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Original Research

Using a Social Application to Manage Women with Gestational Diabetes Mellitus: A Prospective Study

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Abstract

Background: The prevalence of gestational diabetes mellitus (GDM) has been increasing globally, which has led to substantial implications for long-term maternal health including diabetes. The present study aimed to explore the rate of postpartum glucose screening (PGS) of women with GDM based on WeChat management and explore factors affecting the rate of PGS and impaired glucose regulation (IGR). **Methods**: In this prospective trial, GDM patients were enrolled in our WeChat platform groups. Demographic and medical data were collected at the baseline surveys and follow-up visits. GDM patients were managed throughout their pregnancies via the WeChat platform. We sent messages, involving multidisciplinary care, medical nutritional therapy, and glucose monitoring every three days in the chat groups, and reminded them to go to the hospital to complete PGS. Questionnaires about PGS via the WeChat platform were sent to those women who had delivered within 4 to 12 weeks postpartum. Answers to the questionnaires [understanding the necessity of postpartum oral glucose tolerance testing (OGTT) screening, and the results of 42-day postpartum OGTT screening, as well as the reasons for failing to finish postpartum screening, and the ways to get nutrition knowledge for GDM patients] were collected. **Results**: From 1 January 2016 to 31 August 2019, 490 participants were included in our WeChat groups, 375 of whom completed questionnaires. Among the 375 participants, 277 (73.9%) had completed post-partum 75 g OGTT, 202 (72.9%) had normal glucose levels, and 75 (27.1%) had impaired glucose regulation (IGR). Univariable logistic analysis and stepwise regression analysis demonstrated that a previous history of GDM and cesarean delivery were the two variables influencing PGS (odds ratio (OR): 0.44, 95% confidence interval (95% CI): 0.20–0.94; OR: 1.88, 95% CI: 1.04–3.39, respectively). Insulin treatment during pregnancy and cesarean delivery were found to have a significant association with postpartum IGR (OR: 3.74, 95% CI: 1.97–7.08; OR: 1.83, 95% CI: 1.02–3.28, respectively). **Conclusions**: The WeChat messaging platform may be a useful tool to promote postpartum OGTT screening in women with GDM. Women who failed to return for PGS were more likely to have prior GDM than those who returned for PGS. Women who had postpartum IGR were more likely to use insulin treatment during pregnancy and more likely to deliver by cesarean delivery compared to those who had normal postpartum glucose results. **Clinical Trial Registration**: The present study was registered at ClinicalTrials.gov Protocol Registration and Results System https://classic.clinicaltrials.gov/ (No. NCT02893072).

Keywords: gestational diabetes mellitus (GDM); oral glucose tolerance test; postpartum period; WeChat platform; insulin treatment

1. Introduction

Gestational diabetes mellitus (GDM) is defined as any degree of abnormal glucose results during pregnancy [1]. GDM is one of the most common medical complications of pregnancy and it is increasing in prevalence globally, due to the background of an increase in the rates of obesity in women of reproductive age and rise in maternal age [2]. Women with a history of GDM have an increased risk of developing impaired glucose regulation (IGR) [3,4]. Approximately 50% of women with GDM developed diabetes within 5 years after their pregnancies [5]. Also, metabolic syndrome and cardiovascular diseases are commonly reported to be associated with GDM [6]. These long-term outcomes not only threaten the health of women but also increase the economic burden to the health care system. Therefore, it imperative to systematically manage GDM patients and to identify, intervene, and prevent these patients from developing a chronic disease.

The 6-week postpartum visit with a 75 g oral glucose tolerance testing (OGTT) is crucial for the long-term health of GDM women. Therefore, a plethora of clinical practice guidelines recommend postpartum glucose screening [7–9]. In China, women who failed to pass the 75 g OGTT postpartum (fasting $\geq$6.1 mmol/L, 30 min $\geq$11.1 mmol/L, 120 min $\geq$7.8 mmol/L) would be diagnosed with diabetes [9]. Studies have found that certain interventions

may increase the screening rate such as reminding GDM patients of the importance of the screening [10,11]. However, the screening rate is still inadequate worldwide: 13.1% in China and 40.85% in the USA [10,11]. New social media platforms have become a convenient, fast, interactive, and extensive tool for information dissemination. The "Internet healthcare" model is very suitable for China's large population and relative shortage of medical resources [12]. Smartphone applications promote a technological approach to support patient self-management and enhance communication between clinicians and GDM patients in the community and secondary care settings. Currently, there are more than 300,000 mobile health (mHealth) apps available for a broad range of medical disorders [13]. The mHealth apps for GDM are mainly used to record patient information such as blood glucose readings or diet, provide generic patient education or advice, and reduce adverse events by providing medication along with appointment alerts [14]. WeChat platform is one of the most popular message and social media apps in China, with registered accounts estimated to be over 1.1 billion. The WeChat platform rolls the functions of QQ, Facebook, Skype, and Instagram into one source. It is free and easy to use, which can send messages such as text, voice, and photos, and can create group chat, video conference, and location sharing. The characteristics of the WeChat platform make it an ideal app for GDM management. Previous studies have shown that the WeChat platform provides a feasible, effective, and sustainable management plan for chronic diseases such as obstructive pulmonary disease [15] and coronary artery disease [16]. The WeChat platform can deliver health text and video, which may elevate patients' health awareness. Moreover, it also increases the efficacy of disease management when discharged from the hospital, which improves prognosis. Therefore, we hypothesized that the WeChat platform, which doctors could use to spread nutrition knowledge and remind GDM patients to be evaluated periodically, may help enhance the communication between GDM patients and doctors, and may improve the postpartum OGTT screening rate.

Research has shown that maternal age, body mass index (BMI), race/ethnicity, and family history are associated with the prevalence of GDM and type 2 diabetes mellitus (T2DM) [17]. This study aimed to (1) check the screen rate of the WeChat platform management in GDM women; (2) explore independent predictors of the completion rate of postpartum OGTT, and postpartum IGR via the WeChat platform management.

2. Materials and Methods

2.1 Study Design and Participants

In the single-site, prospective trial, we recruited patients diagnosed as GDM during 24 to 28 weeks gestation from the Third Xiangya Hospital of Central South University, Changsha, China. Inclusion criteria included the diagnosis of GDM according to International Association of Diabetes and Pregnancy Study Groups (IADPSG) criteria [18], and ability to give informed consent. Exclusion criteria were the diagnosis of diabetes prior to pregnancy, multiple gestation, and patients who were taking medications known to influence glucose homeostasis prior to enrollment. This study was approved by the Institutional Review Boards of the Third Xiangya Hospital, Central South University (No: 2020-S262), China, and was also registered at ClinicalTrials.gov Protocol Registration and Results System (No. NCT02893072). Written informed consent was obtained from all participants before entering the trial.

2.2 Procedures

GDM patients from 1 January 2016 to 31 August 2019 were enrolled in our WeChat platform groups. The included patients who joined our WeChat platform group were managed by two researchers. Both researchers had undergone systematic academic training, possessed rigorous scientific research thinking and were qualified to organize drug clinical trials. The researchers were responsible for collecting the demographic data and clinical information at baseline survey and follow-up visits via the WeChat platform or face-to-face consultation in the outpatient department. The GDM women who visited in outpatient department would make an appointment with the obstetrics and physician on the same day. The individual participant data was recorded independently by both researchers. GDM patients were invited to the WeChat group on their first visit to the clinical nutrition department. The researchers offered nutrition knowledge about GDM based on the WeChat platform every three days following the establishment of the chat group. The messages involve nutrition advice (such as what is low glycemic index food, and how to prepare a balanced diet etc.), the importance of postpartum screening (such as the incidence of GDM progressing to diabetes mellitus (DM), the importance of postpartum screening to diagnose DM, and what should be done for early identification of T2DM etc.), and multidisciplinary care (such as the original video educating how to test fingertip blood glucose and insulin injection procedure). We reminded them to go to the hospital for the follow-up screening of postpartum OGTT via the WeChat platform. For those patients who did not respond to us on the WeChat platform, researchers sent them a private message to make sure they received our message. In January 2020, we identified participants who had delivered within 4 to 12 weeks from the establishment of the database at the patient's first visit. In February 2020, a questionnaire was sent via WeChat to those participants. The questionnaire included the maternal postpartum OGTT and postpartum glucose results. In addition, medical documents such as OGTT report sheets and prescriptions were delivered as photos via WeChat, and the original data was persevered. Pre-pregnancy body mass index (BMI) was calculated by dividing pre-pregnancy weight in kilograms by the square

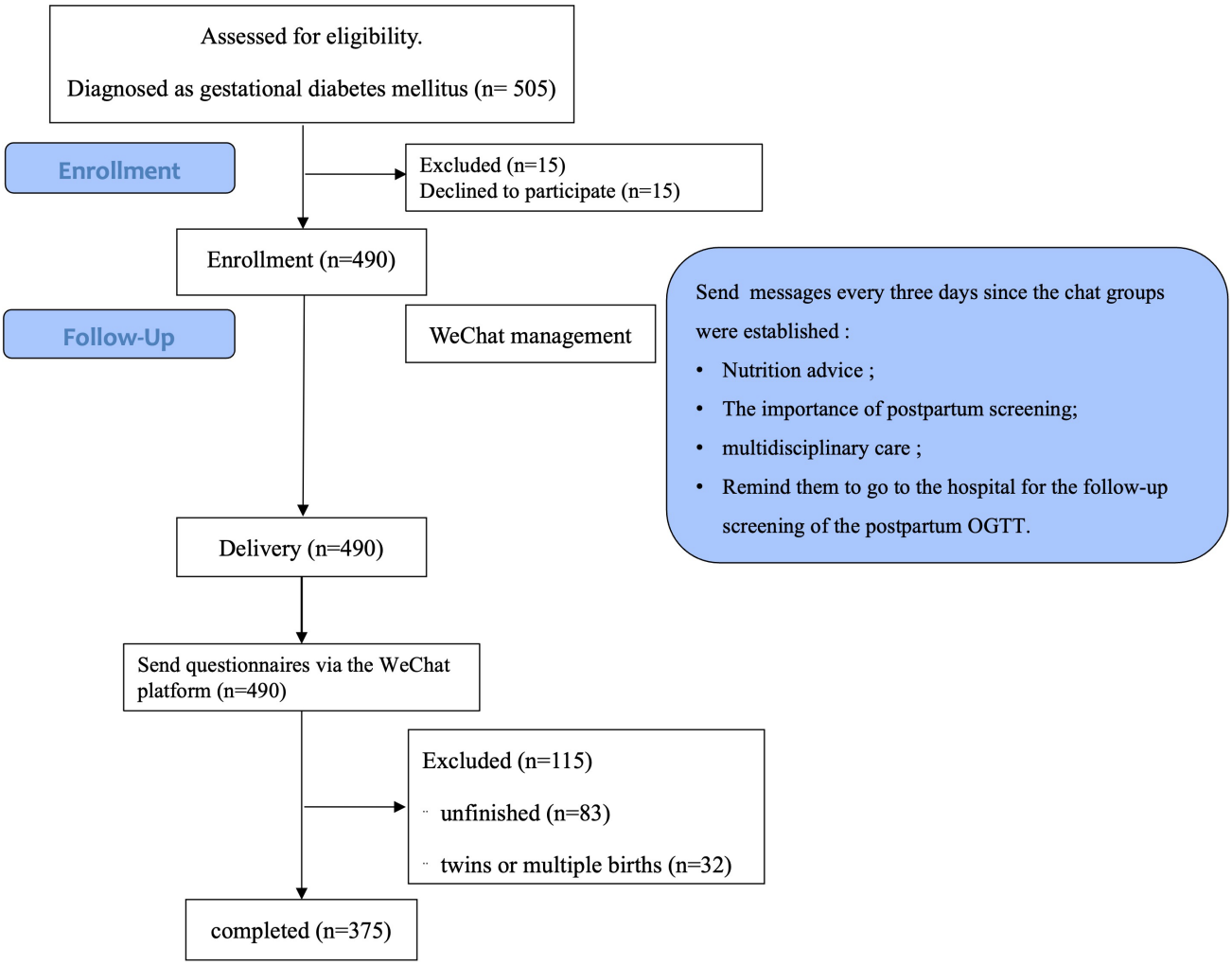

Fig. 1. Flowchart. OGTT, oral glucose tolerance testing.

of height, and categorized as low, normal, and overweight (<18.5, 18.5–23.9, and ≥24 kg/m^2, respectively) [19,20].

We allocated participants who completed questionnaires into two groups: patients who completed OGTT postpartum were included in group 1 and patients who did not complete OGTT postpartum were included in group 2. Postpartum OGTT was defined as completion of the OGTT between 4 and 12 weeks postpartum. We also allocated participants who completed postpartum OGTT into two groups: normal or abnormal glucose tolerance. The collected data is presented in the flowchart (Fig. 1).

2.3 Postpartum OGTT

Postpartum OGTT means that GDM patients who had delivered previously between 4 and 12 weeks finished a standard oral 75 g glucose tolerance test. The diagnosis of postpartum diabetes is based on the diagnostic criteria established by the American Diabetes Association in 2016 [21]. Three situations (normal glucose tolerance (NGT), impaired glucose tolerance (IGT), and DM) were recorded. DM was diagnosed as fasting plasma glucose (FPG) ≥7.0 mmol/L, 2-hour plasma glucose (2 h-PG) ≥11.1 mmol/L, or random plasma glucose level ≥11.1 mmol/L, or 1 of the abnormal values along with 1 of of the classic symptoms of hyperglycemia or hyperglycemic crisis. Impaired fasting glucose (IFG) was diagnosed as FPG ≥5.6 mmol/L (<7.0 mmol/L), while IGT was diagnosed as a 2-hour plasma glucose (2 h-PG) ≥7.8 mmol/L <11.1 mmol/L.

2.4 Statistical Analysis

This study was powered to detect the rate of postpartum OGTT under the management of the WeChat platform. With an expected standard deviation (SD) of 0.1 and an allowable error of 0.01, we calculated that the sample size necessary was 384 participants. We aimed to recruit 480 participants to account for a predicted approximate 20% withdrawal rate.

The principal statistical analysis was for the primary outcome of postpartum OGTT rate and for the secondary outcomes of the normal rate of postpartum OGTT results, factors influencing the obtaining the situation of postpartum OGTT, and factors influencing abnormal postpartum

glucose results. Missing data were assumed to be missing at random. Where the missing values occurred at the baseline visit, we used available data from the follow-up visit. If the missing value occurred at the end of the study, we used a last-observation-carried-forward rule. We imputed missing data within a timed series using a mean imputation rule.

All analyses were performed using Stata version 14.0 (Stata version 14.0, Stata Corp, College Station, TX, USA). The individual participant data at baseline and follow-up was entered independently by both researchers. The percent agreement on the data entry between the two researchers was 100%. The data was compared in the two groups in which women did or did not receive postpartum glucose screening using the two-tailed *t* test and the chi-square test.

Univariable logistic analysis and stepwise regression analysis were used for the following outcomes: factors influencing the obtaining of postpartum OGTT and factors influencing abnormal postpartum glucose results. We included the demographic and clinical parameters as independent variables and completion situation of the postpartum OGTT screening status (or postpartum IGR) as dependent variable. We then conducted univariable logistic analysis and chose the variables whose $p < 0.1$ into the stepwise logistic regression model. All tests were two-tailed and a significance level of 0.05 was used for all hypothesis testing.

3. Results

3.1 Maternal Demographic and Clinical Characteristics

A total of 490 patients participated in our project from 1 January 2016 to 31 August 2019. Three hundred and seventy five completed our online questionnaire in February 2020 and were included in our analysis. The percentage of the participants in the years 2016, 2017, 2018, and 2019 were almost the same (22.5%, 26.1%, 25.3%, and 26.1%, respectively, $p > 0.5$) (Table 1). The overall median pre-pregnancy BMI of the subjects was 22.9 kg/m^2 (ranging from 15.9 to 40.9 kg/m^2) (Table 1). During the pregnancy, 17.6% of patients received insulin treatment. Among the 375 GDM patients, 53.3% had a cesarean section (**Supplementary Table 1**). The percentage of patients who continued to breastfeed to at least 6 months was 65.1%, and only 4.0% of the patients breastfed for less than 4 weeks (**Supplementary Table 1**). Most of the GDM patients (94.9%) understood the necessity of postpartum OGTT screening. Slightly more that seventy three percent (73.9%) of GDM patients completed postpartum OGTT measurement. Most postpartum OGTT measurement results were normal (72.9%). Among the patients who had abnormal postpartum glucose results, most (92.0%) had IGT or IFG, and only 8% were diagnosed with diabetes (Table 2).

Table 1. Baseline characteristics of study participants.

Baseline of study participants	n (%)
Maternal age (years)	
<25	2/375 (0.5)
25∼30	65/375 (17.3)
30∼35	170/375 (45.3)
≥35	138/375 (36.8)
Participants numbers	
In year 2016	84 (22.5%)
In year 2017	98 (26.1%)
In year 2018	95 (25.3%)
In year 2019	98 (26.1%)
Race	
Han nationality	358/375 (95.5)
Others	17/375 (4.5)
Education level	
High school degree or lower	63/375 (16.8)
College or bachelor's degree	280/375 (74.7)
Master's degree or above	32/375 (8.5)
Income (dollars/month per household)	
<139	3/375 (0.8)
139∼417	15/375 (4.0)
417∼696	77/375 (20.5)
696∼1390	162/375 (43.2)
≥1390	118/375 (31.5)
Insurance	
Have medical insurance	364/375 (97.1)
No medical insurance	11/375 (2.93)
Gravidity	
Primigravida	135/375 (36.0)
Multigravida	240/375 (64.0)
Pregnancy methods this time	
Natural conceive	359/375 (95.7)
Assisted reproductive technology	16/375 (4.3)
Medical history	
No diseases	328/375 (87.5)
Polycystic ovary syndrome	37/375 (9.9)
Hyperlipidemia	11/375 (2.9)
Hypertension	4/375 (1.1)
Adverse pregnancy events	
No diseases	123/375 (32.8)
Miscarriage	143/375 (38.1)
Macrosomia	33/375 (8.8)
Caesarean section	104/375 (27.7)
GDM	35/375 (9.3)
Stillbirth fetus	13/375 (3.5)
Family history of diabetes	
Yes	82/375 (21.9)
No	293/375 (78.1)
Pre-pregnancy BMI (kg/m^2)	22.9 (15.9–40.9)
Low (<18.5 kg/m^2)	22/375 (5.9)
Normal (between 18.5 and 23.9 kg/m^2)	245/375 (65.3)
High (≥24 kg/m^2)	108/375 (28.8)

GDM, gestational diabetes mellitus; BMI, body mass index.

Table 2. The findings from the questionnaire.

Findings from the questionnaire	n (%)
Understand the necessity of postpartum OGTT screening	
Yes	356/375 (94.9)
No	19/375 (5.1)
Finished postpartum OGTT screening	
Yes	277/375 (73.9)
Yo	98/375 (26.1)
Results of 42-day postpartum OGTT screening	
Normal	202/277 (72.9)
IGT or IFG	69/277 (24.9)
Diabetes	6/277 (2.2)
Reasons for not completing postpartum screening	
People's time was occupied by taking care of baby	39/98 (39.8)
People believed that glucose could return to normal after delivery	32/98 (32.7)
People had no symptoms	22/98 (22.5)
Waiting time was so long in hospital	20/98 (20.4)
Others	14/98 (14.3)
Ways to get nutrition knowledge for GDM patients	
Obstetrician	24/375 (6.4)
Nutritionist	254/375 (67.7)
Network	85/375 (22.7)
Professional lecture	2/375 (0.5)
Others	10/375 (2.7)

OGTT, oral glucose tolerance testing; IGT, impaired glucose tolerance; IFG, impaired fasting glucose.

3.2 Find Possible Factors Influencing the Completion Rate of Postpartum OGTT

In order to assess predictors for those who were screened for OGTT versus those who were not, questionnaire results were divided into group 1 (completed postpartum OGTT) and group 2 (did not complete postpartum OGTT). There were significant differences between the two groups regarding parameters such as age, race, educational level, gravidity, history of miscarriage, history of macrosomia, history of GDM, family history of diabetes, delivery mode, and average household income ($p < 0.001$) (Table 3). We included these parameters as independent variables and the completion of postpartum OGTT as dependent variable. We found that only two parameters "GDM history" and "delivery mode (cesarean section)" entered into the stepwise logistic regression model, and the two variables were associated with the completion of postpartum OGTT (odds ratio (OR): 0.44, 95% confidence interval (95% CI): 0.20–0.94, $p = 0.03$; OR: 1.88, 95% CI: 1.04–3.39, $p = 0.04$, respectively) (Table 4).

3.3 Find Predictors for Abnormal Postpartum Glucose Results

To assess predictors for those who had abnormal postpartum glucose results, the questionnaire result for those who had completed postpartum OGTT were divided into group 1 (IGT or IFG or DM) and group 2 (normal glucose results). There were significant differences between the two groups regarding parameters such as age, history of miscarriage, and delivery mode ($p < 0.05$) (Table 5). Different maternal demographics, obstetric, and clinical characteristics were collected and were considered to predict postpartum glucose results. We included the parameters as independent variables and the postpartum OGTT results as a dependent variable. We found that six parameters "nationality", "conception way", "family history of diabetes", "insulin treatment during pregnancy", "delivery mode" and "ways of baby feeding" were entered into the stepwise logistic regression model, but only two variables "insulin treatment during pregnancy" and "delivery mode (cesarean section)" were associated with postpartum OGTT results (OR: 3.74, 95% CI: 1.97–7.08, $p < 0.001$; OR: 1.83, 95% CI: 1.02–3.28, $p < 0.05$, respectively) (Table 6).

4. Discussion

The prevalence of GDM has been increasing globally including China. In Tianjin, a cosmopolitan city in North China, the prevalence of GDM increased from 2.3% in 1999 to 8.1% in 2012 [4]. GDM has substantial implications for long-term maternal health including a 13-fold increased risk of GDM [22] in a subsequent pregnancy and a 10-fold higher risk of developing DM later in life as compared to those with normal glycemia level in pregnancy [3]. Given the global prevalence of metabolic diseases, GDM man-

Table 3. Baseline characteristics of those who completed postpartum OGTT (group 1) versus those who did not complete (group 2).

	Group 1 [n (%)]	Group 2 [n (%)]	*p*
Age (years)			
<35	169 (61.0)	68 (69.4)	<0.001
≥35	108 (39.0)	30 (30.6)	
Race			
Han nationality	262 (94.6)	96 (98.0)	<0.001
Other	15 (5.4)	2 (2.0)	
Education level			
High school degree or lower	46 (16.6)	17 (17.3)	<0.001
College or bachelor's degree	203 (73.3)	77 (78.6)	
Master's degree or above	28 (10.1)	4 (4.1)	
Gravidity			
Primigravida (%)	100 (36.1)	35 (35.7)	<0.001
Multigravida (%)	177 (63.9)	63 (64.3)	
History of miscarriage			
Yes (%)	107 (38.6)	36 (36.7)	<0.001
No (%)	170 (61.4)	62 (63.3)	
History of macrosomia	177	63	
Yes (%)	24 (13.6)	9 (14.3)	<0.001
No (%)	153 (86.4)	54 (85.7)	
History of GDM			
Yes (%)	21 (11.9)	14 (22.2)	<0.001
No (%)	156 (88.1)	49 (77.8)	
Family history of diabetes			
Yes (%)	60 (21.7)	22 (22.4)	<0.001
No (%)	217 (78.3)	76 (77.6)	
Pre-pregnancy weight (kg)	57.69 ± 5.24	58.00 ± 7.65	0.800
Pre-pregnancy BMI (kg/m^2)	22.84 ± 2.09	22.93 ± 2.20	0.840
Delivery mode			
Natural birth	123 (44.4)	52 (53.1)	<0.001
Caesarean section	154 (55.6)	46 (46.9)	
Average household income per capita			
139 to 417 Dollars	12 (4.3)	6 (6.1)	<0.001
417 to 696 Dollars	57 (20.6)	20 (20.4)	
696 to 1390 Dollars	117 (42.2)	45 (45.9)	
More than 1390 Dollars	91 (32.9)	27 (27.6)	

agement should now shift to early postpartum prevention strategies to reduce the progression of GDM toward type 2 diabetes and address long-term maternal metabolic risks. Many clinical practice guidelines recommend screening for blood glucose in the postpartum period [7,8]. Persistent hyperglycemia for the diagnosis of T2DM in the immediate postpartum period (within 1–3 days) is uncommon. Thus, delayed glucose testing is recommended to occur 4 to 12 weeks postpartum when IGT is detected in 17% to 23% of women with antecedent GDM pregnancies. The National Institute for Health and Care Excellence (NIHCE) endorses FPG testing at 6 to 13 weeks postpartum. This has the potential to increase the rate of missed diagnosis as up to 40% more women having T2DM using the 75 g OGTT as compared with FPG alone. Thus, the NIHCE recommends an abnormal screening FPG (≥6.0 mmol/L) should be followed with a confirmatory test (second FPG, HbA1c, or OGTT). As the progression to T2DM is partly attributed to decreased insulin sensitivity and impaired beta-cell compensation in women with a history of GDM, women with GDM should receive continued follow-up if their glucose levels were normal during the 6-week postpartum screening. The American Diabetes Association (ADA) recommends diabetes testing every 1 to 3 years thereafter using HbA1c, FPG, or OGTT utilizing nonpregnant thresholds [23]. NIHCE echoes that women with increased postpartum glucose levels that are not diagnostic of diabetes should undergo annual testing, and advises annual HbA1c testing for women diagnosed with GDM who have negative postnatal diabetes screening [6].

Table 4. Further logistic analysis exploring the predictors in those who completed postpartum OGTT.

Predictor variables	Univariable analysis	Stepwise regression analysis	
	OR (95% CI)	OR (95% CI)	*p* value
Maternal age (≥35 years)	1.10 (0.60–2.03)		
Nationality (minority)	1.57 (0.17–14.18)		
Conception way (*in-vitro* fertilization)	2.26 (0.24–20.91)		
BMI before pregnancy	0.85 (0.49–1.49)		
Weight gain during pregnancy	0.97 (0.69–1.37)		
History of GDM	0.42 (0.19–0.94)	0.44 (0.20–0.94)	0.03
History of macrosomia	0.80 (0.32–2.01)		
Level of education	1.62 (0.89–2.95)		
Average household income per capita	1.13 (0.79–1.64)		
Family history of diabetes	1.26 (0.53–2.99)		
Insurance	0.45 (0.05–4.40)		
Insulin treatment during pregnancy	1.57 (0.63–3.90)		
Delivery mode (caesarean section)	1.73 (0.91–3.28)	1.88 (1.04–3.39)	0.04
Gestational age at delivery	0.88 (0.32–2.47)		
Ways of baby feeding (breast feeding)	0.91 (0.69–1.21)		

OR, odds ratio; 95% CI, 95% confidence interval; GDM, gestational diabetes mellitus.

Major organizations have proposed that GDM patients complete postpartum OGTT screening at 4–12 weeks postpartum as it is the most convenient evidence-based approach [9,23]. Ideally, all GDM patients need to undergo an OGTT at their 6-week postpartum visit. Postpartum OGTT screening has the potential to identify individuals with IGT or IFG, which may be reversible [24]. Chang *et al*. [10] found that only 282 (13.1%) of 2152 Chinese GDM patients completed glucose screening after delivery. Researchers from USA found that 40.85% to 45% GDM patients finished postpartum glucose screening in the USA [11,25]. A study from France showed that only 154 (38.1%) of 404 GDM patients participated in the postpartum OGTT [26]. A 13-year Italian cohort study found that only 26.3% of GDM women had a postpartum OGTT [27].

Many researchers are seeking ways to improve the postpartum glucose screening rate following GDM. Carson *et al*. [28] found that contacting patients proactively via phone calls, or postal reminders increased the postpartum testing rate from the average of 33% up to 60%. Another study found that phone calls from nutritionists reminding patients to attend postpartum visits increased postpartum glucose test rates (36% *vs*. 17%) [29]. DIAMIND study of Australia found that a short message service reminder significantly increased the attendance for postpartum OGTT, and mothers preferred to receive electronic reminders, particularly text messages, sent by the study team or their clinicians [30,31]. It was also shown to be effective for the Kaiser Permanente Northwest (KPNW) GDM Care to use electronic medical record data and an electronic system automated reminder call [32]. In our study, we used WeChat as a platform to manage the follow-up issues for GDM patients. With the high usage rate of the WeChat platform in China, almost all GDM women are likely to use it. Our questionnaire distributed via the WeChat platform showed that 94.9% of the GDM patients understood the necessity of postpartum OGTT screening, and 73.9% of those were screened for OGTT 4–12 weeks after delivery. The percentage of postpartum glucose screening in our study was much higher than the other Chinese study which showed that only 13.1% of GDM patients completed glucose screening after delivery [18].

Stepwise logistic regression analysis showed that only two parameters "GDM history" and "delivery mode (cesarean section)" were significant. Women with a previous history of GDM were less likely to complete postpartum OGTT than those who did not have GDM (OR: 3.74, 95% CI: 1.97–7.08), and women who had a cesarean section were more likely to return to the hospital to complete postpartum OGTT than those with a vaginal delivery (OR: 1.83, 95% CI:1.02–3.28). It has been suggested that enhancing education provided to women with a history of GDM may improve postpartum OGTT screening rates. Our results are similar to the findings recently published by Hunt *et al*. [33] who reported that women who failed to return for postpartum glucose testing were more likely to report prior GDM. However, in contrast to our results, the factors they identified as being associated with postpartum glucose testing were public insurance [19], older age, nulliparity, higher income or education [34], lower diagnostic glucose levels, and not requiring insulin during pregnancy [33]. Different ethnicities, and economic abilities of patients and inclusion criteria of studies may lead to differences in the findings.

The other principal finding in our study was that those who used insulin during pregnancy and those who had a cesarean section had a higher rate of abnormal postpartum OGTT results. This may be due to the fact that those who used insulin treatment during pregnancy or had a cesarean

Table 5. Characteristics of participants grouped according to postpartum glucose test results.

Variables	Completed postpartum OGTT (n = 277)	IFG/IGT/DM (n = 75)	NGT (n = 202)	*p* value
Maternal age (years)				
<35	169 (61.0)	38 (50.7)	131 (64.9)	0.030
≥ 35	108 (39.0)	37 (49.3)	71 (35.1)	
Race				
Han nationality	262 (94.6)	68 (90.7)	194 (96.0)	0.080
Other	15 (5.4)	7 (9.3)	8 (4.0)	
Education level				
High school degree or lower	46 (16.6)	14 (18.7)	32 (15.9)	0.880
College or bachelor's degree	203 (73.3)	51 (68.0)	152 (75.2)	
Master's degree or above	28 (10.1)	10 (13.3)	18 (8.9)	
Gravidity				
Primigravida	100 (36.1)	20 (26.7)	80 (39.6)	0.040
Multigravida	177 (63.9)	55 (73.3)	122 (60.4)	
History of miscarriage				
Yes	107 (38.6)	38 (50.7)	69 (34.2)	0.010
No	170 (61.4)	37 (49.3)	133 (65.8)	
History of macrosomia	177			
Yes	24 (13.6)	6 (10.9)	18 (14.8)	0.490
No	153 (86.4)	49 (89.1)	104 (85.2)	
History of GDM	177			
Yes	21 (11.9)	9 (12.0)	12 (11.8)	0.960
No	156 (88.1)	66 (88.0)	90 (88.2)	
Family history of diabetes				
Yes	60 (21.7)	21 (28.0)	39 (19.3)	0.120
No	217 (78.3)	54 (72.0)	163 (80.7)	
Delivery mode				
Natural birth	123 (44.4)	23 (30.7)	100 (49.5)	0.005
Caesarean section	154 (55.6)	52 (69.3)	102 (50.5)	
Average household income per capita				
139 to 417 Dollars	12 (4.3)	3 (4.0)	9 (4.5)	0.220
417 to 696 Dollars	57 (20.6)	19 (25.3)	38 (18.8)	
696 to 1390 Dollars	117 (42.2)	33 (44.0)	84 (41.6)	
More than 1390 Dollars	91 (32.9)	20 (26.7)	71 (35.1)	

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

section had a higher glucose level during pregnancy, making it more difficult to return to normal glucose levels after delivery.

Our study did not use a control group to compare the rate of postpartum blood glucose screening with and without WeChat-based management. The source of nutrition advice provides limited information on the patient's nutrition knowledge. In addition, due to the limitation of experimental samples, our conclusions may not comprehensively reflect all situations, and further expansion of the sample size is needed to promote the generalizability of the findings. All participants received questionnaires to ask whether they had completed their screening in the study. This part of the study could also further increase screening rates independently of the WeChat messaging, which may be a confounding factor. Follow-up via hospital records may avoid this issue. Despite the limitations, our study also has notable strengths.

Considering the close relationship between GDM and chronic diseases like T2DM, identifying and implementing interventions to decrease the incidence of associated health complications is a priority [6]. Previous study has shown that breastfeeding, postpartum healthy dietary intake and regular exercise can reduce progression to diabetes for women with a history of GDM [6]. In a 10 years follow-up observation, intensive lifestyle modifications along with the use of metformin were found to reduce progression to T2DM significantly [6]. Future studies should explore the utility of social medial platforms for enhancing nutrition knowledge and GDM management.

Table 6. Multiple logistic regression for predicting postpartum glucose intolerance following GDM.

Predictor variables	Univariable analysis	Stepwise regression analysis	
	OR (95% CI)	OR (95% CI)	*p* value
Maternal age (≥35 years)	1.03 (0.48–2.18)		
Nationality (minority)	7.72 (1.13–52.83)	NA	
Conception way (*in-vitro* fertilization)	0.06 (0.01–0.67)	NA	
BMI before pregnancy	1.12 (0.37–3.35)		
Weightgain during pregnancy	0.82 (0.54–1.25)		
History of GDM	1.45 (0.49–4.28)		
History of macrosomia	0.38 (0.11–1.37)		
Level of education	0.63 (0.31–1.31)		
Average household income per capita	0.73 (0.46–1.16)		
Family history of diabetes	2.33 (0.89–6.08)	NA	
Insulin treatment during pregnancy	3.84 (1.51–9.73)	3.74 (1.97–7.08)	<0.001
Delivery mode (caesarean section)	2.70 (1.19–6.13)	1.83 (1.02–3.28)	0.040
Gestational age at delivery	0.47 (0.16–1.43)		
Ways of baby feeding (brest feeding)	0.73 (0.52–1.04)	NA	

OR, odds ratio; GDM, gestational diabetes mellitus; NA, not included in the stepwise regression analysis.

5. Conclusions

The WeChat messaging platform may be a useful tool to enhance postpartum OGTT screening among women with GDM. Women who failed to return for postpartum glucose screening (PGS) were more likely to report prior GDM than women who returned for PGS. Women who had postpartum IGR were more likely to use insulin treatment during pregnancy and more likely to deliver by cesarean section compared to women who had normal postpartum glucose results.

Availability of Data and Materials

The data that support the findings of this study are available on request from the corresponding author Min Liu upon reasonable request.

Author Contributions

Study concepts were prepared by ML and YFL. The study was designed by HL. Data acquisition was performed by HYP and CXC. Quality control of data and algorithms was carried out by MW and CMM. Data analysis and interpretation was conducted by GF and JRW. Statistical analysis was performed by HN and JYW. The manuscript was prepared and edited by HL. All authors contributed to editorial changes in the manuscript. All authors read and approved the final manuscript.

Ethics Approval and Consent to Participate

All subjects gave their informed consent for inclusion before they participated in the study. The study was conducted in accordance with the Declaration of Helsinki, and the protocol was approved by the Institutional Review Boards of the Third Xiangya Hospital, Central South University (No: 2020-S262).

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Conflict of Interest

The authors declare no conflict of interest.

Supplementary Material

Supplementary material associated with this article can be found, in the online version, at https://doi.org/10.31083/j.ceog5103071.

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