Cross-sectional Study

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Risk factors and diagnostic performance of predictors as a screening technique for gestational diabetes mellitus: a retrospective cross-sectional study

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Background Gestational diabetes mellitus (GDM) is a condition that can have negative impacts on both mother and baby. Detecting GDM early is crucial, and fasting plasma glucose (FPG) has been suggested as a possible screening method. This retrospective cross-sectional study aims to investigate potential risk factors and complications associated with GDM. Additionally, it aims to establish the diagnostic performance of predictive factors as a screening method for GDM.

Methods Data were collected from the medical records of 247 pregnant women who visited outpatient Obstetrics clinics between 2021 and 2022. The study investigated potential risk factors and complications associated with GDM, including impaired fasting glucose/impaired glucose tolerance (IFG/IGT), family history of diabetes mellitus (DM), and medical conditions. Moreover, the study evaluated the diagnostic performance of potential predictors as screening techniques for GDM.

Results The study found that IFG/IGT ($P < 0.001$), a history of GDM ($P < 0.001$), and a family history of DM ($P = 0.022$) were significant factors associated with GDM. Healthy individuals had a lower risk of developing GDM ($P < 0.001$). No significant correlation was found between GDM and macrosomia, hypertension, polycystic ovarian syndrome, or other obstetric complications. Although a weak association was observed between fasting blood glucose levels during the first trimester and GDM, it was not significant.

Conclusion In conclusion, this study found that IFG/IGT and a past history of GDM were significantly associated with GDM. Additionally, a family history of diabetes increased the likelihood of developing GDM, while no significant association was found between GDM and other obstetric complications. Although a weak association was observed between fasting blood glucose levels during the first trimester and GDM, it was not statistically significant.

Key Words: GDM: Gestational diabetes mellitus, IFG: Impaired fasting glucose, FBG: Fasting blood glucose

Introduction

Gestational diabetes mellitus (GDM) is a prevalent condition that affects women across the globe[1]. It can lead to a range of complications for both the mother and the baby. The mother may be at a higher risk of developing type 2 diabetes and premature cardiovascular disease, while the baby may experience macrosomia, obesity, hypoglycemia, diabetes, hypertension, and cardiovascular disease in their youth and adulthood[2,3]. Early detection of GDM is crucial to avoid its consequences. In 2010, the International Association of Diabetes and Pregnancy Study Groups (IADPSG) recommended a 2-h, 75-g oral glucose tolerance test (OGTT) to diagnose GDM in all pregnant women who did not have a history of overt diabetes during the 24th–28th weeks of pregnancy[4]. The OGTT is considered to be the most

HIGHLIGHTS

- Pregnant patient with impaired fasting glucose or impaired glucose tolerance (IFG/IGT) and a past history of gestational diabetes mellitus (GDM) were significantly associated with GDM.
- Pregnant patient with family history of diabetes increased the likelihood of developing GDM,
- Our study found no significant association was found between GDM and other obstetric complications.
- Our study found a weak association between fasting blood glucose levels during the first trimester and GDM, it was not statistically significant.

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reliable method, but it can be time-consuming, has poor reproducibility, and is often poorly tolerated during pregnancy[5,6]. It is important that pregnant women are not required to attend lengthy clinic sessions for OGTTs, especially during a pandemic. Therefore, simpler yet accurate alternative screening tests should be implemented to reduce the number of OGTTs[7].

Previous research has suggested that fasting plasma glucose (FPG) can be used as a screening technique for GDM diagnosis. FPG is easier and quicker to use, is less expensive, and can lower healthcare costs associated with universal OGTT screening. However, to accurately diagnose GDM, it is necessary to evaluate the diagnostic performance and determine the ideal FPG cut-off[7]. Ping and colleagues found that GDM can be predicted through both pre-BMI and initial FPG levels before 24 weeks[8]. Similarly, Hao *et al.*[9] found that women who develop GDM tend to have significantly higher FPG levels during the first trimester (4.6 ± 0.3 mmol/l) compared to women with normal glucose tolerance (4.4 ± 0.3 mmol/l; $P = 0.001$), as well as higher BMI during the same period. Additionally, Shin Y and colleagues reported that a higher BMI is linked to a greater prevalence of GDM. Despite a higher risk of developing type 2 diabetes, lifestyle interventions that aim to reduce BMI have the potential to lower the risk of GDM[10]. The lack of a standardized agreement on diagnostic criteria and cut-off values for screening tests of fasting plasma glucose (FBG) and pre-BMI has made it difficult to detect women with GDM early[8]. Thus, our study aims to define optimal levels of FBG for the detection of GDM.

Rationale

The aim of this study is to evaluate the initial FBG and pregestional BMI During the first trimester of pregnancy in predicting GDM in Saudi Arabia in addition to examine potential risk factors and complications linked to high-risk pregnancies, with a specific focus on GDM. The study also intends to offer an understanding of the relationship between GDM and factors such as impaired fasting glucose or impaired glucose tolerance (IFG/IGT), family history of DM, and medical conditions. The study also intends to evaluate the diagnostic performance of screening techniques for GDM, including a history of GDM and IFG or IGT.

Methods and materials

Study design and area

This study was a hospital-based retrospective cross-sectional study. Data were collected from the target population through the use of medical records.

Study population

For this study, we looked at all pregnant patients who visited outpatient Obstetrics clinics from 2021 to 2022. Our focus was on singleton pregnant women who received prenatal care services in Obstetrics clinics. However, to ensure accurate and valid results, we excluded pregnant women with diabetes mellitus or autoimmune diseases. By examining this specific population of pregnant women, we aimed to investigate potential risk factors and complications associated with high-risk pregnancies.

Dependent variable:
OGTT–fasting blood glucose–weight –pregestioanl BMI.

Independent variable:
Age–sex–gestional age–chronic disease-family history–past gyne and medical history.

Sampling technique and size

The sampling technique for this study is non-probability consecutive sampling, which will include all pregnant patients who visited outpatient Obstetrics clinics from 2021 to 2022. The study aims to collect data from all members of the target population instead of sampling from a larger population.

Data collection technique and tool

The data collection tool was developed and face-validated by two consultants in the field. The tool was designed to collect data from the medical records of the participants, including their FBG levels and OGTT results. The tool was also used to collect information about the participants' obstetric history, demographic characteristics, and medical conditions.

Data entry and statistical analysis

The researchers used IBM SPSS Statistics (version 29.0) for data analysis. Categorical variables were presented as proportions, while numerical variables were presented as medians and interquartile ranges due to non-normal distribution. Inferential analyses of categorical variables were conducted using statistical tests such as χ^2 and Fisher–Freeman–Halton Exact Tests. Additionally, multivariate analyses were conducted using binary logistic regression, with significance determined by P values less than 0.05 and inferences made with a 95% confidence level. No missed data as we collect the data from hospital medical record

The work has been reported in line with the STROCSS criteria[11].

Results

The study included a total of 247 participants. Table 1 summarizes the demographic characteristics of the study population, including the number of gravidity, number of parity, and other

Table 1

Demographic characteristics.

n = 247	*N* (%)
No. gravidities	
1	51 (20.6)
2	51 (20.6)
3	51 (20.6)
> 3	94 (38.1)
No. parity	
0	67 (27.1)
1	68 (27.5)
2	44 (17.8)
3	33 (13.4)
> 3	35 (14.2)
Gestational diabetes mellitus	86 (34.8)
Hypertension	3 (1.2)
IFG or IGT	31 (12.6)
Polycystic ovarian syndrome	3 (1.2)
Medically free	213 (43.3)
Family history of DM	107 (43.3)

DM, diabetes mellitus; IFG, impaired fasting glucose; IGT, impaired glucose tolerance.

Table 2

Past obstetric history.

n = 247	*N* (%)
Past history of GDM	51 (20.6)
Hypertension	13 (5.3)
Congenital malformation	9 (3.6)
Low birth weight	19 (7.7)
Macrosomia	4 (1.6)
Stillbirth	7 (2.8)
Abortion	93 (37.7)

GDM, gestational diabetes mellitus.

medical conditions. The median age was 30 years [interquartile range (IQR): 8], the median gestational age was seven weeks (IQR: 3), and the median BMI was 27 (IQR: 8.07). Out of 247 participants, 86 (34.8%) had gestational diabetes mellitus (GDM), 3 (1.2%) had hypertension, 31 (12.6%) had IFG/IGT, and 3 (1.2%) had polycystic ovarian syndrome.

Table 2 provides insight into the obstetric history of the study population. The data indicates that a significant number of the 247 individuals had experienced various obstetric complications. Specifically, 51 individuals (20.6%) had a history of GDM, 13 individuals (5.3%) had a history of hypertension, and 19 individuals (7.7%) had a history of low birth weight. Additionally, the study found that 93 individuals (37.7%) had a history of abortion.

Table 3 investigates factors that are potentially associated with GDM. The study shows that there are significant associations between GDM and people with IFG/IGT ($P < 0.001$). This suggests that women who have higher blood sugar levels before pregnancy may be at higher risk of developing GDM. Moreover, having a family history of DM ($P = 0.022$) increases the likelihood of GDM. On the other hand, medically healthy individuals ($P < 0.001$) have a lower risk of developing GDM. Interestingly, there were no significant associations found between GDM and hypertension or polycystic ovarian syndrome, suggesting that these conditions may not be risk factors for GDM.

Table 4 outlines the different factors commonly associated with past obstetric history and their relationship with GDM. The findings of the study showed that women who had a history of GDM were more likely to develop GDM later on ($P < 0.001$). Notably, the study found no significant association between GDM and a number of other potential risk factors, including gestational hypertension, abortion, stillbirth, macrosomia, low birth weight, or congenital malformation, implying that these factors may not be risk factors for GDM.

Table 5 shows the results of a binary logistic regression analysis that aimed to identify factors associated with GDM. The analysis found no significant association between GDM and FBG levels during the first trimester ($P = 0.088$). Similarly, there was no significant association between GDM and BMI during the first trimester ($P = 0.891$).

Table 6 shows the outcomes of a binary logistic regression analysis that aimed to predict GDM. The analysis indicated two significant predictors of GDM: IFG/IGT (B = 1.491, df = 1, $P = 0.003$) and a previous history of GDM (B = 1.544, df = 1, $P < 0.001$). The model had a value of R square equal to 0.228, with $P < 0.001$.

Table 3

Factors associated with GDM.

	GDM *N* (%)		
n = 247	No	Yes	*P*
IFG or IGT			
No	154 (71.3)	62 (28.7)	< 0.001
Yes	7 (22.6)	24 (77.4)	
HTN			
No	160 (65.6)	84 (34.4)	0.278
Yes	1 (33.3)	2 (66.7)	
Family history of DM			
No	100 (71.4)	40 (28.6)	0.022*
Yes	61 (57.0)	46 (43.0)	
Medically free			
No	9 (26.5)	25 (73.5)	< 0.001*
Yes	152 (71.4)	61 (28.6)	
PCOS			
No	159 (65.2)	85 (34.8)	1.00
Yes	2 (66.7)	1 (33.3)	
No. parity			
0	46 (68.7)	21 (31.3)	0.183
1	50 (73.5)	18 (26.5)	
2	28 (63.6)	16 (36.4)	
3	19 (57.6)	14 (42.4)	
> 3	18 (51.4)	17 (48.6)	
No. gravidities			
1	33 (64.7)	18 (35.3)	0.148
2	40 (78.4)	11 (21.6)	
3	32 (62.7)	19 (37.3)	
> 3	56 (59.6)	38 (40.4)	

χ^2 test, Fisher–Freeman–Halton exact test.

DM, diabetes mellitus; GDM, gestational diabetes mellitus; HTN, hypertension; IFG, impaired fasting glucose; IGT, impaired glucose tolerance; PCOS, polycystic ovarian syndrome.

Discussion

Worldwide incidence of GDM is at an alarming 14% and ranges between 9.2 and 14.2% for low-medium and high-income countries[12]. The etiology of GDM is complex and not completely understood; however, several factors such as BMI greater than 25, low physical activity, type 2 diabetes mellitus (T2DM) in blood relation, polycystic ovarian syndrome (PCOS) are known to increase the incidence of GDM[13]. Thus, there is an unmet need for biomarkers that are easy to use in clinical practice, which can help in early detection and, in turn, prevent the disease[14].

One study in Saudi women found that the incidence of GDM is 19.7%, which is lower than the 34.8% that we have observed in our study; this may be because the former study did not include women who were more than 45 years old as these women have a higher incidence of GDM[15]. However, in concurrence with our study, Alfadhli *et al.*[16] found that the incidence of diabetes in Saudi women was (39.4% vs. 34.8%). Along similar lines, both our study and the study by Alfadhli *et al.*[16] found that the previous history of GDM ($P = 0.001$ vs. $P < 0.001$) and family history of diabetes ($P = 0.002$ vs. $P = 0.022$) are significantly correlated and known risk factors of GDM. This was also corroborated by other studies, which found that the incidence of diabetes is higher in Saudi women than worldwide incidence (34.8% vs. 14%)[12].

Macrosomia can lead to GDM; GDM is also known to cause macrosomia[14,17]. On the other hand, it is known that 15–45% of

Table 4

Past obstetric history factors associated with GDM.

	GDM N (%)		
n = 247	No	Yes	P
Past history of GDM			
No	146 (74.5)	50 (25.5)	< 0.001
Yes	15 (29.4)	36 (70.6)	
Gestational HTN			
No	154 (65.8)	80 (34.2)	0.384
Yes	7 (53.8)	6 (46.2)	
Abortion			
No	101 (65.6)	53 (34.4)	0.891
Yes	60 (64.5)	33 (35.5)	
Stillbirth			
No	154 (64.2)	86 (35.8)	0.100
Yes	7 (100.0)	0	
Macrosomia			
No	159 (65.4)	84 (34.6)	0.612
Yes	2 (50.0)	2 (50.0)	
Low birth weight			
No	146 (64.0)	82 (36.0)	0.220
Yes	15 (78.9)	4 (21.1)	
Congenital malformation			
No	155 (65.1)	83 (34.9)	1.00
Yes	6 (66.7)	3 (33.3)	

χ^2 test, Fisher–Freeman–Halton exact test.
GDM, gestational diabetes mellitus; HTN, hypertension.

Table 5

First-trimester factors association with GDM.

	P
BMI during the first trimester	0.891
FBG level during the first trimester	0.088

Binary logistic regression.
FBG, fasting plasma glucose.

children born to mothers with GDM have macrosomia. However, our study showed no significant correlation between GDM and macrosomia for the tested population[18]. Another study on Iranian women found that GDM and hypertension were positively associated with stillbirth[19]. This contrasts with our study, which found no significant correlation between hypertension and stillbirth or GDM and stillbirth. The study on Iranian women was multi-center and thus had a large population size; this may be the reason behind the different outcomes observed between the studies. Similarly, a systematic review of a large population of women with GDM found that BMI, history of GDM and family history of T2DM are significantly correlated with incidence of GDM[20]. Our study did find that a family history of T2DM and a history of GDM are co-related with incidences of GDM. However, it did not find any association between BMI and GDM.

Glucose intolerance leads to GDM, and fasting blood glucose can be a good predictor. In this line of thought, a study in the Chinese population on pregnant women in their first trimester found that FBG can predict GDM with a sensitivity of 64.29%, specificity of 56.45%, and a *P* value of less than 0.05[21]. Although our study did not find any direct correlation between FBG in the first trimester and GDM, we found a weak association, although non-significant ($P = 0.088$), between levels of FBG and the incidence of GDM. Another study of 22,398 singleton pregnancies in the first trimester also found that FBG is an independent predictor of GDM regardless of whether the OGTT was normal or high. Interestingly, this study also found that high FBG in the first trimester was associated with an increased risk of macrosomia, large for gestational age (LGA) and pregnancy-induced hypertension (PIH)[22]. In contrast, another study found that OGTT was a better predictor of GDM in the first trimester than FBG or HbA1c independently[23]. These differences may arise due to different population sizes, inclusion or exclusion of older women and ethnicity.

Our study used impaired fasting glucose and impaired glucose tolerance as a predictive biomarker for GDM. Although several other studies have used FBG, HbA1c, OGTT or other markers to find the incidence of GDM, they have inherent drawbacks of maternal and prenatal safety, increased cost, and complex process, to name a few[21–23]. Our study results can thus be easily implemented into clinical practice. Moreover, our study included all Saudi pregnant women irrespective of their ethnicity, lifestyle choices and socio-economic status; thus, it is representative of the total population. Briefly, the results of our study can be applied to a larger population. However, our study has a few limitations, such as inaccuracies, recall and sampling bias, as this is a retrospective study[24]. Additionally, the period of our study was one year and thus, long-term follow-up, whether GDM leads to T2DM in mothers, and whether other genetic, epigenetic or environmental factors have any role in GDM could not be studied.

Conclusion

In summary, this study aimed to examine potential risk factors and complications associated with GDM. Additionally, it aimed to establish the diagnostic performance of a past history of GDM and IFG or IGT as a screening technique for GDM. Results indicated that IFG/IGT and a history of GDM were significant predictors of GDM. Additionally, a family history of DM increased the likelihood of GDM. Conversely, healthy individuals

Table 6

Predictors of GDM.

							95% CI for Exp (B)	
	B	SE.	Wald	df	Sig.	Exp (B)	Lower	Upper
IFG or IGT	1.491	0.494	9.093	1	0.003	4.441	1.685	11.705
Past history of GDM	1.544	0.373	17.112	1	< 0.001	4.685	2.254	9.739
Constant	−1.166	0.170	47.213	1	< 0.001	.312		

Binary logistic regression.
GDM, gestational diabetes mellitus; Exp, experiment; IFG, impaired fasting glucose; IGT, impaired glucose tolerance; Sig., significance.

had a lower risk of developing GDM. The study did not observe any notable correlation between GDM and hypertension or polycystic ovarian syndrome. Lastly, the study found a weak but insignificant connection between FBG levels during the first trimester and the incidence of GDM.

Ethical approval

Ethical approval was granted by the Institutional Review Board of King Abdullah International Medical Research Center, Jeddah, Saudi Arabis # NRJ22J/105/04.

Consent

Written informed consent was obtained from the patient for publication and any accompanying images. A copy of the written consent is available for review by the Editor-in-chief of this journal on request.

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There were no sources of funding received for the current study.

Author contribution

All authors contributed to the proposal and manuscript writing in addition to data collection and analysis.

Conflicts of interest disclosure

The authors declare no conflicts of interest.

Research Registration Unique Identifying Number (UIN):

In accordance with the declaration of Helsinki, this study was registered in clinical trial organization: https://www.clinicaltrials.gov/ with a unique identifying number which is NCT06109597.

Guarantor

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Data availability statement

Yes available.

Provenance and peer review

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