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Original Research Article

DETERMINATION OF RELATIONSHIP BETWEEN 1ST TRIMESTER HBA1C LEVELS AND EARLY DIAGNOSIS OF GDM

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ABSTRACT

Background: Gestational diabetes mellitus (GDM) is a common metabolic disorder with significant maternal and foetal effects. Early identification of this condition remains challenging. This study aimed to evaluate whether first-trimester HbA1c levels can predict GDM and serve as an early screening tool before routine glucose testing. **Materials and Methods:** This prospective cohort study included 200 pregnant patients who were < 14 weeks of gestation. Baseline demographic and clinical data were also recorded. First-trimester HbA1c levels were measured. Patients underwent routine screening with OGCT and OGTT later during pregnancy. Maternal and neonatal outcomes were also documented. The relationship between early HbA1c levels and subsequent GDM diagnosis, along with the associated risk factors and outcomes, was assessed. **Results:** GDM occurred in 26% of the patients. Higher HbA1c levels were associated with increased GDM rates (8.5% in the lowest to 75% in the highest HbA1c category) and earlier diagnosis, with early detection rates rising from 25% (HbA1c <5.0%) to 100% (HbA1c ≥5.6%). An HbA1c level of ≥5.2% showed a sensitivity of 65.4% and specificity of 81.1%. Patients with GDM had higher age (30.2 vs. 27.3), BMI (25.1 vs. 22.6), FBG (91.2 vs. 84.8), HbA1c (5.4 vs. 4.8), and birth weight (3298 vs. 3092) ($p<0.05$). HbA1c was correlated with BMI ($r=0.448$) and FBG ($r=0.402$). The adjusted OR for HbA1c was 2.12. The combined model showed the highest AUC (0.892). GDM was associated with previous GDM (30.8%), family history (42.3%), and BMI ≥25 (50%). **Conclusion:** First-trimester HbA1c level is a useful early predictor of GDM and may aid in early risk stratification and screening, particularly in high-risk patients. When combined with clinical risk factors, the predictive performance improved further, supporting its integration into a composite early screening model.

INTRODUCTION

Gestational Diabetes Mellitus (GDM) is defined as glucose intolerance that was not previously diagnosed before pregnancy but manifests through insulin resistance and insufficient β-cell function due to placental hormones. GDM poses a threat to the well-being of both the mother and foetus and is a worldwide issue.[1,2] The prevalence of GDM is between 1% and 28%, depending on the criteria used, ethnicity, and lifestyle, with an average rate of 14% of pregnancies and 18 million births per year.[1] Obesity, delayed childbirth age, and inactive lifestyles contribute to GDM and are linked to complications. Maternal risks include preeclampsia, hypertensive disorders, and caesarean delivery due to hyperglycemia.[2-4] Women who have GDM have a seven- to tenfold risk of developing type 2 diabetes mellitus and cardiovascular diseases in the future.[2,3] Foetuses have a risk of being macrosomia, experiencing birth trauma, and neonatal hypoglycemia.[4]

Offspring tend to be obese and suffer from metabolic syndrome and type 2 diabetes, thereby repeating a cycle of metabolic disorders as a result of foetal programming.[2,5] GDM becomes more common, which poses many public health issues, especially for countries with fewer resources.[6] It does not only affect pregnant women, necessitating early detection and treatment of this problem. This issue is difficult to diagnose due to the lack of clear symptoms and screening guidelines.[1] Screening relies on glucose-based tests in the late second trimester (24-28 weeks). Screening and diagnosis of GDM are commonly performed using the 75 g Oral Glucose Tolerance Test (OGTT) as per IADPSG/WHO criteria, typically between 24–28 weeks of gestation.[7] However, this testing approach has certain drawbacks because of the time spent on screening.[8]

The OGTT has poor compliance due to fasting, multiple blood draws, and discomfort, reducing uptake, and the lack of consistent diagnostic standards makes standardisation difficult.[9,10] There is increasing evidence that metabolic alterations associated with GDM begin earlier than traditional screening methods. Research has found early insulin resistance, adipokine modulation, and metabolic abnormalities in individuals who are eventually diagnosed with GDM.[7,11] Markers of inflammation, placental activity, and protein expression can be used to predict GDM during early gestation.8 Existing screening strategies emphasise the assessment of glucose levels in late pregnancy, failing to take advantage of the possibility of early interventions. HbA1c may serve as an early biomarker as it measures glucose levels in plasma over a period of 8-12 weeks.[7,12] It may detect early metabolic disturbances due to insulin resistance and β-cell dysfunction, identifying glycaemic abnormalities before OGTT detection.

The predictive value of the first-trimester HbA1c level remains questionable, as there have been associations between an increased level of HbA1c in early pregnancy and GDM in later periods, recommending cutoff points between 5.5% and 6%.[13,14] An increased HbA1c level is associated with poor pregnancy outcomes, despite no GDM presence.[15] Other studies report limited predictive value of HbA1c, by sensitivity, specificity, and varying thresholds because of population diversity and differences in criteria.[16,17] Pregnancy-related physiological processes, including changes in erythrocyte turnover rate and iron metabolism, might influence the HbA1c concentration, and significant literature gaps remain.[7]

Only limited data exist on the utility of first-trimester HbA1c levels before week 14 through reliable ROC analysis to determine the optimal cut-off value. The sensitivity and specificity can differ among populations, thus limiting generalisability.[18,19] Integrating HbA1c with maternal risk factors such as BMI, age, and familial diabetes history has not been standardised; however, combining these variables increases prediction accuracy.[20] Early detection of GDM is critical because changes in metabolism occur even before the onset of testing. These changes affect the proper functioning of the placenta and foetal growth. Detecting at-risk pregnancies in the first trimester could enable timely interventions and reduce adverse maternal and neonatal outcomes. Although OGCT and OGTT are the standards, their late application limits early risk stratification.

Aim:

This study aimed to determine whether first-trimester HbA1c levels could be used to predict gestational diabetes mellitus earlier for detection purposes and to examine whether HbA1c could serve as a screening tool for higher-risk pregnancies prior to people receiving a routine OGCT screening.

MATERIALS AND METHODS

This prospective observational cohort study was conducted in 200 pregnant women attending the Department of Obstetrics and Gynecology at KAPV Medical College over a period of 12 months. Ethical approval was obtained from the Institutional Ethics Committee, and written informed consent was obtained from all participants before the study initiation.

Inclusion and Exclusion criteria

This study included pregnant women aged 18-45 years with singleton pregnancies, less than 14 weeks of gestation confirmed by ultrasound, and who consented to participate. Women with pre-gestational diabetes mellitus (type 1 or type 2), haemoglobinopathy or anaemia (haemoglobin <10 g/dL), multiple gestation, chronic diseases affecting glucose metabolism such as Cushing’s syndrome or polycystic ovary syndrome with insulin resistance, those on medications affecting glucose levels such as steroids or metformin, and those with incomplete follow-up were excluded from the study.

Materials

The materials used in the study included standardised laboratory equipment for HbA1c estimation using a high-performance liquid chromatography (HPLC)-based assay, appropriately sized syringes, vacutainers, and standard antenatal monitoring equipment.

Methods

Two hundred pregnant women were recruited through consecutive sampling before 14 weeks of gestation. Baseline demographic and clinical data, including age, body mass index, obstetric history, and family history of diabetes, were recorded. First-trimester HbA1c levels were measured using a standardised high-performance liquid chromatography (HPLC)-based assay. All participants underwent an early oral glucose challenge test (OGCT) between 12–16 weeks of gestation where clinically indicated, followed by routine confirmatory screening at 24–28 weeks using a 75 g OGTT according to the IADPSG/WHO criteria. The relationship between first-trimester HbA1c levels and GDM diagnosis at both screening time points was evaluated. The relationship between first-trimester HbA1c levels and subsequent gestational diabetes mellitus diagnosis was evaluated.

Statistical Analysis

Data are presented as mean, standard deviation, frequency, and percentage. Continuous variables were compared using the unpaired t-test, while categorical variables were compared using the Chi-square or Fisher's exact test. The correlation between continuous variables was assessed using Pearson's correlation coefficient. ROC curve analysis was used to evaluate the diagnostic performance. Multivariate analysis used logistic regression to adjust for confounding factors. Statistical significance was set at P<0.05, and analyses were performed using IBM SPSS statistics version 21.0 (IBM SPSS Science Inc., Chicago, IL, USA).

RESULTS

Most patients were 25–29 years old (41.5%), followed by <25 years (25%), 30–34 years (23%), and ≥35 years (10.5%) of age. Most had a normal BMI (65%), followed by overweight (24.5%), obese (8.5%), and underweight (2%) status. Most participants were married (95.5%) and had regular menstrual cycles (86%). Sedentary lifestyle was common (42%), followed by light (29%) and moderate (20%) activities.

Most patients did not develop GDM (74%), and 26% were diagnosed with GDM. Early OGCT was performed in 90% of patients, and 67.5% had negative results. OGTT at 24–28 weeks showed 70.5% negative and 26% positive results. Vaginal delivery was more common (66.5%) than LSCS (33.5%). Most patients did not have macrosomia (92.5%), NICU admission (90%), neonatal hypoglycaemia (91.5%), preeclampsia (92.5%), or polyhydramnios (89.5%). The largest HbA1c category was <5.0% (47%), followed by 5.0–5.2% (34.5%), 5.3–5.5% (14.5%), and ≥5.6% (4%). [Table 1]

Table 1: Distribution of Demographic Characteristics, Clinical Parameters, and Pregnancy Outcomes among Patients

		N (%)
Age group	<25	50 (25%)
	25-29	83 (41.5%)
	30-34	46 (23%)
	≥35	21 (10.5%)
BMI	Underweight	4 (2%)
	Normal	130 (65%)
	Overweight	49 (24.5%)
	Obese	17 (8.5%)
Marital status	Married	191 (95.5%)
	Single	9 (4.5%)
Menstrual history	Regular	172 (86%)
	Irregular	28 (14%)
Physical activity	Sedentary	84 (42%)
	Light	58 (29%)
	Moderate	40 (20%)
	Active	18 (9%)
GDM diagnosis	Yes	52 (26%)
	No	148 (74%)
Early OGCT done	Yes	180 (90%)
	No	20 (10%)
Early OGCT result	Positive	45 (22.5%)
	Negative	135 (67.5%)
	Not done	20 (10%)
OGTT (24-28 weeks)	Positive	52 (26%)
	Negative	141 (70.5%)
	Not done	7 (3.5%)
Mode of delivery	Vaginal	133 (66.5%)
	LSCS	67 (33.5%)
Macrosomia	Yes	15 (7.5%)
	No	185 (92.5%)
NICU admission	Yes	20 (10%)
	No	180 (90%)
Neonatal hypoglycaemia	Yes	17 (8.5%)
	No	183 (91.5%)
Preeclampsia	Yes	15 (7.5%)
	No	185 (92.5%)
Polyhydramnios	Yes	21 (10.5%)
	No	179 (89.5%)
HbA1c Category	<5.0	94 (47%)
	5.0-5.2	69 (34.5%)
	5.3-5.5	29 (14.5%)
	≥5.6	8 (4%)

Patients with GDM were older (30.2 ± 4.6 years) than those without GDM (27.3 ± 4.7 years) (p<0.001). BMI was higher in patients with GDM (25.1 ± 3.1 kg/m²) than non-GDM (22.6 ± 2.9 kg/m²) (p<0.001). Fasting blood glucose was elevated in GDM patients (91.2 ± 8.4 mg/dl) compared to non-GDM patients (84.8 ± 6.8 mg/dl) (p<0.001). First-trimester HbA1c levels were higher in patients with GDM (5.4 ± 0.3%) than in those without GDM (4.8 ± 0.3%) (p<0.001). Birth weight was greater in patients with GDM (3298 ± 421 g) than in those without (3092 ± 395 g) (p=0.003). Gestational age at delivery was lower in patients with GDM (38.7 ± 1.4 weeks) than in those without GDM (39.2 ± 1.2 weeks) (p=0.028). No significant difference was found in weight gain (10.3 ± 3.1 kg vs. 10.9 ± 3.2 kg; p=0.282), haemoglobin levels (11.4 ± 1.4 g/dl vs. 11.6 ± 1.3 g/dl; p=0.402), and mean corpuscular volume (83.8 ± 7.5 fl vs. 84.2 ± 7.1 fl; p=0.749). [Table 2]

Table 2: Comparison of Patient Characteristics between Patients with and without GDM

	Mean ± SD		p-value
	GDM Yes (n=52)	GDM No (n=148)	
Age (in years)	30.2 ± 4.6	27.3 ± 4.7	<0.001
BMI (kg/m²)	25.1 ± 3.1	22.6 ± 2.9	<0.001
Weight gain (Kg)	10.3 ± 3.1	10.9 ± 3.2	0.282
FBG (mg/dl)	91.2 ± 8.4	84.8 ± 6.8	<0.001
HbA1c (%)	5.4 ± 0.3	4.8 ± 0.3	<0.001
Haemoglobin (g/dl)	11.4 ± 1.4	11.6 ± 1.3	0.402
MCV (fl)	83.8 ± 7.5	84.2 ± 7.1	0.749
Birth weight (g)	3298 ± 421	3092 ± 395	0.003
Gestational age at delivery (weeks)	38.7 ± 1.4	39.2 ± 1.2	0.028

Patients with GDM had a higher history of previous GDM (30.8%) than those without (8.1%) (p<0.001). A positive family history of diabetes was more frequent in patients with GDM (42.3%) than in those without GDM (18.2%) (p=0.001). History of macrosomia was higher in patients with GDM (15.4%) than non-GDM (3.4%) (p=0.004). Polycystic ovary syndrome was more common in patients with GDM (26.9%) than non-GDM (11.5%) (p=0.011). More patients with GDM had BMI ≥25 (50%) than those without GDM (21.6%) (p<0.001). No significant differences were found in anaemia (34.6% vs. 29.7%; p=0.536), age ≥35 years (17.3% vs. 8.1%; p=0.064), and sedentary lifestyle (46.2% vs. 40.5%; p=0.498). [Table 3]

Table 3: Association of Clinical Risk Factors between Patients with and without GDM

	N (%)		p-value
	GDM Yes (n=52)	GDM No (n=148)	
Previous GDM	16 (30.8%)	12 (8.1%)	<0.001
Family history	22 (42.3%)	27 (18.2%)	0.001
Macrosomia history	8 (15.4%)	5 (3.4%)	0.004
PCOS	14 (26.9%)	17 (11.5%)	0.011
Anaemia	18 (34.6%)	44 (29.7%)	0.536
Age ≥35	9 (17.3%)	12 (8.1%)	0.064
BMI ≥25	26 (50%)	32 (21.6%)	<0.001
Sedentary	24 (46.2%)	60 (40.5%)	0.498

GDM cases rose with higher HbA1c levels: 8.5% for <5.0%, 26.1% for 5.0–5.2%, 55.2% for 5.3–5.5%, and 75.0% for ≥5.6% (6 GDM cases among 8 patients in this category). Early diagnosis (≤24 weeks) also increased progressively: 25.0% for <5.0%, 27.8% for 5.0–5.2%, 50.0% for 5.3–5.5%, and 100% for ≥5.6%. [Table 4]

Table 4: Distribution of GDM Cases and Early Diagnosis across HbA1c Categories

		N (%)	
		GDM cases	Early diagnosis ≤24 weeks
HbA1c Category	<5.0	8 (8.5%)	2 (25%)
	5.0-5.2	18 (26.1%)	5 (27.8%)
	5.3-5.5	16 (55.2%)	8 (50%)
	≥5.6	6 (75%)	6 (100%)

The diagnostic performance of HbA1c at different cutoffs showed a trade-off between sensitivity and specificity. At ≥4.5%, the sensitivity was 100% with no specificity, resulting in low accuracy (26%) and a Youden index of 0. Increasing the cutoff to ≥4.7% and ≥4.9% kept the sensitivity high (98.1% and 94.2%) with improved specificity (15.5% and 35.1%) and increased accuracy (35.5% and 50.5%). At ≥5.0%, the sensitivity decreased to 84.6%, whereas the specificity increased to 52.7%, with further improvement at ≥5.1% (sensitivity 75%, specificity 68.9%). The optimal balance was at ≥5.2% and ≥5.3%, both with the highest Youden index (0.47), sensitivity of 65.4% and 57.7%, and specificity of 81.1% and 89.2%. Higher cutoffs (≥5.4% to ≥5.6%) further increased specificity

(94.6% to 98.6%) but reduced the sensitivity (46.2% to 19.2%). The positive predictive value increased with higher cutoffs, whereas the negative predictive value slightly decreased. [Table 5]

Table 5: Diagnostic Performance of HbA1c Cutoff Values for Prediction of GDM

		Sens (%)	Spec (%)	PPV (%)	NPV (%)	Accuracy (%)	Youden
HbA1c Cutoff	≥4.5	100	0	26	—	26	0
	≥4.7	98.1	15.5	28.7	95.8	35.5	0.14
	≥4.9	94.2	35.1	32.9	94.5	50.5	0.29
	≥5.0	84.6	52.7	38.3	91.8	60.5	0.37
	≥5.1	75	68.9	44.3	89.5	70	0.44
	≥5.2	65.4	81.1	54.8	87	77	0.47
	≥5.3	57.7	89.2	65.2	85.7	81	0.47
	≥5.4	46.2	94.6	75	83.3	82.5	0.41
	≥5.5	36.5	97.3	82.6	81.2	82	0.34
	≥5.6	19.2	98.6	83.3	77.2	78	0.18

NPV = (—) (due to zero specificity)

Correlation analysis revealed a significant positive relationship between HbA1c levels and clinical parameters. HbA1c levels were moderately correlated with BMI (r=0.448, p<0.001) and fasting glucose (r=0.402, p<0.001), showing that higher HbA1c levels were linked to increased BMI and fasting glucose levels. A weaker correlation was reported between HbA1c and age (r=0.336, p<0.001) and birth weight (r=0.205, p=0.004). Age was also moderately correlated with BMI (r=0.444, p<0.001). [Table 6]

Table 6: Correlation between HbA1c and Selected Clinical Parameters

		r	p-value
Variables	HbA1c vs BMI	0.448	<0.001
	HbA1c vs FBG	0.402	<0.001
	HbA1c vs Age	0.336	<0.001
	HbA1c vs Birth weight	0.205	0.004
	Age vs BMI	0.444	<0.001

Multivariate analysis identified factors independently associated with GDM. HbA1c significantly increased the likelihood of GDM (adjusted OR 2.12, 95% CI: 1.58–2.84; p<0.001). Age was significant, with older age increasing the odds of GDM (adjusted OR 1.08, 95% CI: 1.01–1.16; p=0.032). A higher BMI predicted GDM (adjusted OR 1.18, 95% CI: 1.04–1.34; p=0.012). A history of GDM was strongly associated with current GDM (adjusted OR 3.78, 95% CI: 1.52–9.41; p=0.004). A positive family history of diabetes increased the risk (adjusted OR 2.41, 95% CI: 1.12–5.18; p=0.024). [Table 7]

Table 7: Multivariate Analysis of Factors Associated with GDM

	Adjusted	p-value
HbA1c	2.12 (1.58–2.84)	<0.001
Age	1.08 (1.01–1.16)	0.032
BMI	1.18 (1.04–1.34)	0.012
Previous GDM	3.78 (1.52–9.41)	0.004
Family history	2.41 (1.12–5.18)	0.024

The combined model showed the highest diagnostic performance, with an AUC of 0.892, sensitivity of 84.6%, and specificity of 81.1%. It achieved the highest negative predictive value (92.3%) and a high positive predictive value (64.7%). HbA1c alone had an AUC of 0.821, sensitivity of 65.4%, and specificity of 81.1%, with a high negative predictive value (87.7%). The clinical model had a lower AUC of 0.756, with higher sensitivity (73.1%) but lower specificity (71.6%) and positive predictive values (48.7%). The HbA1c with fasting blood glucose model improved performance (AUC 0.847) compared to HbA1c alone, with balanced sensitivity (78.8%) and specificity (79.7%). The risk score model showed good predictive accuracy (AUC 0.863), with a sensitivity of 80.8% and specificity of 83.8%. [Table 8]

Table 8: Comparison of Predictive Models for Detection of GDM

	AUC	Sens (%)	Spec (%)	PPV (%)	NPV (%)
HbA1c	0.821	65.4	81.1	63	87.7
Clinical	0.756	73.1	71.6	48.7	87.6
Combined	0.892	84.6	81.1	64.7	92.3
HbA1c + FBG	0.847	78.8	79.7	59.4	90.8
Risk score	0.863	80.8	83.8	65.6	91.9

Subgroup analysis showed HbA1c's predictive performance varied across patient categories. High-risk patients had the highest GDM prevalence (41.4%) and diagnostic performance (AUC 0.85) at ≥5.1%. Low-risk patients had a lower GDM prevalence (4.8%) and predictive performance (AUC 0.72) at ≥4.9%. Patients aged ≥30 years had a GDM prevalence of 35.8%, with a predictive ability (AUC 0.83) at ≥5.2%. Patients with BMI ≥25 had the highest GDM prevalence (46.6%) and predictive performance (AUC 0.87) at ≥5.2%. [Table 9]

Table 9: Diagnostic Performance of HbA1c Cutoff Values for Prediction of GDM

		N	GDM %	AUC	Cutoff
Subgroup analysis	High-risk	116	41.4	0.85	≥5.1
	Low-risk	84	4.8	0.72	≥4.9
	Age ≥30	67	35.8	0.83	≥5.2
	BMI ≥25	58	46.6	0.87	≥5.2

A comparison of the screening strategies showed differences in diagnostic performance. Universal screening (≥4.8) included all 200 patients and detected all 52 GDM cases, achieving 100% sensitivity and 0% specificity. Selective screening (≥5.0) reduced the number of screened patients to 106, detecting 44 cases with 84.6% sensitivity and 58.1% specificity. Targeted screening (≥5.2) further reduced the number of screened patients to 54, detecting 34 cases with a sensitivity of 65.4% and the highest specificity (86.5%). [Table 10]

Table 10: Comparison of Screening Strategies for Detection of GDM

		Screened	Detected	Sens (%)	Spec (%)
Strategy	Universal ≥4.8	200	52	100	0
	Selective ≥5.0	106	44	84.6	58.1
	Targeted ≥5.2	54	34	65.4	86.5

DISCUSSION

Our study assessed first-trimester HbA1c levels as an early GDM predictor and found a significant link between elevated HbA1c levels and GDM development. In this population, 26% developed GDM, while 74% remained normoglycaemic. Most patients were aged 25-29 years (41.5%) with normal BMI (65%), reflecting a low-to-moderate risk. However, those with GDM were older (30.2 ± 4.6 vs. 27.3 ± 4.7 years, $p<0.001$) and had a higher BMI (25.1 ± 3.1 vs. 22.6 ± 2.9 kg/m², $p<0.001$), consistent with risk profiles. These findings align with a meta-analysis by Ayele et al., identifying age >30 years (AUC 0.60), BMI (AUC 0.65), and previous GDM (AUC 0.73) as predictors, with combined models achieving AUC up to 0.88.[21]

The distribution of HbA1c values in our study showed that the majority of patients had HbA1c <5.0% (47%), followed by 5.0-5.2% (34.5%), 5.3-5.5% (14.5%), and ≥5.6% (4%). Importantly, a progressive increase in GDM incidence was observed with increasing HbA1c levels, demonstrating a dose–response relationship. This trend is consistent with the previous literature, indicating that increasing HbA1c levels reflect worsening glycaemic status, even in early pregnancy. A key finding was higher first-trimester HbA1c levels in patients who developed GDM (5.4 ± 0.3%) than in those who did not (4.8 ± 0.3%) ($p<0.001$). This aligns with Hinkle et al., where HbA1c levels were higher in GDM cases (5.3 ± 0.3%) compared to controls (5.1 ± 0.3%) ($p\leq0.001$), with each 0.1% increase linked to a 22% increased GDM risk.[22] Similarly, Sun et al. reported higher HbA1c in GDM patients (5.23 ± 0.29% vs 5.06 ± 0.28%, $p<0.05$), supporting HbA1c as an independent early risk marker.[23]

Our study identified an optimal HbA1c cutoff of approximately 5.2–5.3%, balancing sensitivity and specificity. Desai et al. found a 5.3% cutoff with 69.6% sensitivity, 77.2% specificity, and an AUC of 0.82.[24] Sahoo et al. reported a slightly higher cutoff of ≥5.54% with 88% sensitivity, 82% specificity, and an AUC of 0.894.[25] Cutoff variations likely reflect differences in population characteristics, GDM prevalence, and diagnostic criteria. Supporting these findings, a systematic review by Kattini et al. showed HbA1c levels >5.7% consistently associated with increased GDM risk, while >6.0% identified nearly all cases but with reduced screening sensitivity.[26] Brancazio et al. reported patients with HbA1c levels between 5.7%–6.4% had higher GDM incidence (68.5% vs 13.8%, $p<0.00001$), with an odds ratio of 14.12 and AUC of 0.75, indicating strong predictive capability at higher thresholds.[27]

Our study shows that HbA1c alone may not suffice as a diagnostic tool, but are better with clinical risk factors. This aligns with Ayele et al.'s meta-analysis, indicating that combining factors such as age, BMI, and family history improves predictive accuracy (AUC up to 0.88).[21] Hinkle et al. also showed that HbA1c enhances prediction beyond traditional risk factors, supporting early screening.[22] Regarding pregnancy outcomes, our study found higher birth weight in GDM patients (3298 ± 421 g vs. 3092 ± 395 g, $p=0.003$) and lower gestational age at delivery (38.7 ± 1.4 vs. 39.2 ± 1.2 weeks, $p=0.028$). These findings agree with Kattini et al., linking elevated HbA1c with adverse outcomes like macrosomia, preeclampsia, and cesarean delivery.[26]

CONCLUSION

This study showed that first-trimester HbA1c levels predict the development (GDM). Higher HbA1c levels were correlated with increased GDM incidence, earlier diagnosis, and higher risk of adverse outcomes. An HbA1c cut-off of ≥5.2% provided a balanced diagnostic performance with moderate sensitivity and good specificity. First-trimester HbA1c levels were also aligned with key risk factors and were better predictors than conventional clinical parameters. Its early use may aid in early risk stratification and support timely intervention in high-risk pregnancies. Incorporating HbA1c levels into early pregnancy assessments could enhance diagnosis and outcomes. Further large-scale studies are required to validate these results and guide recommendations.

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