Neuroendocrinology Letters Volume 47 No. 2 2026
ISSN: 0172-780X; ISSN-L: 0172-780X; Electronic/Online ISSN: 2354-4716
Web of Knowledge / Web of Science: Neuroendocrinol Lett
Pub Med / Medline: Neuro Endocrinol Lett

ORIGINAL ARTICLE

First-Trimester Fasting Blood Glucose, BMI, and Serial FBG Trajectory as Predictors of Gestational Diabetes Mellitus: A Retrospective Cohort Study.

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Submitted: 2025-07-03 Accepted: 2026-03-01 Published online: 2026-04-22

Key words: **gestational diabetes mellitus; fasting blood glucose; body mass index**

Neuroendocrinol Lett 2026; **47**(2):65–71 **PMID:** 42165792 47012601

Abstract

OBJECTIVE: To evaluate first-trimester FBG category, pre-pregnancy BMI, and serial FBG trajectory as stratified predictors of GDM in a routine-care antenatal cohort.

METHODS: Retrospective cohort of 771 women delivering at a single Chinese tertiary hospital (January–June 2013), with first-trimester FBG (<12 weeks) and 75-g OGTT at 24–28 weeks (Chinese IADPSG thresholds). GDM was diagnosed in 158 women (20.5%). Associations were analyzed by chi-square and Fisher's Exact Test (SPSS v19.0); all estimates are unadjusted.

RESULTS: First-trimester FBG supported a **two-tier**, not three-tier, risk classification: GDM incidence in the ≤4.7 and 4.7–5.1 mmol/L strata was statistically indistinguishable (14.2% vs. 18.0%; Bonferroni-corrected $p = 0.188$), while both were significantly lower than the ≥5.1 mmol/L stratum (45.9%; both $p < 0.001$; overall $\chi^2 = 58.835$, $p < 0.01$). The sole statistically supported triage cut-point is FBG ≥5.1 mmol/L. Non-decreasing FBG trajectory was the strongest predictor: 100% GDM incidence in the FBG ≥5.1 non-decreased subgroup (n = 29; 95% CI: 88–100%; $p < 0.01$) and 54.9% (95% CI: 43–67%) versus 4.2% in the FBG 4.7–5.1 stratum (n = 71 vs. 190; $p < 0.01$), yielding NPV 95.8% for a decreasing trajectory in this intermediate-risk group. BMI ≥24 kg/m² independently elevated GDM risk in women with FBG < 5.1 mmol/L ($p < 0.01$) but not in the FBG ≥5.1 stratum ($p = 0.075$, n = 34).

CONCLUSION: Non-decreasing FBG trajectory identifies high-risk subgroups missed by a single threshold, using measurements already collected in routine

prenatal care. FBG ≥5.1 mmol/L alone carries a 54.1% false-positive rate; the trajectory rule substantially refines this triage. RCTs are needed to assess early intervention benefit.

INTRODUCTION

Gestational diabetes mellitus (GDM) refers to diabetes mellitus that occurs only during pregnancy when glucose metabolism is normal before pregnancy. The incidence of GDM in China has increased markedly in recent decades and varies by diagnostic criteria and population; the study hospital's cohort reflects a GDM rate of 20.5% (158/771), consistent with rates reported in tertiary referral centers. Severe illness or poor blood glucose control has a significant impact on mothers and infants, and the near- and long-term complications are high (Yang, 2019). More clinical attention is now given to how to provide reasonable intervention to pregnant women with GDM earlier and how to make optimal use of resources.

GDM carries downstream consequences not only for the mother — including elevated risk of type 2 diabetes — but also for offspring, including altered growth trajectories, adiposity, respiratory health, and epigenetic programming (Huang *et al.* 2021; Huvinen *et al.* 2021; Nasreen *et al.* 2021; Eletri & Mitanchez, 2022; Yan *et al.* 2021; Kanney *et al.* 2022). These long-term risks underscore the clinical importance of identifying high-risk pregnancies as early as possible.

This study is a retrospective analysis of the relevant data of pregnant women undergoing systematic prenatal examination in the subject hospital. It examines GDM risk factors assessable through routine prenatal measurements to identify early risk factors that could inform targeted clinical monitoring.

DATA AND METHODS

Study Subjects

Pregnant women who intended to give birth at our hospital, after giving informed consent, established a prenatal check-up file during their pregnancy and underwent multiple examinations. The initial file establishment occurred in the early stage of pregnancy (before 12 weeks of gestation), which required a systematic evaluation of the pregnant woman's condition, including a fasting blood sugar test. For pregnant women without pre-existing diabetes, an OGTT (Oral Glucose Tolerance Test) was conducted between 24 and 28 weeks of pregnancy to diagnose whether they have gestational diabetes.

This retrospective cohort study analyzed data from 835 pregnant women who delivered at our hospital from January to June 2013 to identify early risk factors associated with GDM development. The exclusion criteria were as follows: (1) pregnant women with pre-existing diabetes diagnosed before pregnancy, (2) incomplete test data (pregnant women without test results in early

Tab. 1. BMI and GDM incidence stratified by first-trimester FBG levels

Group	BMI category (kg/m²)	n	Age (years)	GDM cases	GDM incidence (%)
Overall BMI (unstratified)					
Low body weight	<18.5	83	28.5±3.1	13	15.7
Normal	18.5–23.9	512	29.0±3.3	86	16.8
Over weight	24–27.9	136	30.1±3.9	41	30.1
Obesity	≥28	40	29.3±4.0	18	45.0
Stratified by first-trimester FBG					
FBG ≤4.7 mmol/L	<24	310	28.6±3.0	36	11.6
	≥24	78	29.5±3.7	19	24.4
FBG 4.7–5.1 mmol/L	<24	197	29.4±3.3	27	13.7
	≥24	64	30.8±4.4	20	31.3
FBG ≥5.1 mmol/L	<24	88	29.5±3.6	36	40.9
	≥24	34	29.5±3.1	20	58.8

Note: BMI categories follow Chinese criteria: underweight (<18.5 kg/m²), normal (18.5–23.9 kg/m²), overweight (24–27.9 kg/m²), obese (≥28 kg/m²).
Overall BMI analysis (unstratified): Underweight vs. normal: $\chi^2 = 0.066$, $p = 0.797$ (NS). Overweight vs. obese: $\chi^2 = 3.060$, $p = 0.080$ (NS). Combined normal-weight (underweight + normal) vs. combined excess-weight (overweight + obese): $\chi^2 = 23.764$, $p < 0.01$. The statistically significant finding applies only to the combined contrast; individual adjacent group comparisons were non-significant.
Stratified analysis by first-trimester FBG (BMI <24 vs. ≥24 kg/m²):
FBG ≤4.7 mmol/L: $\chi^2 = 8.322$, $p = 0.004$ (11.6% vs. 24.4%)
FBG 4.7–5.1 mmol/L: $\chi^2 = 10.071$, $p = 0.002$ (13.7% vs. 31.3%)
FBG ≥5.1 mmol/L: $\chi^2 = 3.170$, $p = 0.075$, NS (40.9% vs. 58.8%; n = 34 in BMI ≥24 group)

Tab. 2. Relationship between the FBG in the first trimester and the incidence of GDM in pregnant women

FBG group (mmol/L)	Age ($\bar{x}$ ± SD, years old)	Total	Number of cases of GDM	Incidence of GDM %
≤4.7	28.8±3.2	388	55	14.2
4.7-5.1	29.8±3.7	261	47	18.0
≥5.1	29.5±3.5	122	56	45.9

Notes: Overall $\chi^2 = 58.835$, $p < 0.01$. Post-hoc pairwise comparisons with Bonferroni correction (adjusted α = 0.017, 3 comparisons):
• FBG ≤4.7 vs. 4.7–5.1 mmol/L: $\chi^2 = 1.730$, $p = 0.188$ — **not significant**
• FBG ≤4.7 vs. ≥5.1 mmol/L: $\chi^2 = 54.866$, $p < 0.001$ — **significant**
• FBG 4.7–5.1 vs. ≥5.1 mmol/L: $\chi^2 = 32.902$, $p < 0.001$ — **significant**
The dose-response gradient is driven entirely by the ≥5.1 mmol/L stratum; the difference between the ≤4.7 and 4.7–5.1 strata (14.2% vs. 18.0%) is not statistically distinguishable after correction.

or middle pregnancy), and (3) nonsingleton pregnancies. Among 835 potentially eligible women, 64 (7.7%) were excluded: women with pre-existing diabetes diagnosed before pregnancy, incomplete test data (missing first-trimester FBG or mid-pregnancy OGTT results), and nonsingleton pregnancies. The relatively small exclusion rate (7.7%) and systematic application of exclusion criteria minimize selection bias, though characteristics of excluded women were not compared to included participants. In the remaining 771 cases, there were 158 patients with GDM.

Diagnostic Basis for Gestational Diabetes Mellitus

According to the Chinese GDM diagnostic standard first issued in 2011 and reaffirmed in the 2022 update (Department of Obstetrics and Gynecology *et al.* 2022), a 75-g oral glucose tolerance test (OGTT) was performed at 24–28 weeks of gestation on pregnant women without diabetes. The diagnostic thresholds applied to the 2013 data (fasting ≥5.1 mmol/L, 1-h ≥ 10.0 mmol/L, 2-h ≥8.5 mmol/L) are identical across the 2011 and 2022 editions.

Blood glucose was measured using a Hitachi 7600 fully automatic biochemical analyzer and original reagents.

Patient Groups

This study focused on identifying early predictive factors for GDM rather than evaluating treatment outcomes; clinical management details (diet and exercise guidance; insulin required in 8 cases) are noted for context only. Among the 158 patients, FBG trajectory was classified as 'decreased' if the mid-pregnancy OGTT fasting value (24–28 weeks) was lower than the first-trimester FBG value by any magnitude, and 'non-decreased' if it was equal to or higher. On this basis, FBG had not decreased in 118 cases and decreased in 40 cases. This binary direction-based definition does not account for the magnitude of change; a sensitivity analysis using a continuous FBG variable was not performed but would be informative in future work.

Among the patients with normal glucose metabolism, FBG in the early pregnancy (before 12 weeks) and in the middle pregnancy (24–28 weeks, OGTT FBG) were compared. Of these, 224 cases had no decrease in blood glucose, and 389 cases had a decrease.

Statistical analysis

Case data were presented as counts (percentages). The incidence rates of gestational diabetes at different stages

Tab. 3. Relationship between the change in FBG during pregnancy and the incidence of GDM in pregnant women with different FBG levels during the first trimester

Group		Number of cases	Age ($\bar{x}$ ± SD, years old)	Number of cases of GDM	Incidence of GDM %
FBG in the first trimester (mmol/L)	Changes in FBG during pregnancy				
≤4.7[a]	Decreased group	146	28.3±2.9	5	3.4
	Non-decreased group	242	29.1±3.4	50	20.7
4.7-5.1 (excluding 4.7 and 5.1) [b]	Decreased group	190	29.4±3.6	8	4.2
	Non-decreased group	71	30.8±3.6	39	54.9
≥5.1[c]	Decreased group	93	29.3±3.4	27	29
	Non-decreased group	29	30.1±3.7	29	100

Notes: Within each first-trimester FBG stratum, non-decreased vs. decreased FBG groups:
a. FBG ≤4.7 mmol/L: $\chi^2 = 22.238$, $p < 0.01$ (3.4% vs. 20.7%)
b. FBG 4.7–5.1 mmol/L: $\chi^2 = 90.050$, $p < 0.01$ (4.2% vs. 54.9%)
c. FBG ≥5.1 mmol/L: $p < 0.01$ by Fisher's Exact Test (29.0% vs. 100%; n = 29 in non-decreased group)

Tab. 3a. 2×2 contingency table: Screening performance of a non-decreasing FBG trajectory for GDM detection within the first-trimester FBG 4.7–5.1 mmol/L stratum (n = 261).

	GDM	No GDM	Total
Non-decreased FBG	39	32	71
Decreased FBG	8	182	190
Total	47	214	261

Cell counts are derived directly from Table 3. A non-decreasing trajectory was defined as a mid-pregnancy OGTT fasting value (24–28 weeks) equal to or higher than the first-trimester FBG value. Sensitivity = 83.0% (39/47); Specificity = 85.0% (182/214); PPV = 54.9% (39/71); NPV = 95.8% (182/190). $\chi^2 = 90.050$, $p < 0.01$.

of pregnancy were analyzed using the Chi-square test. Fisher's Exact Test was substituted for Chi-square test when expected cell frequencies in any group were less than 5. Chi-square tests and Fisher's Exact Test evaluated associations between FBG levels, BMI categories, and GDM incidence across pregnancy stages. Interaction terms were tested to assess combined effects of FBG category and BMI on GDM incidence; results are reported in the Results section alongside Table 1. All analyses were performed using SPSS™ Statistics v19.0 with significance set at $p < 0.05$.

Maternal age was not adjusted for in the analyses. Age varied across BMI groups (28.5±3.1 years in underweight vs. 30.1±3.9 years in overweight women) and FBG groups (28.8±3.2 years in FBG ≤4.7 vs. 29.8±3.7 in FBG 4.7-5.1 mmol/L), representing a potential confounding variable given established associations between advanced maternal age and GDM risk. Reported associations should be interpreted as crude rather than adjusted estimates.

RESULTS

GDM incidence rose monotonically with first-trimester FBG category: 14.2% (FBG ≤4.7, mean age 28.8±3.2 years), 18.0% (FBG 4.7–5.1, 29.8±3.7 years), and 45.9% (FBG ≥5.1, 29.5±3.5 years) ($\chi^2 = 58.835$, $p < 0.01$; Table 2). As age differed across strata, all reported associations are unadjusted and should be interpreted as crude estimates. Using FBG ≥5.1 mmol/L as a screening threshold, 56 of 158 GDM cases were captured (sensitivity 35.4%), with 66 of 122 screen-positive women not developing GDM (false-positive rate 54.1%; positive predictive value 45.9%).

The trajectory effect was observed across all FBG strata (Table 3): FBG ≤4.7: 20.7% vs. 3.4% ($\chi^2 = 22.238$, $p < 0.01$); FBG 4.7–5.1: 54.9% vs. 4.2% ($\chi^2 = 90.050$, $p < 0.01$); FBG ≥5.1: 100% vs. 29.0% ($p < 0.01$, Fisher's Exact Test). The largest chi-square value was observed in the middle FBG stratum. To characterize the clinical utility of a non-decreasing FBG trajectory as a screening signal within the FBG 4.7–5.1 stratum — the group where trajectory adds the greatest incremental information over a single threshold — a 2×2 contingency table was constructed from the counts in Table 3 (non-decreased GDM: 39; non-decreased no GDM: 32; decreased GDM: 8; decreased no GDM: 182). This yields a sensitivity of 83.0% (39/47), specificity of 85.0% (182/214), PPV of 54.9% (39/71), and NPV of 95.8% (182/190) for the non-decreasing trajectory rule in this stratum. The high NPV indicates that a decreasing FBG trajectory effectively rules out GDM in this intermediate-risk group and may inform decisions about targeted monitoring intensity.

In the unstratified BMI analysis (Table 1), only the combined contrast of normal-weight (underweight + normal BMI, n = 595) versus excess-weight (overweight + obese, n = 176) was statistically significant ($\chi^2 = 23.764$, $p < 0.01$); adjacent group comparisons (underweight vs. normal: $p = 0.797$; overweight vs. obese: $p = 0.080$) were non-significant. Within FBG strata, BMI ≥24 kg/m² was associated with significantly higher GDM incidence in women with FBG <5.1 mmol/L (FBG ≤4.7: 24.4% vs. 11.6%, $p = 0.004$; FBG 4.7–5.1: 31.3% vs. 13.7%, $p = 0.002$; Table 1), but not in those with FBG ≥5.1 mmol/L (58.8% vs. 40.9%, $p = 0.075$, n = 34). The FBG × BMI interaction term did not reach statistical significance ($\chi^2 = 1.87$, $p = 0.39$), indicating that the effect of BMI on GDM incidence did

Tab. 4. Relationship between the change in FBG and the incidence of GDM in pregnant women

Group	Number of cases	Age ($\bar{x}$ ± SD, years old)	Number of cases of GDM	Incidence of GDM %
Decreased blood glucose during pregnancy group	429	29.0±3.3	40	9.3
Non-decreased blood glucose during pregnancy group	342	29.5±3.5	118	34.5

Notes: Non-decreased vs. decreased FBG group; χ^2=74.045, p<0.01. All associations are unadjusted (age differed between groups: 29.5±3.5 vs. 29.0±3.3 years).

not differ significantly across FBG strata. Accordingly, the stratified analyses in Table 1 represent independent rather than synergistic effects of the two risk factors.

No prospective sample size calculation was performed. The sample of 771 pregnant women represents all eligible deliveries during the six-month recruitment period (January–June 2013) after applying exclusion criteria. The small sample size in some subgroups, particularly the FBG ≥5.1 + BMI ≥24 group (n = 34), limited statistical power to detect clinically meaningful differences, as evidenced by the non-significant result in Table 1 ($p = 0.075$).

DISCUSSION

Pregnant women with first-trimester FBG ≥5.1 mmol/L had a 45.9% GDM incidence. Moreover, within each first-trimester FBG stratum, women whose FBG did not decrease by mid-pregnancy had substantially higher GDM incidence than those whose FBG decreased (Table 3): 20.7% vs. 3.4% in the ≤4.7 stratum, 54.9% vs. 4.2% in the 4.7–5.1 stratum, and 100% vs. 29.0% in the ≥5.1 stratum — consistent with non-decreasing FBG trajectory as the strongest within-stratum discriminator in this cohort (Table 4). In contrast, for those with lower FBG (<5.1 mmol/L) during the first trimester, the incidence of GDM was higher when the BMI was higher (≥24 kg/m^2).

Our findings align with established first-trimester GDM prediction research. Multiple validated models have been published with AUROC 0.74-0.76: Syngelaki *et al.* (2025) achieved AUROC 0.757 in 41,587 women using maternal demographics and history (Syngelaki *et al.* 2025); Basil *et al.* (2024) developed a nomogram incorporating age, BMI, family history, and prior macrosomia (Basil *et al.* 2024); Zhang *et al.* (2020) integrated triglycerides and HbA1c (Zhang *et al.* 2020). Our study confirms these established risk factors in a Chinese hospital cohort but does not develop a prediction algorithm or provide discrimination statistics for comparison. Although GDM incidence appeared to rise monotonically across FBG strata (14.2% → 18.0% → 45.9%), post-hoc pairwise analysis reveals that this gradient is not uniform: the ≤4.7 and 4.7–5.1 mmol/L strata were statistically indistinguishable ($\chi^2 = 1.730$, $p = 0.188$ after Bonferroni correction), while both differed significantly from the ≥5.1 mmol/L stratum ($\chi^2 = 54.866$ and 32.902, respectively; both $p < 0.001$). The data therefore support a two-tier rather than a smooth three-tier classification: a lower-risk group (FBG <5.1 mmol/L, pooled GDM incidence ~15–18%) and a high-risk group (FBG ≥5.1 mmol/L, 45.9%), with the ≥5.1 threshold as the sole statistically supported triage cut-point in this cohort. The independent contributions of pre-pregnancy BMI and early FBG to GDM risk are consistent with prior Chinese cohort work showing that their combined predictive value (AUROC 0.71) exceeded either marker alone (Peng & Zheng, 2021).

A key practical implication of Table 2 is that a single threshold of FBG ≥5.1 mmol/L is the only statistically supported triage cut-point: the ≤4.7 and 4.7–5.1 groups were indistinguishable after correction ($p = 0.188$). A binary triage (FBG <5.1 vs. ≥5.1 mmol/L) is better supported by these data, with BMI ≥24 kg/m^2 serving as a secondary modifier in the lower-risk tier (FBG <5.1 mmol/L, where it was independently significant at $p = 0.004$ and $p = 0.002$).

The trajectory analysis (Table 3) revealed that a non-decreasing FBG from the first to second trimester was a stronger discriminator than first-trimester FBG level alone in every stratum. Notably, in the FBG 4.7–5.1 mmol/L stratum — women who would not typically be flagged as high-risk by a single FBG measurement, yet represent an intermediate-risk group in which first-trimester FPG >4.7 mmol/L is associated with steeply rising GDM risk (Tong *et al.* 2022) — a non-decreasing trajectory identified a subgroup with 54.9% GDM incidence (vs. 4.2% if FBG decreased; $\chi^2 = 90.050$, $p < 0.01$). Since physiological fasting glucose normally declines from early to mid-gestation in women without glucose dysregulation, a non-decreasing trajectory likely reflects persistent insulin resistance or impaired early beta-cell compensation (Bochkur Dratver *et al.* 2022). These data suggest that serial FBG monitoring between the first-trimester visit and the 24–28 week OGTT, which uses measurements already collected under standard prenatal care at this institution, may refine risk stratification beyond a single early threshold (Deitch *et al.* 2024; Tong *et al.* 2022); this is further consistent with trajectory-based analyses demonstrating that the pattern of fasting glucose change across gestation differentially predicts both GDM diagnosis and fetal growth outcomes beyond what any single measurement can capture (Regnault *et al.* 2022; Bochkur Dratver *et al.* 2022).

This retrospective single-center study in a Chinese hospital limits generalizability, as GDM risk and BMI distributions vary across populations. Associations were estimated using only univariate Chi-square tests, without adjustment for confounders such as maternal age—which differed between FBG and BMI groups—and other established risk factors (Lu *et al.* 2021; Karavasileiadou *et al.* 2022; Craig *et al.* 2020). The six-month recruitment window from 2013 and the lack of a formal prediction model or discrimination metrics (e.g., AUROC) mean our findings predate and cannot be directly compared with contemporary first-trimester GDM prediction tools, body composition–based risk stratification, and structured lifestyle interventions developed in the last decade (Minami *et al.* 2022; Lawrence *et al.* 2021; Helmersen *et al.* 2021; Xinyang *et al.* 2021). Small subgroup sizes, particularly in women with first-trimester FBG ≥5.1 mmol/L

and BMI ≥24 kg/m² (n = 34), limited power to detect differences, as reflected by the non-significant *p*-value (0.075) despite an 18-percentage-point incidence difference in GDM. Finally, although exclusion criteria were applied consistently, we did not compare characteristics of excluded versus included women, and as a retrospective observational study, our findings demonstrate associations rather than causal effects; the benefits and cost-effectiveness of early interventions in these high-risk groups require confirmation in prospective randomized trials.

CONCLUSION

First-trimester FBG ≥5.1 mmol/L was associated with 45.9% GDM incidence (vs. 14.2% at FBG ≤4.7 mmol/L), and BMI ≥24 kg/m² was associated with elevated incidence in women with FBG <5.1 mmol/L (24.4%–31.3% vs. 11.6%–13.7% in BMI <24). No statistically significant difference was found between adjacent BMI categories in the unstratified analysis; significance was observed only in the combined excess-weight contrast and within the FBG <5.1 strata. Most strikingly, all 29 women with first-trimester FBG ≥5.1 mmol/L whose FBG did not decrease by mid-pregnancy developed GDM (100%), identifying non-decreasing FBG trajectory as the strongest predictive signal in this cohort. These findings support continued use of first-trimester FBG and BMI for GDM risk stratification, consistent with published prediction models. The optimal timing, intensity, and target populations for early intervention require evaluation in randomized controlled trials. At FBG ≥5.1 mmol/L as a single screening threshold, PPV was 45.9% and the false-positive rate 54.1%, underscoring the value of the trajectory rule for refining this initial triage.

DECLARATIONS

Ethics approval and consent to participate

This study was approved by the Ethics Committee of Peking University Third Hospital (2019(313-02)) and conducted in accordance with the Declaration of Helsinki. Written informed consent was obtained from all participants.

Competing interests

The authors declare that they have no competing interests.

Funding

This study is funded by the National Key Research and Development Program of China (2018YFC1313900, 2018YFC1313905).

Availability of data and materials

The datasets used and/or analyzed during the current study are available from the corresponding author upon reasonable request.

Authors' contributions

Lei Cui conceived the idea and conceptualized the study. Hong Ren and Ru Ye collected the data. Xiao-Lin Qiao and Wen-Yi Wang analyzed the data. Lei Cui drafted the manuscript, then Lei Cui reviewed the manuscript. All authors read and approved the final draft.

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