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Original Research Article

Evaluation of maternal serum vitamin D levels and their correlation with adverse perinatal outcomes: a prospective study

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ABSTRACT

Background: Vitamin D, a fat-soluble prohormone, is critical for calcium absorption, immune regulation, and placental development. In pregnancy, its role extends beyond skeletal health to vascular regulation and fetal growth. Increasing evidence links hypovitaminosis D with complications such as preeclampsia, gestational diabetes, and adverse neonatal outcomes. This study aimed to evaluate maternal serum vitamin D levels during the third trimester of pregnancy and assess their correlation with maternal and neonatal outcomes.

Methods: A prospective observational study was conducted on 150 antenatal women beyond 28 weeks of gestation at a tertiary care centre in Himachal Pradesh, India, between January and December 2023. Maternal serum 25-hydroxyvitamin D [25(OH)D] levels were measured and women were classified as deficient (<20 ng/ml), insufficient (20–29 ng/ml), or sufficient (≥30 ng/ml). Maternal outcomes studied included preeclampsia, gestational diabetes mellitus (GDM), and preterm delivery. Neonatal outcomes studied were low birth weight (LBW) and NICU admissions. Statistical analysis was performed using statistical package for the social sciences (SPSS) version 25 with a significance level set at $p<0.05$.

Results: Vitamin D deficiency was found in 68% of women. Deficient women had significantly higher rates of preeclampsia (21.5% versus 6.3%, p=0.01), GDM (18.6% versus 4.2%, p=0.008), and LBW babies (27.4% versus 10.4%, p=0.01). NICU admission rates were also higher among deficient women (23.5% versus 8.3%, p=0.02). Preterm birth did not show a significant association.

Conclusions: Vitamin D deficiency is highly prevalent among Indian pregnant women and is significantly correlated with maternal complications and adverse perinatal outcomes. Routine screening and supplementation may improve pregnancy outcomes.

Keywords: Vitamin D deficiency, Pregnancy, Preeclampsia, Gestational diabetes, Neonatal outcomes, Perinatal complications

INTRODUCTION

Vitamin D is a secosteroid hormone well known for its essential role in calcium and phosphorus metabolism, but its influence extends far beyond bone health. It regulates placental vascularisation, modulates immune function, and impacts cellular proliferation. In pregnancy, vitamin D ensures maternal skeletal health while simultaneously supporting fetal growth and development. Deficiency during this critical period has been linked to preeclampsia, gestational diabetes mellitus (GDM), intrauterine growth restriction, preterm labour, and neonatal morbidity.[1-3]

Despite India's abundant sunshine, hypovitaminosis D is alarmingly common. Studies have shown that up to 80% of pregnant Indian women have suboptimal levels.[3] The paradox of deficiency despite ample sunlight can be explained by dark skin pigmentation, cultural practices restricting sun exposure, air pollution, and low dietary intake of vitamin D.[4] Urbanisation has further worsened

the problem, as sedentary indoor lifestyles limit outdoor activity.

Globally, several meta-analyses have demonstrated associations between maternal hypovitaminosis D and adverse pregnancy outcomes.[5,6] However, prevalence rates vary across populations, with South Asian cohorts consistently reporting higher deficiency compared to Western populations.[7] Indian data, in particular, highlight a strong association between vitamin D deficiency and obstetric complications such as preeclampsia, GDM, and poor neonatal outcomes.[8,9]

Northern India, especially hilly states like Himachal Pradesh, has unique geographical and cultural factors that may influence vitamin D status. Limited exposure to sunlight in winter months, combined with dietary insufficiency, could contribute to higher prevalence. Yet, there is a paucity of prospective studies from this region. This study was therefore conducted to determine the prevalence of vitamin D deficiency among third-trimester pregnant women in Himachal Pradesh and to evaluate its association with maternal and neonatal outcomes.

METHODS

This prospective observational study was conducted in the Department of Obstetrics and Gynaecology, Dr. Rajendra Prasad Government Medical College, Kangra, Himachal Pradesh, between January and December 2024. Institutional Ethics Committee approval was obtained, and written informed consent was taken from all participants.

Pregnant women aged 18–40 years, with singleton pregnancies beyond 28 weeks of gestation, were included. Women with chronic systemic diseases (renal, hepatic, or cardiac), pre-existing diabetes or hypertension, multiple gestations, fetal anomalies, or those on high-dose vitamin D supplementation (>1000 IU/day) were excluded. Sample size was calculated assuming a prevalence of 70% vitamin D deficiency in pregnancy[3] with 95% confidence and 10% precision. The minimum sample size was 138, but 150 participants were recruited to account for possible attrition.

Detailed history and examination were conducted. Serum 25-hydroxyvitamin D [25(OH)D] levels were measured by chemiluminescence immunoassay. According to Endocrine Society guidelines, vitamin D status was defined as deficient (<20 ng/ml), insufficient (20–29 ng/ml), or sufficient (≥30 ng/ml).[10]

Maternal outcomes included preeclampsia, defined as per ACOG criteria, GDM diagnosed using DIPSI guidelines, and preterm delivery (<37 weeks).[11,12] Neonatal outcomes included birth weight (LBW <2500 g) and NICU admission.

Data analysis was performed using statistical package for the social sciences (SPSS) version 25. Continuous variables were expressed as mean±SD and compared using Student's t-test, while categorical data were analysed using Chi-square or Fisher's exact test. A p value <0.05 was considered statistically significant.

RESULTS

Table 1 shows baseline characteristics of participants. The mean maternal age was 27.8±4.1 years, mean gestational age at sampling was 31.6±2.9 weeks, and mean BMI was 24.3±3.2 kg/m².

Table 1: Baseline characteristics of study participants (n=150).

Characteristic	Mean±SD/N (%)
Maternal age (years)	27.8±4.1
Gestational age (weeks)	31.6±2.9
BMI (kg/m²)	24.3±3.2

The distribution of vitamin D status is presented in Table 2. Deficiency was widespread, with 68% of women classified as deficient, 18.7% as insufficient, and only 13.3% as sufficient.

Table 2: Distribution of participants according to vitamin D status.

Vitamin D category	N (%)
Deficient (<20 ng/ml)	102 (68.0)
Insufficient (20–29 ng/ml)	28 (18.7)
Sufficient (≥30 ng/ml)	20 (13.3)

The association between vitamin D and maternal complications is shown in Table 3. Women with deficiency had significantly higher rates of preeclampsia and GDM.

Preterm delivery was also more frequent among deficient women, though not statistically significant.

Table 3: Maternal outcomes by vitamin D status.

Maternal outcome	Deficient (n=102), N (%)	Non-deficient (n=48), N (%)	P value
Preeclampsia	22 (21.5)	3 (6.3)	0.01
Gestational diabetes	19 (18.6)	2 (4.2)	0.008
Preterm delivery	13 (12.7)	3 (6.3)	0.19 (NS)

Neonatal outcomes are summarised in Table 4. Neonates of vitamin D–deficient mothers had significantly higher incidence of LBW and NICU admissions.

Table 5 shows combined adverse outcomes. Deficient women were significantly more likely to experience any maternal or neonatal complication.

Table 4: Neonatal outcomes by vitamin D status.

Neonatal outcome	Deficient (n=102), N (%)	Non-deficient (n=48), N (%)	P value
Low birth weight	28 (27.4)	5 (10.4)	0.01
NICU admission	24 (23.5)	4 (8.3)	0.02

Table 5: Comparison of adverse outcomes between vitamin D–deficient and non-deficient groups.

Outcome	Deficient (n=102), N (%)	Non-deficient (n=48), N (%)	P value
Any maternal complication	54 (52.9)	8 (16.7)	<0.001
Any neonatal complication	52 (51.0)	9 (18.7)	<0.001

DISCUSSION

This study demonstrates that vitamin D deficiency is a widespread problem in pregnancy and is strongly associated with maternal and neonatal complications. The high prevalence observed in our cohort reflects earlier systematic reviews that established vitamin D deficiency as a global issue in pregnancy and a risk factor for adverse outcomes.[1] A recent meta-analysis further confirmed that supplementation during pregnancy improves maternal outcomes, highlighting the importance of preventive strategies.[2]

In India, deficiency remains disproportionately high, affecting up to 80% of pregnant women, despite abundant sunlight exposure.[3] The paradox has been attributed to cultural clothing practices, skin pigmentation, air pollution, and poor dietary intake. Similar conclusions were reached by Wei et al who demonstrated in a meta-analysis that maternal deficiency contributes significantly to hypertensive disorders of pregnancy.[4]

The relationship between vitamin D and GDM has been supported by meta-analyses, including the work of Zhang et al, who showed that maternal deficiency increases the risk of developing GDM.[5] Holick described the broader implications of vitamin D deficiency, emphasising that its effects extend beyond skeletal health and involve glucose metabolism and immune regulation.[6] Our study supports these mechanistic insights, as deficient women showed a significantly higher incidence of GDM compared with those with sufficient vitamin D.

Bi et al. demonstrated that vitamin D supplementation during pregnancy reduced risks of preeclampsia, GDM, and NICU admission, providing strong evidence for supplementation as a preventive measure.[7] Roth et al further supported these findings in a systematic review of randomised trials, consolidating the role of vitamin D in improving maternal and neonatal health.[8] Pérez-López et al confirmed similar benefits in their meta-analysis of supplementation, especially in high-risk populations.[9]

Indian data continue to strengthen this association. Batra et al reported that hypovitaminosis D in Indian women was strongly linked with poor neonatal outcomes, including low birth weight and preterm birth.[10] The Endocrine Society guidelines by Holick et al standardised definitions of deficiency and sufficiency, which were adopted in our study for classification of vitamin D status.[11]

The criteria for preeclampsia diagnosis in our study were based on ACOG Practice Bulletin No. 222, which defines hypertension and proteinuria in pregnancy.[12] For GDM, we followed the DIPSI criteria, widely used in India and validated in previous studies.[13] Both conditions were significantly more common in vitamin D–deficient women, reinforcing the causal link suggested in prior research.

Mechanistically, Bodnar et al showed that vitamin D deficiency increases the risk of preeclampsia by impairing angiogenesis and endothelial function.[14] Barrera et al elaborated on the role of vitamin D in regulating placental inflammation, further supporting its involvement in hypertensive disorders of pregnancy.[15] Tabesh et al conducted a meta-analysis confirming that women with low vitamin D levels were at significantly increased risk of preeclampsia.[16]

Poel et al provided a systematic review linking vitamin D deficiency with gestational diabetes, consolidating evidence from multiple observational studies.[17] Curtis et al highlighted the importance of maternal supplementation in ensuring optimal fetal skeletal growth and preventing intrauterine growth restriction.[18] Finally, Sharma et al contributed recent Indian evidence showing that maternal hypovitaminosis D was associated with adverse perinatal outcomes including LBW and NICU admission.[19]

Our findings, therefore, are consistent with both global and Indian evidence. The strengths of our study lie in its prospective design and robust evaluation of clinically relevant maternal and neonatal outcomes. Limitations include its single-centre setting and lack of dietary assessment, which may restrict generalisability.

Nevertheless, the study provides valuable regional data from Himachal Pradesh and supports the integration of vitamin D screening and supplementation into routine antenatal care.

CONCLUSION

This prospective study demonstrates that vitamin D deficiency is not only highly prevalent in the antenatal population of Himachal Pradesh but also strongly

associated with important maternal and neonatal complications. Nearly seven out of ten women in our study were deficient, which is in line with national estimates and confirms that hypovitaminosis D is a significant public health concern in India. The associations with preeclampsia, gestational diabetes mellitus, low birth weight, and increased NICU admissions underline the role of vitamin D as a key determinant of pregnancy outcomes.

Our results are consistent with earlier international studies and meta-analyses that have shown vitamin D deficiency to be an independent risk factor for adverse maternal outcomes including preeclampsia and gestational diabetes, as well as neonatal morbidity such as growth restriction and higher rates of NICU admissions. The biological mechanisms are well supported in literature, with deficiency contributing to impaired placental vascularisation, endothelial dysfunction, and abnormal glucose metabolism. By confirming these associations in an Indian cohort, our study adds regional evidence to the growing global consensus that maternal vitamin D sufficiency is vital for healthy pregnancy and neonatal outcomes.

The clinical implications of these findings are considerable. Screening for vitamin D deficiency and providing timely supplementation during pregnancy represent simple, safe, and cost-effective interventions that can reduce the risk of major complications. While supplementation is recommended in existing guidelines, adherence remains suboptimal, and practices are inconsistent across regions. Our findings reinforce the need for routine implementation of supplementation protocols and consideration of vitamin D testing in antenatal care, particularly in high-risk women or in regions with known high prevalence.

From a public health perspective, strategies should extend beyond individual supplementation to population-level interventions. These include health education regarding safe sun exposure, dietary diversification, and food fortification policies. Future multicentric studies with larger sample sizes and long-term neonatal follow-up are warranted to better establish causal relationships and to evaluate the benefits of supplementation at the community level. In conclusion, addressing hypovitaminosis D during pregnancy is a feasible and effective step that has the potential to significantly improve maternal and perinatal health outcomes in India and globally.

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