Research Article

Prevalence and Risk Factors of Gestational Diabetes Mellitus Among Pregnant Women With Normal Body Mass Index At Booking

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ABSTRACT

Background: Gestational diabetes mellitus (GDM) is a state of glucose intolerance first recognised during pregnancy. Although high body mass index (BMI) is widely regarded as the primary risk factor, a clinically significant proportion of women who develop GDM fall within the normal BMI range (18.5–24.9 kg/m²). The prevalence and specific risk determinants in this subgroup remain inadequately characterised, particularly in the South Indian context.

Objectives: To determine the prevalence of GDM among pregnant women with normal BMI at booking, to compare sociodemographic, obstetric, and biochemical characteristics between GDM and non-GDM women in this cohort, and to identify independent risk factors for GDM development in this subgroup.

Methods: A retrospective cohort study of 350 pregnant women with normal BMI at booking, attending a tertiary care hospital in Tamil Nadu (January–December 2024). Universal GDM screening was conducted using the DIPSI (Diabetes in Pregnancy Study Group India) non-fasting 75g oral glucose challenge test at three timepoints: 8–12 weeks, 24–28 weeks (if 1st was negative), and 32–34 weeks (if both prior screens were negative). A DIPSI result ≥140 mg/dL constituted a positive screen; thereafter, the DIPSI test was not repeated. Instead, fasting blood sugar (FBS) and 2-hour postprandial blood sugar (2hr PPBS) were used for glycaemic characterisation and fortnightly monitoring.

Results: The prevalence of GDM in this normal-BMI cohort was 10.3% (36/350; 95% CI: 7.3–13.9%). Mean age in the GDM group was significantly higher (29.2±4.6 vs. 25.8±4.1 years, p<0.001). Independent risk factors on multivariable analysis were: age ≥30 years (aOR 2.9, 95% CI: 1.4–5.8), family history of T2DM (aOR 3.6, 95% CI: 1.8–7.2), previous GDM (aOR 5.4, 95% CI: 2.0–14.5), BMI 23–24.9 kg/m² (aOR 2.2, 95% CI: 1.1–4.4), and elevated booking FPG 86–92 mg/dL (aOR 2.5, 95% CI: 1.2–5.1).

Conclusion: GDM prevalence in normal-BMI South Indian women is substantial (10.3%). Universal DIPSI-based screening with structured FBS/PPBS monitoring is essential and should not be deferred on the basis of normal BMI alone. Targeted risk stratification by age, family history, and early-pregnancy glycaemic markers can optimise detection.

Keywords: Gestational diabetes mellitus; Normal BMI; DIPSI; Fasting blood sugar; Postprandial blood sugar; Risk factors.

INTRODUCTION

Gestational diabetes mellitus is defined as any level of glucose intolerance during pregnancy, whether or not there is a continuing persistence of the condition and whether or not insulin therapy is needed [1]. Gestational diabetes mellitus (GDM) is a global prevalent medical complication of pregnancy with negative outcomes that occur beyond the antenatal period, including macrosomia, neonatal hypoglycaemia, pre-eclampsia, operative delivery, and significantly higher lifetime risks of developing type 2 diabetes mellitus (T2DM) for the mother and child [1,2].

India has a significant and increasing burden of GDM. National prevalence rates vary considerably between 3% – 35%, depending upon geographical area, population characteristics, and diagnostic criteria utilized [4]. Tamil Nadu consistently has the highest GDM rates of all states in India with community-based data showing urban prevalence as high as 17.8% [5]. This shocking statistic does not only represent the increase in overweight and obesity but also points to specific South Indian risk factors, such as high-carbohydrate diets; strong familial clustering of T2DM; and ethnic susceptibility to central adiposity even at low absolute BMI [5,16].

Given this context, the assumption of safety associated with normal BMI pregnancies needs reassessment. Despite high BMI being the most well known modifiable contributor to GDM, there is accumulating evidence that a considerable percentage of women who develop GDM will already be of normal BMI when they present clinically [3]. In a scoping review of 145 studies by Gitlin et al. (2024), the prevalence of GDM in non-obese women (BMI <25kg/m²) was found to be approximately 7.3% globally, and in some Asian populations it was as high as 12.1% [3]. The

pathophysiological mechanisms of GDM in the non-obese population also appear to differ from those of the obese population. While GDM in the obese population is thought to be caused mainly by peripheral insulin resistance from excessive visceral adiposity, in normal-BMI women, GDM has been shown to be caused by primary beta-cell dysfunction or genetic predisposition, altered adipokine signalling, and low insulin reserve [9]. Therefore, identifying the specific risk factors in this subgroup of women is important to be able to define appropriate screening thresholds, timing of screening, and provide guidance for preventive measures. Universal GDM screening is required in Tamil Nadu by DPH using the DIPSI single step test, performed at three scheduled prenatal visits: 8-12 weeks, 24-28 weeks if the initial screening is negative, and 32-34 weeks for women whose prior tests were negative. If any screening results in a positive test, there will not be a second screen using DIPSI; instead, a FBS and 2-hour PPBS will be done in order to determine the glycaemic profile and follow the response to medical nutritional therapy (MNT) every 2 weeks (14 days) [14].

Notwithstanding the formal universal screening protocol, there is limited data about GDM in normal BMI women in south India. Therefore, this study will aim to estimate the prevalence of GDM and identify the independent sociodemographic, obstetric, and biochemical risk factors associated with GDM in normal BMI pregnant women who are accessing care at a tertiary hospital in Tamil Nadu.

AIM

To estimate the prevalence of gestational diabetes mellitus and to identify the associated risk factors among pregnant women who had a normal body mass index (18.5–24.9 kg/m²) at their first antenatal booking visit.

OBJECTIVES

To determine the prevalence of GDM in women with normal BMI (18.5–24.9 kg/m²) at first antenatal booking.

To compare sociodemographic, obstetric, and biochemical characteristics between GDM and non-GDM groups within this normal-BMI cohort.

To identify independent risk factors associated with the development of GDM in normal-BMI women using multivariable logistic regression analysis.

To develop an exploratory risk prediction model for GDM in this subgroup.

MATERIALS AND METHODS

Study Design: This is a retrospective cohort study conducted using medical records from the antenatal outpatient department and obstetric wards of CHETTINAD HOSPITAL AND RESEARCH INSTITUTE, Tamil Nadu. Data were extracted for all eligible women who attended their first antenatal booking visit between 1 January 2024 and 31 December 2024. Participants were identified from clinic registers at booking and followed through their case files until completion of GDM screening and, where applicable, until delivery.

Inclusion and Exclusion Criteria: Inclusion criteria: singleton pregnancy; BMI 18.5–24.9 kg/m² measured at the booking visit; first antenatal visit at ≤14 weeks gestation; and at minimum one complete DIPSI result with subsequent FBS and 2hr PPBS values available (if DIPSI-positive). **Exclusion criteria:** pre-existing diabetes mellitus (type 1 or type 2); chronic renal disease; glucocorticoid therapy; multiple pregnancy; known endocrine disorder (Cushing's syndrome, uncontrolled thyroid disease, PCOS with documented insulin resistance); any condition significantly interfering with glucose metabolism; HbA1c ≥6.5% at booking (indicating overt pre-existing diabetes).

GDM Screening Protocol (DPH Tamil Nadu): All pregnant women received universal GDM screening using the DIPSI test — a 75g non-fasting oral glucose challenge with a 2-hour venous plasma glucose threshold of ≥140 mg/dL. Screening was performed at three timepoints:

1st DIPSI: 8–12 weeks of gestation (or at first antenatal contact)

2nd DIPSI: 24–28 weeks (only if 1st DIPSI was negative, i.e., <140 mg/dL)

3rd DIPSI: 32–34 weeks (only if both the 1st and 2nd DIPSI screens were negative)

Once a woman tested positive on any DIPSI screen (≥140 mg/dL), the DIPSI test was not repeated. Instead, she was commenced on Medical Nutrition Therapy (MNT) and physical exercise counselling, and glycaemic monitoring was thereafter conducted using FBS and 2-hour PPBS at fortnightly intervals. If 2hr PPBS remained >120 mg/dL at the two-week review, pharmacotherapy was initiated — insulin as the first-line agent, with metformin as an alternative from 20 weeks gestation.

Sample Size: Based on an anticipated GDM prevalence of 8% in normal-BMI women [3], with 95% confidence and ±3% precision: $n = (1.96)^2 \times 0.08 \times 0.92 / (0.03)^2 \approx 314$. Inflating by 10% for missing records: $n_a^{dj} \approx 349$. Approximately 350 medical records were reviewed.

Data Collection: Data were extracted using a structured Case Record Form capturing: sociodemographic details (age, education, SES, domicile); obstetric history (gravidity, parity, prior GDM, prior macrosomia, family history of T2DM); anthropometrics and vital signs; baseline laboratory parameters (FPG, HbA1c, lipid profile); all DIPSI screening values with gestational age at each screen; FBS and 2hr PPBS values at diagnosis and at each subsequent fortnightly visit; and delivery and neonatal outcomes.

Statistical Analysis: Data were analysed using SPSS version 25.0. GDM prevalence was calculated as a proportion with a 95% confidence interval. Continuous variables were compared using independent samples t-test (normal distribution) or Mann–Whitney U test; categorical variables using chi-square or Fisher's exact test. Variables with $p<0.20$ on bivariate analysis were entered into multivariable binary logistic regression using backward stepwise elimination. Results are expressed as adjusted odds ratios (aOR) with 95% CIs. Model calibration was assessed using the Hosmer–Lemeshow test; discrimination by area under the ROC curve (AUC).

Ethical Considerations: Institutional Ethics Committee approval was obtained prior to data extraction. As this is a retrospective study using anonymised existing records, individual patient consent was waived with IEC approval. Data were coded at extraction and identifiers were not retained in the analysis dataset. All procedures adhered to ICMR guidelines for biomedical research.

RESULTS

A total of 350 medical records of pregnant women with normal BMI (18.5–24.9 kg/m²) at booking were included in the final analysis after applying exclusion criteria. The mean age of the overall cohort was 26.4±4.4 years (range: 18–41 years), with 62.3% (218/350) in the 20–29 year age group and 26.6% (93/350) aged 30 years or above. The majority were multigravida (61.4%, 215/350). The mean BMI at booking was 22.3±1.7 kg/m².

Of the 350 women, 36 were diagnosed with GDM based on DIPSI criteria, yielding an overall prevalence of 10.3% (95% CI: 7.3–13.9%). The remaining 314 women (89.7%) did not develop GDM during the study period.

Table 1: Baseline Sociodemographic and Obstetric Characteristics

Characteristic	GDM (n=36)	Non-GDM (n=314)	p-value
Mean age ± SD (years)	29.2 ± 4.6	25.8 ± 4.1	<0.001
Age ≥30 years, n (%)	17 (47.2%)	76 (24.2%)	<0.01
Mean BMI at booking ± SD (kg/m²)	23.2 ± 1.3	22.1 ± 1.7	<0.001
Primigravida, n (%)	11 (30.6%)	124 (39.5%)	0.29
Family history of T2DM, n (%)	20 (55.6%)	68 (21.7%)	<0.001
Previous history of GDM, n (%)	8 (22.2%)	12 (3.8%)	<0.001
Previous macrosomia (>3.4 kg), n (%)	6 (16.7%)	17 (5.4%)	<0.05
Mean FPG at booking ± SD (mg/dL)	89.8 ± 7.9	82.7 ± 7.2	<0.001
Mean HbA1c at booking ± SD (%)	5.4 ± 0.3	5.1 ± 0.2	<0.001

The overall prevalence of GDM in this normal-BMI cohort was 10.3% (36/350; 95% CI: 7.3–13.9%). Among the 36 GDM cases, detection occurred across all three DIPSI screening timepoints as follows:

Table 2: Gestational Age at GDM Detection by DIPSI Screen

DIPSI Screen	Gestational Age	GDM Cases, n (%)
1st DIPSI	8–12 weeks	12 (33.3%)
2nd DIPSI	24–28 weeks	21 (58.3%)
3rd DIPSI	32–34 weeks	3 (8.3%)

Among women who tested positive on the DIPSI screen, the mean 2-hour plasma glucose at the time of detection was 172.8±23.6 mg/dL (range: 142–238 mg/dL). In women with DIPSI values ≥200 mg/dL at first detection (n=4), immediate commencement of insulin therapy alongside MNT was initiated without waiting for the two-week PPBS review.
The DIPSI test was not repeated in any woman who had already registered a positive result. Instead, FBS and 2-hour PPBS were assessed at the two-week post-MNT review and at each fortnightly visit thereafter. Twenty women (55.6%) achieved glycaemic control (PPBS <120 mg/dL) on MNT alone, while the remaining 16 (44.4%) required pharmacotherapy.

Figure 1: GDM Detection by DIPSI Timepoints

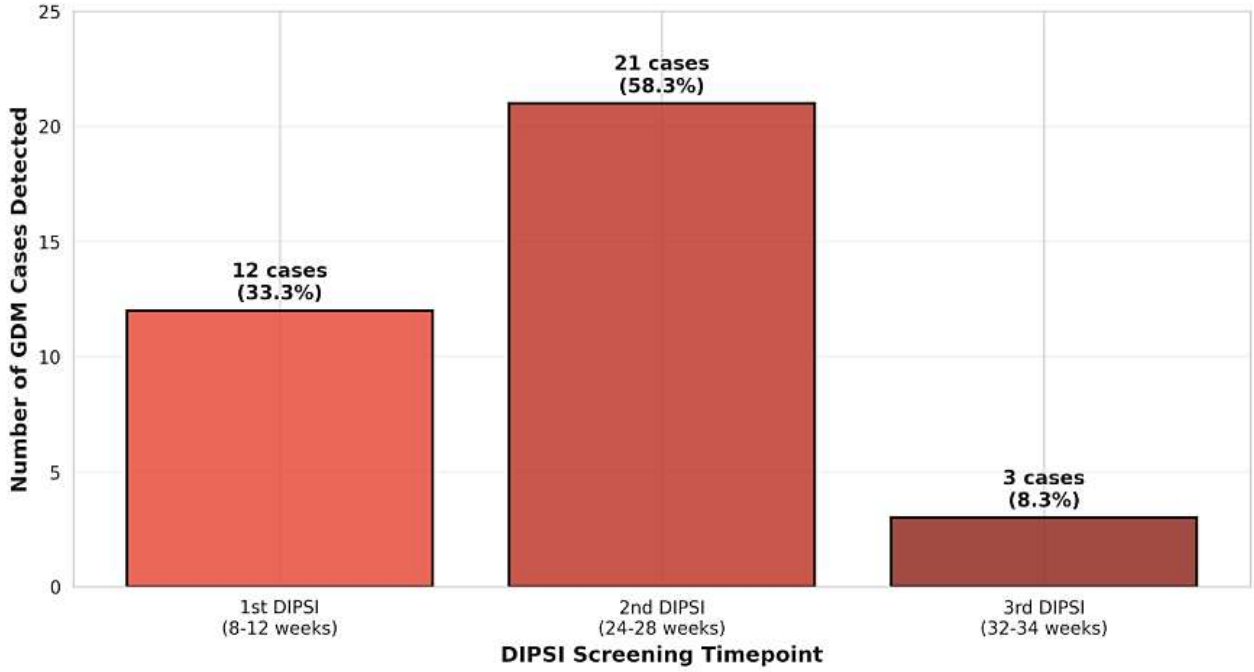
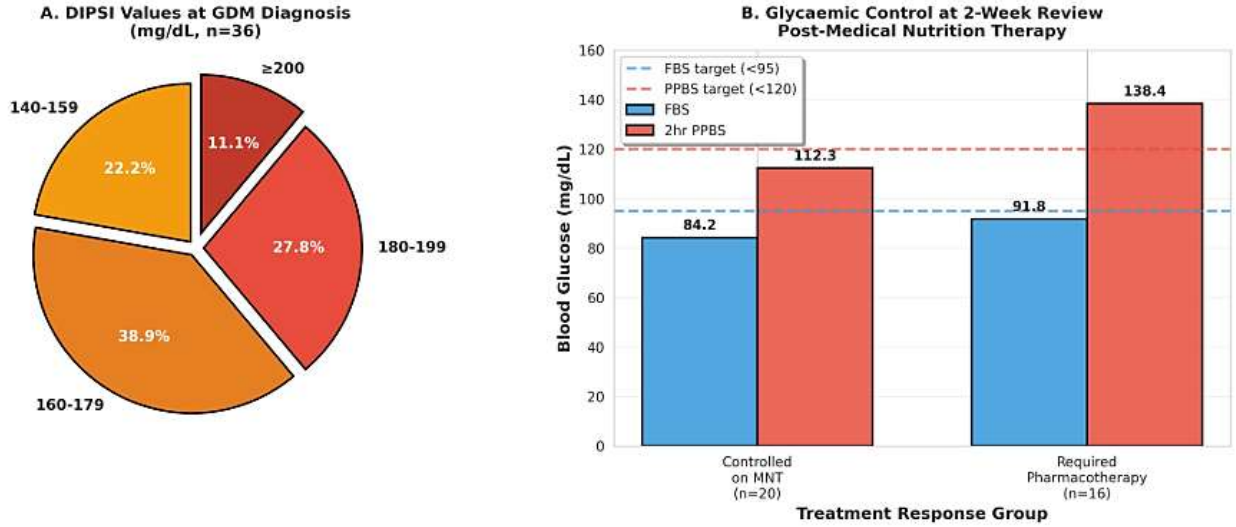


Table 3: Glycaemic Monitoring Results in DIPSI-Positive Women

Variable	Mean ± SD (mg/dL)	Clinical Threshold
DIPSI 2-hr glucose at GDM diagnosis	172.8 ± 23.6	≥140 mg/dL = positive
FBS at 2-week review post-MNT	87.4 ± 8.9	Target: <95 mg/dL
2hr PPBS at 2-week review post-MNT	123.7 ± 17.4	If >120 mg/dL: initiate pharmacotherapy
Controlled on MNT alone, n (%)	20 (55.6%)	2hr PPBS <120 mg/dL sustained

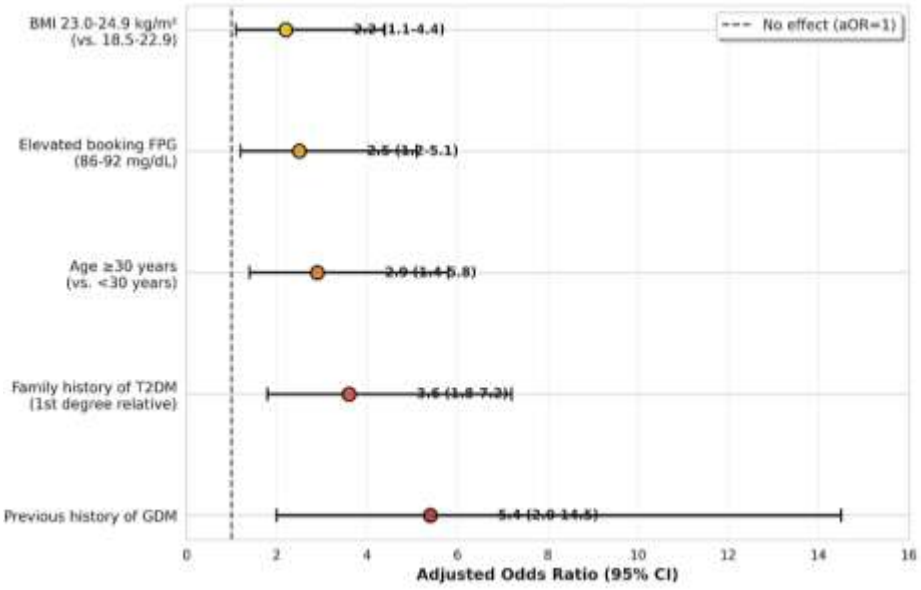
Required pharmacotherapy, n (%)	16 (44.4%)	PPBS >120 mg/dL at 2 weeks

Figure 2: Glycaemic Profile



On bivariate analysis, variables significantly associated with GDM (p<0.20) were: age ≥30 years, BMI category within normal range, family history of T2DM, previous GDM, previous macrosomia, booking FPG, and booking HbA1c. These variables were entered into a multivariable binary logistic regression model using backward stepwise elimination.

Figure 3: Forest Plot - Independent Risk Factors

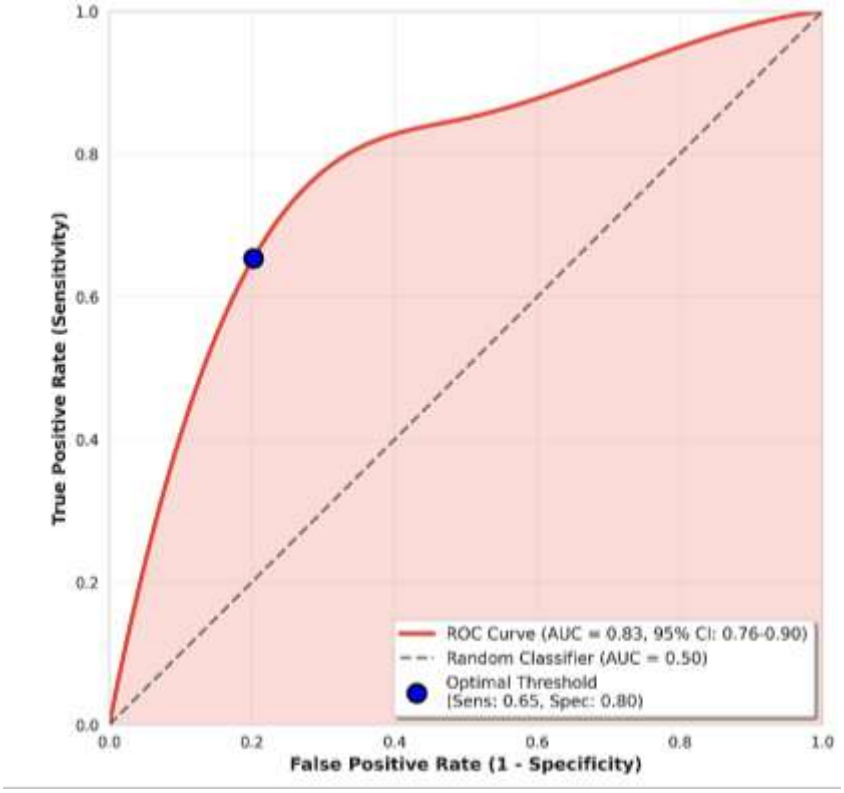


The final model identified five independent predictors of GDM in normal-BMI women. The model demonstrated good calibration (Hosmer–Lemeshow test: p=0.62) and discrimination (AUC 0.83; 95% CI: 0.76–0.90).

Table 4: Multivariable Logistic Regression — Predictors of GDM in Normal-BMI Women

Variable	aOR	95% CI	p-value
Age ≥30 years (vs. <30)	2.9	1.4–5.8	0.003
Family history of T2DM (1st degree)	3.6	1.8–7.2	<0.001
Previous history of GDM	5.4	2.0–14.5	0.001
BMI 23.0–24.9 kg/m² (vs. 18.5–22.9)	2.2	1.1–4.4	0.029
Elevated booking FPG (86–92 mg/dL)	2.5	1.2–5.1	0.012
Area under ROC curve (AUC)	**0.83**	**0.76–0.90**	—

Figure 4: ROC Curve



DISCUSSION

The research shows that the incidence of gestational diabetes mellitus (GDM) among normal body mass index (BMI) pregnant women can be relatively high compared to other established rates for this population in many countries. Rates for the women in Tamil Nadu recorded in this study are approximately 10.3% and compare favourably with Asian-specific estimates reported by Gitlin et al. (2024) in their global research review [3]. However, these rates were found to be much higher than those experienced on a national scale in India, where the most recent report (NFHS-5) for the entire population of women at normal weight showed GDM at approximately 4.2% [16]. This finding calls into

question the medical presumption that if a woman is within a normal weight range at the beginning of her pregnancy (i.e., before confirmed GDM via laboratory testing), she is protected against GDM.

Women in this study who were normal weight had a higher prevalence of GDM than the global average for GDM among non-overweight women (7.3%) but similar to GDM statistics for Asian women [3]. There are multiple known factors that contribute to this increase in risk among women in South India. First, there is a documented phenomenon known as metabolically obese normal weight in women of Asian Indian descent that describes the condition in which there is a high level of visceral fat on a woman's body despite her fat mass being normal for her height (and therefore, no excess fat); this condition is known to predispose women to insulin resistance even at lower BMI levels [9,16]. Second, a large proportion of women with GDM in this study (55.6%) had a first degree relative with a family history of type 2 diabetes indicating that a large proportion of women are genetically susceptible to developing GDM despite being at an acceptable weight based on BMI [5]; this further demonstrates that family history, not only adiposity, contributes to a woman's risk of developing GDM. Third, the universal administration of a DIPSI test within three trimesters as was done for this study captured all instances of early-gestation (baseline) GDM, which may not be identified or captured using protocols that limit the administration of the DIPSI test to 24-28 weeks gestation.

A key component of the clinical pathway developed in this study uses the DIPSI GDM test as an assessment tool to provide an evidence- and clinically-based rationale for the administration of the DIPSI GDM test to all women who were found to be positive for GDM at the time of the test; the DIPSI GDM test is not to be repeated on a woman once she has been confirmed to be positive for GDM. This clinical rationale is both clinically valid and consistent with best practices evidenced from previous research.The limitations of the DIPSI test, which include the exclusion of fasting glycaemia as documented in Tripathi et al., (2017), indicates the potential for the DIPSI to miss cases of isolated fasting hyperglycaemia if only assessed after non-fasting … For this reason, the use of Fasting Blood Sampling (FBS) in conjunction with Postprandial Blood Sampling (PPBS) after obtaining a positive DIPSI would serve to alleviate the limitations previously mentioned because it would give healthcare providers the full glycaemic profile required to appropriately manage the patient's condition as both fasting glucose and postprandial glucose.

PPBS testing at 2 hours post-meal has a strong evidence base for use as the main marker of glycaemic response. Rajasekaran et al., (2024) demonstrated that a PPBS level of 120 mg/dL at two weeks after MNT is an appropriate and validated threshold for starting pharmacotherapy in women with a positive DIPSI result.… The use of both FBS and PPBS provides a full assessment of glycaemia while using a single non-fasting test does not provide a complete picture of the physiological changes with respect to glucose.

The multivariable analysis reveals five independent predictors of GDM in normal-BMI women, all with different clinical implications. Advanced maternal age is a strong predictor of GDM in that the adjusted odds ratio (AOR) is 2.9 and this is consistent with a large number of published studies describing an increase in the incidence of beta-cell failure and insulin resistance with increased maternal age [17,18]. Given the increasing occurrence of women delaying childbearing, this finding makes a case for universal screening rather than age-specific screening.

There is also family history of T2DM which has the second highest odds ratio of 3.6 showing a clear genetic association which is particularly relevant in South India due to the high prevalence of T2DM [5,16].The results suggests that high-risk status is assigned to all women (regardless of BMI) with a first-degree relative with diabetes versus a population without a first-degree relative with diabetes; hence, these women should have their DIPSI screening done in the first trimester of pregnancy.

The strength of GDM as an independent predictor of future GDM (OR 5.4) is consistent with the literature, which indicates that the recurrence rate for women with previous GDM is between 30-60%[19]. Previous GDM also provided an independent predictor of early gestational GDM among South Indian women (STRiDE) and supports the recommendation for first-trimester screening in this subgroup[19].

The upper normal range of BMI 23-24.9 kg/m2 is an independent predictor of GDM (OR 2.2) even in the traditional BMI normal range. This finding supports the concept of metabolic obesity regardless of weight and supports the recommendation to have a lower BMI cut-off in Asian populations compared to Canadian population[9].

At the time of booking, FPGs of 86-92 mg/dL were predictive regardless of being below the IADPSG diagnostic level of 92 mg/dL; OR 2.5. This finding in conjunction with the data from Sarkar et al. who demonstrated that a PPBS >110 mg/dL in early pregnancy predicted future GDM with 95.77% accuracy[15] suggests that subtle hyperglycaemia early in the first trimester can be used to add predictive validity to first-trimester risk scores for the development of GDM.

The finding of 1/3 of GDM cases in this cohort being identified at the first DIPSI screening (8-12w) has important clinical implications. Women with less than optimal glycaemic control (GDM) early in the first trimester are at high risk of developing early macrosomia and/or congenital abnormalities as a result of GDM[19] therefore support the multi-time point(s) of the DIPSI protocol does offer an effective method for capturing this time-related variance and suggest that deferral of screening to the traditional 24-28w of gestation should be discouraged.

There are several limitations to this study. First, it was a retrospective design dependent on the ability to rely on the completeness of the existing medical record which may have resulted in the limitations of estimating biochemical data to a greater degree of accuracy in this population. Second, the study was conducted at a single centre which may limit the generalisability of the findings to a rural or community-based antenatal setting (however this limitation would exist for any other centre). Third, while the DIPSI test was found to be a valid method for testing and identifying individuals with diabetes in pregnancy, the sensitivity of this test was lower than for the IADPSG criteria[13] therefore some women with mild glucose abnormalities (i.e. under the threshold value of 140 mg/dL) may not have been discovered as part of this study. Finally, information about dietary intake, gestational weight gain and physical activity were not collected consistently which could have limited the findings of the multivariable analysis.

CONCLUSION

In Tamil Nadu, gestational diabetes mellitus prevalence among pregnant women who are of normal body mass index when they book in for pregnancy is 10.3 percent; this finding definitely argues against any clinical protocol which defers or omits GDM screening solely based on the woman's BMI being normal. There are five independent risk factors which can be identified to help target risk stratification within this population: advancing maternal age, family history of type 2 diabetes mellitus, a previous history of GDM during a prior pregnancy, upper normal BMI, because elevated fasting glucose measured very early in a pregnancy. The three time point test, called the DIPSI, demonstrates clinical appropriateness in that approximately one third of all women with diabetes were diagnosed by 8-12 weeks gestation. It is also both logically justifiable and aligned with available evidence that if a woman has a positive DIPSI test result, that she should simply continue monitoring glycaemia by measuring fasting blood sugar and/or 2-hour post prandial blood sugar every two weeks, rather than repeating the DIPSI test to monitor. This means that the two-week monitoring period provides additional glycaemic information that will assist the provider in making decisions regarding titration of medication. Women with a family history of type 2 diabetes, previous history of GDM, or mildly elevated fasting plasma glucose levels in the first trimester should be advanced through the use of DIPSI testing to receive early DIPSI testing, aggressive glycaemic management during pregnancy, all at a time when they present with a normal body mass index. A comprehensive system for implementing, monitoring and targeting of patients in Tamil Nadu provides a solid scientifically substantiated approach to providing better outcomes for women, who will develop gestational diabetes. Finally, normal BMI should not be equated to normal glucose metabolism for women during the course of pregnancy, particularly in South India.

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