, 95% CI: 0.660–1.240).

The results of this study were similar to those of studies conducted in India and Ghana (2015), which reported that living in urban or rural areas did not affect the risk of GDM [100, 101]. However, several studies have shown that women residing in urban areas are at a higher risk of developing GDM than those living in rural areas. These include domestic studies conducted in the Mekong Delta region (2017–2022) and at Can Tho Obstetrics and Gynecology Hospital (2023), as well as international studies in South India (2008) and New Zealand (2001–2010) [79, 89, 102, 103].

The differences among studies may be explained by variations in study period and socioeconomic context. As economic and social development progresses, rural women may adopt lifestyles, dietary habits, and exposure to risk factors (such as overweight and physical inactivity) similar to those of urban women. In addition, most women attending the National Hospital of Obstetrics and Gynecology were from Hanoi and nearby northern provinces, where the distinction between "urban" and "rural" areas is less pronounced, leading to similarities in lifestyle and nutritional patterns between the two groups.

4.3.4. Family history (first-degree relatives) of type 2 diabetes mellitus

Table 4.6. Univariate analysis of family history of type 2 diabetes mellitus (T2DM) associated with GDM

Family history of T2DM	GDM n (%)	Without GDM n (%)	Total	Crude OR (95%CI)	p-value
No	155 (82%)	803 (95.1%)	958 (92.7%)	1	< 0.001
Yes	34 (18%)	41 (4.9%)	75 (7.3%)	4.296 (2.642 – 6.985)	
Total	189	844	1033	-	-

There was a statistically significant association between a first-degree family history of type 2 diabetes and the risk of GDM ($\chi^2 = 39.547$; $p < 0.001$). Pregnant women with a first-degree family history of type 2 diabetes had a 4.296-fold higher risk of developing GDM compared with those without such a history (OR = 4.296; 95% CI: 2.642–6.985) (Table 4.6).

Several studies conducted in Vietnam have reported a significant association between a first-degree family history of type 2 diabetes and the risk of GDM. This relationship has been examined in multiple studies, highlighting the role of genetic and familial factors in the development of GDM among pregnant women. A study conducted at Hue University of Medicine and Pharmacy in 2017 reported a statistically significant association, with a p-value of 0.019. Another study at Ca Mau Obstetrics and Pediatrics Hospital in 2023 showed an even stronger association, with a p-value of < 0.001, further emphasizing the importance of family history in GDM risk. In addition, a study conducted in Thai Binh Province during 2023–2024 reported an odds ratio (OR) of 2.0, with a 95% confidence interval (CI) of 1.4–3.0, indicating that women with a first-degree relative with type 2 diabetes had a higher risk of GDM. Similarly, studies from the Mekong Delta region between 2017 and 2022 reported an OR of 2.42 (95% CI: 1.70–3.46), supporting the association between a first-degree family history of type 2 diabetes and the risk of GDM [84, 88, 89, 99].

The consistency among these findings is in accordance with the recommendations of the American College of Obstetricians and Gynecologists (ACOG), the National Institute for Health and Care Excellence (NICE, UK), and Diabetes Canada (DC), all of which recognize a first-degree family history of type 2 diabetes as a major risk factor that should be screened for [8, 104].

The underlying mechanism of this association is thought to involve both genetic predisposition and shared environmental factors, although it has not been fully elucidated. Nevertheless, even after adjusting for potential confounders such as pre-pregnancy BMI, waist circumference, and physical activity, family history remains an important and independent risk factor that should be carefully considered in the screening and prevention of GDM among pregnant women [105, 106].

4.3.5. History of stillbirth

Table 4.7. Univariate analysis of history of stillbirth associated with GDM

History of stillbirth	GDM n (%)	Without GDM n (%)	Total	Crude OR (95%CI)	p-value
No	129 (63.8%)	666 (78.9%)	875 (77.0%)	1	0.002
Yes	60 (31.7%)	178 (21.1%)	238 (23.0%)	1.740 (1.229 – 2.465)	
Total	189	844	1033	-	-

Table 4.7 indicates that a history of stillbirth was significantly associated with the risk of GDM ($\chi^2 = 9.889$; $p = 0.002$). Pregnant women with a history of stillbirth had a 1.740-fold higher risk of developing GDM compared with those without such a history.

The association between a history of stillbirth and the risk of GDM observed in our study was consistent with several domestic studies. Specifically, the study by Thi Khanh Nga Chan and colleagues at Can Tho Obstetrics and Gynecology Hospital (2018–2019) reported a statistically significant association between these two factors (OR = 5.61, p = 0.001). Similarly, Minh Anh Nguyen and colleagues at Kien Giang Obstetrics and Pediatrics Hospital found that women with a history of stillbirth had a fivefold higher risk of developing GDM after multivariable logistic regression analysis [89, 107].

Meta-analyses conducted in Asia and other regions of the world have also concluded that women with a history of stillbirth have a 2.3–2.4-fold higher risk of developing GDM compared with those without such a history [7, 108]. A study conducted in Brazil even reported an odds ratio as high as 4.365 [109]. However, a study from Iran in 2019 did not find a statistically significant association between these two factors [110].

The current evidence regarding the association between a history of stillbirth and the risk of GDM remains conflicting and inconclusive. Several studies have suggested that this association may be mediated by oxidative stress and chronic inflammation—factors known to contribute both to early miscarriage and to the pathogenesis of GDM. In addition, early pregnancy loss may trigger abnormal immune responses that

promote metabolic disturbances, thereby predisposing women to GDM or gestational hypertension in subsequent pregnancies [111, 112]. Overall, although existing data remain limited, recent studies have demonstrated a clear trend toward an increased risk of GDM among women with a history of stillbirth, highlighting the need for further research to elucidate the underlying mechanisms.

4.3.6. History of macrosomia (birth weight ≥ 4000 grams)

Table 4.8. Univariate analysis of history of macrosomia associated with GDM

History of macrosomia	GDM n (%)	Without GDM n (%)	Total	Crude OR (95%CI)	p-value
No	182 (96.3%)	828 (98.1%)	1010 (97.8%)	1	0.128
Yes	7 (3.7%)	16 (1.9%)	23 (2.2%)	1.990 (0.807 – 4.908)	
Total	189	844	1033	-	-

According to Table 4.8, The proportion of women with a history of macrosomia accounted for 2.2% of the total study population. In the GDM group, 3.7% of women had a history of macrosomia, compared with 1.9% in the non-GDM group. Univariate logistic regression analysis showed that a history of macrosomia had a crude OR of 1.990 (95% CI: 0.807–4.908), and this association was not statistically significant (p = 0.128).

The findings of our study are similar to those reported by Le Minh Hieu in Thai Binh Province, which also found no statistically significant association between a history of macrosomia and the risk of GDM [84].

Nevertheless, several other studies have reported the opposite results. Research conducted in Hai Phong (2015), at Kien Giang Obstetrics and Pediatrics Hospital (2024), and in Sweden all indicated that women with a history of delivering a macrosomic infant (≥ 4000 g) were at higher risk of developing GDM [86, 107, 113]. Furthermore, a large international survey conducted between 2005 and 2019 (n = 47,823) reported a positive association between a history of macrosomia and the risk of GDM in subsequent pregnancies (p < 0.001) [114].

Several factors may explain these discrepancies among studies. First, differences in data collection methods may have affected the accuracy of the results. Information on a history of macrosomia was often obtained through self-reporting, which is prone to recall bias, especially when previous medical records were not verified. Second, in our study, most participants were urban women who received comprehensive antenatal care and nutritional counseling, which may have reduced the risk of macrosomia.

4.3.7. Gravidity (number of pregnancies)

Table 4.9. Univariate analysis of gravidity associated with GDM

Gravidity	GDM n (%)	Without GDM n (%)	Total	Crude OR (95%CI)	p-value
1	73 (38.6%)	366 (43.4%)	439 (42.5%)	1	0.234
≥ 2	116 (61.4%)	478 (56.6%)	594 (57.5%)	1.217 (0.881 – 1.680)	
Total	189	844	1033	-	-

As shown in Table 4.9, women with two or more pregnancies accounted for 57.5% of the total study population, while those experiencing their first pregnancy accounted for 42.5%. The proportion of GDM was higher among women with gravidity ≥ 2 (61.4%) compared with primigravida women (38.6%). However, univariate logistic regression analysis showed that gravidity ≥ 2 had a crude OR of 1.217 (95% CI: 0.881–1.680), which was not statistically significant (p = 0.233).

When compared with other studies, three investigations conducted in China and Arab countries reported opposite findings: univariate analysis showed a statistically significant association between the number of pregnancies and the risk of GDM—women with two or more pregnancies had a higher risk of developing GDM than primigravid women. However, this association lost statistical significance after multivariable logistic regression, when confounding factors such as maternal age, pre-pregnancy BMI, and family history of type 2 diabetes were adjusted for [115-117].

Conversely, another cohort study reported an entirely opposite result: women with a

higher number of pregnancies had a lower likelihood of developing GDM, particularly among younger women [118].

These conflicting findings highlight the need for studies with larger sample sizes to better clarify the role of parity as a potential risk factor for GDM.

4.3.8. Use of assisted reproductive technology (ART)

Table 4.10. Univariate analysis of assisted reproductive technology (ART) use associated with GDM

ART use	GDM n (%)	Without GDM n (%)	Total	Crude OR (95%CI)	p-value
No	144 (76.2%)	731 (86.6%)	875 (84.7%)	1	< 0.001
Yes	45 (23,8%)	113 (13.4%)	158 (15.3%)	2.022 (1.370 – 2.983)	
Total	189	844	1033	-	-

Table 4.10 indicates a statistically significant association between assisted reproductive technology (ART) and the risk of GDM ($\chi^2 = 12.943$; $p < 0.001$).

Pregnant women who conceived using ART had twice the risk of developing GDM compared with those who conceived naturally.

The association between ART and GDM risk was also reported in a study conducted at the Vietnam–Sweden Uong Bi Hospital (2023–2024), where the prevalence of GDM among women who underwent ART reached 100% [119]. Similarly, a retrospective cohort study based on U.S. birth certificate data found a 1.6-fold higher risk of GDM in women who conceived using ART compared with those with spontaneous conception. A meta-analysis further reported an increased risk of 1.51 times (95% CI: 1.18–1.93) [120, 121].

This consistent finding can be explained by the fact that women undergoing ART are typically older, are exposed to hormonal treatments that alter metabolic function, and may have underlying conditions such as ovarian hyperstimulation syndrome, polycystic ovary syndrome, or other chronic diseases [122].

Although a statistically significant association was observed, the prevalence of GDM among studies varied. This discrepancy may be attributed to differences in sample characteristics, population size, and inclusion criteria for ART procedures.

Our study included only women who conceived via in vitro fertilization (IVF), whereas international studies also encompassed less complex interventions such as ovulation induction or intrauterine insemination (IUI).

4.3.9. Hypertension during pregnancy

Table 4.11. Univariate analysis of hypertension during pregnancy associated with GDM

Hypertension during pregnancy	GDM n (%)	Without GDM n (%)	Total	Crude OR (95%CI)	p-value
No	168 (88.9%)	779 (92.3%)	947 (91.7%)	1	0.125
Yes	21 (11.1%)	65 (7.7%)	86 (8.3%)	1.498 (0.891 – 2.518)	
Total	189	844	1033	-	-

Table 4.11 shows that most pregnant women did not have hypertension during pregnancy (91.7%). The proportion of hypertension was 11.1% in the GDM group and 7.7% in the non-GDM group. Univariate logistic regression analysis indicated that hypertension during pregnancy had a crude OR of 1.498 (95% CI: 0.891–2.518), with no statistically significant association (p = 0.125).

There have been few studies in Vietnam investigating the relationship between hypertension and GDM, whereas several studies in other Asian countries have reported that hypertension increases the risk of GDM. A multicenter cohort study conducted in Malaysia (2016–2022) found a statistically significant association between hypertension and GDM, reflecting the interaction between blood pressure regulation and glucose metabolism during pregnancy [97]. A cross-sectional study in Indonesia reported that hypertension increased the risk of GDM by 2.121 times (95% CI: 1.405–3.203, $p < 0.05$) [123]. Another meta-analysis in Asia (2017–2018) confirmed that hypertension is an independent risk factor for GDM (OR = 3.2, 95%

CI: 2.19–4.68) [7].

The association observed was not statistically significant, even though our findings indicated a higher prevalence of GDM among women with hypertension. It is important to note that our sample size and study setting were limited, as the data was sourced from a single institution, which may not accurately reflect the broader population of pregnant women. Additionally, we hypothesize that the strength of the association between hypertensive disorders and GDM could differ based on factors such as ethnicity, dietary habits, and gestational stage. These variables may help account for the discrepancies between our findings and those reported in international studies.

4.3.10. Urinary glucose

Table 4.12. Univariate analysis of urinary glucose during pregnancy associated with GDM

Urinary glucose	GDM n (%)	Without GDM n (%)	Total	Crude OR (95%CI)	p-value
No	182 (96.3%)	823 (97,5%)	1005 (97.3%)	1	0.355
Yes	7 (3.7%)	21 (2,5%)	28 (2.7%)	1.51 (0.631 – 3.596)	
Total	189	844	1033	-	-

As shown in table 4.12, the majority of pregnant women did not have urinary glucose in both “With GDM’ group and “Without GDM” group. The proportion of women with urinary glucose was 3.7% in the GDM group and 2.5% in the non-GDM group. Univariate logistic regression analysis showed that urinary glucose had a crude OR of 1.51 (95% CI: 0.631–3.596), and this association was not statistically significant (p = 0.355).

There is considerable uncertainty regarding the relationship between urinary glucose levels and the risk of GDM, both in Vietnam and globally, with some conflicting information. For instance, a study conducted in Uong Bi, Quang Ninh, found that women with positive urinary glucose results had a high prevalence of GDM. Similarly, research by Bushman et al. indicated that positive urinary glucose,

combined with a body mass index (BMI) over 30, was linked to an increased risk of developing GDM [119, 124].

However, there are contrary findings from studies by Kikula (2025) and Agbozo (2018) revealing that urinary glucose testing failed to detect many cases of GDM [125, 126].

Overall, the results of this study align with several other international studies. This discrepancy may be attributed to the physiological nature of urinary glucose excretion and the variability in urine glucose concentrations based on the timing of sampling, suggesting that urinary glucose levels should not be relied upon as definitive evidence for diagnosing GDM.[127].

4.3.11. Number of fetuses (singleton/ multiple pregnancy)

Table 4.13. Univariate analysis of number of fetuses associated with GDM

Number of fetuses	GDM n (%)	Without GDM n (%)	Total	Crude OR (95%CI)	p-value
Singleton	175 (92.6%)	805 (95.4%)	980 (94.9%)	1	0.117
Multiple	14 (7.4%)	39 (4.6%)	53 (5.1%)	1.651 (0.978 – 3.107)	
Total	189	844	1033	-	-

As presented in Table 4.13, the majority of pregnant women had singleton pregnancies (94.9%), while multiple pregnancies accounted for 5.1%. The proportion of GDM was higher among women with multiple pregnancies (7.4%) compared with those with singleton pregnancies. Univariate logistic regression analysis showed that multiple pregnancy had a crude OR of 1.651 (95% CI: 0.978–3.107); however, this association was not statistically significant ($p = 0.117$).

Our findings were comparable to those reported by Liran Hiersch et al. in Canada and Surabhi et al. in India, who found an increased risk of GDM in women with multiple pregnancies, with adjusted relative risks (aRR) of 1.13 (95% CI: 1.01–1.28) and odds ratios (OR) of 11.3 (95% CI: 6.6–19.3; $p < 0.01$), respectively [128, 129]. However, unlike these studies, our results did not show a statistically significant association.

The discrepancy may be attributed to several factors: the relatively small sample size of our study, differences in population characteristics across studies, and the time gap between previous international studies and the present one, which was conducted in the context of more comprehensive prenatal care and stricter GDM screening practices. Therefore, although our results indicated a trend toward higher GDM risk in multiple pregnancies, this relationship could not be confirmed in our setting, and further studies with larger sample sizes and updated data are warranted.

4.3.12. Fetal sex

Table 4.14. Univariate analysis of fetal sex associated with GDM

Fetal sex	GDM n (%)	Without GDM n (%)	Total	Crude OR (95%CI)	p-value
Male	125 (66.1%)	485 (57.5%)	610 (59.1%)	1.45 (1.04 – 2.01)	0.028
Female	64 (33.9%)	359 (42.5%)	423 (40.9%)	1	
Total	189	844	1033	-	-

As shown in Table 4.14, fetal sex was significantly associated with the risk of GDM in mothers ($\chi^2 = 4.804$; $p = 0.028$). Women carrying male fetuses had a 1.45-fold higher prevalence of GDM compared with those carrying female fetuses (OR = 1.45, 95%CI: 1.04 – 2.01).

The findings of our study were consistent with those from a study conducted in Canada and a global meta-analysis, which reported that women carrying male fetuses had a 39% (OR = 1.39, 95% CI: 1.01–1.09) and 4% (RR = 1.04, 95% CI: 1.01–1.06) higher risk of developing GDM, respectively [130, 131]. In contrast, studies from the United States and France reported no statistically significant association between fetal sex and the risk of GDM [132, 133] .

Overall, limited evidence suggests that fetal sex may be a potential risk factor for GDM. Possible mechanisms include sex-related differences in placental hormones such as human placental lactogen (hPL), which may alter maternal glucose and insulin metabolism. However, existing studies remain inconclusive and insufficiently robust to establish fetal sex as a major predictive factor for GDM [134].

4.4. Independent factors related to GDM (multivariable logistic regression)

After conducting a thorough univariate analysis, we selected variables that exhibited a p-value of 0.20 or lower for inclusion in our subsequent analyses. This decision was made to ensure that only those variables with a potentially significant relationship to the outcome were considered. Following this initial filtering process, the identified variables were systematically entered into a multivariable logistic regression model. This model was employed to ascertain the independent associations between the selected variables and the outcome of interest, allowing for a more nuanced understanding of the relationships at play.

Table 4.15. Independent factors related to GDM (multivariable logistic regression)

Factor	Crude OR (95% Cl)	p-value (univariate)	Adjusted OR (95% CI)	p-value (multivariable)
Constant = -1.496				
Age group				
< 25	0.303 (0.137 – 0.668)	0.003	0.329 (0.146 – 0.470)	0.007
≥ 35	**2.188 (1.567 – 3.056)**	**<0.001**	**1.716 (1.201 – 2.452)**	**0.003**
BMI classification (IDI & WPRO)				
< 18.5 Underweight	0.406 (0.212 – 0.777)	0.006	0.557 (0.286 – 1.086)	0.086
23 – 24.9 Overweight	1.335 (0.871 – 2.045)	0.185	1.232 (0.786 – 1.933)	0.363

≥ 25 Obese	**2.199 (1.362–3.549)**	**0.001**	**2.293 (1.373 – 3.830)**	**0.002**
Family history (1st-degree relatives) of type 2 diabetes mellitus	**4.296 (2.642 – 6.985)**	**<0.001**	**3.625 (2.164 – 6.071)**	**< 0.001**
History of stillbirth	1.740 (1.229 – 2.465)	0.002	1.392 (0.959 – 2.020)	0.082
History of macrosomia	1.990 (0.807 – 4.908)	0.128	1.628 (0.625 – 4.243)	0.319
ART	2.022 (1.370 – 2.983)	p < 0.001	1.387 (0.897 – 2.145)	0.141
Hypertension	1.498 (0.891 – 2.518)	0.125	1.002 (0.563 – 1.783)	0.995
Multiple	1.651 (0.978 – 3.107)	0.117	1.417 (0.710 – 2.826)	0.323
Fetal sex	1.45 (1.04 – 2.01)	0.028	1.290 (0.910 – 1.830)	0.153

After adjusting for potential confounding factors, maternal age ≥ 35 years, pre-pregnancy obesity, and a family history of type 2 diabetes were identified as independent and statistically significant risk factors for GDM ($p < 0.05$) (Table 4.14). Specifically, the analysis revealed that individuals with a family history of type 2 diabetes faced a strikingly increased risk of developing GDM, with an adjusted odds ratio (aOR) of 3.625. This finding indicates a robust association, supported by a 95% confidence interval (CI) ranging from 2.164 to 6.071.

Specifically, the analysis revealed that individuals with a family history of type 2 diabetes faced a strikingly increased risk of developing GDM, with an adjusted odds ratio (aOR) of 3.625. This finding indicates a robust and clinically meaningful association, further supported by a 95% confidence interval (CI) ranging from 2.164 to 6.071, suggesting a consistently elevated risk across the study population.

Similarly, pre-pregnancy obesity was found to significantly elevate the risk of GDM, with an aOR of 2.293. The confidence interval for this association ranged from 1.373 to 3.830, and the p-value of 0.02 confirms the statistical significance of this relationship, highlighting the important role of excess adiposity prior to pregnancy in GDM development.

Additionally, maternal age was identified as a critical contributing factor, with women aged 35 years or older exhibiting a 1.7-fold increased risk of GDM. This association was reflected by an aOR of 1.716 and a 95% CI of 1.201 to 2.452, indicating a moderate but consistent increase in risk with advancing maternal age.

In contrast to these identified risk factors, the analysis also indicated that pregnant women under the age of 25 tended to have a lower risk of developing GDM. The adjusted odds ratio for this younger age group was 0.329, with a 95% confidence interval of 0.146 to 0.470 and a p-value of 0.007, suggesting a statistically significant protective effect against GDM.

Variables that were no longer statistically significant included BMI < 25, history of macrosomia, history of stillbirth, use of assisted reproductive technology, hypertension, multiple pregnancy, singleton pregnancy, urinary glucose and fetal sex. These findings may be explained by two main reasons: (1) the aforementioned variables acted as confounding factors and were excluded after adjustment, and (2) differences in population characteristics and timing of data collection may have influenced the results.

Our findings are consistent with major international and national guidelines on GDM, including those of the American Diabetes Association (ADA), the U.S. Centers for Disease Control and Prevention (CDC), the National Institute for Health and Care Excellence (NICE, UK), and the Vietnamese Ministry of Health (2021) [8, 104, 135].

4.4.1. First-degree family history of type 2 diabetes

A family history of type 2 diabetes is not only a significant risk factor for GDM but also plays a role in determining risk from the early stages of pregnancy [35].

Women with such a background often exhibit an underlying predisposition to glucose

intolerance even before conception, which may become more apparent as metabolic demands increase during pregnancy. This link is likely a result of a multifactorial and synergistic effect of genetic vulnerability and common environmental factors, including dietary patterns, lifestyle, and metabolic well-being within families. Because of the common pathophysiology, GDM is classified as a polygenic disorder, similar to type 2 diabetes, in which numerous common single nucleotide polymorphisms (SNPs) in diverse genes interact with environmental factors to influence insulin sensitivity, β-cell function, and overall glucose metabolism.

Pregnant women with a first-degree family history of type 2 diabetes are significantly more likely to harbor multiple diabetes risk alleles. Such genetic loading results in insufficient β-cell compensation for physiological insulin resistance during pregnancy, thereby predisposing to GDM [105, 136]. A number of susceptibility genes have been found including TCF7L2 and HHEX genes involved in transcriptional regulation and insulin secretion, ADIPOQ and SHBG which play roles in regulating hormones involved in insulin sensitivity, and VEGFA and MIF that involve growth factor signaling and inflammatory processes. Combined, these genetic factors lead to an imbalance of glucose homeostasis and increased susceptibility to GDM in genetically susceptible women [137]. However, current evidence suggests that genetic factors alone explain only about 10% of GDM cases, indicating the need for further research [105].

In conclusion, although the precise mechanism remains under investigation, a family history of type 2 diabetes is considered an independent and significant risk factor in the pathogenesis of GDM.

4.4.2. Maternal age ≥ 35 years

Numerous large-scale meta-analyses have shown a linear increase in the risk of GDM with advancing maternal age, with no clear threshold. Women aged ≥ 35 years were found to have a 3–4 times higher risk of GDM compared with those aged 20–24 years [138, 139]. Advanced maternal age has been identified as an independent and statistically significant risk factor in most studies, even after adjustment for confounding variables.

The main biological mechanism explaining this association is age-related metabolic aging, which leads to decreased insulin sensitivity. In addition, oxidative stress increases progressively with age, while the compensatory capacity of pancreatic β-cells declines, resulting in insufficient insulin secretion to meet the increased

physiological demands of pregnancy [15, 140].

In our study population at the National Hospital of Obstetrics and Gynecology, women aged ≥ 35 years showed a significantly significant association with GDM; this finding aligns with broader international trends that have been documented in recent research, highlighting a growing recognition of the risks associated with advancing maternal age.

The difference in the magnitude of risk observed among older women may be attributed to several factors, including the implementation of more rigorous and systematic screening procedures that have been adopted in recent years. These enhanced screening protocols are designed to identify potential cases of GDM earlier and more effectively, thereby allowing for timely interventions that can significantly improve maternal and fetal health outcomes.

In conclusion, our findings strengthen the understanding that advanced maternal age is an independent and nonmodifiable risk factor for the development of GDM mellitus. This underscores the critical importance of initiating early and proactive screening measures from the initial stages of pregnancy.

4.4.3. Pre-pregnancy BMI ≥ 25

The relationship between pre-pregnancy BMI and the risk of GDM is predominantly linear. Numerous meta-analyses conducted globally have consistently shown that the risk of GDM increases by 2 to 8 times, correlating with the severity of overweight and obesity, thereby identifying obesity as a critical risk factor for insulin resistance [141].

Mechanistically, a higher BMI is indicative of greater visceral fat accumulation, which functions as an active endocrine tissue. This increase in visceral adiposity results in elevated secretion of free fatty acids (FFAs) and pro-inflammatory cytokines, such as TNF-α and IL-6, which disrupt insulin signaling in both the liver and skeletal muscles, ultimately leading to reduced insulin sensitivity [142].

According to Taylor et al.'s "personal fat threshold" hypothesis, when an individual's capacity for safe fat storage is surpassed, excess fat triggers an increase in hepatic production of very-low-density lipoproteins (VLDL) and leads to ectopic fat accumulation in organs like the pancreas, consequently impairing β-cell function [143].

Furthermore, Wang et al. have reported that elevated BMI is associated with alterations in specific classes of plasma lipids, particularly glycerophospholipids and

glycerolipids, which are essential for maintaining cell membrane integrity and facilitating insulin receptor signaling [144].

Overall, a high pre-pregnancy BMI is linked to an increased risk of GDM through a variety of interrelated mechanisms and has been established as an independent and significant risk factor in the pathophysiology of this condition.

CHAPTER 5. CONCLUSION

5.1. Summary and concluding remarks

(1) According to the study results, 18.3% of pregnant women at the National Hospital of Obstetrics and Gynecology were diagnosed with GDM, and this rate is similar to that reported in earlier studies at the same institution. This finding reflects the stability in the characteristics of the patient population seeking antenatal care and delivery, as well as the effectiveness of disease management at this institution. This prevalence is also comparable to those reported in studies from other developing countries.

(2) Analysis of the general characteristics of the entire study sample showed that the mean maternal age at pregnancy was 31.0 ± 5.7 years, which is comparable to data reported in major urban areas of Vietnam. In addition, although the differences in maternal age at pregnancy (33.6 ± 5.5 years vs. 30.4 ± 5.6 years) and pre-pregnancy BMI (22.35 ± 2.91 vs. 21.1 ± 4.2) between the "With GDM" group and the "Without GDM" group were not large, these differences were statistically significant. The intellectual labor group accounted for the highest proportion (45.2%), followed by the self-employed/other group (44.5%), while manual laborers represented the lowest proportion (10.3%). Primigravid women constituted the largest proportion (42.5%), whereas women with four or more pregnancies accounted for only 4.9%.

(3) In the initial analysis phase, differences in the prevalence of GDM were observed across groups of maternal characteristics. Factors that tended to be associated with an increased risk of the GDM condition included maternal age of 35 years or older, obesity, a first-degree family history of type 2 diabetes mellitus, history of stillbirth, the use of assisted reproductive technologies, and male fetal sex. These associations were descriptive and comparative in nature and were used to screen potential factors for inclusion in the multivariable analysis in order to clarify the independent role of each factor.

(4) After performing multivariable logistic regression analysis, three independent risk factors for GDM were identified, including maternal age ≥ 35 years, pre-pregnancy obesity, and a first-degree family history of type 2 diabetes mellitus, with corresponding increased risks (adjusted odds ratios of 1.716, 2.293, and 3.625, respectively). These findings are consistent with both national and international studies. Conversely, younger maternal age (< 25 years) appeared to have a protective effect (*aOR* = 0.557. No statistically significant associations were found for other

examined variables.

In conclusion, gestational diabetes remains a major public health concern, reflected by its considerable prevalence in pregnant women, with potential long-term consequences for maternal and neonatal health. The assessment of disease prevalence and identification of independent risk factors in this study provides a solid evidence base for the development of targeted early screening strategies and risk prediction models, thereby supporting more effective prevention and management of GDM in clinical practice.

5.2. Limitations of the research

Our study was conducted at a central-level hospital over a relatively short period, which may not fully represent the characteristics of the broader population of Vietnamese women across different regions and time frames. Although the sample size met the required threshold, some variables with low frequencies—such as assisted reproductive technology (ART) interventions and history of stillbirth—might have reduced the precision of the odds ratio (OR) estimates.

Certain variables, including history of macrosomia and first-degree family history of type 2 diabetes, were collected based on participants' recall, which may have led to missing or inaccurate data. Additionally, several important factors potentially associated with GDM risk—such as dietary patterns, physical activity, and gestational weight gain—were not comprehensively recorded.

Furthermore, data collection relied on medical records, which limited control over the exact timing of diagnosis and the availability of detailed laboratory parameters. Lastly, the cross-sectional study design only allows for identifying associations rather than establishing causal relationships.

5.3. Recommendations

(1) Early screening for GDM should be strengthened, particularly among women with one or more high-risk factors such as advanced maternal age (≥ 35 years), pre-pregnancy BMI ≥ 25 kg/m², and a first-degree family history of type 2 diabetes.

(2) Alongside early screening, greater attention should be given to health education for women of reproductive age to improve their understanding of GDM and related risk factors. Providing information on modifiable risk factors, such as pre-pregnancy weight, diet, and lifestyle, may help pregnant women take a more proactive role in disease prevention. In addition, appropriate nutritional counseling, guidance on health weight management, and encouragement of suitable physical activity

throughout pregnancy are necessary measures that may help reduce insulin resistance and support more effective management of GDM.

(3)These studies could be performed in larger samples with multicenter designs and longer follow-up periods to make the results more representative as well as reliable. More studies could also collect and analyze paraclinical data regarding glucose metabolism disorders, including blood glucose levels at different time points during oral glucose tolerance testing, HbA1c, urinary glucose, and urinary protein. Additional studies are also needed to describe the effects of less frequent factors like the use of assisted reproductive technologies, multiple pregnancies, and a history of stillbirth, as well as lifestyle-related factors including dietary patterns and levels of physical activity. This is further important since prospective studies are needed to better elucidate the causal relationships of GDM with its risk factors.

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Supervisor's Confirmation

I hereby confirm that I have read and approved the student's research proposal titled:

"Current status of gestational diabetes and some related factors in pregnant women at National Hospital of Obstetrics and Gynecology"

Supervisor 1

Name: Assoc.Prof.Dr. Chu Dinh Toi

Signature:

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Supervisor 2

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