



Original Article

Maternal Vitamin D Deficiency and Its Association with Preeclampsia and Disease Severity: A Comparative Cross-Sectional Study

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ABSTRACT

Background: Maternal vitamin D deficiency has been linked with hypertensive disorders of pregnancy, although the relationship with preeclampsia and its severity remains uncertain.

Objectives: To compare maternal vitamin D status in preeclamptic and normotensive pregnancies and examine its association with disease severity.

Methods: A hospital-based comparative cross-sectional study enrolled 150 women with preeclampsia and 150 gestational-age-matched normotensive pregnant women at J.L.N. Medical College, Ajmer, from June 2024 to May 2025. Serum 25-hydroxyvitamin D was estimated by chemiluminescent immunoassay. Group comparisons and unadjusted odds ratios were reported.

Results: Vitamin D deficiency occurred in 112/150 (74.7%) preeclamptic women and 56/150 (37.3%) controls (odds ratio 4.95, 95% confidence interval 3.02–8.11; $p < 0.001$). Deficiency was observed in 54/60 (90.0%) women with severe preeclampsia and 58/90 (64.4%) with mild disease. A body mass index ≥ 25 kg/m² was associated with higher unadjusted odds of preeclampsia (odds ratio 2.00, 95% confidence interval 1.24–3.22). Maternal and perinatal complications were more common among cases.

Conclusion: Vitamin D deficiency was more frequent in women with preeclampsia, particularly those with severe disease. The cross-sectional findings demonstrate association and do not establish that deficiency preceded or caused preeclampsia.

Keywords: vitamin D; 25-hydroxyvitamin D; preeclampsia; pregnancy; disease severity; observational study.

INTRODUCTION

Preeclampsia is a pregnancy-specific hypertensive disorder associated with substantial maternal and perinatal morbidity. Clinical manifestations may include proteinuria, thrombocytopenia, renal or hepatic dysfunction, neurological symptoms and placental insufficiency. The condition is usually recognised after 20 weeks of gestation, and delivery remains central to definitive management when maternal or fetal status is threatened.^{1,2}

Vitamin D participates in immunoregulation, endothelial function and the placental response to inflammation. Placental vitamin D metabolism and vitamin D receptor expression suggest possible roles in trophoblastic activity and fetoplacental development.^{3,4} Vitamin D deficiency is also frequently reported among pregnant women in India, making its relationship with obstetric complications particularly relevant to routine antenatal practice.⁵

Evidence from observational studies and pooled analyses indicates that lower maternal 25-hydroxyvitamin D concentrations are associated with preeclampsia, although reported effect sizes vary between populations and study designs.^{6,7} Indian case-control observations have also supported an association between low vitamin D status and

hypertensive disease in pregnancy.⁸ However, a single vitamin D measurement taken after the onset of disease cannot determine whether deficiency preceded the disorder.

Our study compared maternal vitamin D status between women with preeclampsia and normotensive controls attending a tertiary obstetric centre in Ajmer. The main objectives were to assess the frequency of vitamin D deficiency in the two groups and to examine its relationship with the severity of preeclampsia.

MATERIALS AND METHODS

Study design and setting

A hospital-based, comparative cross-sectional observational study was carried out in the Department of Obstetrics and Gynaecology, Rajkiya Mahila Chikitsalaya, J.L.N. Medical College, Ajmer, Rajasthan, India, from June 2024 to 31 May 2025. A total of 300 pregnant women were enrolled: 150 with preeclampsia and 150 gestational-age-matched normotensive controls.

Selection of participants

Eligible participants were pregnant women aged 18–45 years with singleton pregnancy beyond 20 weeks of gestation who provided written informed consent. Preeclampsia was diagnosed according to the clinical criteria specified in the study protocol. Women with pre-existing hypertension or renal disease, multifetal pregnancy, placental abnormalities, selected chronic systemic diseases, or ongoing vitamin D supplementation were excluded.

Clinical and laboratory assessment

Demographic characteristics, obstetric history, parity, body mass index, socioeconomic status, sunlight exposure and relevant clinical findings were recorded. Maternal blood pressure, haematological and biochemical parameters, and maternal and neonatal outcomes were documented. Serum 25-hydroxyvitamin D [25(OH)D] was measured using chemiluminescent immunoassay. Under the study-defined criteria, vitamin D deficiency was classified as ≤ 10 ng/mL, insufficiency as >10 – 30 ng/mL, and sufficiency as >30 ng/mL. Preeclamptic women were categorised as having mild or severe disease for subgroup assessment.

Statistical analysis and ethical considerations

Data were analysed using SPSS version 24.0. Continuous variables were summarised as mean $\pm$ standard deviation, while categorical data were presented as frequencies and percentages. Independent-samples t tests and chi-square or Fisher exact tests were specified for comparisons. Unadjusted odds ratios (OR) with 95% confidence intervals (CI) were reported for selected factors. Statistical significance was defined as $p < 0.05$. Institutional ethics approval was obtained before data collection, and all participants provided written informed consent.

RESULTS

Baseline characteristics

The study included 150 preeclamptic women and 150 normotensive controls. Most participants were 21–25 years old. Women with preeclampsia were more frequently from rural areas (57.3% vs 48.0%), while the proportions of primigravidae were similar (58.7% vs 61.3%). Body mass index ≥ 25 kg/m² occurred in 45.3% of cases and 29.3% of controls (Table 1).

Table 1. Selected baseline characteristics of study participants (N=300)

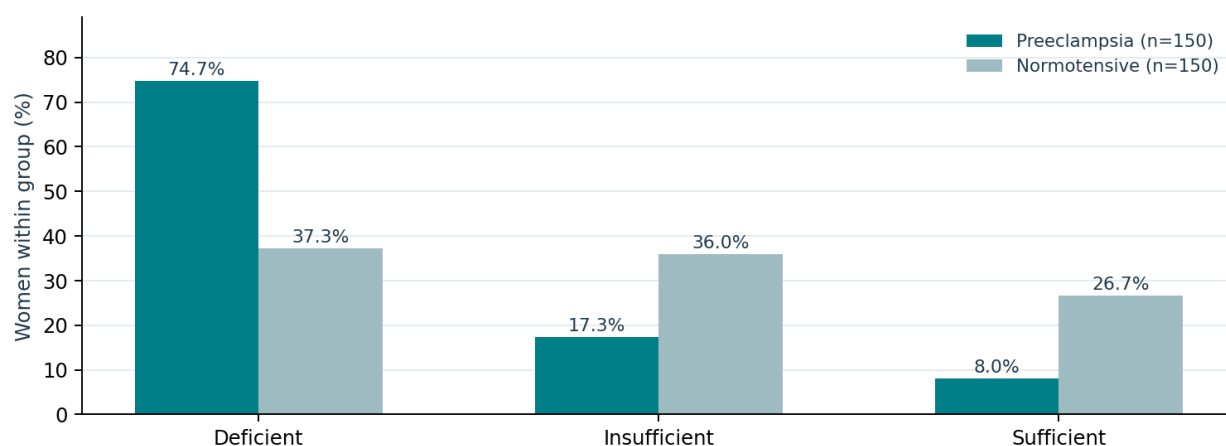
Characteristic	Preeclampsia (n=150)	Controls (n=150)
Age 18–20 years	18 (12.0%)	20 (13.3%)
Age 21–25 years	62 (41.3%)	68 (45.3%)
Age 26–30 years	50 (33.3%)	46 (30.7%)
Age >30 years	20 (13.3%)	16 (10.7%)
Rural residence	86 (57.3%)	72 (48.0%)
Primigravida	88 (58.7%)	92 (61.3%)
BMI ≥ 25 kg/m ²	68 (45.3%)	44 (29.3%)

Vitamin D status and association with preeclampsia

The mean serum 25(OH)D concentration was lower in women with preeclampsia (14.8 ± 6.2 ng/mL) than in controls (22.6 ± 7.4 ng/mL; $p < 0.001$). Vitamin D deficiency was recorded in 112 (74.7%) cases compared with 56 (37.3%) controls; the corresponding unadjusted OR was 4.95 (95% CI 3.02–8.11; $p < 0.001$). Adequate vitamin D levels were less frequent among cases (8.0%) than controls (26.7%) (Table 2 and Figure 1).

Table 2. Maternal vitamin D profile by preeclampsia status

Vitamin D measure	Preeclampsia (n=150)	Controls (n=150)
Mean serum 25(OH)D (ng/mL)	14.8 ± 6.2	22.6 ± 7.4
Deficient, ≤10 ng/mL	112 (74.7%)	56 (37.3%)
Insufficient, >10–30 ng/mL	26 (17.3%)	54 (36.0%)
Sufficient, >30 ng/mL	12 (8.0%)	40 (26.7%)

**Figure 1. Vitamin D status categories among women with preeclampsia and normotensive controls.****Vitamin D status according to disease severity**

Among the 150 women with preeclampsia, 90 had mild and 60 had severe disease. Vitamin D deficiency was recorded in 58 of 90 (64.4%) women with mild preeclampsia and 54 of 60 (90.0%) with severe preeclampsia. Mean vitamin D concentrations were lower in severe than in mild disease (11.1 ± 4.6 vs 17.2 ± 5.8 ng/mL) (Table 3 and Figure 2).

Table 3. Maternal vitamin D profile by severity of preeclampsia

Vitamin D measure	Mild (n=90)	Severe (n=60)
Deficient, ≤10 ng/mL	58 (64.4%)	54 (90.0%)
Insufficient, >10–30 ng/mL	22 (24.4%)	4 (6.7%)
Sufficient, >30 ng/mL	10 (11.1%)	2 (3.3%)
Mean 25(OH)D (ng/mL)	17.2 ± 5.8	11.1 ± 4.6

Factors associated with preeclampsia

In univariate analysis, vitamin D deficiency showed the strongest association with preeclampsia (OR 4.95, 95% CI 3.02–8.11). A BMI ≥ 25 kg/m² (OR 2.00, 95% CI 1.24–3.22) and lower socioeconomic status (OR 1.63, 95% CI 1.03–2.59) were also associated with preeclampsia. Maternal age >25 years, rural residence and primigravidity were not statistically significant in these unadjusted comparisons (Table 4).

Table 4. Univariate factors associated with preeclampsia

Characteristic	Preeclampsia	Controls	OR (95% CI)	p value
Age >25 years	70 (46.7%)	62 (41.3%)	1.24 (0.79–1.96)	0.352
Rural residence	86 (57.3%)	72 (48.0%)	1.46 (0.92–2.30)	0.105
Primigravida	88 (58.7%)	92 (61.3%)	0.89 (0.56–1.42)	0.637
Lower socioeconomic group	94 (62.7%)	76 (50.7%)	1.63 (1.03–2.59)	0.036
BMI ≥ 25 kg/m ²	68 (45.3%)	44 (29.3%)	2.00 (1.24–3.22)	0.004
Vitamin D deficiency	112 (74.7%)	56 (37.3%)	4.95 (3.02–8.11)	<0.001

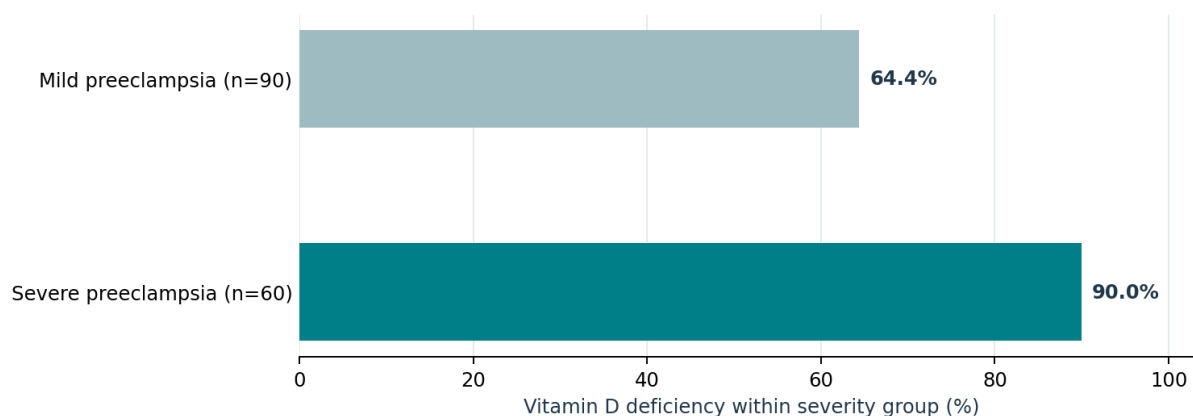


Figure 2. Prevalence of vitamin D deficiency among women with mild and severe preeclampsia.

Maternal and perinatal outcomes

Compared with normotensive women, those with preeclampsia had higher frequencies of caesarean delivery, preterm delivery and intensive care admission. Low birth weight, neonatal intensive care admission, intrauterine growth restriction, stillbirth and intrauterine death were also more commonly reported in the preeclampsia group (Table 5). A positive correlation was observed between maternal vitamin D concentration and neonatal birth weight ($r=0.42$; $p<0.001$). These outcome comparisons are descriptive and were not adjusted for disease severity or other factors.

Table 5. Selected maternal and perinatal outcomes

Outcome	Preeclampsia (n=150)	Controls (n=150)
Caesarean delivery	96 (64.0%)	54 (36.0%)
Preterm delivery	58 (38.7%)	24 (16.0%)
Maternal ICU admission	22 (14.7%)	4 (2.7%)
Low birth weight	72 (48.0%)	30 (20.0%)
Neonatal ICU admission	66 (44.0%)	28 (18.7%)
Intrauterine growth restriction	46 (30.7%)	18 (12.0%)
Stillbirth	10 (6.7%)	2 (1.3%)
Intrauterine death	8 (5.3%)	1 (0.7%)

DISCUSSION

Our study found that vitamin D deficiency was substantially more common among women with preeclampsia than among gestational-age-matched normotensive controls. The observed unadjusted odds of preeclampsia were approximately fivefold higher in the deficient category, with a clear difference in the distribution of vitamin D status between groups. This pattern is consistent with the hypothesis that poor vitamin D status accompanies hypertensive disease in pregnancy; however, the comparative cross-sectional design does not establish temporality or a causal effect.

The finding is broadly consistent with hospital-based studies in India and other settings that have documented lower maternal vitamin D status among women with preeclampsia.^{7,8,9} Differences in sampling time, population characteristics, vitamin D assays and deficiency thresholds limit direct numerical comparison across studies. The biochemical measurements in our study were obtained after 20 weeks, when preeclampsia had already been diagnosed in the case group. The relation with disease severity is another relevant observation. Vitamin D deficiency occurred in 90.0% of women classified as having severe preeclampsia compared with 64.4% of women with mild disease. Because these are subgroup proportions rather than adjusted risk estimates, the findings should be interpreted as a severity-associated pattern rather than evidence that deficiency produces more severe disease. Low vitamin D status may also coexist with other nutritional or clinical factors that influence the course of preeclampsia.

Higher body mass index and lower socioeconomic status were associated with preeclampsia in the univariate analyses. Both factors may influence vitamin D status and pregnancy-related vascular risk. The absence of a multivariable model means that residual confounding cannot be excluded. Therefore, the magnitude of the vitamin D association should not be regarded as an adjusted or independent effect estimate.

Prospective evidence has linked vitamin D status during pregnancy with the subsequent occurrence of preeclampsia, but other approaches have not established a consistent causal relationship.^{10,11} Reviews of supplementation trials suggest possible benefit in selected populations, with considerable variation in baseline deficiency, intervention regimens and study quality.^{12,13} Our findings alone do not justify the use of serum vitamin D as a diagnostic test for preeclampsia or a change in standard antenatal supplementation practices.

Women in the preeclampsia group also had higher frequencies of adverse maternal and neonatal outcomes. These differences are clinically expected in pregnancies complicated by hypertensive placental disease and should not be attributed specifically to vitamin D deficiency. Further studies linking individual-level vitamin D measurements to outcomes while controlling for disease severity and obstetric risk factors would be needed to assess any additional prognostic contribution.

Strengths and limitations

The study included equal numbers of cases and controls from the same tertiary-care setting and used a standard laboratory method to measure 25(OH)D. Its limitations include single-centre recruitment, single-point vitamin D estimation, selection bias inherent in hospital-based sampling, possible unmeasured dietary and sunlight-related confounding, and lack of multivariable adjustment. The cross-sectional nature of the study prevents inference about vitamin D status before disease onset.

CONCLUSION

Maternal vitamin D deficiency was substantially more frequent among women with preeclampsia than among normotensive pregnant women and was particularly common in severe preeclampsia. The findings support an association between vitamin D status and hypertensive disease during pregnancy but cannot establish causation. Larger longitudinal studies with uniform vitamin D thresholds and adjustment for important maternal confounders are needed.

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