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Research Article

Association of Maternal Vitamin D, Ferritin Level and Glycemic Status with Pregnancy Outcomes in Women with Gestational Diabetes Mellitus

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ABSTRACT

Background: Gestational diabetes mellitus is associated with an increased risk of adverse maternal and neonatal outcomes. In addition to hyperglycemia, alterations in maternal vitamin D and ferritin levels may contribute to metabolic dysfunction and influence pregnancy outcomes.

Objective: To determine the association of maternal vitamin D, serum ferritin level and glycemic status with pregnancy outcomes in women with gestational diabetes mellitus.

Methodology: This prospective observational cohort study was conducted at Department of Medicine Unit-4, Jinnah Hospital Lahore from 1st January 2026 to 30th June 2026 included 146 pregnant women with gestational diabetes mellitus recruited through non-probability consecutive sampling at a tertiary care hospital in Pakistan. Maternal serum vitamin D, ferritin, fasting plasma glucose and glycated hemoglobin (HbA1c) were measured, and participants were followed until delivery.

Results: The mean maternal age was 30.8±4.7 years. Adverse pregnancy outcomes occurred in 58 (39.7%) women. Women with adverse outcomes had significantly lower serum vitamin D levels than those without adverse outcomes (15.6±6.8 vs. 22.8±7.5 ng/mL; $p<0.001$), significantly higher serum ferritin level (72.4±31.5 vs. 49.7±22.9 ng/mL; $p<0.001$), fasting plasma glucose (112.2±15.7 vs. 99.6±11.8 mg/dL; $p<0.001$), and HbA1c (6.7±0.7% vs. 5.9±0.5%; $p<0.001$).

Conclusion: Lower maternal vitamin D levels and higher ferritin and glycemic parameters were associated with adverse pregnancy outcomes among women with gestational diabetes mellitus.

Keywords: Gestational Diabetes Mellitus, Vitamin D, Ferritin, Haemoglobin A1c, Glycemic Control, Pregnancy Outcomes.

INTRODUCTION

Gestational diabetes mellitus (GDM) is a glucose intolerance that is newly diagnosed during pregnancy and is one of the most prevalent metabolic disorders seen during pregnancy.[1] It is linked to an elevated risk for maternal and fetal complications such as hypertension, cesarean delivery, fetal macrosomia, neonatal hypoglycemia, preterm delivery, and incidence of T2DM in the mother and offspring.[2] Hyperglycaemia is the main metabolic disturbance in GDM but several nutritional and biochemical risk factors can affect the severity of GDM and pregnancy outcomes. Vitamin D is essential for the regulation of calcium, immune function, placental support and glucose metabolism.[3] Vitamin D deficiency has been linked to disturbances in insulin sensitivity and pancreatic beta-cell function in pregnant women. Low levels of vitamin D are linked to worse glycemic control in GDM and may be related to adverse maternal and neonatal outcomes. Its strength and consistency is,

however, different in different populations and further evaluation is clinically relevant.[4]

Ferritin is frequently used as a marker of body iron stores and is also an acute-phase protein and can reflect the presence of underlying inflammation. In some studies, a high level of ferritin is associated with a high insulin resistance and an imbalance of glucose metabolism in pregnant women.[5] However, low ferritin can also be a sign of iron deficiency, a condition also prevalent among pregnant women and that can have negative consequences on both mother and babies' health and growth.[6] Thus, it may be a complex relationship between ferritin and metabolic control and pregnancy outcomes in women with GDM. One of the most important factors in gestational diabetes is glycemic status, which is measured by fasting glucose, postprandial glucose or glycated haemoglobin.[7] The higher risk for uncontrolled hyperglycemia leads to complications such as excessive fetal growth, birth trauma, cesarean delivery, neonatal metabolic problems and other complications. However, there may be some other biochemical markers that influence risk, as women with similar glucose levels may have different pregnancy outcomes.[8]

The quality of metabolic control during pregnancy also affects the outcome of pregnancy in women with GDM. Hyperglycaemia in the mother will lead to an increased delivery of glucose across the placenta, leading to fetal hyperinsulinemia and fetal overgrowth.[9] This can lead to macrosomia, shoulder dystocia, birth trauma, cesarean delivery, neonatal hypoglycemia. Meanwhile, alterations of maternal vitamin D and ferritin may have an independent effect on the development of the placenta, fetal growth and maternal health, both alone and in combination with suboptimal glycemic control.[10] The simultaneous evaluation of these variables might thus shed light in understanding whether specific biochemical subgroups have an increased risk of adverse pregnancy outcomes. This information might be of special interest for routine antenatal care where vitamin D, ferritin and glycemic parameters are relatively easy to obtain in the laboratory.[11] If strong correlations are found, such markers might be able to be used as an early risk marker and increase the monitoring of women with GDM. This relationship might also help inform future studies regarding the role of correction of micronutrient abnormalities in addition to optimal glycemic control in improving maternal and neonatal outcomes.[12]

MATERIALS AND METHODS

This prospective observational cohort study was conducted at Department of Medicine Unit-4, Jinnah Hospital Lahore from 1st January 2026 to 30th June 2026. There were 146 pregnant women with GDM who participated in the study. The sampling technique used in the recruitment of the participants was non-probability consecutive sampling technique. All female patients who presented in the study period and were eligible were taken up for the study in consecutive manner till the required sample size was obtained. Included were pregnant women of age 18-45 years, singleton pregnancy and diagnosed GDM during pregnancy. Women with type 1 or 2 diabetes mellitus, a history of multiple pregnancies, chronic renal or hepatic disease, inflammatory or infectious disease, malabsorption disorder, known parathyroid disease, major fetal congenital anomaly, or condition that is likely to significantly affect vitamin D and/or ferritin levels were excluded.

Demographic and obstetric data were obtained after written informed consent, such as maternal age, parity, gestational and BMI, previous history of GDM and relevant medical comorbidities. The 75-g oral glucose tolerance test (OGTT) was used to diagnose GDM following the criteria applied in the institution. Maternal venous blood samples were drawn for the serum 25-hydroxyvitamin D, serum ferritin, fasting plasma glucose and glycated hemoglobin (HbA1c) measurements. Vitamin D and ferritin were measured as continuous variables and also divided into four categories based on the laboratory reference value. Fasting plasma glucose and HbA1c level were used to determine glycemic status. All the study participants were treated routinely for antenatal and GDM as per institutional protocol and followed till delivery. Clinical examination, hospital records and delivery notes were used to record maternal and neonatal outcomes. Maternal outcomes measured were gestational hypertension or pre-eclampsia, mode of delivery, preterm delivery and other pregnancy-related outcomes. Neonatal outcomes included were gestational age at birth, birth weight, macrosomia, low birth weight, LGA/SGA, Apgar score, and NICU admission. The main outcome was the relationship between maternal vitamin D, serum ferritin and glycemic status with poor pregnancy outcomes in women with GDM.

The data was entered and analysed using SPSS-26. Continuous variables, such as maternal age, vitamin D level, serum ferritin, fasting plasma glucose, HbA1c, and birth weight of the baby

were presented as mean ± SD or median and IQR. The Shapiro–Wilk test was used to determine normality. Categorical variables were reported as frequency and percentages. All the p-values were statistically significant if < 0.05.

RESULTS

The mean age was 30.8±4.7 years and the mean BMI was 29.4±4.2 kg/m². Most participants were multigravida, accounting for 97 (66.4%) cases, while 49 (33.6%) were primigravida. A family history of diabetes was reported in 62 (42.5%) women, whereas 31 (21.2%) had a previous history of gestational diabetes mellitus. The mean serum vitamin D level was 19.9±8.1 ng/mL and the mean serum ferritin level was 58.7±29.1 ng/mL. Mean fasting plasma glucose was 104.6 ± 14.8 mg/dL, while the mean HbA1c was 6.2 ± 0.7% (Tables 1-2).

Regarding maternal and neonatal outcomes, cesarean delivery was the most frequent outcome and occurred in 72 (49.3%) women. Pre-eclampsia was observed in 21 (14.4%) participants and preterm delivery occurred in 18 (12.3%). Among neonatal outcomes, macrosomia was reported in 25 (17.1%) newborns, neonatal hypoglycemia in 19 (13.0%), low birth weight in 14 (9.6%), and NICU admission in 22 (15.1%). Overall, a composite adverse pregnancy outcome was observed in 58 (39.7%) women (Table 3).

Mean serum vitamin D was significantly lower among women with adverse outcomes compared with those without adverse outcomes (15.6±6.8 vs. 22.8±7.5 ng/mL, p<0.001). In contrast, mean serum ferritin was significantly higher in the adverse outcome group (72.4±31.5 vs. 49.7±22.9 ng/mL, p<0.001). Similarly, fasting plasma glucose was higher among women with adverse outcomes (112.2±15.7 vs. 99.6±11.8 mg/dL, p<0.001), as was HbA1c (6.7±0.7% vs. 5.9±0.5%, p<0.001) [Table 4].

Each 5 ng/mL increase in vitamin D was associated with a 28% reduction in the odds of an adverse pregnancy outcome (aOR 0.72, 95% CI 0.58–0.89; p=0.003). Each 10 ng/mL increase in ferritin was associated with a 14% increase in the odds of an adverse outcome (aOR 1.14, 95% CI 1.04–1.26; p=0.007). Similarly, each 1% increase in HbA1c was associated with more than twofold higher odds of an adverse pregnancy outcome (aOR 2.21, 95% CI 1.35–3.62; p=0.002) [Table 5, Figs. 1-2].

Table 1: Baseline Clinical and Biochemical Characteristics of Women with Gestational Diabetes Mellitus (N = 146)

Variable	No.	%
Primigravida	49	33.6
Multigravida	97	66.4
Family history of diabetes	62	42.5
Previous history of GDM	31	21.2

Table 2: Descriptive Statistics of the Women with Gestational Diabetes Mellitus

Variable	Mean±SD
Age (years)	30.8±4.7
BMI (kg/m²)	29.4±4.2
Serumvitamin D (ng/mL)	19.9±8.1
Serum ferritin (ng/mL)	58.7±29.1
Fasting plasma glucose (mg/dL)	104.6±14.8
HbA1c (%)	6.2±0.7

Table 3: Maternal and Neonatal Pregnancy Outcomes (N=146)

Outcome	No.	%
Cesarean delivery	72	49.3
Pre-eclampsia	21	14.4
Preterm delivery	18	12.3
Macrosomia	25	17.1
Low birth weight	14	9.6
Neonatal hypoglycemia	19	13.0
NICU admission	22	15.1

Composite adverse pregnancy outcome	58	39.7

Table 4: Comparison of Biochemical Parameters According To Pregnancy Outcome

Variable	No Adverse Outcome (n=88)	Adverse Outcome (n = 58)	p-value
Serum vitamin D (ng/mL)	22.8±7.5	15.6±6.8	<0.001
Serum ferritin (ng/mL)	49.7±22.9	72.4±31.5	<0.001
Fasting plasma glucose (mg/dL)	99.6±11.8	112.2±15.7	<0.001
HbA1c (%)	5.9±0.5	6.7±0.7	<0.001

Table 5: Multivariable Logistic Regression Analysis for Predictors of Adverse Pregnancy Outcomes

Predictor	Adjusted OR	95% CI	p-value
Vitamin D, per 5 ng/mL increase	0.72	0.58–0.89	0.003
Ferritin, per 10 ng/mL increase	1.14	1.04–1.26	0.007
HbA1c, per 1% increase	2.21	1.35–3.62	0.002
Maternal age, per year	1.04	0.97–1.12	0.256
BMI, per kg/m²	1.05	0.98–1.13	0.168
Multigravidity	1.18	0.57–2.45	0.654

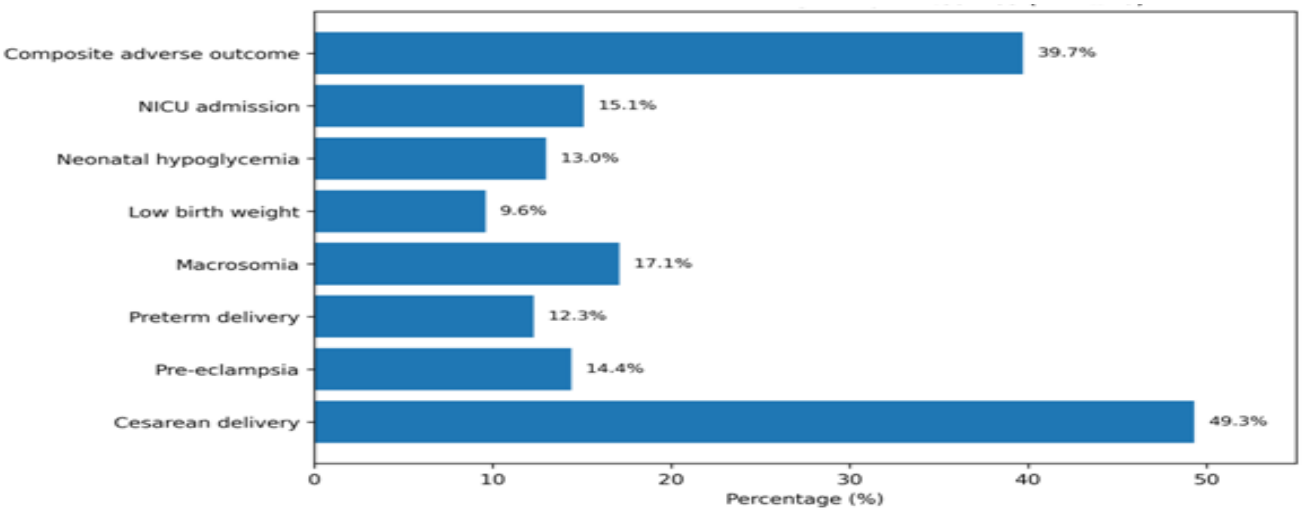


Fig. 1: Maternal and Neonatal Pregnancy Outcomes among Women with Gestational

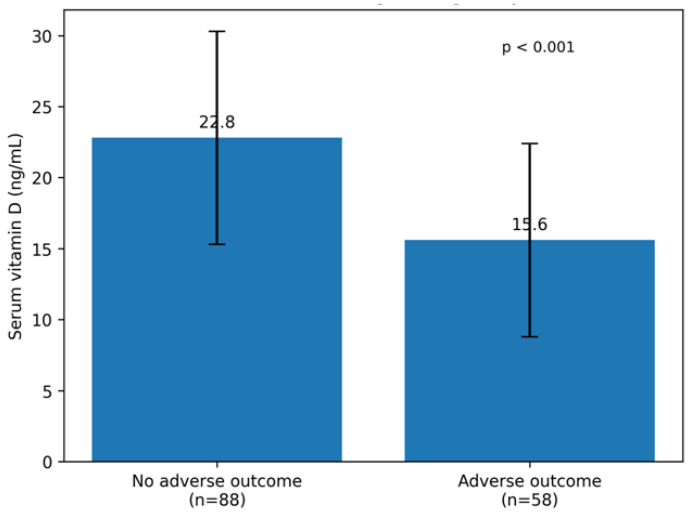


Fig. 2: Mean Serum Vitamin D Level According To Pregnancy Outcome

DISCUSSION

In the present study, adverse pregnancy outcomes were noted in 39.7% of the participants. Women who had adverse outcomes had significantly lower serum vitamin D levels and significantly higher serum ferritin, fasting plasma glucose, and HbA1c levels than women who did not have adverse outcomes. In addition, results from multivariable analysis indicated that the associations of vitamin D, ferritin and HbA1c with adverse pregnancy outcomes persisted when controlling for maternal age, BMI and parity. Based on these results, we concluded that the micronutrient and iron-storage status of the mother could serve as an additional assessment tool for pregnancy risk in women with GDM, in addition to the traditional assessment of glycemic control. The mean serum vitamin D was significantly lower in women with adverse pregnancy outcomes (15.6±6.8 ng/mL) vs. women with no adverse pregnancy outcomes (22.8±7.5 ng/mL).[13] The multivariate analysis also showed that for every 5 ng/mL increase in vitamin D, the odds of an adverse outcome decreased (adjusted OR 0.72, 95% CI 0.58-0.89). This observation is biologically plausible, as vitamin D plays a role in pancreatic beta-cell functions, insulin secretion, insulin sensitivity, immune function, and placental function. Observational studies consistently have shown an association between low maternal vitamin D status and GDM as well as other adverse obstetric outcomes. A meta-analysis that included 37,838 pregnant women showed that the odds ratio for vitamin D deficiency and an increased risk of GDM was 1.38.[14] An earlier systematic review also showed links between low maternal levels of 25-hydroxyvitamin D and an increased risk of pre-eclampsia, GDM, preterm delivery and small-for-gestational-age infants. The other important factor associated with the pregnancy outcome in the present study was the serum ferritin. The mean ferritin level was 72.4±31.5 ng/mL in women who experienced an adverse outcome, and 49.7±22.9 ng/mL in women who did not experience an adverse outcome.[15] For every 10 ng/mL increase in ferritin, the adjusted odds of an adverse outcome rose by ~14%. Ferritin levels are used generally as a marker of iron stores, but are also a marker of acute-phase reactants and can be elevated in an inflammatory state and/or metabolic dysfunction. Both low-grade chronic inflammation and oxidative stress play a role in the pathogenesis of insulin resistance and GDM, and iron stores may play a role in causing oxidative stress.[16] Thus, high ferritin levels in women with GDM could reflect an increase in iron stores as well as inflammation or a metabolic imbalance. The glycemic status was highly correlated with bad outcomes in the current study. The fasting plasma glucose levels (112.2±15.7 versus 99.6±11.8 mg/dL) and HbA1c levels (6.7±0.7% versus 5.9±0.5%) were significantly higher in women with adverse pregnancy outcomes. In addition, there were more than 2-fold greater adjusted odds of adverse pregnancy outcomes for a 1% increase in HbA1c (adjusted OR 2.21, 95% CI 1.35–3.62). The results highlight the significance of a proper control of glycemia during pregnancy. Hyperglycemia in the mother leads to enhanced glucose crossing the placenta, causing insulin hypersecretion in the foetus, a process that may lead to excess foetal growth, macrosomia, neonatal hypoglycemia and other metabolic complications. This relationship has been extensively supported by previous studies. In a cohort study of 4,383 women with GDM, higher HbA1c levels at the time of GDM testing was associated with macrosomia, cesarean delivery, preterm delivery, and a composite of adverse pregnancy outcomes.[17-19]

Another significant finding of the current study is the evaluation of these markers (vitamin D, ferritin, glycemic status) all together, rather than individually. The pregnancy outcomes seen in GDM are polyfactorial and the associations observed could be due to interlinked pathways of insulin resistance, micronutrient status, inflammation, oxidative stress, maternal adiposity, and placental function. Significant associations with these biomarkers were observed after controlling for selected confounding variables, indicating that these markers might have complementary information about pregnancy risk. The relationships observed in this study should, however, be viewed as tentative and not as evidence of a direct cause and effect between low vitamin D levels, high ferritin levels and adverse outcomes.[20]

There are several limitations to the study that need to be taken into account. This was performed at one facility and in a relatively small sample size, potentially limiting generalizability of the results. Variations in vitamin D and ferritin during pregnancy were not investigated as it was only measured at one time point. Other factors that can affect serum ferritin levels include inflammation and

infections, as well as dietary intake and iron supplements, and vitamin D levels can fluctuate with the season, exposure to sunlight, dietary intake, clothing, and iron supplements. Other factors that could potentially be confounding, such as socioeconomic status, dietary factors, gestational weight gain, treatment for GDM and glycemic control, also have a potential influence on pregnancy outcomes. More multi-centre prospective studies with repeated biochemical measurements would thus be useful.

CONCLUSION

Maternal vitamin D, serum ferritin and glycemic status was significantly associated with pregnancy outcome in women with gestational diabetes mellitus. Women who developed adverse pregnancy outcomes had lower serum vitamin D levels and higher ferritin, fasting plasma glucose, and HbA1c levels compared with those without adverse outcomes. Vitamin D, ferritin, and HbA1c also were independently associated with adverse pregnancy outcomes following adjustment for important maternal factors. In addition to optimal glycemic control, vitamin D and ferritin measurements could be used to help identify women with GDM who are at higher risk of maternal and neonatal complications, these findings indicate.

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