

Original Research

# Impact of Personalized Education and Supervision on Pregnancy Outcomes in Women with Gestational Diabetes Mellitus

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## Abstract

**Background:** To evaluate the effect of distance, professional behaviour education and guidance on reducing adverse pregnancy outcomes in women with gestational diabetes mellitus (GDM). **Methods:** Women with GDM who had undergone regular prenatal care and gave birth at Jinshan Branch of Shanghai Sixth People's Hospital from January 2019 to October 2020 were enrolled. A random number table method was utilized to divide the patients into a control group (168 cases) and an intervention group (182 cases). In the control group, routine prenatal education was conducted, while in the intervention group, in addition to routine prenatal education, providers used video and the WeChat public platform to regularly impart knowledge and behaviour education to women with GDM and supervise the implementation of their actions. The pregnancy outcomes of the two groups were compared. **Results:** ① Fasting plasma glucose (FPG), 2-hour postprandial blood glucose (2hPG) and glycohemoglobin (HbA1c) in the intervention group were significantly lower than that of the control group ( $p < 0.05$ ). ② In the intervention group, the thyroid peroxidase antibody (TPOAb) positive rate was lower and free thyroxine (FT4) was higher than that in the control group ( $p > 0.05$ ). The vaginal pH in the intervention group was significantly higher than that of the control group. ③ Thyroid-stimulating hormone (TSH), weight gain during pregnancy, incidences of preeclampsia, polyhydramnios, preterm premature rupture of membranes (PPROM), premature rupture of membranes (PROM), caesarean section, puerperal infection, amniotic fluid pollution chorioamnionitis, macrosomia, large for gestational age infant, neonatal care, neonatal hypoglycaemia, neonatal pneumonia, detection rates of bacterial vaginosis (BV), vulvovaginal candidiasis (VVC), Ureaplasma urealyticum (UU), Group B streptococcus (GBS), cleanliness III/IV and positive rates of hydrogen peroxide, neuraminidase and leukocyte esterase were all significantly lower in the intervention group than those in the control group ( $p < 0.05$ ) and relative risk (RR)  $< 1$ . ④ The rates of trichomonas vaginitis (TV), Neisseria gonorrhoeae, chlamydia trachomatis (CT), positive rates of N-acetyl-D-glucosaminidase (NAG), and proline aminopeptidase (PA), and the incidences of oligohydramnios, foetal growth restriction (FGR), placenta previa, placental abruption, foetal distress in utero, postpartum haemorrhage, preterm infant, neonatal Apgar score less than 7 at one minute, neonatal abnormality, neonatal death, small for gestational age and hyperbilirubinemia were lower in the intervention group than those in the control group ( $p > 0.05$ ). **Conclusions:** WeChat group and other online intervention measures were adopted for women with GDM. These are simple interventions which can automatically upload, classify, and analyse data. An increased use of telemedicine can closely supervise the intervention, adjust the personalized plan at any time, effectively control blood sugar levels, maintain vaginal microecological balance and reduce the occurrence of adverse pregnancy outcomes.

**Keywords:** gestational diabetes; standardized knowledge and active education; diet and exercise management; adverse pregnancy outcome

## 1. Background

Gestational diabetes mellitus (GDM) is characterized by abnormal glucose tolerance, which is caused by increased insulin resistance during pregnancy [1]. The incidence of GDM is approximately 5.12%–33.3% in China [2] with an increasing upwards trend. There is evidence that GDM and the resulting maternal hyperglycaemia are associated with adverse perinatal outcomes, and evidence exists that monitoring and treatment of GDM can reduce these adverse outcomes [3]. Women with GDM can experience reproductive tract infections that can cause varying degrees of harm to the quality of life of patient, her infant's health and increase adverse pregnancy outcomes [4]. WHO suggests that pregnant women perform self-management, con-

trol their blood glucose and maintain their vaginal microecological balance, all which can improve pregnancy outcomes. Diet and blood glucose monitoring is the first-line therapy method for women with GDM [5]. However, often medication is more valued by doctors and researchers than lifestyle interventions, and methods using diet and exercise are often ignored. Personalized nutritional intervention therapy for women with GDM significantly reduces their blood glucose levels and improves their pregnancy outcomes [6]. Without professional medical supervision, nearly 90% of women with GDM fail to adopt a successful self-administered diet and exercise program [7]. Carolan Olah's study [8] demonstrated that the use of interventions including low glycaemic index diet and increased activity



levels can successfully reduce the blood glucose level of pregnant women and reduce insulin demand during pregnancy, thereby reducing maternal weight gain and associated macrosomia. Impacted by a lack of patient compliance, follow-up conditions and living in remote areas, face-to-face communication between doctors and patients is limited. Adesina *et al.* [9] have shown that using digital tools is likely to be an effective method to support GDM patients' self-management in healthy diet, healthy behaviour and adherence to treatment. Therefore, we remotely guided pregnant women to manage their diet, exercise, blood glucose and vaginal microecological environment through the form of a WeChat group, which has achieved supportive data in improving pregnancy outcomes.

## 2. Methods

### 2.1 Participants

#### 2.1.1 Case Sources

Participants included women with GDM who had undergone regular prenatal care and gave birth at the Jinshan Branch of Shanghai Sixth People's Hospital from January 2019 to October 2020. A random number table method was used to divide the patients into a control group and an intervention group. Inclusion criteria: (1) women with GDM and age  $\geq 18$  years old; (2) good physical health and singleton pregnancy; (3) pre-pregnancy body mass index (BMI)  $\leq 24.9$  kg/m<sup>2</sup>; and (4) voluntary participation following informed consent. Exclusion criteria: (1) pregestational diabetes mellitus (PGDM); (2) gestational week of delivery  $< 28$  weeks; (3) a diagnosis of chronic disease, pregnancy complications or recent trauma; (4) women with GDM requiring medical treatment during pregnancy; (5) communication disorders or other reasons for not being able to cooperate with the researchers; (6) lost to follow-up during the study; (7) poor compliance. 400 cases were included in the study through eligibility and were randomised into two groups in a 1:1 ratio. Participants who ultimately adhered to the study protocol and completed the entire study included there were 168 cases in the control group ( $n = 168$ ) with an average age ( $29.89 \pm 3.42$ ), pre-pregnancy BMI ( $23.05 \pm 2.38$ ) kg/m<sup>2</sup>, pregnancy number ( $2.39 \pm 0.48$ ), and delivery number ( $1.98 \pm 0.23$ ); 182 cases in the intervention group ( $n = 182$ ) with an average age ( $30.27 \pm 3.21$ ), pre-pregnancy BMI ( $23.12 \pm 2.32$ ) kg/m<sup>2</sup>, pregnancy number ( $2.45 \pm 0.36$ ) and delivery number ( $2.02 \pm 0.36$ ). There were no significant differences in the demographic data between the two groups ( $p > 0.05$ ). Flow chart of subject recruitment for personalized education and supervision clinical research of women with gestational diabetes mellitus is shown in Fig. 1. This study was approved by the committee of the Jinshan Branch of Shanghai Sixth People's Hospital. Also, this study was undertaken in accordance with CONSORT guidelines to ensure the rationality and accuracy of the clinical research results.

#### 2.1.2 GDM Diagnostic Criteria

Diagnosis of GDM: oral glucose tolerance test (OGTT) at 24 to 28 weeks of gestation, fasting, 1 hour and 2 hours blood glucose levels that meets or exceeds 5.1 mmol/L, 10.0 mmol/L or 8.5 mmol/L, respectively [4].

### 2.2 Specific methods

#### 2.2.1 Preparation before the Intervention

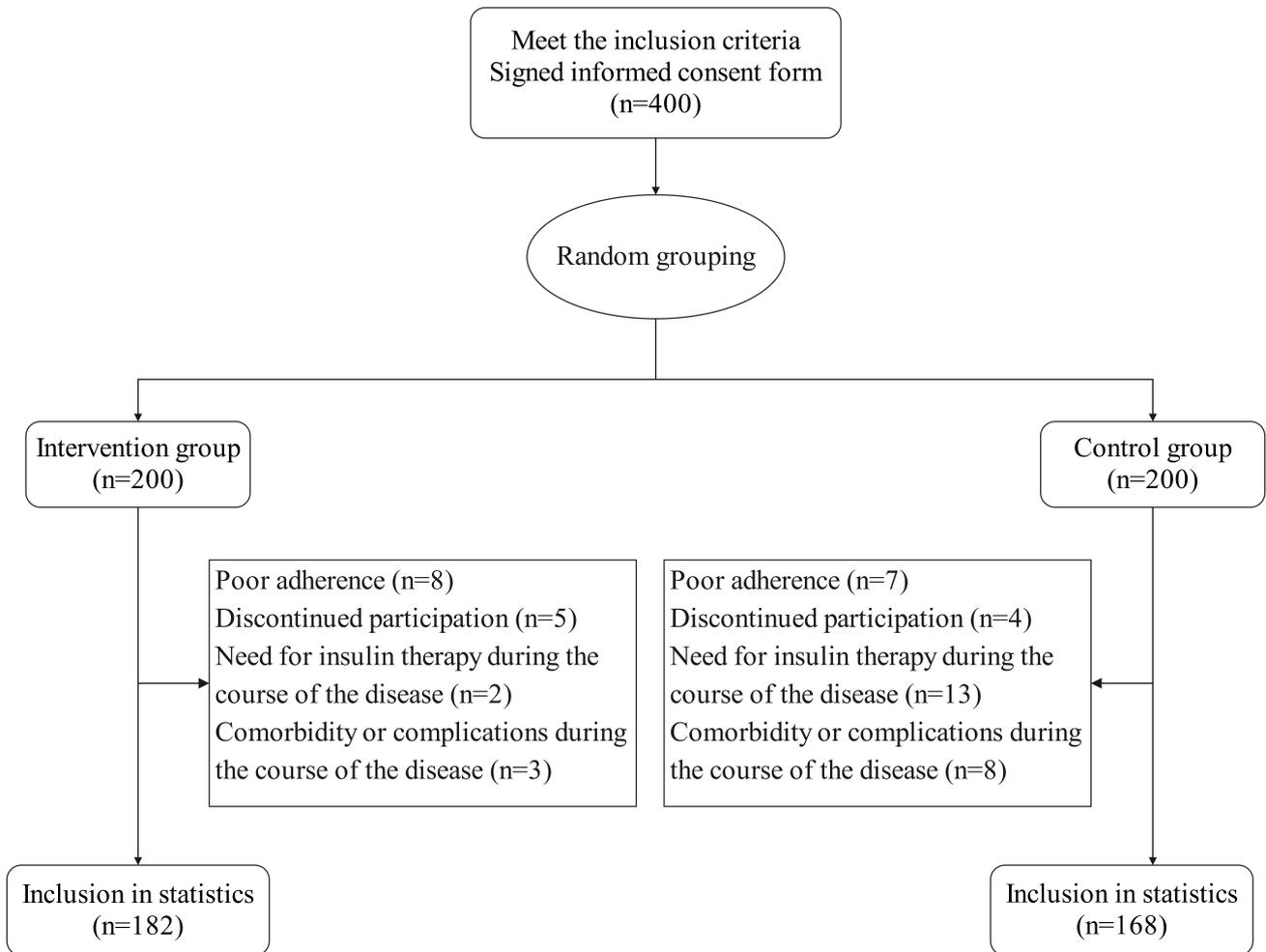
The research team consisted of 2 obstetricians, and one of them is the chief physician of gestational diabetes, 2 dietitians, 1 psychological consultant and 8 nursing staff. The established research team developed a unified process, and conducted training prior to the intervention. The team consisted of 2 obstetricians who performed regular antenatal examinations, assessed the risks of GDM, and conducted nutrition and exercise health education; 2 dietitians who designed the diet plan; 1 psychological consultant for counselling; and 8 clinical nursing staff responsible for the online knowledge and WeChat group supervision of the women according to the diet and exercise plan implemented and being available to answer questions, engage in data collection and conduct follow-up.

#### 2.2.2 Intervention Methods

Control group: A routine hospital obstetric examination mode was adopted. Routine health care guidance was provided for women with GDM during each antenatal visit. Printed materials were distributed to provide health education and guidance on GDM knowledge, nutrition during pregnancy, exercise, vaginal microecology, the childbirth process, neonatal nursing methods, breastfeeding and an understanding of the postpartum period.

Intervention group: In addition to the practices for the control group, professionals on the research team conducted online guidance and supervision of new media, publicized education and behaviour supervision by using the WeChat group and the "Obstetrics and Gynaecology" public account. WeChat group is a platform for individuals to chat and exchange. It can send voice messages, videos, pictures and text through a mobile phone network. Compared with traditional office methods, a WeChat work group has the advantages of being paperless, convenient, interactive and timely.

(1) Knowledge: ① GDM and vaginal microecology knowledge education: teaching pregnant women about GDM vaginal microecology knowledge, adverse effects on maternal and infant outcomes, and issues requiring attention during pregnancy were explained to the women by means of school lectures, videos and the WeChat public platform. ② Dietary education: the pregnant women were guided to keep food diaries, engage in self-monitoring of blood glucose four times a day (fasting blood glucose and blood glucose 2 hours after each meal), and according to the blood glucose monitoring results, the blood glucose was monitored for 2 or 3 days a week. They were asked to



**Fig. 1. Flow chart of subject recruitment for personalized education and supervision clinical research of women with gestational diabetes mellitus.**

record their weight each day. The pregnant women were asked to check in with the WeChat group daily. The dietitians adjusted their dietary intake according to their blood glucose level and weight, developed personalized dietary programs to ensure an adequate supply of calories and nutrients during pregnancy and to avoid the occurrence of postprandial hyperglycaemia and starvation ketosis. The diet plan involved obtaining 45–50% of calories from carbohydrates, 20–25% from protein, and 30% from fats. The blood glucose control target range was fasting 3.6–5.3 mmol/L and 2 hours after a meal <6.7 mmol/L. The weight goal was a weight gain of 0.5 kg/week during the 2nd and 3rd trimesters. ③ Exercise guidance: the pregnant women were asked to perform 30–60 minutes of moderate-intensity exercise 30 minutes after a meal. According to their personal physique and hobbies, individual exercises, such as yoga and health exercises for pregnant women, should be performed 2–3 times a week. The WeChat group required logging in and supervising its implementation. ④ Vaginal microecological self-management: maintain the vulva clean and dry, pay attention to sexual hygiene, wear loose

cotton underwear, avoid the use of vaginal drugs and vaginal lavage. ⑤ Perinatal guidance: during the prenatal period, pregnant women with anxiety and fear were given prenatal psychological counselling by consultations to keep them happy and reduce their anxiety and other negative emotions. At the same time, the measures of prevention and treatment of perinatal adverse events were explained to the pregnant women to reduce their fear and anxiety. The pregnant women were made aware of the elevated risk of GDM for their infants and were given insight into prevention and nursing to avoid complications, such as temperature maintenance, providing oxygen inhalation and supplementation as needed with glucose water. The goal was to reduce panic and fear among the pregnant women and encourage breastfeeding.

(2) Behaviour: the pregnant women could contact the nursing staff through WeChat to answer any questions and to regularly monitor and evaluate the GDM women's progress according to their medical behaviour and self-management ability. The team could provide the corresponding nursing care according to the maternal situation

and provide regular telephone follow-ups or on-site visits to investigate and evaluate the maternal education content, supervise or strengthen their self-management, health, science and rational behaviour based on the importance of disease prevention and control in accordance with the doctor's advice.

### 2.2.3 Self-Management Behaviour Assessment after the Intervention

The two groups of patients were evaluated before delivery by the Summary of Diabetes Self Care Activities (SDSCA) [10] for the six dimensions of general diet, special diet, exercise, blood glucose monitoring, foot care, and medicine use. The total score of each dimension was the total score of the scale. The lowest score was 0 and the highest was 77. The score was positively correlated with good self-management behaviour. The SDSCA score of the study group ( $55.68 \pm 11.37$ ) was significantly higher than that of the control group ( $41.95 \pm 12.98$ ) ( $p < 0.05$ ).

### 2.2.4 Vaginal Microecological Detection

In the third trimester (28 weeks to delivery) in both groups, vaginal secretions were collected from the posterior fornix with sterile cotton swabs. Dry chemical examination indices of the vaginal secretions (Production Lot No. 20208110, Zhuhai Lizhu Reagent Company Limited, Zhuhai, Guangdong, China) included the following: pH, hydrogen peroxide ( $H_2O_2$ ), leukocyte esterase (LE), neuraminidase (NA), N-acetyl-D-glucosaminidase (NAG), and proline aminopeptidase (PA). The vaginal secretions were used to diagnose bacterial vaginosis (BV), vulvovaginal candidiasis (VVC), trichomonas vaginitis (TV) or Group B streptococcus (GBS). Diagnostic criteria for BV were as follows: vaginal pH  $>4.5$ , positive amine test, and vaginal secretions with a fish-like stench. Diagnostic criteria of VVC: 10% KOH hanging drop method, spore and pseudomycelium observed under the light microscope. Diagnostic criteria of TV: Trichomonads were observed under an optical microscope by wet prep method. After culture on a GBS chromogenic plate (Production Lot No. 20200510, Zhengzhou Antu Biological Engineering Ltd, Zhengzhou, Henan, China), a drug sensitivity test was carried out by an automatic bacterial identification drug sensitivity analyser.

Alternate types of vaginitis refer to infections with *Neisseria gonorrhoeae*, *Ureaplasma urealyticum* (UU) and *Chlamydia trachomatis* (CT). Cervical secretions were collected to detect the DNA of *Neisseria gonorrhoeae* (Production Lot No. 20200320, Shanghai Comaga Microbial Technology Ltd, Shanghai China), UU (Production Lot No. 20200510, Zhengzhou Antu Biological Engineering Ltd, Zhengzhou, Henan, China) and CT (Production Lot No. 20200430, Abbott Biopharmaceuticals Ltd, Suzhou, Jiangsu, China) by PCR [11]. Cleanliness inspection of vaginal secretion: Cleanliness III is less vaginal bacilli, more mixed bacteria and white blood cells; There were no

vaginal bacilli in Cleanliness IV, all of which were mixed bacteria and more white blood cells. Cleanliness III/IV indicates that the vaginal flora is dysregulated, which is of great significance for the diagnosis of vaginitis.

Sexual activity, vaginal medication and irrigation were prohibited within 48 hours before sample collection.

### 2.3 Outcome Measures

(1) One month before delivery in both groups: fasting plasma glucose (FPG), 2-hour postprandial blood glucose (2hPG), and glycohemoglobin (HbA1c);

(2) In the third trimester (28 weeks to delivery) in both groups: thyroid peroxidase antibody (TPOAb), free thyroxine (FT4), and thyroid-stimulating hormone (TSH);

(3) In the third trimester (28 weeks to delivery) in both groups: vaginal secretion pH, hydrogen peroxide ( $H_2O_2$ ), leukocyte esterase (LE), neuraminidase (NA), N-acetyl-D-glucosaminidase (NAG), proline aminopeptidase (PA), Cleanliness III/IV, bacterial vaginosis (BV), vulvovaginal candidiasis (VVC), trichomonas vaginitis (TV) and Group B streptococcus (GBS). *Neisseria gonorrhoeae*, *Ureaplasma urealyticum* (UU) and *Chlamydia trachomatis* (CT) were tested from the vaginal secretions;

(4) The women in both groups had any adverse pregnancy outcomes recorded with, the primary observation indicators being: excessive weight gain during pregnancy, preeclampsia (PE), polyhydramnios, preterm premature rupture of membranes (PPROM), premature rupture of membranes (PROM), puerperal infection, foetal growth restriction (FGR) and chorioamnionitis; the secondary observation indicators being: caesarean section, puerperal infection, amniotic fluid pollution, oligohydramnios, placenta previa, placental abruption, foetal distress and postpartum haemorrhage (PPH);

(5) Neonatal adverse outcomes in the 2 groups were recorded with the primary observation indicators being: macrosomia, large for gestational age (LGA), neonatal pneumonia, preterm infant, neonatal hypoglycaemia and neonatal abnormality; the secondary observation indicators being: neonatal care, neonatal Apgar score less than 7 at a minute, neonatal death, small for gestational age (SGA) and hyperbilirubinemia.

### 2.4 Statistical Analysis

The data were analysed by SPSS 26.0 (IBM Corp., Chicago, IL, USA). The Shapiro Wilk method was used to test for normal distribution. Quantitative data that conformed to the normal distribution were expressed as mean  $\pm$  SD, and comparisons between indicators and standard values were made using the one-sample *t*-test; qualitative data were expressed as frequencies (percentages), and comparisons between groups were made using the  $\chi^2$  test.  $p < 0.05$  indicated that the differences were statistically significant.

**Table 1. Comparison of blood glucose and glycosylated haemoglobin index (mean ± SD).**

Group	Cases (n)	FPG (mmol/L)	2hPG (mmol/L)	HbA1c (%)
Intervention group	182	4.83 ± 0.63	6.31 ± 0.86	5.26 ± 0.65
Control group	168	5.61 ± 0.75	7.12 ± 0.95	6.26 ± 0.94
<i>T</i>	/	15.1164	11.9964	16.6182
<i>p</i>	/	<0.001	<0.001	<0.001

**Table 2. Comparison of TPOAb positivity between the two groups.**

Group	Cases (n)	TPOAb positive (n, %)	FT4 (pmol/L)	TSH (mIU/L)
Intervention group	182	10(5.49)	17.59 ± 2.58	2.65 ± 0.69
Control group	168	11(6.55)	17.28 ± 2.45	3.57 ± 0.98
<i>T/χ<sup>2</sup></i>	/	0.172	1.653	14.578
<i>p</i>	/	0.679	0.099	<0.001

### 3. Results

#### 3.1 Comparison of Blood Glucose and Glycosylated Haemoglobin between the Two Groups within One Month before Delivery

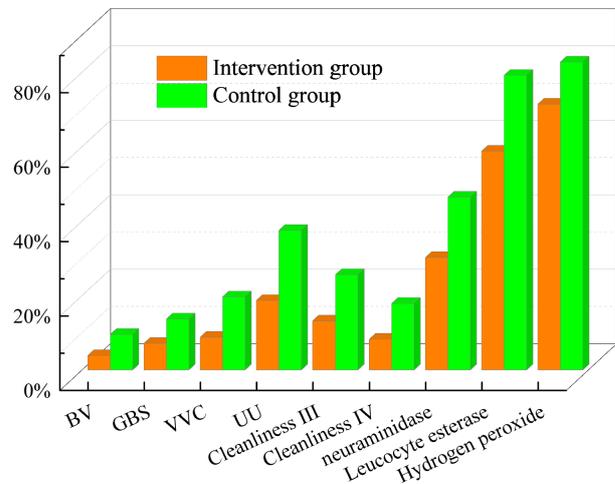
The fasting and 2-hour postprandial blood glucose of the intervention group were within the normal range, while the fasting and 2-hour postprandial blood glucose of the control group were higher than the normal range, and the difference between the two groups was statistically significant ( $p < 0.05$ ). The mean value of the glycosylated haemoglobin in the two groups was normal but the intervention group was lower than the control group with the difference being statistically significant ( $p < 0.05$ ). See Table 1 for details.

#### 3.2 The Levels of TPOAb, FT4 and TSH in the Third Trimester (28 Weeks to Delivery) were Compared between the Two Groups

The positive rate of TPOAb in the study group was lower than that in the control group, and the level of FT4 in the intervention group was higher than that in the control group, but neither reached significant difference ( $p > 0.05$ ). The thyroid stimulating hormone (TSH) level was lower than that of the control group ( $p < 0.05$ ) and is shown in Table 2.

#### 3.3 The Comparison of Vaginal Microorganisms in the Third Trimester (28 Weeks to Delivery) between the Two Groups

The incidences of BV, VVC, UU, GBS, cleanliness III/IV and the positive incidences of hydrogen peroxide, neuraminidase and leukocyte esterase in the intervention group were significantly lower than those of the control group ( $p < 0.05$ ) (Table 3 and Fig. 2). The vaginal pH of the intervention group was significantly higher than that of the control group ( $p < 0.05$ ). The incidences of TV, CT, NAG, PA and *Neisseria gonorrhoeae* were lower than those in the control group, but the difference was not statistically significant ( $p > 0.05$ ).

**Fig. 2. Comparison of vaginal microorganisms in the third trimester ( $p < 0.05$ ).**

#### 3.4 The Effect of the Comparison of Adverse Outcomes of Pregnant Women between the Two Groups

Preeclampsia, polyhydramnios, preterm premature rupture of membranes, premature rupture of membranes, puerperal infection, amniotic fluid pollution, chorioamnionitis and caesarean section in the intervention group were significantly lower than those in the control group ( $p < 0.05$ ) (Table 4 and Fig. 3), and RR < 1. Weight gain during pregnancy was significantly lower than that in the control group ( $p < 0.05$ ). The incidences of oligohydramnios, FGR, placenta previa, placental abruption, foetal distress and postpartum haemorrhage were lower than those in the control group, but there was no significant difference ( $p > 0.05$ ).

#### 3.5 The Comparisons of the Incidence of Adverse Neonatal Outcomes between the Two Groups

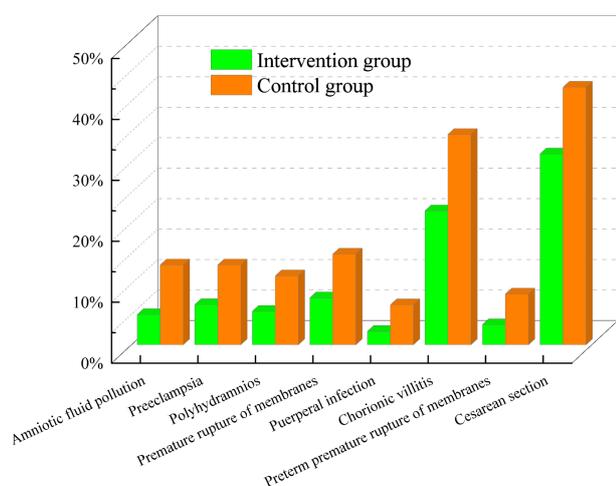
The incidence of macrosomia, gestational age, neonatal care, neonatal hypoglycaemia and neonatal pneumonia in the intervention group was significantly lower than that in the control group ( $p < 0.05$ ) (Table 5 and Fig. 4), and RR

**Table 3. Comparison of vaginitis factors between the two groups (n, %).**

Group	Cases	Vaginal pH	Vaginal BV (+)	VVC	TV	GBS (+)	Cleanliness III	Cleanliness IV
Intervention group	182	4.11 ± 0.19	7 (3.85)	16 (8.79)	2 (1.10)	13 (7.14)	24 (13.19)	15 (8.24)
Control group	168	3.79 ± 0.23	16 (9.52)	33 (19.64)	3 (1.79)	23 (13.69)	43 (25.60)	30 (17.86)
$T/\chi^2$	/	20.362	4.587	8.544	0.293	4.059	8.690	7.209
$p$	/	< 0.001	0.032	0.003	0.589	0.044	0.003	0.007

**Table 3. Continued.**

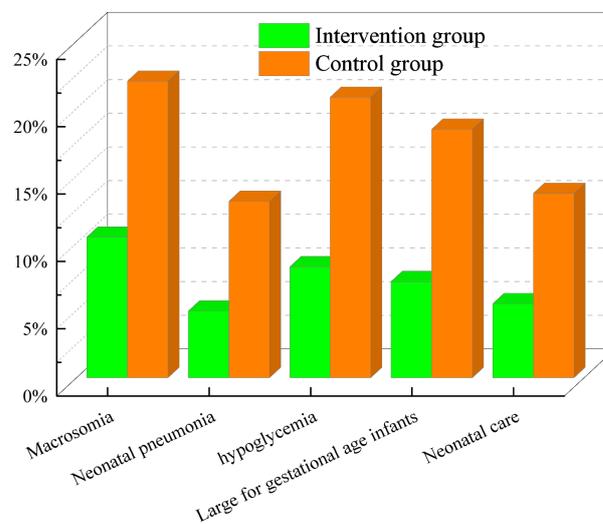
Group	Leucocyte esterase	Neuraminidase	Hydrogen peroxide	NAG	PA	UU	CT	Neisseria gonorrhoeae
Intervention group	107 (58.79)	55 (30.22)	130 (71.43)	19 (10.44)	8 (4.40)	34 (18.68)	2 (1.10)	1 (0.55)
Control group	133 (79.17)	78 (46.43)	139 (82.74)	28 (16.67)	13 (7.74)	63 (37.50)	4 (2.38)	2 (1.19)
$T/\chi^2$	16.829	9.742	6.282	2.914	1.731	15.443	0.852	0.422
$p$	<0.001	0.002	0.012	0.088	0.188	<0.001	0.356	0.516

**Fig. 3. The comparisons of the adverse outcomes between the groups ( $p < 0.05$ ).**

<1. The incidence of a preterm infant, an Apgar score less than 7 at one minute, neonatal defects, neonatal death, small for gestational age and hyperbilirubinemia in the neonatal group was 35% lower than that in the control group, with no significant difference ( $p > 0.05$ ).

#### 4. Discussion

GDM is one of the common complications of pregnancy. Improper control of blood glucose levels can have a negative impact on maternal and infant outcomes. The 2008 “Study on hyperglycaemia and adverse pregnancy outcomes (HAPO)” found that GDM not only increased the risk of perinatal adverse outcomes such as macrosomia, respiratory distress, neonatal hypoglycaemia and shoulder dystocia [12] but also increased the risk of maternal and neonatal long-term metabolic disorders [13]. Therefore, it is necessary to pay attention to pregnant women with GDM. Diet, exercise and self-monitoring of blood glucose are preferred as first-line treatment. Patients should be encouraged to be on a standard diet and engage in exercise, blood glucose monitoring and strict glycaemic control in order to im-

**Fig. 4. The comparison of the incidence of adverse neonatal outcomes ( $p < 0.05$ ).**

prove pregnancy outcome [14]. According to this report, using a social software platform, instant messaging, and utilization of telemedicine in women with GDM may improve patients’ compliance and outcomes [15].

Our study investigated the clinical significance of dietary and exercise interventions, microecological protection, obesity control and other health education tools in order to improve maternal and infant outcomes in women with GDM. The results of the study found that the fasting and 2-hour postprandial blood glucose in the intervention group were within the normal range one month before delivery, while the fasting and 2-hour postprandial blood glucose in the control group were higher than the normal range. The mean value of glycosylated haemoglobin in the two groups was normal, but in the intervention group was significantly lower than in the control group. Koivusalo *et al.* [16] have shown that diet, exercise and weight management before 20 weeks of gestation can reduce the risk of GDM in high-risk pregnant women by 39%. Miremberg *et al.* [17] have shown that using mobile device management of GDM in

**Table 4. Comparison of adverse outcomes of pregnant women [n (%)].**

Group	Cases (n)	Weight gain during pregnancy (kg)	Foetal distress	Preeclampsia	FGR	Oligohydramnios	Puerperal infection	Polyhydramnios
Intervention group	182	13.89 ± 6.82	7 (3.85)	12 (6.59)	3 (1.65)	7 (3.85)	24 (13.19)	10 (5.49)
Control group	168	16.37 ± 2.43	11 (6.55)	22 (13.10)	4 (2.39)	10 (5.95)	43 (25.60)	19 (11.31)
$T/\chi^2$	/	6.4852	1.307	4.211	0.239	0.839	8.690	3.887
$p$	/	0.000	0.253	0.040	0.625	0.360	0.003	0.049
$RR$	/	/	/	0.503	/	/	0.515	0.486

**Table 4. Continued.**

Group	Postpartum haemorrhage	Placenta previa	Premature rupture of membranes	Preterm premature rupture of membranes	Placental abruption	Amniotic fluid pollution	Chorioamnionitis	Caesarean section
Intervention group	11 (6.04)	5 (2.75)	14 (7.70)	6 (3.30)	1 (0.55)	9 (4.95)	40 (21.98)	57 (31.32)
Control group	15 (8.93)	6 (3.57)	25 (14.88)	14 (8.33)	2 (1.19)	22 (13.10)	58 (34.52)	71 (42.26)
$T/\chi^2$	1.057	0.195	4.560	4.113	0.422	7.188	6.821	4.510
$p$	0.304	0.659	0.033	0.043	0.516	0.007	0.009	0.034
$RR$	/	/	0.517	0.396	/	0.378	0.637	0.741

pregnant women can improve the rate of monitoring their compliance and blood glucose, which is consistent with our results. Ming *et al.*'s [18] study on telemedicine for GDM showed a decrease in HbA1c levels, which is consistent with the results of our study.

In this study, the TPOAb-positive rate was slightly lower and the FT4 level was slightly higher in the intervention group in the third trimester; the TSH level was significantly lower than that of the control group. According to the 2011 ATA guidelines, pregnant women with type 1 diabetes are prone to hypothyroidism [19]. Reports exist that when TSH levels during pregnancy are basically normal, the FT4 content is related to the degree of impaired glucose tolerance. The more impaired the glucose tolerance is, the less insulin is secreted, which will lead to a disorder of glucose metabolism and affect the secretion of thyroxine [20]. This study suggests that personalized educational behaviour management has a positive protective effect on thyroid function in women with GDM.

The female vaginal microbial flora, anatomical structure, endocrine regulation function and immune system constitute the female vaginal microecosystem. The increase in blood glucose and hormone levels in patients with GDM leads to an imbalance of the vaginal microecology and a decrease in the number of vaginal Lactobacillus, which can lead to the colonization of abnormal pathogens and an increase in vaginal infections [21]. The influencing factors on the vaginal microecology of pregnant women include vaginal flushing, sexual behaviour and menstrual cycle [22]. Women with GDM in the intervention group were provided with standard vaginal microecological knowledge and methods of self-protection. Their incidences of BV,

VVC, UU, GBS, III/IV and positive incidences of hydrogen peroxide, neuraminidase and leukocyte esterase were significantly lower than those of the control group. The vaginal pH of the intervention group was significantly higher than that of the control group. The incidences of TV, CT, NAG, PA and Neisseria gonorrhoeae were lower than those in the control group, but the difference was not statistically significant. This is consistent with the results of Dunn *et al.* [23] that good personal protection and early recovery of normal vaginal microecology can eliminate all kinds of pathogenic vaginitis.

When maternal GDM occurs, vaginal microecology and immunosuppression can lead to a decline in maternal resistance, which may lead to premature rupture of membranes and other complications [24]. In this study, the incidences of PPRM, PROM, puerperal infection, amniotic fluid contamination and chorionic amniotic separation in the intervention group were significantly lower than that in the control group, and  $RR < 1$ . These results indicate that personalized education and behaviour supervision has the ability to reduce adverse outcomes.

Dall *et al.* [25] have shown that the occurrence of GDM can have adverse effects on pregnant women and newborns including pregnancy-induced hypertension, polyhydramnios, caesarean section, infection, macrosomia, premature infants, neonatal hypoglycaemia, premature rupture of membranes and other pregnancy complications. In addition, GDM also increases the risk of development of maternal and infant diabetes [26]. The risk of caesarean section is increased along with the risk of foetal macrosomia and shoulder dystocia [27]. In our study, the incidence of pregnancy weight gain, preeclampsia, polyhydramnios

**Table 5. Comparison of the incidence of the adverse neonatal outcomes [n (%)].**

Group	Cases (n)	Preterm infant	Foetal macrosomia	Small for gestational age infants	1 minute Apgar <7 points	Neonatal care
Intervention group	182	10 (5.49)	19 (10.44)	4 (2.20)	3 (1.65)	10 (5.49)
Control group	168	16 (9.52)	37 (22.02)	4 (2.38)	6 (3.57)	23 (13.69)
$T/\chi^2$	/	2.062	8.723	0.526	1.290	6.872
$p$	/	0.151	0.003	0.468	0.256	0.009
$RR$	/	/	0.485	/	/	0.401

**Table 5. Continued.**

Group	Hyperbilirubinemia	Hypoglycaemia	Neonatal defects	Large for gestational age infants	Neonatal death	Neonatal pneumonia
Intervention group	21 (11.54)	15 (8.24)	3 (1.65)	13 (7.14)	1 (0.55)	9 (4.95)
Control group	23 (13.69)	35 (20.83)	5 (2.97)	31 (18.45)	1 (0.60)	22 (13.10)
$T/\chi^2$	0.368	10.761	0.690	10.166	0.003	7.188
$p$	0.544	0.001	0.406	0.001	0.955	0.007
$RR$	/	0.936	/	0.387	/	0.378

and caesarean section in women with GDM in the intervention group was significantly lower than that in the control group. The incidences of oligohydramnios, FGR, placenta previa, placental abruption and postpartum haemorrhage were lower than those in the control group. Implementation of personalized nutrition therapy in patients with GDM can significantly control the consequences of GDM and reduce the incidence of complications related to pregnancy [28]. The results of our study further suggest that standardized knowledge and behaviour education and supervision can improve adverse pregnancy outcomes. Lower weight gain is associated with a lower incidence of preeclampsia in women with GDM [29].

Fang *et al.* [30] have shown that the teratogenic rate of GDM pregnant women is 7–10 times higher than that of normal women, but the malformations are likely due to undiagnosed Type 1/2 DM. In our study, the neonatal defects in the intervention group were higher than those in the control group, but the difference was not statistically significant, which was consistent with the literature. Macrosomia has been proven to be the main adverse outcome of GDM patients [31]. GDM is also a risk factor for birth defects [32]. Kalra *et al.* [33] have shown that implementing clinical interventions for women with GDM can effectively control weight gain during pregnancy and reduce the risk of caesarean section and macrosomia along with the occurrence of other adverse pregnancy outcomes. In our study, the incidence of macrosomia, neonatal monitoring care, neonatal hypoglycaemia and neonatal pneumonia in the intervention group was significantly lower than that in the control group, and  $RR < 1$ , indicating that our intervention was effective in reducing these adverse events. The incidence of foetal distress during labour, preterm infant, 1-minute Apgar score less than 7, neonatal defects, neonatal death, small for gestational age and hyperbilirubinemia was lower than that in the control group. These results show that personalized education and behaviour supervision can reduce the

occurrence of neonatal adverse events, which is consistent with the data of Laddu *et al.* [6] that implementation of personalized nutritional intervention in women with GDM can significantly reduce their blood glucose level and improve the foetal outcome.

The WeChat group of remote interventions is a new type of health education mode that eliminates the doctor–patient space distance and guides and supervises patients anytime or anywhere. Medical professional knowledge provided through images, animation, or voice educates women with GDM, making them better understand the potential problems and enhance their self-management ability in order to achieve effective control of their blood glucose. Our study indicates that GDM patients treated with repeated dietary advice, monitoring of blood glucose levels and advice on increasing daily activity, such as walking or other exercise improves the function of their thyroid gland and vaginal microecological condition. This approach reduces rates of adverse outcomes, such as infant death or birth damage and reduces macrosomia and maternal weight gain.

Our study sample size was small, and due to the imperfection of the means of intervention, we hope to conduct a future multicentre study discussing the remote online intervention mode of women with GDM and providing valuable data for the health education and clinical care for women with GDM.

## 5. Conclusions

The professional health educators in this study promoted health education of women with GDM by setting up a WeChat group and providing answers to their questions. At the same time, the establishment of the WeChat group allowed the women to share their experiences with the group, and it was easier to obtain a follow-up focus on health education.

Based on these research results, the specifications of prenatal care are effective in actively improving the preg-

nancy outcomes of women with GDM. We demonstrated that remote mobile medical management can assist pregnant women in controlling their diet, engaging in exercise, improving their blood glucose management awareness, promoting self-management habits and reducing the occurrence of maternal and infant adverse events. We hope that this combination of online management methods can be further researched and promoted, improving the efficiency of disease management research, and furthering the discussion of remote interventions for women with GDM via knowledge management modes. The purpose of this study was to explore a standardized knowledge and behaviour management model for women with GDM to provide valuable data for future GDM guidelines and health promotion plans. Health education and clinical practice to improve self-management of women with GDM will be the focus of future research. In this study, we used statistical comparative analysis to confirm that WeChat group is simple and easy to operate. It can communicate at any time through mobile phones. Online intervention includes medical work-station and remote consultation which can realize automatic uploading, classification, analysis and reminder of test data. More professional team telemedicine, which can be closely supervised while utilizing online education and intervention and allows adjustment of personalized programs at any time can effectively improve the pregnancy outcome of patients with gestational diabetes.

### Availability of Data and Materials

The datasets supporting the conclusions of this article are included within the manuscript. The demanders may contact the corresponding author.

### Author Contributions

YZ finished the conception, design, and implementation of the project, and prepared the manuscript. GG assisted in the conception and design of the project, provided technical assistance. All authors contributed to editorial changes in the manuscript. All authors approved the final manuscript and agreed to be accountable for all aspects of the work.

### Ethics Approval and Consent to Participate

This study was approved by the Ethics Committee of Jinshan Branch of Shanghai Sixth People's Hospital (approval number: jszxyy201803). Written informed consent was obtained from the patients for publication of clinical details, clinical images, and videos.

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### Conflict of Interest

The authors declare no conflict of interest.

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