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Research Article

Effect of Maternal Vitamin D Deficiency and Supplementation on Fetomaternal Outcomes

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A B S T R A C T

Introduction: Vitamin D deficiency during pregnancy is recognized as a health concern with adverse effects on maternal and neonatal outcomes. Despite adequate sunlight exposure in tropical countries, hypovitaminosis D remains prevalent due to lifestyle, dietary, and socioeconomic factors. This study aimed to determine the prevalence of vitamin D deficiency in pregnancy and its association with fetomaternal outcomes.

Materials and Method: This prospective longitudinal observational study was conducted in the Department of Obstetrics and Gynaecology of a tertiary care teaching hospital. A total of 102 antenatal women were included, comprising 52 women who received oral cholecalciferol supplementation (60,000 IU weekly for 8 weeks) and 50 unsupplemented controls. Serum 25-hydroxyvitamin D levels were measured at delivery. Maternal outcomes including gestational diabetes mellitus, preeclampsia, preterm delivery, premature rupture of membranes, and mode of delivery were recorded. Neonatal outcomes such as birth weight, intrauterine growth restriction, APGAR score, NICU admission, and intrauterine death were evaluated. Statistical analysis was performed using SPSS software, with p <0.05 considered statistically significant.

Result: The prevalence of vitamin D deficiency was 90.7%. Preeclampsia/eclampsia, preterm delivery, and low birth weight were significantly lower in the supplemented group compared to controls. No significant association was observed with gestational diabetes mellitus, caesarean section rate, APGAR score, or NICU admission.

Conclusion: Vitamin D deficiency is prevalent among pregnant women and is associated with adverse fetomaternal outcomes. Early screening and supplementation during pregnancy may reduce complications including preeclampsia, preterm birth, and low birth weight.

Keywords: Vitamin D Deficiency, Pregnancy, Cholecalciferol, Preeclampsia, Low Birth Weight

Introduction

Vitamin D is a fat-soluble secosteroid hormone that plays a pivotal role in calcium and phosphorus homeostasis and is essential for bone mineralization and skeletal integrity.[1] In recent years, growing evidence has highlighted the pleiotropic effects of vitamin D beyond bone health, implicating its role in immune modulation, glucose metabolism, cardiovascular regulation, inflammatory pathways, and placental function.[2] These extra-skeletal actions are particularly relevant during pregnancy, a period characterized by profound physiological and metabolic adaptations to support fetal growth and development.

Vitamin D deficiency has emerged as a global public health concern, affecting both developed and developing countries.[3] Despite abundant sunlight in tropical regions, vitamin D deficiency remains highly prevalent in South Asian populations, including India. Factors such as darker skin pigmentation, limited sun exposure due to indoor lifestyles, cultural clothing practices, widespread use of sunscreens, inadequate dietary intake, and poor calcium consumption contribute significantly to low vitamin D levels in pregnant women. Serum 25-hydroxyvitamin D [25(OH) D] is considered the most reliable biomarker for assessing vitamin D status, with levels ≥30 ng/mL generally regarded as sufficient for optimal maternal and fetal health.[4]

Pregnancy represents a critical window during which maternal vitamin D status has long-term implications for both mother and fetus. Vitamin D readily crosses the placenta, and fetal vitamin D levels are entirely dependent on maternal stores.[9] Consequently, maternal deficiency predisposes the fetus and newborn to vitamin D insufficiency, potentially affecting bone mineralization, immune development, and metabolic programming. Several studies have demonstrated associations between low maternal vitamin D levels and adverse pregnancy outcomes, including preeclampsia, gestational diabetes mellitus, preterm labor, low birth weight, intrauterine growth restriction, and increased neonatal morbidity.[5–7]

The role of vitamin D in placental implantation, angiogenesis, immune tolerance, and regulation of inflammatory responses provides a biological basis for its association with hypertensive disorders of pregnancy, particularly preeclampsia and eclampsia.[8] Observational studies and meta-analyses have suggested that vitamin D supplementation during pregnancy may reduce the risk of preeclampsia, preterm birth, and low birth weight, although findings regarding its effect on gestational diabetes mellitus and mode of delivery remain inconsistent.[11] The lack of uniform guidelines on screening and supplementation during pregnancy further contributes to variability in clinical practice.

In populations with high baseline prevalence of vitamin D deficiency and poor nutritional intake, pregnancy-related demands may further exacerbate deficiency due to increased fetal calcium transfer and altered maternal metabolism. Despite growing interest in this field, there remains limited prospective data from North Indian populations evaluating vitamin D status across pregnancy and correlating supplementation with fetomaternal outcomes.

In this context, the present prospective longitudinal study was undertaken to assess the prevalence of vitamin D deficiency among pregnant women, evaluate changes in vitamin D levels following supplementation, and examine its association with key maternal and neonatal outcomes. The findings aim to provide evidence to support early identification and timely intervention for vitamin D deficiency during pregnancy, thereby improving fetomaternal health outcomes.

Materials and Methods

Study Design and Setting

This prospective longitudinal observational study was conducted in the Department of Obstetrics and Gynaecology.

Study Population and Sample Size

A total of 130 antenatal women were initially assessed for eligibility. Of these, 80 booked antenatal women presenting during the first or second trimester were enrolled in the study group. During follow-up, 28 women were excluded due to spontaneous abortion, loss to follow-up, or poor compliance with supplementation. The remaining 52 women constituted the final study group.

For comparison of fetomaternal outcomes, 50 antenatal women who presented in emergency during labour and had not received antenatal vitamin D supplementation were included as the control group. Thus, a total of 102 participants were analysed, comprising 52 women in the study group and 50 women in the control group.

Inclusion Criteria

Pregnant women presenting during the first or second trimester with singleton pregnancy and willing to participate in the study were included.

Exclusion Criteria

Women with chronic medical disorders such as renal disease, hepatic disease, malabsorption syndromes, or endocrine disorders, those already receiving vitamin D or calcium supplementation, multiple pregnancies, and women with poor compliance or loss to follow-up were excluded from the study.

Intervention

Participants in the study group received oral cholecalciferol supplementation at a dose of 60,000 IU once weekly for a duration of 8 weeks during pregnancy. Compliance with supplementation was assessed during follow-up visits. The control group did not receive routine vitamin D supplementation.

Sample Collection and Laboratory Analysis

Peripheral venous blood samples were collected from all participants at the time of hospitalisation for delivery. Samples were immediately centrifuged, and serum was separated and stored at 2–8°C until analysis.

Serum 25-hydroxyvitamin D [25(OH)D] levels were measured using the Elecsys Vitamin D Total Assay, with a measuring range of 3–70 ng/mL. Based on laboratory reference standards, participants were categorised into two groups: vitamin D deficient (≤30 ng/mL) and vitamin D sufficient (>30 ng/mL).

Data Collection and Outcome Measures

Sociodemographic variables including age, residence, socioeconomic status, and occupation were recorded. Obstetric parameters assessed included gravidity, gestational diabetes mellitus, preeclampsia/eclampsia, premature rupture of membranes, mode of delivery, and preterm birth.

Neonatal outcomes evaluated were intrauterine growth restriction, intrauterine death, low birth weight, APGAR score at 5 minutes, and requirement for neonatal intensive care unit admission.

Statistical Analysis

Data were entered into Microsoft Excel and analysed using Statistical Package for Social Sciences software version 15.0. Continuous variables were expressed as mean ± standard deviation, while categorical variables were presented as frequencies and percentages.

Comparisons between categorical variables were performed using the Chi-square test, and comparison of means was carried out using the Student's t-test. Bivariate analysis was used to assess the association between vitamin D status and fetomaternal outcomes. A p-value of less than 0.05 was considered statistically significant.

Results

Study Population

A total of 102 antenatal women were included in the final analysis, comprising 52 women in the study group who received vitamin D supplementation and 50 women in the control group who did not receive supplementation. The majority of participants in both groups belonged to the reproductive age group of 20–30 years. Most women were multigravida and belonged to lower or lower-middle socioeconomic strata. The baseline sociodemographic characteristics and vitamin D status of the study population are summarized in Table 1.

Prevalence of Vitamin D Deficiency

The overall prevalence of vitamin D deficiency in the study population was found to be 90.7%, while only 9.23% of women had sufficient vitamin D levels. In the study group, 91% of women were vitamin D deficient, whereas in the control group, 90% of women were vitamin D deficient. Vitamin D deficiency was observed more frequently among women residing in urban areas compared to rural areas, and this difference was statistically significant ($p < 0.05$).

A higher proportion of vitamin D–deficient women belonged to lower and lower-middle socioeconomic strata, indicating a strong association between low socioeconomic status and vitamin D deficiency. With regard to occupational status, vitamin D deficiency was common among both outdoor workers (89.6%) and housewives (92.5%); however, this difference was not statistically significant ($p = 0.08$). The detailed distribution of sociodemographic variables according to vitamin D status is shown in Table 1.

Obstetric Outcomes

Comparison of obstetric outcomes between the study and control groups is presented in Table 2. The incidence of gestational diabetes mellitus was lower in the study group (3.8%) compared to the control group (12%). Although a higher proportion of GDM cases was observed in the control group, the difference was not statistically significant ($p = 0.12$).

Preeclampsia and eclampsia were significantly less frequent in women who received vitamin D supplementation. The incidence of preeclampsia/eclampsia was 6.1% in the study group compared to 24% in the control group, and this difference was statistically significant ($p = 0.01$). This finding suggests a strong association between vitamin D deficiency and hypertensive disorders of pregnancy.

Premature rupture of membranes occurred in 3.8% of women in the study group and 14% of women in the control group. Although PROM was more common in the control group, the difference did not reach statistical significance ($p = 0.07$).

The rate of caesarean section was comparable between the two groups, with 36% of women in the study group and 46% in the control group undergoing LSCS. No statistically significant association was observed between vitamin D supplementation and mode of delivery ($p = 0.4$).

Preterm delivery was significantly less frequent in the study group. Only 3.8% of women in the study group delivered preterm compared to 16% in the control group, and this difference was statistically significant (p = 0.03). These findings are detailed in Table 2.

Neonatal Outcomes

Neonatal outcomes of both groups are summarized in Table 3. The incidence of low birth weight was significantly lower among neonates born to mothers who received vitamin D supplementation. Low birth weight was observed in 23.07% of neonates in the study group compared to 42% in the control group, and this difference was statistically significant (p = 0.04).

Intrauterine growth restriction was observed in 5.7% of neonates in the study group and 10% in the control group. Although IUGR was more common in the control group, the difference was not statistically significant (p = 0.4).

Intrauterine death occurred in 1.92% of cases in the study group and 6% in the control group, with no statistically significant difference between the groups (p = 0.29).

APGAR scores less than 7 at 5 minutes were observed in 8% of neonates in the study group compared to 20% in the control group. Despite a higher proportion of low APGAR scores in the control group, the difference did not achieve statistical significance (p = 0.08).

NICU admission was required in 5.7% of neonates in the study group and 14% of neonates in the control group. Although NICU admissions were more frequent in the control group, the difference was not statistically significant (p = 0.08). The complete comparison of neonatal outcomes is presented in Table 3.

Table 1.Sociodemographic Characteristics and Vitamin D Status of the Study Population

n = 102

Variable	Vitamin D Deficient n (%)	Vitamin D Sufficient n (%)	p-value
Habitat			
Rural	85 (83.3%)	17 (16.6%)	<0.05
Urban	98 (96.3%)	4 (3.7%)	
Socioeconomic status			
Lower / Lower-middle	92 (90.6%)	10 (9.4%)	
Upper	9 (9.2%)	93 (90.8%)	
Working status			
Outdoor workers	91 (89.6%)	11 (10.4%)	0.08
Housewives	94 (92.5%)	8 (7.5%)	
Overall prevalence	92 (90.7%)	10 (9.23%)	—

Table 2.Comparison of Obstetric Outcomes Between Study and Control Groups

Obstetric Outcome	Study Group (n = 52) n (%)	Control Group (n = 50) n (%)	p-value
Gestational diabetes mellitus	2 (3.8)	6 (12.0)	0.12
Preeclampsia / Eclampsia	3 (6.1)	12 (24.0)	0.01
Premature rupture of membranes	2 (3.8)	7 (14.0)	0.07
Caesarean section	19 (36.0)	23 (46.0)	0.40
Preterm delivery	2 (3.8)	8 (16.0)	0.03

Table 3.Comparison of Neonatal Outcomes Between Study and Control Groups

Neonatal Outcome	Study Group (n = 52) n (%)	Control Group (n = 50) n (%)	p-value
Intrauterine growth restriction	3 (5.7)	5 (10.0)	0.40
Intrauterine death	1 (1.92)	3 (6.0)	0.29
Low birth weight	12 (23.07)	21 (42.0)	0.04
APGAR score <7 at 5 minutes	4 (8.0)	10 (20.0)	0.08
NICU admission	3 (5.7)	7 (14.0)	0.08

Discussion

The present study revealed a very high prevalence of vitamin D deficiency among pregnant women (90.7%), with only 9.23% having sufficient vitamin D levels, as shown in Table 1. This prevalence is comparable to earlier Indian studies reporting deficiency rates ranging from 42% to 93%. Sachan et al. (2005)[10] reported vitamin D deficiency in 84% of pregnant women and 92% of their newborns in North India, despite adequate sunlight exposure. Similarly, Sahu et al. (2009)[11] observed vitamin D deficiency in 74.1% of pregnant women from rural North India, while Johnson et al. (2011)[12] reported vitamin D deficiency or insufficiency in nearly 90% of pregnant women.

In the present study, vitamin D deficiency was predominantly observed among women belonging to lower and lower-middle socioeconomic strata. This finding is consistent with observations by Sahu et al. (2009),[11] who demonstrated significantly lower mean serum 25-hydroxyvitamin D levels among women from lower socioeconomic backgrounds compared to those from higher-income groups. Laitinen et al. (1995)[13] also reported that poor dietary intake associated with low socioeconomic status significantly contributed to micronutrient deficiencies, including vitamin D.

Occupational status did not show a statistically significant association with vitamin D deficiency in the present study, with deficiency rates of 89.6% among outdoor workers and 92.5% among housewives. Similar findings were reported by Sahu et al. (2009),[11] who found no significant difference in vitamin D levels between women with varying degrees of sun exposure, emphasizing that sunlight exposure alone may be insufficient to prevent vitamin D deficiency in this population.

As shown in Table 2, the incidence of preeclampsia and eclampsia was significantly lower in the vitamin D–supplemented group (6.1%) compared to the control group (24%). This finding is supported by previous studies demonstrating a strong association between vitamin D deficiency and hypertensive disorders of pregnancy. Marya et al. (1987)[14] reported a significant reduction in the incidence of toxemia of pregnancy among women receiving calcium and vitamin D supplementation. Pérez-López et al. (2020)[8] also concluded that vitamin D supplementation during pregnancy was associated with a reduced risk of preeclampsia, particularly in women with baseline vitamin D deficiency.

Preterm delivery was significantly less frequent in the study group (3.8%) compared to the control group (16%). Other observational studies have also reported nearly a two-fold increased risk of preterm birth among vitamin D–deficient pregnant women, supporting the protective role of adequate vitamin D levels.

The incidence of gestational diabetes mellitus was higher in the control group (12%) compared to the study group (3.8%); however, this difference was not statistically significant. Veena et al. (2011)[6] reported an association between low maternal vitamin D levels and impaired glucose tolerance, suggesting a potential link between vitamin D status and glucose metabolism. However, as observed in the present study, several studies have failed to demonstrate a consistent reduction in gestational diabetes mellitus with vitamin D supplementation, indicating that this relationship remains inconclusive.

No significant difference was observed in the rate of caesarean section between the two groups (36% in the study group versus 46% in the control group). Similar findings were reported by Johnson et al. (2011),[12] who found no significant association between maternal vitamin D levels and mode of delivery.

Neonatal outcomes presented in Table 3 demonstrated a significantly lower incidence of low birth weight in the study group (23.07%) compared to the control group (42%). This finding aligns with earlier studies demonstrating an association between maternal vitamin D deficiency and low birth weight. Sachan et al. (2005).[10] reported that neonates born to vitamin D–deficient mothers had significantly lower mean birth weights compared to those born to vitamin D–sufficient mothers. Similarly, Malabanan et al. (1998)[15] observed a higher incidence of low birth weight among infants born to mothers with vitamin D deficiency.

The incidence of intrauterine growth restriction was lower in the supplemented group (5.7%) compared to the control group (10%), although the difference was not statistically significant. Previous studies have shown mixed results regarding the association between vitamin D deficiency and intrauterine growth restriction, with some demonstrating a positive association and others reporting no significant relationship.

Intrauterine death was less frequent in the study group (1.92%) compared to the control group (6%), though the difference was not statistically significant. APGAR scores less than 7 at 5 minutes and NICU admissions were also lower in the study group, but these differences did not reach statistical significance. Similar observations were reported by Sachan et al. (2005),[10] who found no significant association between maternal vitamin D status and APGAR scores or NICU admissions.

The dependence of fetal vitamin D levels entirely on maternal vitamin D stores further supports the biological plausibility of these findings. Ashley et al. (2022) demonstrated that placental uptake and metabolism of vitamin D play a critical role in determining fetal vitamin D availability, emphasizing the importance of adequate maternal vitamin D levels during pregnancy.

Conclusion

Vitamin D deficiency was highly prevalent among pregnant women and was significantly associated with adverse outcomes such as preeclampsia, preterm delivery, and low birth weight. Timely screening and supplementation with vitamin D during pregnancy resulted in improved maternal vitamin D status and better fetomaternal outcomes. Routine antenatal assessment and appropriate supplementation of vitamin D may therefore play an important role in improving pregnancy outcomes.

Limitations

The study was limited by a relatively small sample size and loss to follow-up, which may affect the generalizability of the findings. Vitamin D levels were not assessed at multiple time points throughout pregnancy. The effect of vitamin D supplementation initiated in the first trimester was not evaluated.

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