

ASSOCIATION BETWEEN MATERNAL VITAMIN D LEVELS AND PREGNANCY OUTCOMES: IMPLICATIONS FOR SUPPLEMENTATION GUIDELINES

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Abstract

Background: Vitamin D plays a pivotal role in calcium metabolism, immune regulation, placental development, and myometrial function during pregnancy. Despite abundant sunlight in many regions, vitamin D deficiency remains highly prevalent among pregnant women and has been associated with adverse maternal and neonatal outcomes. Evidence regarding its relationship with cesarean section and postpartum hemorrhage remains limited in developing countries.

Aim: To evaluate the association between maternal serum vitamin D levels during the third trimester and adverse pregnancy outcomes, specifically primary cesarean section and postpartum hemorrhage (PPH).

Methods: A retrospective cohort study was conducted among 500 pregnant women who delivered at a tertiary care hospital between January 2022 and December 2023. Maternal serum 25-hydroxyvitamin D [25(OH)D] levels measured during the third trimester were categorized as deficient (<20 ng/mL), insufficient (20–30 ng/mL), and sufficient (>30 ng/mL). Maternal demographic characteristics, obstetric variables, delivery outcomes, and postpartum complications were extracted from hospital records. Chi-square test, ANOVA, and multivariate logistic regression analyses were performed.

Results: Among 500 participants, 55% were vitamin D deficient, 30% insufficient, and 15% sufficient. Primary cesarean section rates were significantly higher in vitamin D-deficient women (45%) compared with insufficient (30%) and sufficient groups (18%) ($p < 0.001$). Postpartum hemorrhage occurred in 22%, 12%, and 5% of women in the deficient, insufficient, and sufficient groups, respectively ($p = 0.002$). Multivariate logistic regression revealed vitamin D deficiency as an independent predictor of cesarean section (OR=2.1, 95% CI:1.5–3.0) and postpartum hemorrhage (OR=2.3, 95% CI:1.4–3.8).

Conclusion: Maternal vitamin D deficiency is significantly associated with increased risks of cesarean delivery and postpartum hemorrhage. Routine screening and appropriate supplementation during pregnancy may improve maternal outcomes and should be considered in antenatal care protocols.

Keywords: Vitamin D deficiency; Pregnancy outcomes; Cesarean section; Postpartum hemorrhage; Maternal health; Antenatal care.

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Introduction

Vitamin D is a fat-soluble secosteroid hormone essential for calcium and phosphorus homeostasis, skeletal health, immunomodulation, and cellular differentiation. During pregnancy, adequate vitamin D status is critical for placental implantation, fetal skeletal development, maternal immune adaptation, and maintenance of uterine muscle function.

Vitamin D deficiency has emerged as a major public health problem worldwide, affecting approximately 30–80% of pregnant women depending on geographical location, dietary habits, skin pigmentation, and sun exposure. Several studies have demonstrated associations between maternal vitamin D deficiency and gestational diabetes mellitus, hypertensive disorders of pregnancy, preeclampsia, fetal growth restriction, preterm birth, and low birth weight.

Recent investigations suggest that vitamin D receptors are expressed in the myometrium, placenta, decidua, and vascular endothelium. Deficiency may impair myometrial contractility and calcium-mediated muscle contractions, potentially leading to dysfunctional labor, increased operative deliveries, and postpartum hemorrhage.

Although vitamin D supplementation is widely recommended during pregnancy, uncertainty remains regarding optimal screening strategies and supplementation thresholds. Understanding the relationship between maternal vitamin D status and clinically important obstetric outcomes may help refine supplementation guidelines and improve maternal health outcomes. Therefore, the present study evaluated the association between maternal third-trimester vitamin D levels and

pregnancy outcomes, particularly primary cesarean section and postpartum hemorrhage.

Aim: To assess the association between maternal vitamin D levels during pregnancy and adverse pregnancy outcomes.

Objectives

1. To determine the prevalence of vitamin D deficiency among pregnant women.
2. To evaluate the association between maternal vitamin D status and primary cesarean section.
3. To assess the relationship between maternal vitamin D status and postpartum hemorrhage.
4. To identify whether vitamin D deficiency independently predicts adverse pregnancy outcomes after adjusting for confounding variables.
5. To provide evidence supporting optimization of vitamin D supplementation guidelines during pregnancy.

Materials and Methods

This hospital-based retrospective cohort study was conducted in the Department of Obstetrics and Gynecology of a tertiary care teaching hospital in Tamil Nadu, India. The study included pregnant women who delivered between January 2019 and December 2020. Medical records of eligible participants were reviewed to evaluate the association between maternal vitamin D levels during pregnancy and adverse pregnancy outcomes.

A total of 500 pregnant women were included in the study through consecutive sampling of eligible medical records. Women aged 18–40 years with singleton pregnancies, delivery at the study institution, documented third-trimester

serum 25-hydroxyvitamin D [25(OH)D] levels, and complete obstetric and delivery records were included in the analysis.

Women with multiple gestations, chronic hypertension, pre-existing diabetes mellitus, chronic renal disease, chronic liver disease, autoimmune disorders, known coagulation disorders, or incomplete medical records were excluded to minimize potential confounding factors.

Data were collected using a structured data extraction form from hospital medical records. Information obtained included maternal demographic characteristics such as age and body mass index (BMI), obstetric variables including parity and gestational age at delivery, history of vitamin D supplementation during pregnancy, serum vitamin D concentrations, mode of delivery, and postpartum complications. Maternal serum 25-hydroxyvitamin D [25(OH)D] levels, measured during the third trimester using a chemiluminescent immunoassay technique, were categorized into three groups: deficient (<20 ng/mL), insufficient (20–30 ng/mL), and sufficient (>30 ng/mL). The primary outcome variables assessed were the incidence of primary cesarean section and postpartum hemorrhage (PPH), defined as blood loss exceeding 1000 mL within the first 24 hours after delivery. Secondary variables included maternal age, BMI, parity, gestational age at delivery, and vitamin D supplementation status.

Prior to commencement of the study, approval was obtained from the Institutional Ethics Committee. As the study involved retrospective analysis of anonymized hospital records, patient

confidentiality and privacy were strictly maintained throughout the research process. The study was conducted in accordance with the ethical principles outlined in the Declaration of Helsinki.

Statistical Analysis: Data were entered into Microsoft Excel and analyzed using Statistical Package for the Social Sciences (SPSS) version 26.0. Continuous variables were expressed as mean \pm standard deviation (SD), while categorical variables were presented as frequencies and percentages. Comparisons of continuous variables among vitamin D status groups were performed using the Independent t-test and One-Way Analysis of Variance (ANOVA), as appropriate.

Associations between categorical variables were assessed using the Chi-square test or Fisher's exact test. Multivariate logistic regression analysis was performed to determine the independent association between maternal vitamin D deficiency and adverse pregnancy outcomes after adjusting for potential confounding variables such as maternal age, BMI, parity, and gestational age at delivery.

Adjusted odds ratios (ORs) with 95% confidence intervals (CIs) were calculated. A p-value of less than 0.05 was considered statistically significant for all analyses.

Results

Baseline Characteristics of the Study Population: A total of 500 pregnant women were included in the study. Among them, 275 (55%) had vitamin D deficiency, 150 (30%) had vitamin D insufficiency, and 75 (15%) had sufficient vitamin D levels.

Table 1: Demonstrates baseline demographic and obstetric characteristics according to vitamin D status.

Variable	Deficient (n=275)	Insufficient (n=150)	Sufficient (n=75)	p-value
Age (years)	28.6 \pm 4.3	28.1 \pm 4.6	27.9 \pm 4.2	0.42
BMI (kg/m ²)	26.8 \pm 3.2	25.9 \pm 3.4	25.5 \pm 3.0	0.08
Nulliparity (%)	60	55	50	0.09

Gestational age (weeks)	38.2 ±1.5	38.5 ±1.3	38.8 ±1.2	0.03
Vitamin D supplement use (%)	30	45	70	<0.001

Women with sufficient vitamin D levels were more likely to report vitamin D supplementation and had slightly higher gestational age at delivery. It shows the distribution of vitamin D levels among study participants. More than half of the women (55%) were vitamin D deficient, indicating a substantial burden of

deficiency in the study population. Distribution of Vitamin D Status Deficient: 55% Insufficient: 30% Sufficient: 15%

Association between Vitamin D Status and Cesarean Section

Primary cesarean section rates differed significantly among the three groups.

Table 2: Association between Vitamin D Status and Cesarean Section

Vitamin D Status	Cesarean Section n (%)
Deficient	124 (45%)
Insufficient	45 (30%)
Sufficient	14 (18%)
p-value	<0.001

Women with vitamin D deficiency demonstrated the highest cesarean section rates (45%), nearly 2.5 times higher than those with sufficient vitamin D levels. Figure 2 illustrates this trend. Cesarean

Section Rates by Vitamin D Status Deficient: 45% Insufficient: 30% Sufficient: 18%

Association between Vitamin D Status and Postpartum Hemorrhage

Table 3: Association between Vitamin D Status and Postpartum Hemorrhage

Vitamin D Status	PPH n (%)
Deficient	61 (22%)
Insufficient	18 (12%)
Sufficient	4 (5%)
p-value	0.002

Postpartum hemorrhage was significantly more common among vitamin D-deficient women compared with those having adequate vitamin D levels. Incidence of

Postpartum Hemorrhage by Vitamin D Status Deficient: 22% Insufficient: 12% Sufficient: 5%

Multivariate Analysis

Table 4: Multivariate Logistic Regression Analysis

Variable	Adjusted OR	95% CI	p-value
Vitamin D deficiency – Cesarean Section	2.1	1.5–3.0	<0.001
Vitamin D deficiency – PPH	2.3	1.4–3.8	0.002
Maternal age >30 years	1.8	1.2–2.6	0.005
BMI >30 kg/m ²	2.5	1.7–3.5	<0.001
Preterm delivery	2.8	1.9–4.1	<0.001

Vitamin D deficiency remained an independent predictor of both cesarean delivery and postpartum hemorrhage after adjustment for confounders.

Discussion

The present study identified a high prevalence (55%) of vitamin D deficiency

among pregnant women. This finding is comparable with reports from India, the Middle East, and other developing nations where vitamin D deficiency during pregnancy ranges from 40–80%. The study demonstrated a strong association between vitamin D deficiency and increased cesarean section rates. Women with deficient vitamin D levels experienced significantly higher operative deliveries compared with women having sufficient levels. Similar observations were reported by Merewood et al., Aghajafari et al., and Sablok et al., who suggested that vitamin D deficiency may impair myometrial contractility due to altered calcium metabolism.

Vitamin D receptors are expressed in uterine smooth muscle tissue. Deficiency may reduce effective uterine contractions, prolong labor, and increase the likelihood of labor dystocia and cesarean section. Additionally, vitamin D deficiency has been associated with obesity, insulin resistance, and inflammation, all of which may contribute to operative deliveries.

Postpartum hemorrhage occurred significantly more frequently among vitamin D-deficient women. The observed incidence of 22% was considerably higher than the 5% noted among women with sufficient vitamin D levels. These findings agree with Poornima et al., who demonstrated a correlation between third-trimester vitamin D deficiency and postpartum hemorrhage.

The biological plausibility for this association may involve impaired myometrial contraction and altered coagulation pathways. Vitamin D influences calcium-dependent muscle contraction, vascular endothelial function, and inflammatory responses. Deficiency may therefore predispose women to uterine atony, the leading cause of postpartum hemorrhage. The logistic regression analysis further confirmed vitamin D deficiency as an independent risk factor for both cesarean section and postpartum

hemorrhage. Even after adjustment for maternal age, obesity, and gestational age, the association remained statistically significant.

Clinical Implications

The high prevalence of deficiency observed in this study highlights the need for routine antenatal screening, especially among high-risk women. Early detection and correction of vitamin D deficiency may represent a cost-effective strategy to reduce maternal morbidity.

Strengths of the Study

- Large sample size.
- Real-world clinical data.
- Assessment of clinically relevant maternal outcomes.
- Multivariate adjustment for confounding factors.

Limitations

- Retrospective design.
- Single-center study.
- Lack of neonatal outcome assessment.
- Absence of seasonal variation analysis.
- Inability to establish causality.

Future Directions

Prospective multicenter studies and randomized controlled trials are needed to determine whether correction of vitamin D deficiency can directly reduce cesarean section and postpartum hemorrhage rates.

Conclusion

Maternal vitamin D deficiency is highly prevalent and significantly associated with adverse pregnancy outcomes. Women with deficient vitamin D levels exhibited substantially higher rates of primary cesarean section and postpartum hemorrhage. Vitamin D deficiency remained an independent predictor of both outcomes after adjustment for potential confounders. Routine screening and evidence-based supplementation during pregnancy should be considered to improve maternal health outcomes and reduce obstetric complications.

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