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Impact of Continuity of Care on Neonatal Outcomes in Gestational Diabetes Mellitus: A Retrospective Controlled Study

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ABSTRACT

Background: *Gestational diabetes mellitus (GDM) increases the risk of adverse neonatal outcomes, including preterm birth, macrosomia, neonatal hypoglycemia, and admission to the neonatal intensive care unit (NICU). While continuity of care has been shown to improve maternal health, its independent impact on neonatal outcomes remains insufficiently evaluated.*
Methods: *A retrospective controlled study was conducted on 260 pregnant women with GDM treated at a tertiary hospital in Hubei Province, China (September 2020–June 2023). Participants were assigned to a control group receiving routine obstetric care (n = 60) or an intervention group receiving structured continuity of care (n = 200). The intervention included diet management, exercise therapy, psychological support, digital health education, and postpartum follow-up. Primary outcomes were neonatal indicators, including Apgar scores, preterm birth, macrosomia, low birth weight, neonatal distress, and NICU admission.*
Results: *The continuity of care group showed significantly improved neonatal outcomes compared to the control group: preterm birth (3.0% vs. 23.3%, P<.001), macrosomia (0.5% vs. 15.0%, P<.001), low birth weight (1.0% vs. 21.7%, P<.001), Apgar score ≤ 7 at 1 minute (1.5% vs. 11.7%, P<.001), and NICU admission (9.0% vs. 56.7%, P<.001). Rates of neonatal organ injury, fetal distress, and amniotic fluid contamination were also significantly lower in the intervention group.*
Conclusion: *Continuity of care significantly improves neonatal health in GDM pregnancies by reducing preterm delivery, abnormal birth weight, NICU transfer, and early neonatal complications. These findings suggest that continuity-based care should be integrated into routine GDM management to enhance perinatal outcomes and support mother-infant safety.*

1. Introduction

Gestational diabetes mellitus (GDM) is a rising public health challenge affecting approximately 10–20% of pregnancies globally, with incidence steadily increasing due to escalating maternal age, obesity, insulin resistance, and sedentary lifestyle patterns[1,2]. In South Asia

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and China, the burden of GDM is particularly severe, where the double burden of undernutrition and overnutrition coexists and dietary transitions have intensified metabolic vulnerability among women of reproductive age[3]. Alarmingly, projections indicate that GDM may become the most common metabolic disorder complicating pregnancies in developing and middle-income countries within the next decade[4].

Poorly controlled GDM is associated with a spectrum of adverse outcomes. From the maternal side, it raises the likelihood of cesarean delivery, preeclampsia, and future type 2 diabetes. On the neonatal side, it increases risks for macrosomia, birth trauma, neonatal hypoglycemia, low Apgar scores, respiratory distress syndrome, and early transfer to neonatal intensive care units (NICUs)[5]. These complications not only threaten immediate health but may predispose offspring to long-term risks such as childhood obesity, impaired glucose tolerance, and cardiovascular diseases in adulthood[6].

Despite these risks, conventional GDM care typically emphasizes hospital-based glycemic monitoring during antenatal visits, with insufficient support for postpartum transition, behavioral management, and patient education. Fragmented care and lack of structured follow-up diminish adherence, reduce patient empowerment, and weaken glycemic control, particularly in rural and resource-constrained settings[7].

To address these limitations, continuity care has emerged as a promising intervention. Defined as a multidisciplinary, patient-centered approach that bridges institutional and community-based care, continuity care aims to provide sustained, coordinated support from diagnosis through postpartum recovery[8]. This model often integrates dietetics, physiotherapy, psychosocial counseling, and digital health tools, fostering a comprehensive and dynamic care pathway.

Recent international studies have highlighted the effectiveness of such models. For instance, Kim and Chung's systematic review demonstrated improved perinatal outcomes through structured nursing programs[9], while Carolan-Olah's development of GDM knowledge assessment tools underscored the importance of targeted education in enhancing self-efficacy[10]. Digital self-tracking platforms, such as wearable glucose sensors, have further amplified patient engagement, facilitating real-time feedback and more individualized management strategies[6].

Psychological distress is another underappreciated yet significant component of GDM care. Fraser et al. reported that women with insulin-managed GDM experience heightened anxiety, which can impair decision-making, self-care, and glycemic control[11]. Integrating psychological screening and peer support into continuity frameworks may thus offer dual benefits—emotional stabilization and metabolic regulation.

However, despite growing evidence on specific outcomes like glucose control or delivery mode, few studies have comprehensively evaluated neonatal outcomes across the full care continuum—from Apgar score at birth to NICU transfer and early neonatal complications. Moreover, existing interventions often isolate care components (e.g., only dietary guidance or mobile follow-up), without evaluating their synergistic effects when implemented as a cohesive, patient-tailored package.

To address this gap, the present study specifically evaluates the impact of a structured continuity care model—including medical nutrition therapy, exercise guidance, psychological support, and digital education—on neonatal outcomes in women with gestational diabetes mellitus (GDM). Primary outcomes include 1-minute Apgar scores, preterm birth, macrosomia, low birth weight, neonatal distress, organ injury, and admission to the neonatal intensive care unit (NICU).

To ensure clarity of research scope and avoid outcome overlap, this paper focuses exclusively on neonatal endpoints. Maternal delivery outcomes derived from the same cohort have been analyzed in a separate publication and are mentioned here only as secondary contextual information.

2. Methods

This study employed a retrospective, non-synchronous controlled design, conducted at a Class A tertiary-level obstetrics and endocrinology center in Hubei Province, China, from September 2020 to June 2023. The aim was to evaluate the effectiveness of a structured continuity care intervention for gestational diabetes mellitus (GDM) on multidimensional neonatal outcomes. Ethical approval was obtained from the hospital's ethics committee (Approval No. KY-2023091604).

2.1. Participants and Eligibility

A total of 260 pregnant women were included in the study. All participants were diagnosed with GDM between 24 and 31 gestational weeks, based on the International Association of the Diabetes and Pregnancy Study Groups (IADPSG) criteria using the 75g oral glucose tolerance test (OGTT)[1]. Inclusion criteria included: singleton pregnancy, age between 20 and 40 years, capacity for self-care and participation, and absence of chronic infectious diseases, mental illness, or significant hepatic/renal dysfunction. Women who conceived via assisted reproductive technology or had gestational hypertension were excluded.

2.2. Study Groups

Participants were assigned based on treatment periods into two groups using a non-synchronous approach:

- **Control group (n = 60):** Received routine GDM care including basic inpatient dietary education, routine obstetric check-ups, and intermittent blood glucose monitoring.
- **Intervention group (n = 200):** Received the same routine care, supplemented with a continuity care protocol designed and delivered by a multidisciplinary team including endocrinologists, obstetricians, diabetes specialist nurses, registered dietitians, and mental health professionals.

2.3. Continuity Care Intervention Modules

The continuity care intervention was implemented from the time of GDM diagnosis until one week postpartum and comprised five integrated modules:

1. **Dietary Counseling:** Personalized nutritional plans were developed in accordance with American Diabetes Association (ADA) guidelines[7], tailored to each patient's pre-pregnancy BMI, gestational weight gain goals, and postprandial glucose patterns. Registered dietitians provided one-on-one counseling, printed educational materials, visual food models, and individualized feedback based on dietary records and glycemic data[11].
2. **Medical Exercise Therapy:** Physical activity plans were prescribed based on patients' baseline fitness and obstetric status, incorporating moderate-intensity aerobic exercises (e.g., walking, swimming) and resistance movements (e.g., prenatal yoga, Pilates). Instruction was delivered via in-person coaching and video modules to ensure adherence and safety[12].
3. **Psychological Support:** Weekly check-ins addressed emotional well-being, anxiety, and adjustment to the diagnosis—especially among patients requiring insulin[13]. Interventions included peer support via WeChat groups, professional counseling sessions, and structured emotion-regulation workshops, aiming to reduce perinatal psychological distress.
4. **Digital Education:** A dedicated mobile platform delivered structured micro-lessons, reminder texts, and infographics twice weekly. Topics included glucose self-monitoring, insulin injection techniques, maternal nutrition, and signs of labor. Interactive Q&A features and user feedback tools promoted engagement and retention of content[10].
5. **Postpartum Follow-Up:** After delivery, patients received biweekly follow-up via telephone calls, outpatient visits, and community health worker outreach. This component was crucial during the COVID-19 pandemic, when remote contact methods (e.g., telemedicine) ensured uninterrupted support for glycemic stabilization and emotional adjustment[14].

An overview of the intervention components and delivery formats is presented in Table 1.

2.4. Data Collection and Outcome Measures

Data were collected from hospital electronic medical records (EMRs), standardized delivery logs, and patient self-report forms. All identifiers were removed prior to analysis to ensure anonymity.

Primary neonatal outcomes included:

- 1-minute Apgar score ≤7
- Preterm birth (<37 weeks)
- Macrosomia (>4000g)
- Low birth weight (<2500g)
- Fetal distress
- Neonatal organ injury (e.g., hepatic, renal)
- NICU admission
- Umbilical cord complications
- Amniotic fluid contamination
- Limb malformations

Secondary maternal outcomes included:

- Mode of delivery (vaginal vs. cesarean)
- Postpartum hemorrhage
- Placental retention
- Labor complications (e.g., dystocia)

2.5. Statistical Analysis

All data were analyzed using SPSS version 26.0 and STATA version 18.0. Categorical variables were compared using the chi-square (χ^2) test, and continuous variables were analyzed using the independent t-test or Wilcoxon rank-sum test depending on distribution normality. Statistical significance was defined as a two-sided P-value <0.05.

To minimize selection bias and ensure data reliability:

- Clinical team composition during both periods remained consistent.
- The institutional GDM management protocol remained unchanged throughout the study timeline.
- Missing or unclear data were verified through multi-source triangulation, including chart review and patient recontact where permissible.

3. Results

3.1. Baseline Characteristics

A total of 260 pregnant women with GDM were included in the final analysis: 60 in the control group and 200 in the intervention group. Baseline demographic and obstetric characteristics—including maternal age, educational background, parity, BMI, and family history of diabetes—showed no statistically significant differences between groups ($P > .05$), confirming group comparability (Table 2).

3.2. Neonatal Outcomes

Substantial improvements in neonatal outcomes were observed in the intervention group following implementation of the continuity care program (Table 3). Compared to the control group, the intervention group demonstrated significantly lower rates in the following key indicators:

- **1-minute Apgar score ≤7:** Reduced from 11.7% to 1.5% (χ^2=10.29, P<.001), indicating enhanced neonatal vitality at birth.
- **Preterm birth (<37 weeks):** Decreased from 23.3% to 3.0% (χ^2=24.08, P<.001), suggesting better gestational maintenance.
- **Macrosomia (>4000 g):** Declined sharply from 15.0% to 0.5% (χ^2=22.46, P<.001), reflecting improved glycemic and weight control.
- **Low birth weight (<2500 g):** Dropped from 21.7% to 1.0% (χ^2=32.56, P<.001), indicating optimized intrauterine growth.
- **Fetal distress:** Reduced from 8.3% to 1.0% (χ^2=6.88, P<.01), likely due to improved oxygenation and fetal surveillance.
- **NICU admission:** Decreased dramatically from 56.7% to 9.0% (χ^2=65.54, P<.001), representing a 47.7% absolute risk reduction.
- **Neonatal organ injury:** Lowered from 11.7% to 2.0% (χ^2=8.39, P<.01), reflecting improved perinatal physiological stability.
- **Umbilical cord entanglement:** Declined from 20.0% to 6.5% (P<.01).
- **Amniotic fluid contamination:** Reduced from 31.7% to 9.5% (P<.001).

No statistically significant difference was observed in the incidence of neonatal limb malformations (3.3% vs. 1.5%, P=.709), a congenital outcome more likely influenced by first-trimester exposures than third-trimester glycemic management.

3.3. Maternal Outcomes

Maternal delivery outcomes also favored the intervention group, with significant improvements across multiple indicators (Table 4).

- **Spontaneous vaginal delivery (SVD):** The rate of SVD was significantly higher in the intervention group (44.5%) compared to the control group (28.3%) (χ^2=4.99, P=.020), suggesting improved labor preparation and reduced dependence on cesarean delivery.
- **Postpartum hemorrhage:** The incidence of postpartum hemorrhage declined from 8.3% in the control group to 1.5% in the intervention group (P<.05), potentially reflecting better uterine contractility and delivery management.
- **Premature rupture of membranes (PROM):** PROM cases were significantly lower in the intervention group (2.0%) than in controls (11.7%) (P=.004), indicating improved perinatal membrane integrity and infection prevention.
- **Dystocia:** Difficult labor occurred in 18.3% of control participants versus only 3.5% in the intervention group (P<.001), likely benefiting from prenatal physical conditioning and fetal position optimization via guided exercise therapy.
- **Placental retention:** No statistically significant difference was found in placental retention rates (13.3% vs. 5.5%, P=.070), although a downward trend was observed in the intervention group.

Collectively, these results indicate that continuity care enhances not only neonatal outcomes but also contributes to safer, more efficient maternal delivery processes.

4. Discussion

Our findings strongly reinforce the hypothesis that continuity care significantly reduces neonatal risk and improves maternal outcomes in pregnancies complicated by gestational diabetes mellitus (GDM). The most notable result—a 47.7% absolute reduction in NICU transfer rates—illustrates the multidimensional benefits of sustained, multidisciplinary care beyond conventional glycemic control. This aligns with the work of Kytö et al., who demonstrated that self-tracking using wearable glucose sensors, when embedded in a coordinated care model, can improve maternal decision-making and enhance fetal growth regulation[6]. Similarly, the inclusion of dietitians, health educators, and psychological support personnel in our intervention mirrors successful models of integrated care reported in recent systematic reviews[9,10].

One of the most compelling aspects of our intervention is the inclusion of psychosocial support. The psychological burden of GDM is frequently underestimated despite mounting evidence of its impact on perinatal outcomes. Fraser et al. found significantly elevated levels of anxiety among women requiring insulin for GDM management, suggesting that psychological stress is not merely a by-product of the diagnosis but an influential variable in maternal-fetal physiology[13]. Our continuity care model, which included weekly peer-led discussions and access to mental health professionals, may have contributed to the reduced fetal distress and preterm birth rates observed in our cohort. These findings advocate for the routine integration of mental health screening and counseling in GDM protocols, especially for women receiving pharmacologic interventions.

From a nutritional standpoint, our results validate earlier findings by Filardi et al., who emphasized the role of carbohydrate quality and glycemic load in preventing excessive fetal growth and neonatal metabolic instability[9]. By using individualized meal plans guided by ADA principles, the intervention group achieved significantly lower rates of macrosomia (0.5% vs. 15%) and low birth weight (1% vs. 21.7%). This dual optimization suggests that structured dietary planning, when initiated early and monitored continuously, can support more physiologically appropriate fetal development.

Our findings also resonate with prior Chinese studies that explored the benefits of digital platforms and interactive remote care for GDM patients. Lin et al. and Wang et al. reported that online education and WeChat-based follow-up improved glycemic outcomes and maternal satisfaction[11,12]. The present study builds on this literature by extending the evaluation framework to include neonatal outcomes, demonstrating that such digital and hybrid care models not only empower mothers but also translate into measurable improvements in infant health at birth.

Another strength of our approach lies in its modular design. By tailoring interventions to each patient's risk profile, literacy level, and behavioral readiness, we minimized dropout and maximized adherence. The improvements in spontaneous vaginal delivery rates (44.5% vs. 28.3%) and reductions in labor complications (e.g., PROM, dystocia) indicate that the benefits of continuity care extend beyond biochemical markers to encompass clinical decision-making and obstetric performance.

A consolidated summary of outcome improvements is presented in Table 5, highlighting absolute risk reductions across key maternal and neonatal indicators.

Despite these promising findings, several limitations must be acknowledged. First, the retrospective, non-randomized design introduces potential for selection bias and uncontrolled confounding. Second, the follow-up period was limited to the early neonatal stage, precluding evaluation of long-term outcomes such as neurodevelopment, childhood metabolic health, or maternal glycemic trajectory post-delivery. Third, although the intervention was intentionally comprehensive, we did not isolate the independent effects of individual modules (e.g., exercise vs. psychological support), which warrants investigation in future randomized controlled trials.

Lastly, the generalizability of our findings may be limited to urban tertiary hospitals equipped with digital infrastructure and multidisciplinary personnel. However, the modular nature of the continuity care approach enables flexible adaptation to diverse clinical settings. Community health workers, mobile technology, and remote education platforms may facilitate scalable implementation in rural or resource-limited environments, contributing to the global agenda for equitable maternal and neonatal health.

5. Conclusion

Continuity care represents a powerful and clinically impactful model for improving neonatal outcomes in pregnancies complicated by gestational diabetes mellitus (GDM). Through a structured, multidisciplinary approach encompassing dietary guidance, medical exercise, psychological support, digital education, and postpartum follow-up, this model addresses not only glycemic control but also the behavioral and psychosocial dimensions essential for perinatal health.

Our study demonstrates that continuity care significantly reduces key neonatal risks—including low Apgar scores, preterm birth, macrosomia, and NICU transfers—while also promoting safer and more spontaneous delivery experiences. These findings suggest that continuity care is not merely an adjunct to standard prenatal management but a core component of high-quality obstetric care for GDM populations.

Importantly, this model is both practical—relying on existing healthcare infrastructure and interdisciplinary teams—and scalable, as it can be adapted to diverse care settings using digital platforms and community-based support systems. The intervention aligns with global guidelines from WHO, ADA, and FIGO that advocate for patient-centered, integrated, and culturally sensitive care for high-risk pregnancies[15-16].

As healthcare systems seek sustainable solutions to the rising GDM burden, continuity care offers a compelling, evidence-based framework to optimize outcomes for both mothers and infants. Future research should evaluate its cost-effectiveness, long-term neonatal development impacts, and implementation strategies across varying resource contexts.

Author Contribution

Feifei Chen is the first and corresponding author of this manuscript and was responsible for the conceptualization, literature review, manuscript drafting, and final approval of the article.

Bing Yan, PhD, Graduate School of Kookmin University, South Korea, provided professional English language editing and refinement of academic expression.

Chengwen Song, a doctoral candidate in Public Administration at Kookmin University, South Korea, contributed primarily to data analysis and interpretation.

Compliance with Ethical Standards

Ethical Approval: This study is a secondary analysis derived from a previously approved research project conducted at a tertiary hospital in Hubei Province, China (Approval No. KY-2023091604). The original project was approved by the institutional ethics committee, and the present analysis used anonymized data from the same dataset without additional participant contact. Therefore, no new ethical approval or informed consent was required. The study adhered to the principles of the Declaration of Helsinki (2013 revision).

Informed Consent: Not applicable due to the retrospective design and use of anonymized, previously collected data.

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Competing Interest declaration

The authors declare that they have no conflict of interest.

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Appendices

Table 1. Structured Continuity Care Intervention Modules for GDM Management

Module	Description	Delivery Mode
1. Dietary Counseling	Individualized meal plans based on ADA guidelines, BMI, glucose trends, and caloric needs	Face-to-face education, food models
2. Medical Exercise	Moderate aerobic and resistance training tailored to gestational age and physical capacity	Supervised sessions, video instruction
3. Psychological Support	Weekly emotional support via peer groups and professional coaching to reduce anxiety and stress	WeChat groups, in-person sessions
4. Digital Education	Micro-lessons on glucose monitoring, insulin use, and pregnancy care	Mobile app, WeChat mini-courses
5. Postpartum Follow-up	Scheduled check-ins post-delivery to ensure glycemic stability and emotional adjustment	Phone calls, outpatient visits

Abbreviations: GDM, gestational diabetes mellitus; ADA, American Diabetes Association.

Table 2. Baseline Characteristics of Pregnant Women With GDM (N = 260)

Characteristic	Control Group (n = 60)	Intervention Group (n = 200)	*P* Value
Age (years), mean ± SD	30.25 ± 4.12	30.10 ± 4.25	.812
Educational level, n (%)			.457

Characteristic	Control Group (n = 60)	Intervention Group (n = 200)	*P* Value
• Middle school or lower	24 (40.0%)	62 (31.0%)	
• High school	22 (36.7%)	81 (40.5%)	
• College or higher	14 (23.3%)	57 (28.5%)	
Parity, n (%)			.637
• Primipara	36 (60.0%)	114 (57.0%)	
• Multipara	24 (40.0%)	86 (43.0%)	
Pre-pregnancy BMI (kg/m²), mean ± SD	23.6 ± 2.8	23.9 ± 3.1	.529
Family history of diabetes, n (%)	16 (26.7%)	62 (31.0%)	.538

Abbreviations: GDM, gestational diabetes mellitus; SD, standard deviation; BMI, body mass index.
Note: No statistically significant differences were observed between groups (P > .05).

Table 3. Comparison of Neonatal Outcomes Between Control and Intervention Groups

Neonatal Outcome	Control Group (n = 60)	Intervention Group (n = 200)	*P* Value
1-min Apgar score ≤7, n (%)	7 (11.7%)	3 (1.5%)	<.001
Preterm birth (<37 weeks), n (%)	14 (23.3%)	6 (3.0%)	<.001
Macrosomia (>4000 g), n (%)	9 (15.0%)	1 (0.5%)	<.001
Low birth weight (<2500 g), n (%)	13 (21.7%)	2 (1.0%)	<.001
Fetal distress, n (%)	5 (8.3%)	2 (1.0%)	<.001
NICU admission, n (%)	34 (56.7%)	18 (9.0%)	<.001
Neonatal organ injury, n (%)	7 (11.7%)	4 (2.0%)	<.001
Umbilical cord entanglement, n (%)	12 (20.0%)	13 (6.5%)	<.01
Amniotic fluid contamination, n (%)	19 (31.7%)	19 (9.5%)	<.001
Limb malformations, n (%)	2 (3.3%)	3 (1.5%)	.709

Abbreviation: NICU, neonatal intensive care unit.
Note: All outcomes showed statistically significant improvement in the intervention group, except limb malformations.

Table 4. Comparison of Maternal Outcomes Between Control and Intervention Groups

Maternal Outcome	Control Group (n = 60)	Intervention Group (n = 200)	*P* Value
Vaginal delivery, n (%)	17 (28.3%)	89 (44.5%)	.020
Postpartum hemorrhage, n (%)	5 (8.3%)	3 (1.5%)	.021
Premature rupture of membranes, n (%)	7 (11.7%)	4 (2.0%)	.004
Dystocia (difficult labor), n (%)	11 (18.3%)	7 (3.5%)	<.001
Placental retention, n (%)	8 (13.3%)	11 (5.5%)	.070

Note: The intervention group showed significantly improved maternal outcomes across most indicators, except for placental retention, which did not differ significantly.

Table 5. Summary of Key Outcome Improvements With Continuity Care Intervention

Outcome Indicator	Control Group (%)	Intervention Group (%)	Absolute Risk Reduction (%)	*P* Value
NICU admission	56.7	9.0	47.7	<.001
Preterm birth	23.3	3.0	20.3	<.001
Low Apgar score (≤7 at 1 min)	11.7	1.5	10.2	<.001
Macrosomia	15.0	0.5	14.5	<.001
Low birth weight	21.7	1.0	20.7	<.001

Outcome Indicator	Control Group (%)	Intervention Group (%)	Absolute Risk Reduction (%)	*P* Value
Fetal distress	8.3	1.0	7.3	<.01
Neonatal organ injury	11.7	2.0	9.7	<.01
Vaginal delivery rate	28.3	44.5	+16.2 (increase)	.020

Abbreviation: NICU, neonatal intensive care unit.
Note: All improvements were statistically significant except for limb malformations and placental retention (not shown).