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Effect of a Three-Dimensional Doctor-Nurse-Patient Collaborative Model on Maternal and Infant Outcomes in Elderly Patients with Gestational Diabetes Mellitus in the Context of Internet+ Smart Hospitals

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Abstract: *This study investigated the effect of a three-dimensional doctor-nurse-patient collaborative model integrated with an Internet+ smart hospital platform on elderly patients with gestational diabetes mellitus (GDM). A total of 120 eligible patients were randomly assigned to an intervention group, which received this integrated model, or a control group receiving routine care. The intervention group demonstrated significantly greater improvements in key metabolic indicators—including fasting and postprandial blood glucose, glycated hemoglobin, lipid profiles, and body mass index—compared to the control group. Furthermore, knowledge of GDM and self-efficacy scores were significantly higher in the intervention group. Regarding clinical outcomes, the intervention group exhibited a substantially lower cesarean section rate and a reduced incidence of neonatal abnormal blood glucose. The quality of life at 42 days postpartum was also significantly better among participants who received the collaborative model. These findings suggest that this innovative, technology-supported tripartite collaboration model is an effective strategy for improving glycemic control, enhancing patient self-management capabilities, and optimizing both maternal and infant outcomes in elderly GDM patients, offering a promising approach for contemporary perinatal care.*

Keywords: *Elderly; Gestational diabetes mellitus; Internet+; Smart hospital; Three-dimensional doctor-nurse-patient collaborative model*

1. Introduction

Gestational diabetes mellitus (GDM) is defined as hyperglycemia first detected during pregnancy with glucose concentration below that of overt diabetes. Globally, approximately 14% of pregnancies are affected by GDM, and hyperglycemia earlier in pregnancy is associated with poorer pregnancy outcomes than later onset [1]. Therefore, timely screening and intensive management of GDM are crucial. Traditionally, GDM management primarily relied on outpatient prenatal check-up guidance and education. However, due to the intermittent nature of guidance and limited patient knowledge, patient self-management often lacks initiative or adherence, leading to suboptimal blood glucose control. Recent advancements in information technology have made Internet+-based health education and medical-nursing management a hotspot in clinical research. Concurrently, the development of smart hospitals utilizing information technology and artificial intelligence aims to comprehensively improve the efficiency and quality of healthcare services [2,3]. Nevertheless, the adoption rate of Internet+-based nursing services in smart hospitals in China remains below 41% [4], indicating this field is still exploratory . Studies applying the internet in group-based care for GDM patients have shown promising results in glycemic control and improving self-management capacity and delivery outcomes [5]. The three-dimensional doctor-nurse-patient collaborative model emphasizes close cooperation among doctors, nurses, and patients, with patient needs as the core, facilitating mutual communication and collaboration throughout the healthcare process to improve efficiency and patient satisfaction. To enhance health management outcomes and improve maternal and infant outcomes for GDM patients, this study implemented an Internet+ smart hospital-based three-dimensional

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doctor-nurse-patient collaborative model for elderly GDM patients, aiming to provide further clinical reference for managing this population.

2. Subjects and Methods

2.1. Subjects

A total of 120 elderly GDM patients who visited the obstetrics department of our hospital from January 2024 to March 2025 were selected by convenience sampling. Inclusion Criteria: (1) Age >35 years, singleton pregnancy; (2) Positive oral glucose tolerance test at 24-28 weeks of gestation, meeting the diagnostic criteria for GDM [6] (fasting blood glucose (FBG) >5.1 mmol/L, 2-hour postprandial blood glucose (2hPG) >8.5 mmol/L); (3) Registered, receiving prenatal care, and planning delivery at our hospital; (4) No history of diabetes prior to pregnancy; (5) Education level at least junior high school, with normal communication ability; (6) Proficient in smartphone use. Exclusion Criteria: (1) Long-term use of medications affecting metabolic indicators or insulin function; (2) Combined with other severe pregnancy complications such as pregnancy-related nephropathy; (3) Accompanied by significant liver/kidney dysfunction, severe cardiovascular/cerebrovascular diseases, or malignant tumors; (4) Presence of severe mental or psychological disorders; (5) Family members involved in this trial. Drop-out Criteria: (1) Delivery gestational age <37 weeks or >42 weeks; (2) Explicit withdrawal from the study; (3) Inability to continue participation due to emergencies or severe diabetic complications; (4) Non-compliance after >2 reminders during the study. Patients were randomly divided into a experimental group (n=60) and a control group (n=60) using a random number table. Baseline characteristics such as age, gestational week at GDM diagnosis, and pre-pregnancy body mass index (BMI) were comparable between the two groups (all P > 0.05, Table 1), indicating comparability.

Table 1. Comparison of Baseline Characteristics between the Two Groups of Elderly GDM Patients

Item	*Experimental Group (n=60)*	*Control Group (n=60)*	*t/χ^2 value*	*P value*
Age (years)	*37.15±1.41*	*37.18±1.42*	*-0.129*	*0.898*
Gestational Week at GDM Diagnosis (weeks)	*25.08±0.87*	*24.93±0.84*	*0.961*	*0.339*
Pre-pregnancy BMI (kg/m²)	*21.82±1.57*	*21.68±1.57*	*0.492*	*0.623*
Number of Pregnancies (times)	*1.63±0.76*	*1.57±0.77*	*0.479*	*0.633*
Parity [n (%)]			*1.815*	*0.178*
Multiparous	*36(60.00)*	*43(71.67)*		
Primiparous	*24(40.00)*	*17(28.33)*		
Baseline FBG (mmol/L)	*7.31±0.34*	*7.39±0.41*	*-1.221*	*0.225*
Education Level [n (%)]			*0.300*	*0.861*
Junior High School	*10(16.67)*	*9(15.00)*		
High School/Technical Secondary	*22(36.66)*	*20(33.33)*		
College or above	*28(46.67)*	*31(51.67)*		

2.2. Methods

2.2.1. Intervention Methods

The control group received routine GDM care. After diagnosis, based on the electronic health record, outpatient obstetric nurses scheduled prenatal visits every 2 weeks before 32 weeks and weekly thereafter. Routine guidance and education covering the "five pillars"—medication, diet, exercise,

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monitoring, and education—were provided, emphasizing the importance of self-monitoring blood glucose (SMBG). Patients and families were instructed on SMBG techniques, with telephone follow-ups for home monitoring. Individualized advice based on electronic records, lifestyle, and baseline glucose was given. Patients were encouraged to attend hospital lectures, received psychological support as needed, and inpatient medical intervention when necessary. Discharge education and instructions were provided, including reminders for the 42-day postpartum check-up.

The Experimental group received the Internet+ smart hospital-based three-dimensional doctor-nurse-patient collaborative model in addition to routine care. (1) Internet+ Smart Hospital Platform: A platform was developed, comprising a clinician/nurse terminal and a patient terminal. The clinician terminal allowed authorized healthcare providers to view patient information and conduct remote health management, consultations, and follow-up. The patient terminal required real-name authentication via phone/ID and included modules for personal profile, health education, blood glucose management, online consultation, and an interactive community. Additionally, training on using DingTalk (a communication app) for pushing knowledge, assigning tasks, and check-ins was provided. (2) Team Establishment: A multidisciplinary team was formed, including senior specialists, a nutritionist, a primary physician, a head nurse, a midwife, and three specialized nurses. All members received unified training on GDM knowledge, platform/software use, and communication skills before the study, clarifying their respective responsibilities. (3) Implementation of the Model: Before discharge, an obstetric nurse collected comprehensive patient data (demographics, disease, psychology, social factors) and fed it back to the team. After discussion and formulation of a care plan, it was shared with the patient/family to co-create a management plan. A specialized nurse then instructed the patient/family on platform login and use.

1) Platform Management: Patients logged in to view/update their personalized management plan in their profile. The health education module, designed by the team, covered GDM knowledge, complications, nutrition, exercise, psychology, and medication, with content updated by specialized nurses. In the blood glucose management module, patients recorded SMBG, diet, medication, and exercise data, which nurses analyzed and escalated abnormalities for team discussion. The online consultation module allowed patients to seek advice, receive assessments, and schedule follow-ups. An interactive community featured games (e.g., quizzes on monitoring, diet, exercise) with reward points.

2) DingTalk Group: Patients/families joined a dedicated obstetric DingTalk group managed by the head nurse (group owner), primary physician (consultant), and two specialized nurses (administrators). Nurses explained group functions. Specialized nurses interacted in the group, pushing GDM knowledge and skills dynamically, encouraging patient communication, check-ins, and live-streaming for experience sharing. Daily online interactions were scheduled (12:30-13:00; 19:30-20:00). Nurses collated patient questions daily for timely feedback. Content was pushed 3-6 times/week (<32 weeks), 2-5 times/week (32-37 weeks), and 2-4 times/week (≥37 weeks), with weekly personalized guidance until delivery. Prenatal DingTalk live streams introduced the delivery room environment and midwives, teaching breathing/relaxation techniques. Postpartum care knowledge was pushed weekly post-discharge, along with weekly 15-20 minute one-on-one guidance sessions within the group.

2.2.2. Observation Indicators

(1) Metabolic Indicators: FBG, 2hPG, glycated hemoglobin (HbA1c), total cholesterol (TC), triglycerides (TG), and BMI.

(2) GDM-Related Knowledge: A 14-item questionnaire adapted from the Michigan Diabetes Knowledge Test and literature [7, 8], covering diet, exercise, glucose monitoring, hypoglycemia management, and GDM risk factors/hazards. Each correct answer scored 1 point (total 0-14; higher score indicates better knowledge). Cronbach's α was 0.82.

(3) Self-efficacy: Assessed using the 21-item Diabetes Self-Efficacy Scale by Lorig et al.[9], scored 1-5 per item (total 21-105; higher score indicates higher self-efficacy). Cronbach's α was 0.90.

(4) Maternal and Infant Outcomes: Cesarean section, postpartum hemorrhage (blood loss ≥500 ml), macrosomia (birth weight ≥4000g), neonatal abnormal blood glucose (hyperglycemia >7 mmol/L or hypoglycemia <2.2 mmol/L), and 1-minute Apgar score.

(5) Quality of Life (QoL): A 17-item scale adapted from diabetes-specific QoL scales and study objectives [10, 11], covering impact on work/future (5 items), social relationships (7 items), limitations in daily activities (1 item, scored 1-8), and self-rated health status (4 items, scored 1-4). Higher total score indicates better QoL. Cronbach's α was 0.80.

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2.2.3. Data Collection

Metabolic indicators, GDM knowledge, and self-efficacy were assessed at GDM diagnosis (pre-intervention) and hospital admission for delivery (post-intervention). QoL was assessed at the 42-day postpartum check-up. Questionnaires were administered by trained investigators using standardized instructions; patients completed them independently.

2.2.4. Statistical Analysis

SPSS 28.0 was used. Categorical data are presented as n (%) and analyzed by χ^2 test. Normally distributed continuous data are presented as mean ± standard deviation (Mean±SD) and analyzed using independent samples t-test (between groups) or paired t-test (within groups). The significance level was set at $\alpha=0.05$.

3. Results

3.1. Comparison of Metabolic Indicators before and after Intervention

Pre-intervention, no significant differences existed in metabolic indicators between groups (all $P > 0.05$). Post-intervention, both groups showed significant decreases in FBG, 2hPG, HbA1c, TC, and TG levels (all $P < 0.05$ vs. pre-intervention), with the experimental group having significantly lower levels than the control group (all $P < 0.05$). BMI increased post-intervention in both groups, but the increase was significantly smaller in the experimental group ($P < 0.05$) (Table 2).

Table 2. Comparison of Changes in Metabolic Indicators between the Two Groups (Mean±SD)

Group	n	FBG (mmol/L)		2hPG (mmol/L)		HbA1c(%)		TC (mmol/L)		TG (mmol/L)		BMI(kg/m²)	
		Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post
Experimental group	60	7.31±0.34	4.55±0.30	11.85±0.65	6.21±0.55	7.39±0.40	5.40±0.0.45	5.11±0.29	3.99±0.29	2.15±0.34	1.01±0.30	21.67±1.60	23.15±1.60
Control Group	60	7.40±0.41	5.48±0.48	12.10±0.72	7.20±0.70	7.56±0.58	6.23±0.67	5.26±0.53	4.79±0.49	2.29±0.43	1.70±0.47	22.00±1.64	25.09±1.72
t value		-1.221	-12.763	-1.938	-8.643	-1.842	-7.980	-1.881	-10.738	-1.967	-9.486	-1.131	-6.417
P value		0.225	<0.001	0.055	<0.001	0.068	<0.001	0.063	<0.001	0.052	<0.001	0.261	<0.001

3.2. Comparison of GDM-Related Knowledge and Self-Efficacy Scores

Pre-intervention scores were comparable between groups (both $P > 0.05$). Post-intervention, both scores increased significantly in both groups (both $P < 0.05$), with the experimental group achieving significantly higher scores than the control group (both $P < 0.05$) (Table 3).

Table 3. Comparison of Changes in GDM-Related Knowledge and Self-Efficacy Total Scores between the Two Groups

Group	n	GDM-Related Knowledge		Self-Efficacy	
		Pre-intervention	Post-intervention	Pre-intervention	Post-intervention
Experimental group	60	5.17±1.03	11.02±1.28	60.33±9.37	88.65±9.72
Control Group	60	5.02±1.00	9.92±1.23	60.98±9.96	80.23±11.19
t value		0.810	4.804	0.368	4.399
P value		0.419	<0.001	0.713	<0.001

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3.3. Comparison of Maternal and Infant Outcomes

The experimental group had significantly lower rates of cesarean section and neonatal abnormal blood glucose compared to the control group (both $P < 0.05$). No significant differences were found in postpartum hemorrhage, macrosomia rates, or 1-minute Apgar scores (all $P > 0.05$) (Table 4).

Table 4. Comparison of Maternal and Infant Outcomes between the Two Groups

Group	n	Cesarean Section [n (%)]	Postpartum Hemorrhage [n (%)]	Macrosomia [n (%)]	Neonatal Abnormal Blood Glucose [n (%)]	1-min Apgar Score (Mean±SD)
Experimental group	60	13(21.67)	6(10.00)	8(13.33)	4(6.67)	8.25±0.50
Control Group	60	30(50.00)	7(11.67)	7(11.67)	12(20.00)	8.09±0.54
χ^2/t value		10.474	0.086	0.076	4.615	0.514
P value		0.001	0.769	0.783	0.032	0.616

3.4. Comparison of Quality of Life

At 42 days postpartum, the experimental group showed significantly higher scores in all QoL dimensions except "impact on social relationships" ($P > 0.05$), and a significantly higher total QoL score compared to the control group (all $P < 0.05$) (Table 5).

Table 5. Comparison of Postpartum (42-day) Quality of Life Scale Scores between the Two Groups

Group	n	Impact on Work & Future	Impact on Social Relationships	Limitations in Daily Activities	Self-Rated Health Status	Total Score
Experimental group	60	16.31±0.85	24.23±0.73	5.31±0.48	8.15±0.69	54.00±2.48
Control Group	60	13.90±0.71	23.60±1.25	4.07±0.58	6.50±0.57	46.17±2.83
t value		9.584	1.695	8.373	8.182	8.633
P value		<0.001	0.098	0.002	<0.001	<0.001

4. Discussion

Impact on Metabolic Indicators: Glycemic control is paramount in GDM management, crucial not only for alleviating symptoms and reducing adverse maternal outcomes like cesarean section and postpartum hemorrhage but also for decreasing risks of macrosomia and neonatal hypoglycemia [12, 13]. Effective self-management, particularly early and continuous glucose monitoring, is key to control , with glucose fluctuations linked to other metabolic markers like lipids and BMI [14, 15]. Our intervention significantly improved glycemic and lipid profiles and mitigated BMI increase. This may be attributed to the continuous, boundary-spanning (hospital-home-community) management enabled by the digital platform and DingTalk group under the smart hospital framework. It facilitates real-time knowledge dissemination, feedback collection, and timely adjustment of diet/exercise plans. The tripartite collaboration ensures information sharing and prompt intervention, fostering active patient engagement and stabilizing metabolic control.

Impact on Knowledge and Self-efficacy: GDM knowledge underpins self-management, and self-efficacy is a prerequisite for health behavior adoption [16]. Studies show GDM self-management behaviors correlate positively with self-efficacy and family support [17]. Xu et al [18] found Internet+ glucose management enhances self-efficacy and self-management in GDM patients. Nurse-patient interactive interventions also improve self-management efficacy [19]. Consistent with these findings, our model significantly boosted both knowledge and self-efficacy. Internet technologies break spatiotemporal barriers, providing timely access to information and interactive Q&A via the platform and group, enhancing learning interest and knowledge acquisition. The collaborative model fosters positive health beliefs and active participation through real-time communication, thereby improving self-efficacy and glycemic control.

Impact on Maternal-Infant Outcomes and Quality of Life: Advanced maternal age and GDM are independent risk factors for adverse outcomes [20, 21], and their combination exacerbates risks and maternal psychological distress, impacting QoL. Zhang et al [22] reported that multidisciplinary team-based Internet+ remote management reduced complications like polyhydramnios, neonatal hypoglycemia, and fetal growth restriction, improving QoL. Li et al. found a doctor-nurse-patient "trinity" intervention combined with action research significantly reduced pregnancy complications and adverse perinatal outcomes. Building on this, our Internet+-based three-dimensional model significantly lowered cesarean section and neonatal dysglycemia rates and improved postpartum QoL. The platform and group provide multi-layered post-discharge support, enhancing self-management through diet and exercise for optimal fetal growth. The patient-centered collaborative approach increases initiative, enabling timely monitoring, feedback, and plan adjustments, promoting glycemic control, healthy fetal development, and ultimately better outcomes and QoL.

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