Vitamin D and Incidence of Postpartum Depression - Investigating the Link Between Nutritional Deficiencies and Maternal Mental Health

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ABSTRACT

Postpartum depression (PPD), which is a public health issue, affects the quality of life of both the mother and the child. Vitamin D, which is a neuroactive steroid hormone, plays a role in the regulation of mood and the pathophysiology of depressive states.

Objectives

This study aimed to evaluate the relationship between Vitamin D levels and postpartum depression among women in the early stages of the postpartum period.

Methodology

This is a hospital-based cross-sectional study involving 143 women in the early stages of the postpartum period. The participants were selected from the population attending the primary care hospital in Ghaziabad, Uttar Pradesh. PPD diagnosis was done using the Edinburgh Postnatal Depression Scale. Vitamin D levels were assessed, and the participants were categorized into Vitamin D-deficient, Vitamin D-insufficient, and Vitamin D-sufficient groups. Data analysis was done using the SPSS statistical package. Pearson's correlation coefficient was used to determine the relationship between Vitamin D levels and PPD. $P < 0.05$ was considered significant.

Results

This study established that the mean Vitamin D level among the participants was 23.21 ± 13.46 ng/ml. This indicates Vitamin D insufficiency among the participants. Using the EPDS scale, it was established that 39.9% of the participants had PPD. Vitamin D level and EPDS category had a significant relationship ($p = 0.02$). Vitamin D level among women with moderate depression is lower compared to those with non-depression. Vitamin D level among women with mild depression is unexpectedly high.

Conclusion

Vitamin D insufficiency is widespread among women in the early stages of the postpartum period. Vitamin D insufficiency is related to PPD.

Keywords: Postpartum depression, Vitamin D deficiency, maternal mental health, Edinburgh Postnatal Depression Scale (EPDS), postnatal women, Nutritional deficiency.

How to cite this article: Yazdani S, Butola LK, Sangwan A. Vitamin D and Incidence of Postpartum Depression - Investigating the Link Between Nutritional Deficiencies and Maternal Mental Health. Int J Drug Deliv Technol. 2026;16(23s): 890-899. DOI: 10.25258/ijddt.16.23s.95

Source of support: Nil.

Conflict of interest: None

Introduction:

Postpartum depression has been categorized as a major depressive episode with a peripartum onset, typically within a range of one to four weeks after childbirth [1]. PPD is different from postpartum blues, which affects 70% of women and subsides on its own within two weeks [2]. PPD has a significant impact on maternal functioning and has been linked to poor cognitive, emotional, and behavioural outcomes in children [3]. PPD affects 10-15% of women worldwide, though in developing countries, such as those in Asia, PPD prevalence is as high as 25% because of socioeconomic factors and lack of access to care [2, 4]. PPD prevalence in India varies between 11% and 22% [2],

depending on geographical location and methods of assessment.

A systematic review conducted by Upadhyay et al. indicated that 22% of Indian mothers experience PPD, thus calling for intervention strategies to address the problem [2]. Postpartum psychiatric disorders include postpartum blues, postpartum depression, and postpartum psychosis, affecting 30-75%, 10-20%, and less than 1% of women, respectively [5].

Etiology and Risk Factors

The Etiology of PPD is a combination of biological, psychological, and environmental factors.

Biological Factors- It includes rapid decrease in estrogen and progesterone levels after childbirth, dysregulation of serotonin, dopamine, and norepinephrine levels, thyroid disorders and anemia and genetic vulnerability to mood disorders [1, 6]

Psychological Factors- It includes history of depression or anxiety disorders, low self-esteem and poor coping skills and unwanted pregnancy or a difficult birth experience [6]

Social and Environmental Factors- It includes unavailability of social support systems and partners, domestic violence or marital discord, economic instability and cultural factors, such as a desire for a male child, particularly in South Asia [2]

Sleep deprivation, especially if the woman had a complicated delivery or had to take care of twins, is also said to increase the risk for PPD [6].

Pathophysiology

The pathophysiology of PPD involves the following biological systems:

1. **Neuroendocrine Systems-** The abrupt decline in sex hormones causes changes in neurotransmitters, leading to mood swings [1].
2. **Hypothalamic-Pituitary-Adrenal (HPA) System-** Dysregulation of the HPA system causes abnormal cortisol levels, leading to depression [6].
3. **Inflammatory Hypothesis-** The increase in pro-inflammatory cytokines such as IL-6 and TNF-alpha has been related to PPD [1].
4. **Neuroplasticity and GABAergic Systems-** Impairment of GABAergic function and neuroplasticity have been related to PPD. New medications such as brexanolone have been developed to treat the condition [7].

Clinical Features

The clinical features of PPD are similar to those of major depressive disorder. They are:

- Persistent feelings of sadness or tearfulness
- Lack of interest in activities (anhedonia)
- Fatigue or sleep problems
- Change in appetite
- Anxiety, irritability, or panic attacks
- Difficulty bonding with the new-born
- Feelings of guilt, worthlessness, or helplessness
- Suicidal thoughts or thoughts of harming the new-born [4]

The symptoms last for more than two weeks. The condition interferes with daily activities. The diagnosis of PPD is made by applying the DSM-5 criteria for major depressive disorder. The EPDS and PHQ-9 are the most commonly used screening tools for PPD. EPDS has been found to be effective in diagnosing PPD. The cut-off for probable depression is a score of 13 or more [3]. Furthermore there are some of the impact of postpartum depression like the impact of PPD on mothers is chronic depression, weakened maternal function, risk of suicide, which is a major cause of death among mothers [6] The impact of PPD on the child is poor cognitive development, poor language development, poor behavioural development, risk of future psychiatric illness [3] The impact of PPD on the family is poor marital relations and poor family function

Management

Non-Pharmacological Treatment

- Cognitive Behavioural Therapy (CBT)
- Interpersonal Therapy (IPT)
- Peer support and counselling

These treatments are considered first-line treatments for mild to moderate PPD [4].

Pharmacological Treatment

- SSRIs, such as sertraline and fluoxetine
- Brexanolone, an intravenous allopregnanolone analog, for severe PPD
- Zuranolone, an oral neuroactive steroid, recently approved [7]

The SSRIs appear to be safe for breastfeeding, with careful monitoring.

Preventive Strategies

- Antenatal risk assessment
- Psychoeducation
- Strengthening family and social support
- Nutrition and sleep strategies

Vitamin D

Vitamin D, which is traditionally believed to play a role in the maintenance of calcium homeostasis and bone health, is increasingly being studied to play a role in the functioning of the brain and mental well-being. Vitamin D receptors are expressed in the mood-

regulating centers of the brain, including the hippocampus and prefrontal cortex. This has generated much interest in the possible relationship between vitamin D deficiency and the etiology of depressive disorders, including PPD.[5,8]

Vitamin D is derived either from 7-dehydrocholesterol or from ergosterol by the action of ultraviolet radiations. The 7- dehydrocholesterol, an intermediate of a minor pathway of cholesterol synthesis, is available in the malpighian layer of epidermis. In the skin, ultraviolet light (290-315nm) breaks the bond between position 9 and 10 of the steroid ring. So the ring B is opened, to form the provitamin, secosterol. The cis double bond between 5^{th} and 6^{th} carbon atom, is then isomerized to a trans double bond to give rise to vitamin D3 or cholecalciferol. So the vitamin D is called the sun shine vitamin.

It gets hydroxylated in the liver to give 25-hydroxyvitamin D [25(OH)D], the predominant circulating metabolite and vitamin D status marker. Vitamin D deficiency is traditionally characterized by serum concentrations of 25(OH)D less than 20 ng/mL, and is common worldwide, particularly in those with obesity and metabolic syndrome. [9,10].

Vitamin D plays several roles in neurobiological processes:

- Regulation of neurotransmitters such as serotonin and dopamine
- Neuroprotection via antioxidant mechanisms
- Modulation of neurotrophic factors
- Regulation of calcium signaling in the nervous system [8]

Pathophysiological Link between Vitamin D and PPD

Serotonin Regulation- Vitamin D plays a role in regulating tryptophan hydroxylase, an important enzyme in the production of serotonin. Lower vitamin D levels might lead to decreased serotonin, resulting in depression. [11]

Inflammatory Pathways- PPD has been linked to elevated levels of pro-inflammatory cytokines. Vitamin D has anti-inflammatory effects, which include the suppression of cytokines like IL-6 and TNF-α.[12]

HPA Axis Modulation- Vitamin D can affect the hypothalamic-pituitary-adrenal axis, which is often impaired in patients with depression. [13]

Neuroplasticity- Vitamin D plays a role in promoting neurogenesis and synaptic plasticity, which are important in mood regulation.[8]

Several observational studies have established an inverse relationship between vitamin D and PPD. A cohort study established that women with low vitamin D levels during pregnancy had significantly higher EPDS postpartum. [14] Vitamin D deficiency can increase the risk of PPD by up to two-fold, according to another study.[15] Recent meta-analytic studies indicate a small but significant association between vitamin D deficiency and risk of depression, including PPD.[16] Some studies have demonstrated the efficacy of vitamin D in relieving depression, while others have not found vitamin D to have a significant impact in relieving depression, which might be attributed to differences in dosage and vitamin D levels. [17] One overlooked risk factor for PPD may be low vitamin D levels. Maternal vitamin D inadequacy (vitamin D levels <25–50 nmol/L) during pregnancy and at delivery has been shown to be highly prevalent (5–20% in light-skinned populations and 30–70% in dark-skinned or veiled populations) in a variety of populations living at different latitudes, most likely because of the demands of the developing fetus. An association between vitamin D deficiency and PPD could have a significant impact on public health given the known high prevalence of low vitamin D levels among pregnant women and the frequent occurrence of PPD.[18]

Material and method:

This study was designed as a hospital-based cross-sectional analytical study conducted in the department of Obstetrics and gynaecology at 11 Air Force Hospital, Hindan, Ghaziabad, Uttar Pradesh. Participants for the study was chosen from both IPD and OPD, based on inclusion and exclusion criteria. Postpartum depression (PPD) was assessed using the Edinburgh Postnatal Depression Scale (EPDS), a validated 10-item self-administered questionnaire scored from 0–3 (total score: 0–30). It evaluates maternal emotional status over the previous seven days, including symptoms such as sadness, anxiety, anhedonia, and sleep disturbance. Participants completed the EPDS under standardized postpartum conditions. The Edinburgh Postnatal Depression Scale (EPDS) scores were categorized as follows: a score of 0–6 indicated none or minimal depression, 7–13 indicated mild depression, 14–19 indicated moderate depression, and 19–30 indicated severe depression. [19]

The EPDS is widely used due to its high sensitivity and specificity; however, it remains a screening tool, not diagnostic and further we have investigated Vitamin D levels. Informed consent was obtained after explaining the study procedures and outcomes and privacy of data

was maintained throughout the study duration. We have included all the pregnant women's attending OPD and IPD of hospital and total 143 participants have participated in the study.

Sample size

n- Z^2 X p X q/d ^{2}

Where:

- n = required sample size
- Z = standard normal deviate at 95% confidence level (1.96)
- p = estimated prevalence of postpartum depression (assumed from previous studies, e.g., 15%)
- $q = 1 - p$
- d = allowable error (e.g., 5%)

Based on this formula, the calculated sample size was approximately 196. However, due to feasibility and study duration constraints, a total of 143 participants were included in the present study.

The numbers of studies that have addressed the relationship between vitamin D and postpartum depression is very less, in the present study we will see the role of Vitamin D in postpartum depression as it is considered as essential nutrients because acting in concert, it perform hundreds of role in body. Thus evaluating levels in serum would provide early diagnosis of the deficiency status, while recovery takes work, support, awareness, and proper medical assistance being able to openly discuss PPD can decrease stigma, get more women to acknowledge when they need help, and finally promote healthy mothers and healthy children and at last but not the least pharmacological and psychosocial interventions, coupled with early identification, are both necessary and crucial in proper management.

This research was crucial for the following reasons:

- To fill the existing gap in literature by providing evidence on the role of Vitamin D deficiencies in PPD.
- To enable early identification and screening for women at risk of PPD through simple blood tests.
- To promote cost-effective, non-pharmacological interventions through nutritional supplementation as part of maternal healthcare.
- To improve maternal mental health outcomes, which are intrinsically linked to infant health, development, and family well-being.

Inclusion criteria

- Women aged 18–45 years.
- Women in the postnatal period (up to 12 weeks postpartum).
- Willingness to participate and provide informed consent.

Exclusion Criteria

- Women with known psychiatric disorders or on antidepressant therapy prior to pregnancy.
- Women with chronic illnesses affecting vitamin metabolism (e.g., renal disease, liver disease).

Statistical analysis:

All estimated results were expressed as mean ±SD. Mean values will be assessed for significance by unpaired student –t test. A statistical analysis will be performed using the Statistical Package for the Social Science program (SPSS, 24.0). Frequencies and percentages will be used for the categorical measures. Correlation between them was done by Karl Pearson's correlation coefficient method and Probability values $p < 0.05$ will be considered statistically significant.

Result:

Table 1: Characteristics of study population (n=143)

Variables		No. of subjects
Age	18-25 years	52
	26-35 years	84
	36-45 years	7
BMI	18.5-22.5 Kg/m^2	40
	23-24.9 Kg/m^2	81
	>25 Kg/m^2	22
Gravidity	1	56
	2	75
	More than 2	12
Dietary habits	Vegetarian	60 %
	Non-Vegetarian	40%
Vitamin D supplements taken during pregnancy	Yes	15%
	No	85%
Vitamin D supplements taken after pregnancy	Yes	10%
	No	90%
History of depression	Yes	0%
	No	100%
Family history of depression	Yes	0%
	No	100%

Mode of delivery	Vaginal	86
	C- section	57
Currently Breastfeeding	Yes	131
	No	12
Infant gender	Male	73
	Female	70

Figure 1: Age wise distribution of study population.

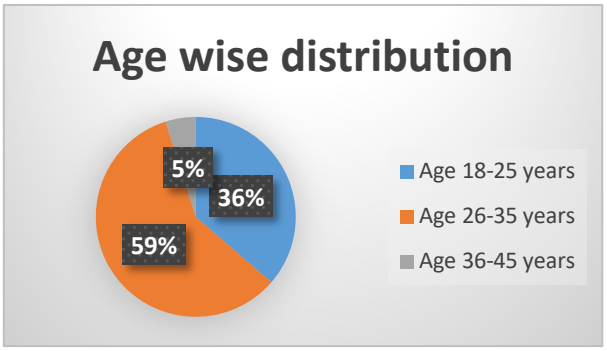


Figure 2: BMI wise distribution of study population.

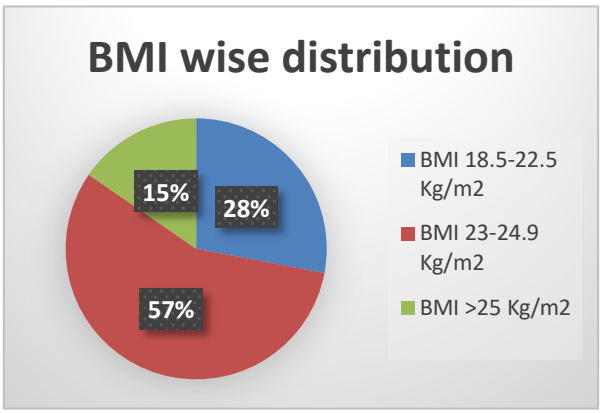


Figure 3: Gravidity wise distribution of study population.

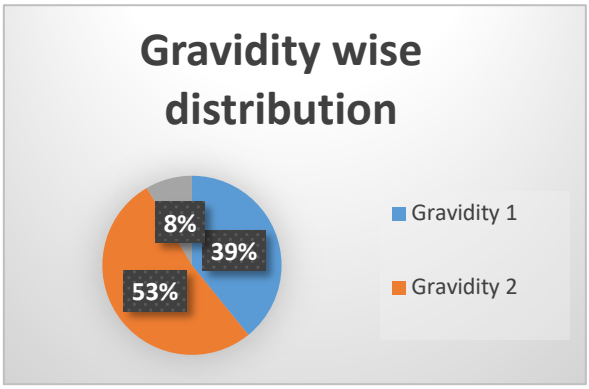


Figure 4: Dietary habits wise distribution of study population.

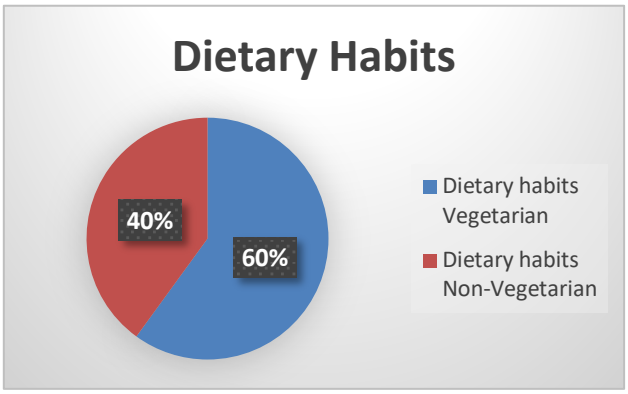


Figure 5: Vitamin D supplements taken during and after pregnancy wise distribution of study population.

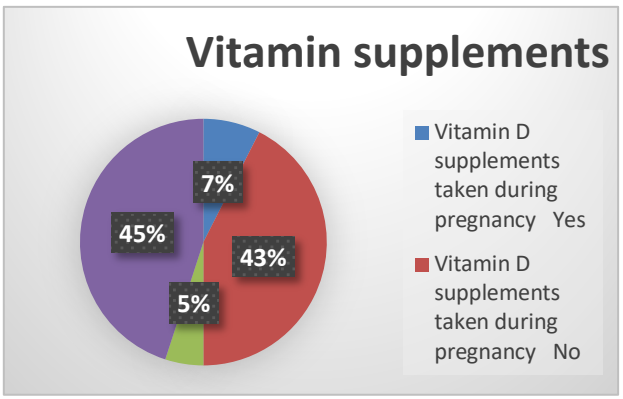


Figure 6: Mode of delivery wise distribution of study population.

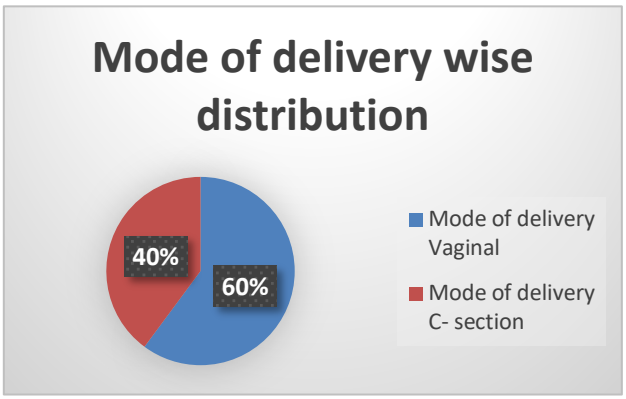


Figure 7: Breastfeeding wise distribution of study population.

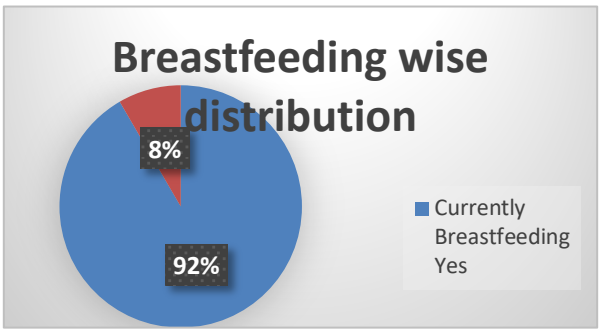


Figure 8: Infant gender wise distribution of study population.

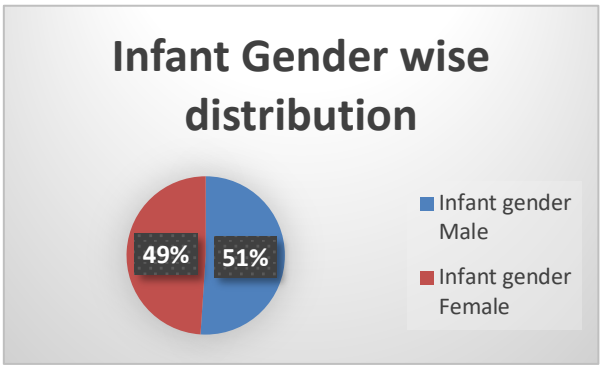
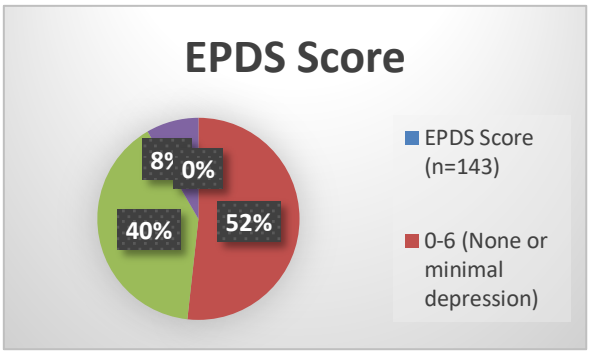


Table 2- EPDS score of study population.

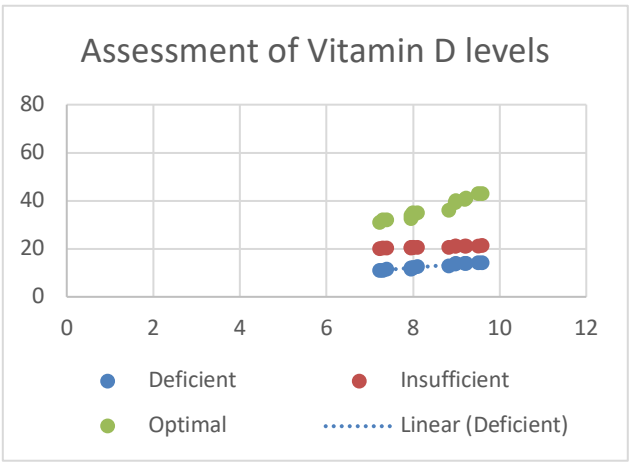
EPDS Score (n=143)	
0-6 (None or minimal depression)	74
7-13 (Mild depression)	57
14-19 (Moderate depression)	12
19-30 (Severe depression)	0

Figure 9: EPDS Score wise distribution of study population.



The Edinburgh Postnatal Depression Scale (EPDS) scores were categorized as follows: a score of 0–6 indicated none or minimal depression, 7–13 indicated mild depression, 14–19 indicated moderate depression, and 19–30 indicated severe depression. The EPDS is widely used due to its high sensitivity and specificity; however, it remains a screening tool, not diagnostic and further we have investigated Vitamin D levels.

Graph 1: Assessment of Vitamin D levels.



Above graph have assessed the vitamin D deficiency criteria as the optimal blood concentration of >30ng/ml; 20-29ng/ml is considered as insufficient and 10-19ng/ml is vitamin D deficiency. A level below 10ng/ml indicates severe deficiency. Concentrations more than 150ng/ml is toxic. This distribution suggests a high prevalence of suboptimal Vitamin D status (deficiency and insufficiency) in the study population, highlighting the need for routine screening and supplementation, especially during the postpartum period. The study participants' mean serum vitamin D level was 23.21 ± 13.46 ng/ml, suggesting that the population's vitamin D status varied widely. The mean value is in the insufficient range (20–29 ng/ml), indicating that the study population's Vitamin D levels were generally below ideal. Significant variation in vitamin D concentrations is reflected in the relatively high standard deviation (±13.46), with some participants showing severe deficiencies and others having adequate or optimal levels. The variation in postpartum women's nutritional status is highlighted by this broad distribution. These results point to a high rate of vitamin D deficiency and insufficiency in the study population, which may have significant effects on maternal health, especially with regard to postpartum depression and general wellbeing.

Table 3- Vitamin D levels according to EPDS Score.

EPDS Score (n=143)	Mean Vitamin D levels
0-6 (None or minimal depression) (74)	19.93 ±7.86
7-13 (Mild depression) (57)	28.8± 17.46
14-19 (Moderate depression) (12)	16.89 ±8.61
19-30 (Severe depression)	0

The mean Vitamin D levels varied significantly across different EPDS score categories. Women with mild depression had higher mean Vitamin D levels (28.8 ± 17.46 ng/ml) compared to those with minimal (19.93 ± 7.86 ng/ml) and moderate depression (16.89 ± 8.61 ng/ml). This difference was found to be statistically significant (p = 0.02), suggesting an association between Vitamin D levels and severity of depressive symptoms."

Table 4: Comparison of Mean Vitamin D Levels between Non-Depressed and Mildly Depressed Postpartum Women.

Variables	Mean±SD (None PPD Group)	Mean±SD (Mild depressive group)	t-value	p-value
Vitamin D Levels	19.93±7.86	28.80±17.4	3.8913	0.002

The mean Vitamin D levels were compared between women with no postpartum depression (EPDS 0–6) and those with mild depression (EPDS 7–13) using an unpaired Student's t-test. The mean Vitamin D level in the non-depressed group was 19.93 ± 7.86 ng/ml**,** whereas in the mild depression group it was 28.80 ± 17.46 ng/ml**.**

This difference was found to be extremely statistically significant (p = 0.0002)**.** The mean difference between the two groups was −8.87 ng/ml (95% CI: −13.38 to −4.36), indicating significantly higher Vitamin D levels in the mild depression group."

Table 5: Comparison of Mean Vitamin D Levels between Non-Depressed and Moderate Depressed Postpartum Women.

Variables	Mean±SD (None PPD Group)	Mean±SD (Moderate depressive group)	t-value	p-value
Vitamin D Levels	19.93±7.86	16.89±8.61	1.2269	0.2233

The mean Vitamin D levels were compared between women with no postpartum depression (EPDS 0–6) and those with moderate depression (EPDS 14–19) using an unpaired Student's t-test. The mean Vitamin D level in the non-depressed group was 19.93 ± 7.86 ng/ml, whereas in the moderate depression group it was 16.89 ± 8.61 ng/ml.

The difference between the two groups was not statistically significant (p = 0.2233). The mean difference was 3.04 ng/ml (95% CI: −1.89 to 7.97), indicating no significant association between Vitamin D levels and moderate depression in this comparison."

Discussion:

The present study aimed to assess the relationship between postpartum depression and Vitamin D levels among 143 postpartum women and showed a significant relationship between Vitamin D and postpartum depression. The average level of Vitamin D among postpartum women was found to be 23.21 ± 13.46 ng/ml, showing overall insufficiency among postpartum women. A significant difference in Vitamin D levels among EPDS categories (p = 0.02) indicates the possible role of Vitamin D in postpartum depression among women. The study also showed that postpartum women experiencing moderate depression have lower levels of Vitamin D compared to those who are not depressed. The finding supports the hypothesis that Vitamin D deficiency may play a role in the development of depression. Vitamin D is a neuroactive steroid hormone and plays a major role in the synthesis of serotonin and in neuroplasticity and anti-inflammatory responses [11-13].

The study also showed that postpartum women experiencing mild depression have significantly high levels of Vitamin D compared to those who are not depressed (p = 0.0002). The finding indicates that the relationship between Vitamin D and postpartum depression may not be direct. Such a finding is also supported by previous studies showing an inconsistent relationship between Vitamin D and postpartum depression due to confounding variables such as dietary intake of Vitamin D, exposure to sunlight, and socioeconomic status [16, 17].

The lack of statistical significance in both groups of non-depressed and moderately depressed women (p = 0.2233) may be due to a small number of subjects in the second group, which comprised 12 women. Recent studies have further validated the relationship between Vitamin D deficiency and postpartum depression. A recent meta-analysis conducted in 2024 found that there was a significant relationship between lower levels of Vitamin D and increased risk of perinatal depression [20]. Recent studies have highlighted the importance of Vitamin D deficiency as a biological factor in postpartum depression. Emerging evidence from 2025 studies indicates that Vitamin D may play a

protective role in depression through its action on neurotransmitters and neuroinflammation [22]. However, other studies have found no relationship between Vitamin D deficiency and postpartum depression. Recently, a Mendelian randomization analysis found no strong genetic evidence for a relationship between Vitamin D deficiency and postpartum depression, indicating that other confounding factors may play a role in this relationship.

The findings of this study are in line with previous studies on this topic. Robinson et al. found in their study that there was a significant relationship between low levels of Vitamin D in pregnant women and high levels of EPDS in postpartum women [14]. Fu et al. found in their study that there was a significant relationship between Vitamin D deficiency and increased risk of postpartum depression [15]. Anglin et al. conducted a meta-analysis on this topic and found a small but significant relationship between Vitamin D deficiency and depression [16].

From an Indian perspective, the results are particularly relevant as the prevalence rates of Vitamin D deficiency as well as postpartum depression are high. In fact, as revealed by the systematic review by Upadhyay et al., the prevalence rate of postpartum depression among Indian mothers is as high as 22%. This highlights the need for early intervention and preventive measures [2].

Biologically, Vitamin D is known to play an important role in the regulation of various pathways involved in the manifestation of depression. Specifically, Vitamin D is known to regulate tryptophan hydroxylase, which is involved in the synthesis of serotonin. Vitamin D also regulates the hypothalamic-pituitary-adrenal axis as well as the anti-inflammatory response by reducing cytokines such as IL-6 and TNF-alpha. The non-linear association between Vitamin D and postpartum depression suggests that Vitamin D is not the primary causative factor but rather acts as an associated factor. This is also supported by the fact that various psychosocial as well as environmental factors play an important role.

From the clinical perspective, the results highlight the need for routine screening for Vitamin D deficiency during pregnancy as well as the postpartum period. In fact, Vitamin D supplementation is known to play an important role as a preventive strategy against postpartum depression. In fact, the role of Vitamin D supplementation is not clear from the available evidence [17, 24, 25].

Limitations of study:

The cross-sectional design is one limitation, while the small sample size is another limitation. In addition, the role of confounding variables such as sunlight exposure as well as dietary intake was not assessed. Future research is required to be conducted with the aim of establishing causality as well as the effectiveness of Vitamin D supplementation as an effective preventive strategy against postpartum depression.

Conclusion:

The current research has shown a significant association between Vitamin D and postpartum depression in early postnatal women. The average Vitamin D level observed in this study falls in the insufficient category, thus highlighting a high prevalence of Vitamin D deficiency in the population studied. Vitamin D levels in women experiencing moderate depressive symptoms were comparatively lower than those in the control group, thus confirming the hypothesis that Vitamin D deficiency may lead to the occurrence of postpartum depression. The results of this study showed a high level of Vitamin D in women experiencing mild depressive symptoms compared to those in the control group. This may indicate a non-linear association between Vitamin D and postpartum depression. This may highlight the role of various determinants in addition to biological determinants in the mental health of mothers. Vitamin D deficiency is a major public health problem in today's world, and in the Indian population in particular. Postpartum depression is another significant problem in today's world. Considering the high prevalence of Vitamin D deficiency and postpartum depression in the Indian population, screening during pregnancy and in the early postnatal period may prove useful in reducing the burden of these diseases. It is expected that Vitamin D supplementation may prove useful in reducing the burden of these diseases in today's world.

Recommendation

- In fact, we can say there are non-linear relations – as mild depression ladies had higher vitamin D levels, so it is necessary to conduct properly designed randomized controlled trials in order to investigate how effective vitamin D can be to prevent or treat PPD.
- Longitudinal cohort control studies should be conducted among pregnant women in order to identify the development of deficiency throughout time and the impact on the PPD manifestation.

- Indeed, the lack of vitamin D in early pregnancy (29.9 nM or less) may cause postpartum anxiety and depression. But as far as PPD prevention is concerned, then the dose of 2000 IU will be sufficient.

Acknowledgments

All authors would like to express our deepest gratitude to all respected patients and all technical staff for their valuable contribution in our research.

Ethical standard:

1) This article is an original piece of work by the authors, and no other publications contain similar articles.

2) The current paper is not under consideration by any other journal at this moment.

3) The article includes the authors' own research and analysis and accurately represents the research findings.

Financial Disclosure: None

Conflict of interest: None

Ethical approval: Approved

Informed Consent: Informed consent was obtained from all study participants.

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