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Association between Maternal Vitamin D Deficiency and Low Birth Weight Baby

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KEYWORDS

Vitamin D deficiency, low birth weight, pregnancy, neonatal outcome, maternal nutrition.

ABSTRACT:

Background: Low birth weight remains a major contributor to neonatal morbidity and mortality. Maternal vitamin D deficiency has been proposed as a modifiable risk factor influencing fetal growth. This study aimed to evaluate the association between maternal vitamin D deficiency and low birth weight among term neonates.

Methods: This comparative cross-sectional study was conducted at a tertiary care hospital in Dhaka from July 2023 to December 2024. Sixty term mother–neonate pairs were enrolled, including 30 low birth weight and 30 normal birth weight neonates. Maternal demographic characteristics and neonatal outcomes were recorded. Serum 25-hydroxyvitamin D was measured using chemiluminescence immunoassay. Group comparisons were performed using the t-test and the chi-square test. Pearson correlation and multivariable logistic regression analyses were applied. A p-value less than 0.05 was considered statistically significant.

Results: Mean maternal vitamin D level was significantly lower in the low-birth-weight group compared with the normal birth weight group (12.50 ± 4.73 ng/ml vs 16.15 ± 5.01 ng/ml, p=0.01). A significant positive correlation was observed between maternal vitamin D level and birth weight (r=0.61, p<0.001). Logistic regression analysis identified maternal age (OR 1.145, p=0.029), socioeconomic status (OR 0.197, p=0.039) and serum vitamin D level (OR 0.888, p=0.014) as independent predictors of low birth weight.

Conclusion: Maternal vitamin D deficiency was independently associated with low birth weight. Optimization of maternal vitamin D status may contribute to improved neonatal outcomes.

Introduction

Low birth weight remains a major determinant of neonatal morbidity and mortality worldwide. The World Health Organization defines low birth weight as a birth weight below 2500 grams irrespective of gestational age [1]. Infants born with low birth weight face increased risks of respiratory distress, sepsis, neurodevelopmental delay and long-term metabolic disorders [2]. In South Asia, the burden of low birth weight continues to be substantial, contributing significantly to neonatal and under-five mortality [3].

Fetal growth is influenced by maternal nutritional status, placental function and intrauterine environmental factors. Among nutritional determinants, vitamin D has attracted increasing attention in recent years. Vitamin D is a fat-soluble secosteroid hormone essential for calcium and phosphorus homeostasis and skeletal development [4]. The fetus does not produce vitamin D on its own but rather receives it from the mother. Vitamin D is involved

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in the maturation of the fetal lung and plays a function in the interactions between mesenchymal cells and alveolar epithelial cells. In response to vitamin D, alveolar cells of type II express vitamin D receptor and participate in the synthesis and secretion of surfactants [5]. Beyond bone metabolism, vitamin D exerts immunomodulatory, anti-inflammatory and cellular differentiation effects that may influence placental development and fetal growth [6].

During pregnancy, the fetus relies entirely on maternal vitamin D stores. Maternal serum 25-hydroxyvitamin D concentration reflects vitamin D status and serves as the principal circulating biomarker [7]. Higher vitamin D status in late pregnancy and a greater increase in vitamin D status during pregnancy are associated with a decreased risk of preeclampsia [8]. Vitamin D receptors are expressed in the placenta and fetal tissues, suggesting a biological role in implantation, trophoblastic invasion and vascular development [9]. Experimental data indicate that vitamin D deficiency may impair placental angiogenesis and reduce nutrient transfer, potentially contributing to intrauterine growth restriction [10].

Epidemiological studies investigating the relationship between maternal vitamin D deficiency and low birth weight have yielded variable findings. Khalessi et al. reported significantly lower maternal vitamin D levels among mothers of low-birth-weight neonates compared with those of normal birth weight infants [11]. Fang et al., in a systematic review, demonstrated that maternal vitamin D deficiency was associated with an increased risk of low birth weight, with a pooled odds ratio exceeding two [12]. Conversely, some regional studies have not observed a statistically significant association, highlighting potential population heterogeneity [13].

Vitamin D deficiency is highly prevalent among pregnant women in South Asia, including Bangladesh, where limited sun exposure, cultural practices and dietary inadequacy contribute to suboptimal status [14]. Despite the high burden, nationally representative data linking maternal vitamin D deficiency with low birth weight remain scarce. Understanding this association is critical for informing antenatal nutritional interventions and public health strategies.

The present study was undertaken to evaluate the association between maternal vitamin D deficiency and low birth weight among term neonates. The study also explored the contribution of maternal age and socioeconomic status alongside vitamin D levels in predicting low birth weight. By focusing on measurable biochemical and demographic determinants, this investigation aims to clarify whether maternal hypovitaminosis D independently contributes to adverse birth outcomes within this population.

Materials & Methods

This comparative cross-sectional study was conducted in the Department of Obstetrics and Gynaecology at Bangabandhu Sheikh Mujib Medical University, Dhaka. Data collection was performed over a period of eighteen months from July 2023 to December 2024. A total of 60 term neonates and their mothers were included. Among them, 30 neonates with low birth weight constituted Group I and 30 neonates with normal birth weight constituted Group II.

Inclusion criteria:

1. Term live-born neonates delivered during the study period.
2. Mothers of these neonates were admitted to the obstetrics indoor department.
3. Participants who provided written informed consent.

Exclusion criteria:

Mothers receiving vitamin D supplementation during pregnancy.

1. Multiple gestations.
2. Congenital fetal anomalies.
3. Pregnancies complicated by diabetes with vascular disease, chronic hypertension, preeclampsia, hypothyroidism, chronic renal disease, or other major systemic illness.
4. Use of medications interfering with vitamin D metabolism such as antiepileptics, glucocorticoids, anti-estrogens, or antiretroviral drugs.

Study Procedure

Eligible participants were identified after delivery based on birth weight and gestational age. Informed consent was obtained before enrolment. Maternal demographic and obstetric information including age, education, occupation and socioeconomic status were collected

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using a pretested semi-structured questionnaire. Birth weight was measured immediately after delivery using standardized digital neonatal weighing scales available in the department. APGAR scores at one and five minutes were recorded from delivery records. Three milliliters of maternal venous blood were collected under aseptic conditions for estimation of serum 25-hydroxyvitamin D. Vitamin D levels were measured in the Department of Biochemistry using a direct competitive chemiluminescence immunoassay. All laboratory analyses followed standard operating procedures to ensure reliability and consistency.

Ethical Consideration

Ethical approval was obtained from the Institutional Review Board of Bangabandhu Sheikh Mujib Medical University before study initiation. Written informed consent was secured from each participant. Confidentiality of patient information was strictly maintained and data were anonymized during analysis. Participation was voluntary and participants were free to withdraw at any stage without affecting their clinical care.

Statistical Analysis

Data were analyzed using Statistical Package for the Social Sciences version 26. Continuous variables were expressed as mean and standard deviation and categorical variables as frequency and percentage. Comparisons between groups were performed using the unpaired t-test for continuous variables and the chi-square test for categorical variables. Pearson correlation coefficient was used to assess the relationship between maternal vitamin D levels and birth weight. Logistic regression analysis was conducted to identify independent predictors of low birth weight. A p-value less than 0.05 was considered statistically significant.

Results

Table I. Baseline maternal characteristics according to birth weight group

Variable		**Group I (n = 30)**	**Group II (n = 30)**	**p value**
Age (years)	Mean ± SD	28.20 ± 4.10	25.77 ± 3.51	0.04
Education	Below SSC	9 (30.0%)	6 (20.0%)	0.22
	SSC	6 (20.0%)	12 (40.0%)	
	HSC	11 (36.7%)	6 (20.0%)	
	Graduate	4 (13.3%)	6 (20.0%)	
Occupation	Housewife	22 (73.3%)	21 (70.0%)	0.7
	Non-government employee	7 (23.3%)	6 (20.0%)	
	Business	1 (3.3%)	2 (6.7%)	
	Others	0 (0.0%)	1 (3.3%)	
Socio-economic status	Lower class	10 (33.30%)	5 (16.70%)	0.02
	Middle class	15 (50.00%)	10 (33.30%)	
	Upper class	5 (16.70%)	15 (50.00%)	
	Multipara	22 (73.30%)	19 (63.30%)	

Group I: Low birth weight newborn

Group II: Normal birth weight newborn

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Table I shows the baseline maternal characteristics according to birth weight. Mothers in the low-birth-weight group had a significantly higher mean age compared with the normal birth weight group. Educational attainment and occupational status did not differ significantly between groups.

Table II. Neonatal characteristics of study participants

Variable	Group I (n = 30)	Group II (n = 30)	p value
Birth weight (kg), mean ± SD	2.30 ± 0.13	2.70 ± 0.14	<0.001
APGAR score at 1 minute, mean ± SD	6.97 ± 0.89	7.17 ± 0.38	0.26
APGAR score at 5 minutes, mean ± SD	8.70 ± 0.79	8.93 ± 0.25	0.13

Group I: Low birth weight newborn

Group II: Normal birth weight newborn

Mean birth weight differed significantly between the two groups by definition. APGAR scores at one and five minutes were comparable and showed no statistically significant difference (Table II).

Table III. Maternal serum vitamin D levels according to birth weight group

Serum vitamin D	Group I (n = 30)	Group II (n = 30)	p value
Deficient (<20 ng/ml)	26 (86.7%)	21 (70.0%)	0.12
Insufficient (21–30 ng/ml)	4 (13.3%)	6 (20.0%)	0.49
Sufficient (≥31 ng/ml)	0 (0%)	3 (10.0%)	0.24
Mean ± SD (ng/ml)	12.50 ± 4.73	16.15 ± 5.01	0.01

Group I: Low birth weight newborn

Group II: Normal birth weight newborn

Majority of the mothers in Low-birth-weight Group 26 (86.70%) and Normal birth weight Group 21 (70.00%) were in vitamin D deficiency level with mean vitamin D level of mothers was 12.50±4.73 ng/ml in Low birth weight Group and 16.15±5.01 ng/ml in Normal birth weight Group and it was statistically significant (p = 0.01) (Table III).

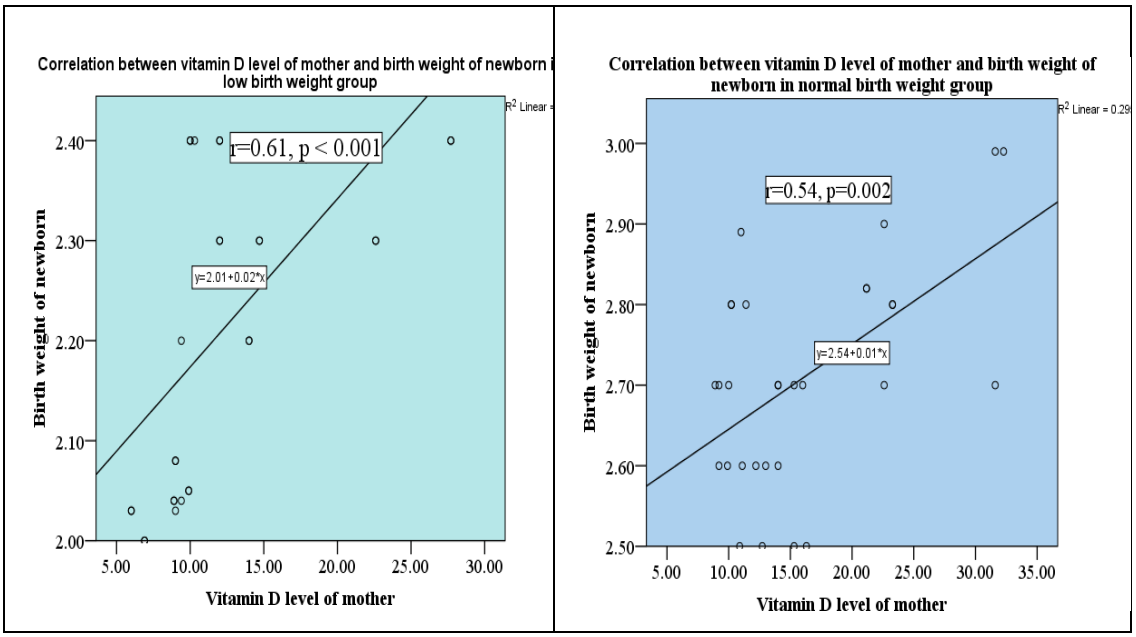

Figure 1. Correlation between maternal serum vitamin D level and neonatal birth weight

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Pearson correlation analysis demonstrated a significant positive correlation between maternal serum vitamin D level and neonatal birth weight. In the low-birth-weight group, the correlation coefficient was r=0.61 with p<0.001. In the normal birth weight group, the correlation coefficient was r=0.54 with p=0.002. These findings indicate that higher maternal vitamin D levels were associated with higher neonatal birth weight.

Table IV. Multivariable logistic regression analysis for determinants of low birth weight

Predictor	Regression Coefficient (B)	Odds Ratio	95% Confidence Interval	p value
Maternal age	0.135	1.145	1.014–1.293	0.029
Socioeconomic status	-1.626	0.197	0.042–0.918	0.039
Serum vitamin D level	-0.685	0.888	0.807–0.976	0.014

Multivariable logistic regression identified maternal age, socioeconomic status and serum vitamin D level as independent predictors of low birth weight. Increasing maternal age was associated with higher odds of low birth weight. Higher socioeconomic status was associated with reduced odds. Increasing serum vitamin D concentration was independently associated with lower odds of delivering a low-birth-weight infant (Table IV).

Discussion

This study demonstrated a significant association between maternal vitamin D deficiency and low birth weight among term neonates. Mothers of low-birth-weight infants had significantly lower mean serum vitamin D levels compared with mothers of normal birth weight infants. A strong positive correlation between maternal vitamin D concentration and neonatal birth weight further supports a biologically plausible relationship.

The high prevalence of vitamin D deficiency observed in both groups is consistent with previous regional reports. Zamal et al. reported widespread maternal hypovitaminosis D in Bangladeshi pregnant women, with a considerable proportion delivering low birth weight infants [14]. Similar findings have been documented in South Asian populations where cultural practices and limited sun exposure contribute to deficiency [16]. The current data confirm that vitamin D insufficiency remains a substantial public health concern.

The mean serum vitamin D level was significantly lower among mothers in the low birth weight group. This finding aligns with Khalessi et al., who observed significantly reduced maternal vitamin D concentrations among mothers of low birth weight neonates compared with controls [11]. Fang et al., in a meta-analysis, concluded that maternal vitamin D deficiency significantly increases the risk of low birth weight, supporting the present findings [12]. The magnitude of association observed in this study is comparable to pooled estimates reported in international literature.

The positive correlation between maternal vitamin D levels and neonatal birth weight strengthens the evidence for a dose–response relationship. Similar correlations have been reported by Schneuer et al., who demonstrated that lower maternal vitamin D levels were associated with reduced fetal growth parameters [10]. The biological plausibility of this association may be explained by vitamin D–mediated modulation of placental angiogenesis and calcium transport. Vitamin D receptors in placental tissues regulate gene expression involved in trophoblastic invasion and vascular development [6]. Deficiency may impair nutrient delivery and contribute to suboptimal intrauterine growth.

Multivariable logistic regression analysis confirmed that serum vitamin D level remained an independent predictor of low birth weight after adjusting for maternal age and socioeconomic status. The odds ratio below one indicates a protective effect of higher vitamin D concentrations. These findings are consistent with Harvey et al., who highlighted the independent contribution of maternal vitamin D status to fetal growth outcomes [9]. The independent association observed in the present study suggests that vitamin D deficiency may act beyond confounding socioeconomic influences.

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Maternal age also emerged as a significant determinant of low birth weight. Increasing age was associated with higher odds of delivering a low birth weight infant. Advanced maternal age has been linked to placental insufficiency and vascular complications, which may impair fetal growth [15]. However, the effect size for vitamin D was stronger, emphasizing the nutritional component as a modifiable factor.

Socioeconomic status was inversely associated with low birth weight. Mothers from lower socioeconomic strata had higher odds of delivering low birth weight infants. This observation is consistent with reports by Karim et al., who identified socioeconomic disadvantage as a persistent determinant of adverse birth outcomes in Bangladesh [3]. Socioeconomic factors may influence diet quality, health-seeking behavior and access to antenatal care, thereby indirectly affecting micronutrient status.

APGAR scores did not differ significantly between groups despite lower birth weights in the affected group. This suggests that immediate neonatal adaptation was not substantially compromised among term low birth weight infants in this cohort. Nevertheless, low birth weight remains a predictor of long-term morbidity and developmental challenges, underscoring the need for preventive strategies.

The strength of this study lies in the biochemical measurement of maternal serum vitamin D using standardized immunoassay techniques and the application of multivariable regression analysis. The findings contribute local evidence to a growing body of literature supporting maternal vitamin D optimization during pregnancy.

Limitations of the study

The study was conducted in a single tertiary care center with a relatively small sample size, which may limit generalizability. The cross-sectional design precludes causal inference. Sun exposure, dietary intake and seasonal variation were not quantitatively assessed. Residual confounding by unmeasured factors cannot be excluded.

Conclusion

Maternal vitamin D deficiency was significantly associated with low birth weight among term neonates. Lower serum vitamin D levels independently increased the odds of delivering a low birth weight infant. Maternal age and socioeconomic status also contributed to risk. These findings support the potential value of screening and correcting vitamin D deficiency during pregnancy as part of comprehensive antenatal care strategies aimed at reducing low birth weight.

Conflicts of interest: There are no conflicts of interest.

Ethical Approval: Ethical approval was obtained from the Institutional Review Board of Bangabandhu Sheikh Mujib Medical University (BSMMU)

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