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Analysis of factors influencing blood glucose self-monitoring behavior in patients with gestational diabetes mellitus and construction of its prediction model

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Abstract

The objective of this study was to investigate the factors influencing self-monitoring of blood glucose (SMBG) behavior in patients with gestational diabetes mellitus (GDM) and to develop a predictive model for clinical intervention. The method of this study was to divide 587 GDM patients admitted to Lishui Maternal and Child Health Hospital from May 2020 to June 2023 into training group (n = 410) and test group (n = 177) by using R 4.3.2 in a ratio of 7:3. The training set cases were divided into target group (n = 109) and non-target group (n = 301) according to whether SMBG was met (monitoring fasting or postprandial 2 h blood glucose 2-4 times per week).Key factors affecting SMBG were identified through univariate analysis and logistic regression, including education level, family income, glucometer possession, and dimensions of the Information-Motivation-Behavior (IMB) model. A nomogram prediction model was developed, with Area Under the Curve (AUC) values of 0.863 and 0.829 in the training and testing cohorts, respectively, demonstrating good predictive performance. The calibration curve confirmed the accuracy of the model. The findings suggest that SMBG behavior in GDM patients is influenced by socioeconomic and psychological factors, and the developed model provides a valuable tool for clinical assessment and intervention.
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Keywords: Gestational Diabetes Mellitus; Self-Monitoring of Blood Glucose (SMBG); Predictive Model; Standard; Influencing Factors

Résumé

L'objectif de cette étude était d'examiner les facteurs influençant le comportement d'autosurveillance de la glycémie (ASG) chez les patientes atteintes de diabète gestationnel (DG) et de développer un modèle prédictif pour une intervention clinique. La méthode de l'étude consistait à répartir 587 patientes atteintes de DG, admises à l'Hôpital de santé maternelle et infantile de Lishui entre mai 2020 et juin 2023, en un groupe d'entraînement (n = 410) et un groupe de test (n = 177) selon un ratio de 7:3, en utilisant R 4.3.2. Les cas du groupe d'entraînement ont été divisés en groupe cible (n = 109) et groupe non cible (n = 301) selon que l'ASG était conforme (contrôle glycémique à jeun ou 2 heures postprandial, 2 à 4 fois par semaine). Les facteurs clés influençant l'ASG ont été identifiés par une analyse univariée et une régression logistique, incluant le niveau d'éducation, le revenu familial, la possession d'un glucomètre et les dimensions du modèle Information-Motivation-Comportement (IMB). Un nomogramme prédictif a été développé, avec des valeurs de l'Aire Sous la Courbe (AUC) de 0,863 et 0,829 pour les cohortes d'entraînement et de test respectivement, démontrant une bonne performance prédictive. La courbe de calibration a confirmé la précision du modèle. Les résultats suggèrent que le comportement d'ASG chez les patientes atteintes de DG est influencé par des facteurs socioéconomiques et psychologiques, et que le modèle développé constitue un outil précieux pour l'évaluation clinique et l'intervention. *(Afr J Reprod Health 2025; 29 [6]: 117-128).*

Mots-clés: Diabète gestationnel ; Autosurveillance de la glycémie (ASG) ; Modèle prédictif ; Norme ; Facteurs influents

Introduction

Gestational diabetes mellitus (GDM) is defined by the presence of increased blood glucose levels during pregnancy and ranks among the most prevalent pregnancy-related complications. It encompasses hyperglycemia or impaired glucose tolerance that emerges or is initially identified during the gestational period[1]. With the implementation of China's two-child policy, the proportion of older mothers has increased significantly, leading to a marked rise in the

incidence of GDM. Recent data indicate that the worldwide prevalence of GDM has been on the rise in recent years[2]. Over the past two years, the incidence of GDM in the United States has climbed to a significant level of 18%, while in China, the incidence is 17.5%, ranking second in the world in terms of proportion of cases. Moreover, due to factors such as national policies, dietary culture, and diagnostic criteria, the incidence in various regions continues to rise[3-4]. Research evidence indicates that if blood glucose levels are not well controlled during pregnancy, GDM can pose serious risks to both maternal and fetal health. It can lead to pregnancy-induced hypertension, polyhydramnios, ketoacidosis, and infections in mothers, as well as increase the incidence of preterm birth, macrosomia, neonatal metabolic abnormalities, neonatal respiratory distress syndrome, fetal malformations, stillbirth, and intrauterine fetal death in offspring[5-6].

Therefore, efficient management of blood glucose levels is essential for enhancing the health outcomes of both mothers and newborns in pregnancies affected by GDM.

Current methods for blood glucose monitoring in GDM patients include self-monitoring of blood glucose (SMBG), glycated albumin (GA), and continuous glucose monitoring (CGM)[7]. As part of diabetes self-management, SMBG has evolved into a crucial instrument for effectively managing diabetes. By enabling patients to monitor their immediate blood glucose status, it not only promotes necessary lifestyle modifications but also enhances their active involvement in self-managing their condition, ultimately leading to better adherence to treatment plans[8]. However, emerging evidence from a recent study shows that the adherence to SMBG among pregnant women with GDM in China is relatively low[9]. How to improve the self-management capabilities of pregnant women has thus become an urgent issue that needs to be addressed.

Most current research reports focus on the risk factors for GDM, while studies on the SMBG behavior of pregnant women with GDM are relatively limited. In particular, there is a lack of in-depth investigation into the specific influencing factors of SMBG behavior and the construction of predictive models in GDM patients. Therefore, the objective of this research is to conduct an in-depth examination of the determinants influencing SMBG behavior in individuals with GDM, and to develop a robust predictive model. This model is intended to offer a scientific foundation for enhancing patients' self-management skills and reducing the risk of complications.

Methods

Sample size

In quantitative surveys, the sample size is estimated to be 5 to 10 times the number of predictor variables. Considering that this study involved 87 predictor variables, the required sample size ranged from 435 to 870 cases. To reduce error and account for a 10% to 20% dropout rate, the study aimed to recruit 587 participants.

Study participants

This study selected 587 GDM patients who came to Department of obstetrical,Lishui Maternal and Child Health Hospital from May 2020 to June 2023 as participants. They were randomly allocated into a training cohort (n = 410) and a testing cohort (n = 177) at a 7:3 ratio using R software version 4.3.2. Within the training cohort, individuals were further classified into two groups: those meeting the standard (n = 109) and those not meeting the standard (n = 301), based on whether their SMBG fulfilled the criteria of monitoring fasting or 2-hour postprandial blood glucose 2 to 4 times per week. Inclusion criteria were: Patients who met the diagnostic criteria for GDM[10]; confirmation of pregnancy between 24 and 28 weeks; age between 18 and 45 years; clear consciousness, good communication skills, and the ability to understand and cooperate with the completion of the questionnaire survey.

Exclusion criteria included: other serious pregnancy complications or comorbidities, such as heart disease, kidney disease, thyroid disease, etc.; pre-existing diabetes before pregnancy.

Grouping criteria for SMBG

The criteria for SMBG behavior were based on the "Chinese Clinical Application Guidelines for Blood Glucose Monitoring (2018 Edition)"[11]. Patients who monitored their fasting or 2-hour postprandial blood glucose levels 2 to 4 times per week were defined as

meeting the standards (standard-meeting group), while those who did not were defined as not meeting the standards (non-standard-meeting group).

Data collection

Clinical information was collected from the study participants, including: General demographic data, such as age, education level, occupation, monthly family income, type of medical insurance, pre-pregnancy body mass index (BMI), occupational status during pregnancy, and method of conception; ②disease-related information, such as whether it was the first pregnancy and family history of diabetes; ③assessment of patients' Information-Motivation-Behavioral Skills (IMB) for SMBG[12-13]. The Chinese adaptation of the IMB-SMBG scale includes three components: information, motivation, and behavioral skills. It comprises 76 items in total, with 30 items assessing information, 25 items evaluating motivation, and 21 items measuring behavioral skills. The scale adopts a 5-point rating method, including options from "strongly disagree" to "strongly agree," assigned scores from 1 to 5. The higher the total score, the better the patient's SMBG behavior. The survey content was transformed into a digital format, and patients completed the questionnaire by scanning a Quick Response (QR) code. The preface of the questionnaire elaborated on the research's aim, importance, and the process of questionnaire completion to the patient participants. Once collected, all questionnaires underwent a review and screening process carried out by experts. Patients who fully completed and passed the review of the questionnaire were given a small reward. Ultimately, any carelessly filled or hastily completed invalid questionnaires were excluded.

Statistical analysis

Data were entered using Epidata 3.1 software, while SPSS 22.0 software was utilized for statistical analysis. Quantitative data following a normal distribution were presented as mean ± standard deviation (x±s). For comparisons between two groups, independent samples t-tests were applied, and for comparisons involving multiple groups, analysis of variance (ANOVA) was conducted. Qualitative data were described using counts (n) and proportions (%), with inter-group differences assessed via the Chi-square (χ^2) test. Factors showing statistical significance ($P < 0.05$) in univariate analysis were further included in multivariable logistic regression to identify independent influencing factors. The predictive model was constructed using R software, and its performance was evaluated by generating a Receiver Operating Characteristic (ROC) curve. Model performance was assessed using indicators such as the area under the curve (AUC), sensitivity, and specificity. Specifically, an AUC of 0.5 indicates no predictive ability; $0.5 < AUC < 0.7$ suggests limited predictive ability with low accuracy; $0.7 \leq AUC < 0.9$ signifies good predictive ability; and an $AUC \geq 0.9$ denotes high predictive performance.

Ethical consideration

Ethical clearance for this study was granted by the ethics committee of Lishui Maternal and Child Health Hospital, with the approval number [2412161041580]. Prior to the commencement of the study, all potential participants were provided with comprehensive information about the study's purpose, procedures, potential risks and benefits, and their rights as participants. This information was delivered both verbally and in written form to ensure that participants had a thorough understanding of what participation in the study would entail.

Informed consent was obtained from all participants. For adult participants, written consent was secured after they had the opportunity to ask questions and seek clarification about any aspects of the study. For participants who were minors, consent was obtained from their legal guardians. The consent forms clearly stated that participation was voluntary and that participants had the right to withdraw from the study at any time without any penalty or loss of benefits to which they would otherwise be entitled.

Other ethical issues that were carefully considered included the protection of participants' privacy and confidentiality. All data collected were anonymized and stored securely to prevent unauthorized access. Measures were also taken to ensure that the study did not cause any undue harm or distress to participants. The study was designed to minimize any potential risks and to provide appropriate support if any adverse events were to occur.

Throughout the study, the research team adhered strictly to the ethical guidelines set forth by the

hospital's ethics committee and relevant national and international regulations.

Results

Baseline features in training and test cohorts

The study research encompassed a total of 587 participants, with an average age of 29.9±4.7 Statistical analysis revealed no significant differences in baseline characteristics, such as age and pre-pregnancy BMI, between the training and test cohorts (P > 0.05) (Table 1).

Univariate analysis of clinical data in the training set

The comparison between the groups of GDM who achieved the standards for SMBG and those who did not, revealed statistically significant differences in educational level, monthly per capita household income, possession of a glucometer, and scores on the Information-Motivation-Behavioral Skills (IMB-SMBG) model including information, personal attitudes, and social support (P<0.05)(Table 2).

Logistic regression analysis of factors influencing SMBG behavior in pregnant women with GDM

Using the outcome of SMBG behavior in GDM pregnant women as the dependent variable, where meeting the standards was coded as "1" and not meeting the standards as "0", and incorporating the potential influencing factors identified from the univariate analysis results in Table 2 as independent variables (see Table 3 for variable coding), a multivariable logistic regression analysis was conducted. The results indicated that educational level, monthly per capita household income, possession of a glucometer, and scores on the Information-Motivation-Behavioral Skills (IMB-SMBG) model, including information, personal attitudes, and social support, are significant factors influencing self-monitoring of blood glucose behavior in GDM pregnant women (P<0.05) (Table 4).

Construction of the predictive model

Based on the results of the logistic multivariable regression analysis, the influencing factors were incorporated into a risk prediction nomogram model. The values for educational level, monthly per capita household income, possession of a glucometer, Information-Motivation-Behavioral Skills (IMB-SMBG) information, IMB-SMBG personal attitudes, and IMB-SMBG social support scores are obtained by aligning them with the corresponding points on the scales located at the upper section of the nomogram through vertical alignment. The total scores were then calculated by summing the points for all variables. Subsequently, the total scores were used to determine the corresponding predicted risk value on the prediction scale at the bottom of the nomogram. See Figure 1.

Model evaluation and validation

Bootstrap resampling was used to perform 1,000 repetitions of sampling to evaluate the model's performance. The results indicated that in the training set, the calibration index (CI) for the nomogram model was 0.9. The analysis of the Receiver Operating Characteristic (ROC) curve showed that the model's Area Under the Curve (AUC) for predicting outcomes in the training set was 0.863, with specificities and sensitivities of 78.0%, 86.7%. To validate the model, it was tested in an independent test set, where the AUC was found to be 0.829. Calibration curves for both the modeling and validation sets demonstrated good fit for the nomogram model ($\chi2$=15.027, P=0.059 for the modeling set; $\chi2$=3.370, P=0.909 for the validation set). See Figures 2 and 3 for the calibration plots.

Table 1: Baseline characteristics between the training and test cohorts

variable	total (n=587)	training sets (n=410)	testing set (n=177)	t	P
Age ($\bar{x}$±s, years)	29.9±4.7	29.9±4.8	29.7±4.4	0.6	0.5
pre-pregnancy BMI ($\bar{x}$±s, kg/m^2)	57.0±9.8	56.9±9.6	57.2±10.4	0.7	0.5
standard of culture				3.2	0.1
college or higher	272 (46.3)	180 (43.9)	85 (48.0)		
High school and below	315 (53.7)	230 (56.1)	92 (52.0)		
Family per capita monthly income (yuan)				3.9	0.1
<3000	339 (57.8)	226 (38.5)	113 (63.8)		
≥3000	248 (42.3)	184 (61.5)	64 (36.2)		
occupational status				0.3	0.6
on-the-job	276 (47.0)	190 (46.3)	86 (48.6)		
Not in work	311 (53.0)	220 (53.7)	91 (51.4)		
pregnancy				1.1	0.3
natural pregnancy	312 (53.2)	212 (51.7)	100 (56.5)		
artificial insemination	275 (46.9)	198 (48.3)	77 (43.5)		
birth history				1.4	0.2
primiparity	283 (48.2)	191 (46.6)	92 (52.0)		
pluriparity	304 (51.8)	219 (53.4)	85 (48.0)		
family history of diabetes				1.2	0.3
Yes	295 (50.3)	200 (48.8)	95 (53.7)		
No	292 (49.7)	210 (51.2)	82 (46.3)		
History of GDM					
Yes	265 (45.1)	184 (44.9)	81 (45.8)	0.0	0.8
No	322 (54.9)	226 (55.1)	96 (54.2)		
Have a blood glucose meter				0.0	1.0
Yes	248 (42.3)	173 (42.2)	75 (42.4)		
No	339 (57.8)	237 (57.8)	102 (57.6)		
medical insurance				3.5	0.1
Yes	290 (49.4)	213 (52.0)	77 (43.5)		
No	297 (50.6)	197 (48.0)	100 (56.5)		
IMB-SMBG					
Information ($\bar{x}$±s,scores)	104.9±12.0	105.0±11.9	104.8±12.6	0.2	0.9
attitudes of individuals ($\bar{x}$±s,scores)	77.8±11.5	77.8±11.6	77.9±11.3	0.1	0.9
social support ($\bar{x}$±s,scores)	12.8±2.1	12.8±2.2	12.8±1.8	0.1	0.9
performance assessment ($\bar{x}$±s,scores)	69.2±10.8	69.6±11.1	68.3±10.2	1.4	0.2

Table 2: Comparison of clinical characteristics between the standard-achieving and Non-standard-achieving Groups of GDM Pregnant Women in the training set for self-monitoring of blood glucose behavior

variable		The target group (n = 109)	Non-compliance group (n = 301)	t	P
Age($\bar{x}$±s,years)		30.2±4.3	29.8±4.9	0.7	0.5
pre-pregnancy BMI ($\bar{x}$±s, kg/m^2)		56.5±8.8	57.1±9.4	-0.5	0.5
standard of culture	college or higher	69 (63.3)	111 (36.9)	22.7	0.0
	High school and below	40 (36.7)	190 (63.1)		
Family per capita monthly income (yuan)	<3000	36 (33.0)	190 (63.1)	29.3	0.0
	≥3000	73 (67.0)	111 (36.9)		
occupational status	on-the-job	53 (48.6)	137 (45.5)	0.3	0.6
	Not in work	56 (51.4)	164 (54.5)		
pregnancy	natural pregnancy	49 (45.0)	163 (54.2)	2.7	0.1
	artificial insemination	60 (55.1)	138 (45.9)		
birth history	primiparity	43 (39.5)	148 (49.2)	3.0	0.1
	pluriparity	66 (60.6)	153 (50.8)		
family history of diabetes	Yes	61 (56.0)	139 (46.2)	3.1	0.1
	No	48 (44.0)	162 (53.8)		
History of GDM	Yes	55 (50.5)	129 (42.9)	1.9	0.2
	No	54 (49.5)	172 (57.1)		
Have a blood glucose meter	Yes	74 (67.9)	99 (32.9)	40.2	0.0
	No	35 (32.1)	202 (67.1)		
medical insurance	Yes	47 (43.1)	150 (49.8)	1.4	0.3
	No	62 (56.9)	151 (50.2)		
IMB-SMBG Information ($\bar{x}$±s,scores)		110.1±11.5	103.2±11.4	5.4	0.0
attitudes of individuals ($\bar{x}$±s,scores)		80.2±11.6	77.0±11.4	2.4	0.0
social support ($\bar{x}$±s,scores)		13.5±1.3	12.6±2.4	3.8	0.0
performance assessment ($\bar{x}$±s,scores)		69.7±11.6	69.5±10.9	0.2	0.9

Table 3: Description of variable coding

variable	Assignment
Whether the self blood glucose monitoring behavior is up to standard	compliance =1， non-compliance =0
standard of culture	college or higher =1， High school and below =0
the monthly per capita income of their families	≥3000 yuan =1，<3000 yuan =0
Have a blood glucose meter	Yes =1， No =0
IMB-SMBG information	Original value input
IMB-SMBG attitudes of individuals	Original value input
IMB-SMBG social support	Original value input

Table 4: Results of multivariable logistic regression analysis

variable	*β*	*SE*	*Wald/χ^2*	*P*	*OR*	*95%CI*
standard of culture	3.631	0.433	70.322	<0.001	37.732	16.151~88.151
Family per capita monthly income	4.324	0.499	75.172	<0.001	75.466	28.397~200.554
Have a blood glucose meter	4.116	0.463	79.102	<0.001	61.329	24.758~151.920
IMB-SMBG information	0.041	0.016	6.864	0.009	1.042	1.010~1.074
attitudes of individuals	0.031	0.015	4.401	0.036	1.032	1.002~1.062
social support	0.316	0.093	11.588	0.001	1.371	1.143~1.645

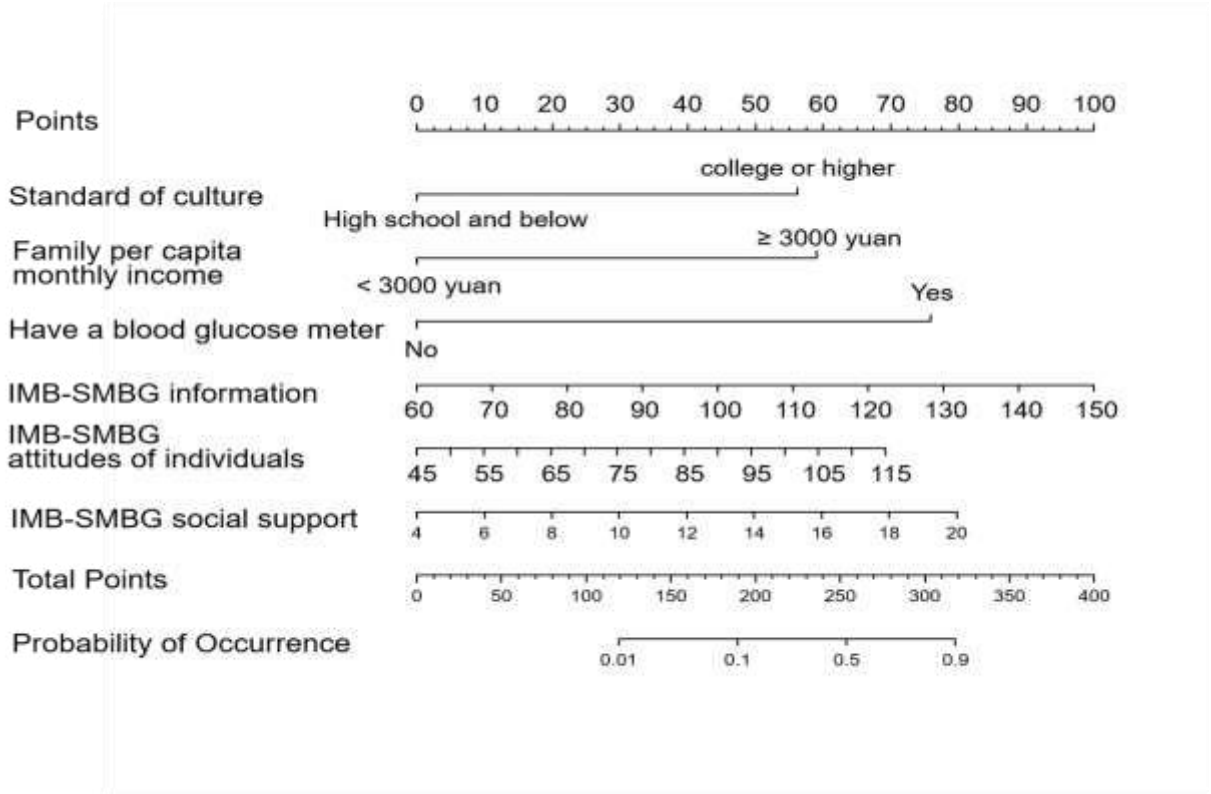
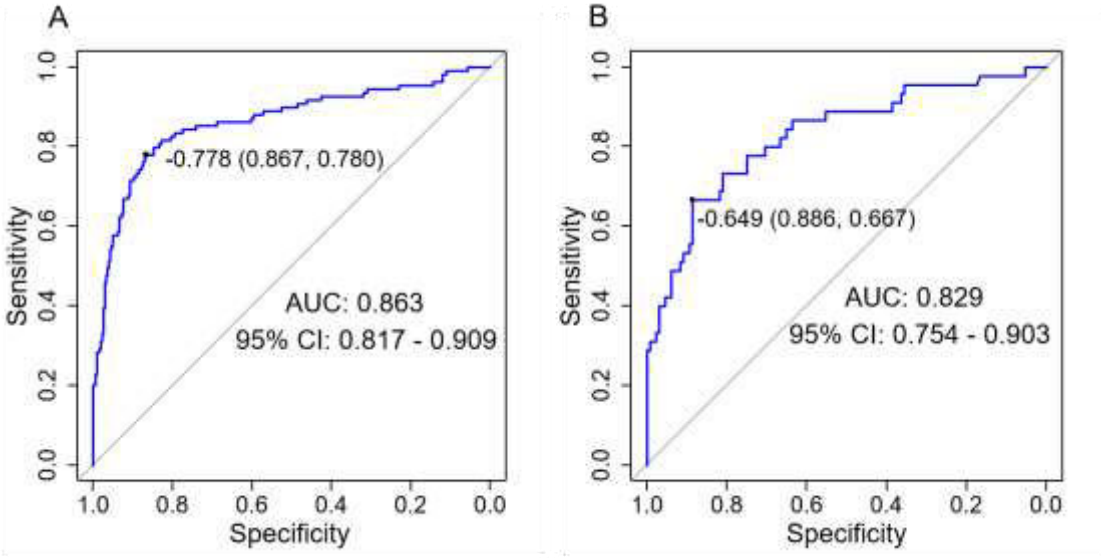
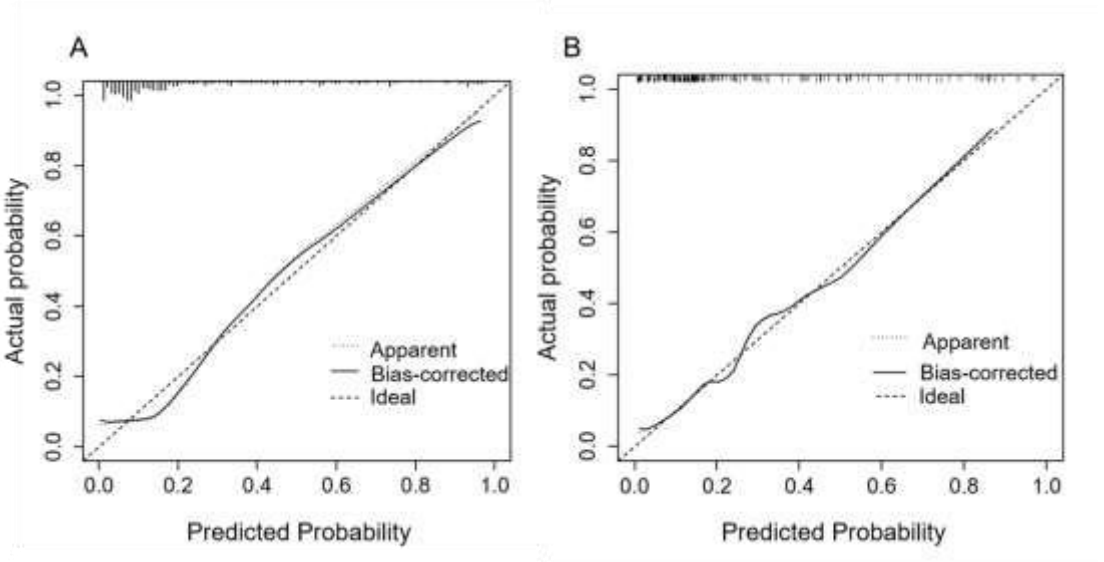


Figure 1: Nomogram for predicting SMBG behavior in patients with GDM



Note: A: ROC curve of training set; B: ROC curve of test set

Figure 2: ROC



Note: A: calibration curve of training set; B: Calibration curve of test set.

Figure 3: Calibration curve

Discussion

GDM refers to a situation where there is an increase in blood glucose levels specifically during the pregnancy period. If blood glucose is not effectively controlled during pregnancy, it can lead to adverse outcomes such as macrosomia and polyhydramnios, which can affect maternal and fetal safety and increase the risk of long-term metabolic problems such as obesity and type 2 diabetes in both GDM patients and their offspring[14]. For pregnant women with GDM, good self-management behaviors, especially SMBG, are vital in managing blood sugar levels and enhancing both maternal and neonatal health outcomes, as indicated in several studies[15-16]. SMBG can provide real-time and accurate blood glucose data, enabling pregnant women to make timely and reasonable adjustments to their diet, exercise intensity, and necessary treatment plans, thereby effectively reducing the risk of adverse

pregnancy outcomes due to blood glucose fluctuations[16]. However, previous studies have shown that GDM patients generally have low adherence to SMBG, and the influencing factors are complex and diverse. Therefore, thoroughly examining the determinants of SMBG behavior among GDM patients and the construction of an effective predictive model are of great significance for improving patient adherence and optimizing clinical management strategies.

Our study results showed that among 410 pregnant women with GDM in the training set, only 109 (26.59%) met the SMBG behavior standards, indicating that the current status of SMBG in GDM patients is not ideal, with a low overall SMBG compliance rate. This may be related to the fact that most pregnant women are diagnosed with GDM for the first time. In routine health education for healthy pregnant women, comprehensive guidance on blood glucose management is lacking. Moreover, when initially diagnosed with GDM, patients may be unfamiliar with blood glucose management due to their lack of prior experience, leading to insufficient knowledge about GDM and poor SMBG behavior. The low SMBG compliance rate also reflects the low self-management awareness among GDM patients.

Our study found that the self-management ability of pregnant women with GDM is affected by educational level, the monthly per capita income of their families, and the availability of a glucometer. The monthly per capita family income has a direct bearing on the attitude of pregnant women towards the disease and serves as a crucial determinant for ensuring compliance with SMBG. Pregnant women with higher per capita monthly family income have less financial burden and psychological stress, and are more likely to actively engage in blood glucose prevention and control, thereby improving their self-management ability. Therefore, for pregnant women with lower per capita monthly family income, it is necessary to enhance their health awareness and understanding of the impact of the disease on mother and baby, and to maintain good self-management ability. Educational level has a positive impact on SMBG behavior in GDM patients. The higher the educational level, the better the SMBG behavior, a finding that aligns with the results reported by Adams *et al*[17]. This is because pregnant women with higher educational levels have a better ability to receive and understand disease-related knowledge and medical information, and have a more comprehensive grasp of knowledge, leading to better adherence to medical advice, weight monitoring, and blood glucose monitoring. In contrast, lower educational levels may limit patients' ability and access to knowledge about SMBG, affecting their understanding of its importance. Additionally, lower educational levels are often associated with lower economic income, further restricting access to medical resources[18]. Therefore, using simple and understandable language to educate pregnant women with lower educational levels about GDM can help them acquire relevant knowledge, improve their cognitive level, and actively participate in SMBG, thereby enhancing their self-management ability.

The absence of a glucometer stands as a significant obstacle to SMBG among diabetic patients[19]. Our study confirmed the direct impact of glucometer availability on SMBG behavior, aligning with the observations made by Lv *et al*[20]. Patients who possess a glucometer are more likely to adhere to SMBG, as the presence of blood glucose monitoring tools facilitates the process for patients. For example, Wang *et al*[13] found that the availability of glucometers is closely related to the frequency of SMBG execution in patients with type 2 diabetes in China. Despite the reform of the medical service system and the widespread coverage of medical insurance, the costs of portable glucometers and test strips for SMBG are still largely borne by patients themselves. Additionally, as diabetes is a chronic condition requiring multiple daily blood glucose measurements, the high costs associated with glucometers, test strips, and lancets represent a significant financial burden for patients. These costs are further exacerbated by the fact that these essential supplies are not covered under urban medical insurance or rural cooperative medical insurance[21]. Therefore, how to reduce the economic burden on patients through policy support and integration of social resources is an issue that needs attention and resolution in the future.

Our study found that the scores of IMB-SMBG information, IMB-SMBG personal attitudes, and IMB-SMBG social support significantly affect the SMBG behavior of GDM patients, consistent with previous studies[22-23]. Existing evidence has highlighted that education on blood glucose monitoring can notably enhance adherence to SMBG. Meanwhile, individuals who have engaged in diabetes education programs tend to achieve more

effective control of their blood glucose levels and glycated hemoglobin[24]. Additionally, Yao *et al*[25] found that the frequency of blood glucose monitoring is related to having better knowledge of blood glucose. In contrast, patients who have not received education on GDM health knowledge and SMBG-related skills often lack awareness and knowledge of SMBG, making it difficult for them to achieve reasonable blood glucose monitoring during pregnancy[26]. This lack of knowledge and awareness poses a potential risk to maternal and fetal health. Patients who know how to use a glucometer tend to have better SMBG compliance. This could be attributed to the fact that individuals proficient in using a glucometer tend to pay closer attention to their blood glucose levels. As a result, they are more driven to acquire and comprehend the necessary skills and knowledge related to SMBG, thereby facilitating effective SMBG. Therefore, health workers should focus on improving GDM patients' awareness of diabetes-related information and enhancing their motivation. Patients with positive IMB-SMBG personal attitudes, who place a high value on their health and have strong self-motivation, are more likely to actively engage in SMBG to manage their condition. In terms of social support, our study confirmed its significant promoting effect on SMBG behavior in GDM patients, consistent with a systematic review showing that husbands, partners, and family members play a crucial role in promoting GDM self-management[27]. A mixed-methods study on SMBG in GDM pregnant women[16] also pointed out that lack of social support and resources (e.g., not purchasing a glucometer) is an important barrier to blood glucose monitoring. A good social support system, including support, encouragement, supervision, and help from family, friends, and society, can greatly enhance patients' motivation and confidence to persist with SMBG.

The predictive nomogram developed here exhibited an AUC value of 0.863 (95% CI: 0.817-0.909) for the training cohort and 0.829 (95% CI: 0.754-0.903) for the test cohort. Both results were above 0.8, suggesting that the model effectively predicts SMBG adherence in GDM patients. The calibration plot further demonstrated that the model possesses strong predictive accuracy and practical clinical significance. However, this research is not without limitations. Firstly, being a retrospective study, it is potentially susceptible to recall bias. Secondly, the study only involved patients from select regional hospitals, and the sample was derived from a single center. This restricts the representativeness of the sample and could influence the broader applicability of the findings. Future studies could adopt a prospective study design, expand the sample scope to include patients from different regions and economic backgrounds, and further verify and improve the influencing factors and predictive model. Although the IMB model provides a theoretical basis for multidimensional assessment, there are still other potential factors (such as psychological stress and pregnancy anxiety) that were not included in the analysis. Therefore, future research could explore other potential influencing factors, such as patients' psychological state and medical service quality, on SMBG behavior to provide a more comprehensive theoretical support for GDM management.

Study strengths and limitations

This study comprehensively analyzed the factors influencing self-monitoring of blood glucose (SMBG) behavior in patients with gestational diabetes mellitus (GDM) and constructed a predictive model, providing a scientific basis for clinical intervention. The study incorporated multiple dimensions of variables, including education level, family income, possession of a glucometer, and the Information-Motivation-Behavioral Skills (IMB) model, revealing their significant impact on SMBG behavior. Additionally, the development of a nomogram prediction model offered a powerful tool for clinical assessment and intervention, with the model demonstrating high predictive accuracy in both the training and testing cohorts (AUC values of 0.863 and 0.829, respectively).

However, the study also has limitations. First, as a single-center study, the sample may not be representative of a broader population, particularly GDM patients from different regions or economic backgrounds. Second, being a retrospective study, it is susceptible to recall bias and may not fully account for confounding factors. Moreover, the study did not delve into the potential impact of other psychological factors (such as pregnancy-related anxiety and stress) on SMBG behavior and lacked long-term follow-up of patients, making it difficult to assess the long-term effects of interventions.

Despite these limitations, the study's findings hold significant implications for policy-making and clinical practice. From a policy perspective, the results suggest that providing glucometers and test strips free of charge or at subsidized prices for low-income patients could reduce their financial burden and improve SMBG adherence. There is also a need to enhance health education programs tailored to patients with varying education levels and to integrate mental health support services into prenatal care. In clinical practice, healthcare providers can use the predictive model to identify patients with poor SMBG adherence and offer personalized interventions, such as providing more accessible health education for patients with lower education levels and encouraging family involvement in patient support. Future research should expand the sample scope, adopt a prospective study design, and explore more potential influencing factors to further refine the relevant theories and practice strategies.

Conclusion

In summary, this study clarified the impact of educational level, economic status, availability of glucometers, and multidimensional IMB factors on SMBG behavior in GDM patients and constructed a nomogram model with high predictive performance. This model can provide a basis for clinical precision interventions, help improve SMBG compliance in GDM patients, and improve maternal and neonatal outcomes. Regarding blood glucose monitoring, many pregnant women feel that blood glucose measurement is unnecessary if their diet is well-controlled according to medical advice. Additionally, the inconvenience of self-monitoring blood glucose can reduce the frequency of regular SMBG behavior in GDM pregnant women. It is suggested that non-invasive blood glucose monitoring or designated service stations provided by community hospitals could be implemented to help GDM pregnant women overcome difficulties and improve SMBG compliance.

Authors' contributions

Yanfei Zhu and Jing Zhou contributed to the study design and methodology. Xiaoe Xie and Chenyang Ding were responsible for data collection and statistical analysis. Chunmei Zhu and Yayan Li assisted in manuscript drafting and literature review. Ping Lan supervised the research, provided critical revisions, and finalized the manuscript for submission. All authors read and approved the final version of the manuscript.

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Conflict of interests

The authors declare no competing interests.

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