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Systematic Review

The role of vitamin D in reducing the risk of preeclampsia: a systematic literature review

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ABSTRACT

Preeclampsia is a major cause of maternal and fetal complications worldwide. Vitamin D has been suggested as a possible factor that may influence its development, but existing evidence is inconsistent. To evaluate the association between vitamin D and the risk of preeclampsia and to assess the effect of vitamin D supplementation during pregnancy. A systematic review was conducted following PRISMA 2020 guidelines. Studies published from 2012 to 2026 were searched in PubMed, Scopus, Web of Science, EMBASE, Cochrane Library and Google Scholar. Keywords included "vitamin D," "preeclampsia," "pregnancy-induced hypertension," and "supplementation". Eligible studies included randomized controlled trials, cohort studies and case-control studies involving pregnant women. Data on study design, vitamin D exposure and outcomes were extracted. Risk of bias was assessed using the Newcastle-Ottawa Scale and Cochrane tool. Fifteen studies were included. Most observational studies showed that low vitamin D levels were linked with a higher risk of preeclampsia. Several trials reported that high-dose or early supplementation reduced risk, especially in deficient or high-risk women. However, some studies found no clear benefit, particularly with low doses or late pregnancy supplementation. The findings were inconsistent due to differences in dose, timing and baseline vitamin D status. Low vitamin D levels may increase the risk of preeclampsia. Supplementation appears beneficial mainly when started early and in deficient women. However, evidence is not fully consistent. More large and well-designed trials are needed to establish clear clinical recommendations for vitamin D use in pregnancy.

Keywords: Vitamin D, Preeclampsia, Pregnancy, Vitamin D deficiency, Maternal outcomes

INTRODUCTION

Preeclampsia is a pregnancy-specific hypertensive disorder characterized by new-onset hypertension and proteinuria after 20 weeks of gestation.[1,2] It remains one of the leading causes of maternal and neonatal morbidity and mortality worldwide, affecting approximately 2-8% of pregnancies.[3,4] This condition contributes to adverse maternal outcomes, which include renal failure, liver dysfunction and cardiovascular complications, while fetal consequences include intrauterine growth restriction, preterm birth and increased perinatal mortality.[4,5] The burden of preeclampsia is particularly high in developing countries, where delayed diagnosis, limited antenatal surveillance and restricted access to specialized obstetric care contribute to poor pregnancy outcomes.[6] In addition to its immediate obstetric consequences, preeclampsia has been increasingly recognized as a condition with long-term health implications for both mothers and offspring, emphasizing the importance of identifying preventable risk factors. The pathophysiology of preeclampsia is complex and not yet fully understood. However, abnormal placental development is widely recognized as a central mechanism.[7-9] Defective trophoblastic invasion and insufficient remodelling of the uterine spiral arteries result in reduced placental perfusion, oxidative stress and

placental ischemia.[5] These alterations subsequently trigger endothelial dysfunction and an exaggerated systemic inflammatory response. Recent evidence has also highlighted the contribution of angiogenic imbalance, particularly increased circulating anti-angiogenic factors such as soluble fms-like tyrosine kinase-1 (sFlt-1) and reduced levels of placental growth factor (PlGF), in the progression of endothelial injury and hypertension associated with preeclampsia.[10] In addition, immune dysregulation and inflammatory responses further contribute to immune maladaptation, oxidative stress, and genetic susceptibility, which are also believed to contribute to disease development.[11] Because these mechanisms are closely linked with vascular and immune regulation, nutritional factors with immunomodulatory and endothelial protective properties have become an important area of investigation in preeclampsia research.

Vitamin D has gained increasing attention as a potential factor in pregnancy outcomes.[12] It is a fat-soluble hormone involved in calcium homeostasis, immune regulation and vascular function. During pregnancy, vitamin D plays an important role in maintaining maternal–fetal immune tolerance and supporting placental development.[11-13] During pregnancy, vitamin D contributes to maternal–fetal immune tolerance and supports normal placental implantation and vascular development. Experimental studies have demonstrated that vitamin D influences trophoblast invasion and regulates angiogenic pathways by modulating the expression of vascular endothelial growth factor (VEGF) and placental growth factor (PlGF).[14]

In addition, vitamin D reduces the production of pro-inflammatory cytokines and supports anti-inflammatory pathways, which may help in preventing endothelial damage.[11] Vitamin D deficiency has also been associated with activation of the renin–angiotensin–aldosterone system, which may contribute to increased vascular resistance and elevated blood pressure during pregnancy.[15,16] These biological mechanisms provide a plausible explanation for the observed association between low maternal vitamin D levels and hypertensive disorders of pregnancy.

A growing body of evidence has linked vitamin D deficiency with adverse pregnancy outcomes, including preeclampsia. Vitamin D deficiency is highly prevalent among pregnant women worldwide, with reported rates varying across regions due to differences in sunlight exposure, dietary intake and lifestyle factors.[3,4] Several observational studies have reported that low maternal vitamin D levels are associated with an increased risk of preeclampsia and other complications such as gestational diabetes, low birth weight and preterm delivery.[3] Furthermore, studies conducted in populations with severe vitamin D deficiency have reported a stronger association between low vitamin D status and preeclampsia severity, suggesting that maternal vitamin D insufficiency may influence both disease occurrence and progression. Moreover, meta-analyses have suggested that vitamin D supplementation may reduce the incidence of preeclampsia, with some studies reporting up to a 39-50% reduction in risk.[4,5] Randomized controlled trials have also demonstrated a protective effect, particularly among women with a history of preeclampsia or vitamin D deficiency.[3,11]

Despite these findings, the current literature shows significant variation. Some studies report a significant protective effect of vitamin D supplementation, while others show no clear association.[11] Ethnic diversity, environmental factors, body mass index and coexisting maternal diseases further complicate the interpretation of the available evidence. Another challenge is that many studies did not adequately adjust for important confounding factors such as seasonal variation, socioeconomic status and dietary supplementation, all of which may influence maternal vitamin D levels and pregnancy outcomes. Another limitation is the lack of standardized definitions and outcome measures across studies, which makes it difficult to draw firm conclusions. As a result, there is still no consensus on the optimal dose, timing and clinical effectiveness of vitamin D supplementation in preventing preeclampsia.

Given these gaps and inconsistencies, there is a clear need for a comprehensive and updated evaluation of the available evidence. Previous systematic reviews have often focused on either observational studies or randomized trials alone, limiting the overall understanding of the relationship between vitamin D and preeclampsia. In addition, newer studies with improved methodologies have emerged, necessitating an updated synthesis of evidence.

Therefore, the objective of this systematic literature review is to evaluate the role of vitamin D in reducing the risk of preeclampsia by analysing evidence from both observational studies and randomized controlled trials. This review aimed to provide a clearer understanding of the association between vitamin D status and preeclampsia and to assess whether vitamin D supplementation can serve as an effective strategy for prevention. By addressing existing gaps and summarizing current evidence, this study seeks to support clinical decision-making and guide future research in maternal health.

METHODS

Study design

This systematic review was performed as per the Preferred Reporting Items for systematic reviews and meta-analyses (PRISMA) 2020 guidelines to guarantee transparency and methodological rigor. A structured review protocol was developed a priori to guide all stages of the study, including literature search, study selection, data extraction, and quality assessment. Only peer-reviewed original research articles were considered for inclusion in this review.

Search strategy

A comprehensive literature search was performed using major electronic databases, including PubMed/MEDLINE, Medscape, Scopus, Google scholar, Web of science, and the Cochrane library. The search was designed to identify relevant studies evaluating the association between vitamin D and the risk of preeclampsia. The search covered studies published between January 2012 and December 2026 to ensure the inclusion of recent and clinically relevant evidence. Relevant keywords and medical subject headings (MeSH) terms were used to develop the search strategy. These included "Vitamin D," "25-hydroxyvitamin D," "Vitamin D deficiency," "Preeclampsia," "Pregnancy-induced hypertension," "Risk," "Prevention," and "Supplementation." Boolean operators such as AND and OR were used to combine the search terms and improve the accuracy of the search.

Table 1: Data selection strategy.

Years	Search engines	Keywords
2012-2026	✓ Google scholar	✓ vitamin D
	✓ Web of science	✓ preeclampsia
	✓ PubMed	✓ pregnancy-induced hypertension
	✓ MDPI	
	✓ Medscape	✓ pregnancy
	✓ Cochrane library	✓ maternal health
	✓ EMBASE	✓ supplementation
		✓ risk

A sample search string used was as follows: ("Vitamin D" OR "25-hydroxyvitamin D" OR "Vitamin D deficiency") AND ("Preeclampsia" OR "Pregnancy-induced hypertension") AND ("Risk" OR "Prevention" OR "Supplementation").

The search strategy was adapted for each database to ensure optimal retrieval of studies. In addition, the reference lists of all included studies were manually screened to identify any additional relevant articles that were not captured during the initial search.

Eligibility criteria

Inclusion criteria

Studies were included if they involved pregnant women and assessed the relationship between vitamin D and preeclampsia. Eligible study designs included randomized controlled trials (RCTs), cohort studies and case-control studies. Studies that evaluated vitamin D supplementation or measured serum vitamin D levels during pregnancy were considered. The primary outcome of interest was the incidence or risk of preeclampsia. Only studies published in English and available in full text were included.

Exclusion criteria

Studies were excluded if they were case reports, review articles, editorials, letters, or conference abstracts. Animal studies and non-English publications were also excluded. Additionally, studies that did not report outcomes related to preeclampsia or lacked sufficient data were not considered for inclusion.

Study selection process

A total of 990 records were initially identified through searches of the selected electronic databases, including PubMed/MEDLINE (n=285), Scopus (n=456), and MEDLINE/EBSCO (n=249). After the removal of 382 duplicate records using reference management software, 608 studies remained for title and abstract screening. During the initial screening phase, 563 records were excluded as they did not meet the predefined eligibility criteria. These exclusions were due to reasons such as irrelevance to the study topic, non-human studies, review articles, or lack of outcome data related to preeclampsia. The remaining 45 articles were sought for full-text retrieval. Of these, 9 studies could not be retrieved, leaving 36 full-text articles assessed for eligibility. After detailed evaluation, 21 studies were excluded due to reasons including inappropriate study design, combined interventions (e.g., vitamin D with calcium), insufficient outcome reporting, or lack of clarity regarding vitamin D exposure. In addition, no additional studies were identified through manual screening of reference lists. Finally, a total of 15 studies (including randomized controlled trials and observational studies) met all inclusion criteria and were included in the final systematic review. The study selection process is illustrated using a PRISMA flow diagram (Figure 1).

Data extraction

Data extraction was carried out using a standardized data extraction form to ensure consistency across studies. The following information was collected from each included study: author name, year of publication, country of study, study design, sample size and participant characteristics. Additional details regarding vitamin D exposure, including dosage, timing of supplementation and serum vitamin D levels, were also extracted.

Outcome measures focused on the incidence or risk of preeclampsia, along with key findings reported by each study. Data extraction was performed by one reviewer and independently verified by another reviewer to ensure accuracy and minimize errors.

Risk of bias assessment

The methodological quality and risk of bias of the included studies were assessed independently by two reviewers. The Newcastle–Ottawa scale (NOS) was used to evaluate observational studies, including cohort and case-control

designs. For randomized controlled trials, the Cochrane risk of bias tool was applied. Each study was assessed based on criteria such as selection of participants, comparability of study groups and outcome assessment. Studies were categorized as having low, moderate, or high risk of bias.

Any disagreements between reviewers were resolved through discussion. The results of the risk of bias assessment were summarized in both narrative and tabular forms and were considered during the interpretation of the findings.

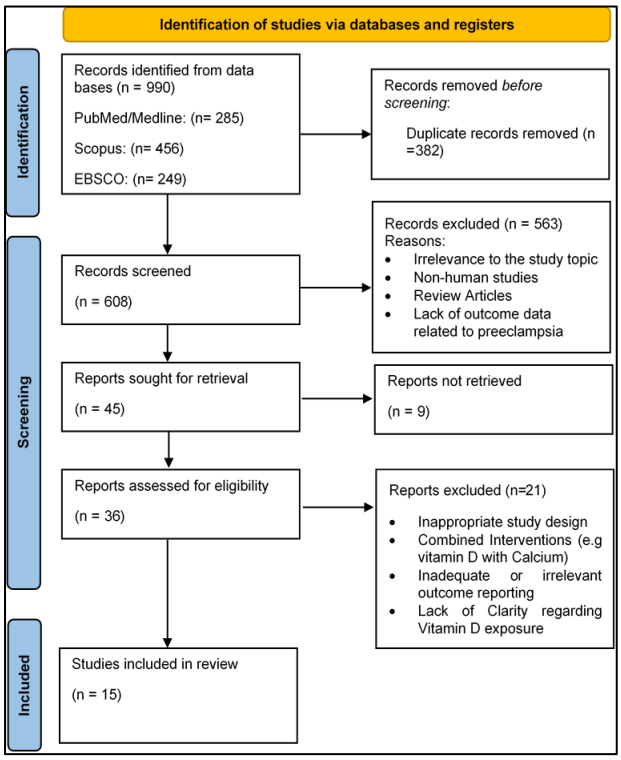

Figure 1: PRISMA flow diagram.

RESULTS

A total of 15 studies published between 2012 and 2026 were included in this systematic review, comprising randomized controlled trials, cohort studies and one case-control study conducted across Asia, Europe, Africa, Australia, and North America (Table 2).

Most studies evaluated maternal serum 25-hydroxyvitamin D levels and/or supplementation at different stages of pregnancy, ranging from preconception and early gestation to late pregnancy.

Vitamin D exposure varied widely in dose (400 IU/day to 60,000 IU biweekly or monthly) and timing of initiation, with follow-up periods extending from antenatal assessment to delivery and in one study, long-term child development outcomes. The primary outcome across studies was the risk or incidence of preeclampsia, with several studies also assessing maternal metabolic, inflammatory and neonatal outcomes.

Thematic synthesis of results

Vitamin D deficiency and risk of preeclampsia

Across the included studies, low maternal vitamin D status emerged as a significant risk factor for preeclampsia, although the strength of association varied widely depending on study design and timing of measurement. Large observational evidence, such as Das et al (OR≈11) and Bener et al, demonstrated a strong dose-dependent relationship between deficiency and disease severity, reinforcing biological plausibility.[24,30] Similarly, Alkhalaf et al and Lee et al highlighted that deficiency in the preconception or early pregnancy period is more strongly associated with adverse outcomes than later measurements.[26,29] However, interventional trials such as Mirzakhani et al and Corcoy et al showed that baseline sufficient vitamin D status, rather than supplementation alone, was more predictive of reduced risk.[17,20] A key inconsistency is the lack of a universally accepted threshold, although most studies converge around <20-30 ng/ml as a clinically relevant deficiency. The literature supports an association, but heterogeneity suggests confounding by BMI, ethnicity and metabolic health.

Effect of vitamin D supplementation

Evidence on supplementation shows mixed but mostly positive trends, influenced by dose, timing and baseline deficiency. High-dose regimens, such as 50,000 IU biweekly and monthly 60,000 IU, demonstrated significant reductions in preeclampsia incidence, particularly in high-risk women.[3,23,27] Jiang et al further supported a dose-response relationship, with higher doses yielding greater risk reduction. In contrast, low-dose or moderate supplementation often showed no statistically significant effect, suggesting a ceiling effect in vitamin D-sufficient populations.[20,22] Timing also appears crucial, as early pregnancy or preconception supplementation showed more consistent benefit than late gestation initiation.[17,26] However, several RCTs failed to demonstrate clinical improvement despite correcting serum levels, indicating that biochemical sufficiency does not always translate into clinical protection.

Mechanisms of action

Although most included studies did not directly investigate mechanistic pathways, several provided indirect evidence supporting multiple biological effects of vitamin D in preeclampsia prevention. Karamali et al demonstrated improvements in insulin resistance, oxidative stress and antioxidant capacity, suggesting a role in metabolic and endothelial regulation.[28] Yap et al and Mirzakhani et al further indicated associations with inflammatory gene expression profiles and glucose metabolism, implying immunomodulatory effects.[17,19] Vitamin D may help lower

overall inflammation in the body, support healthy blood vessel growth (including factors like VEGF and placental growth factors) and regulate blood pressure systems, all of which are important in the development of preeclampsia. It may also improve the function of blood vessels and support proper placental development when levels are adequate. However, a key limitation is that most studies do not directly confirm these effects in pregnant women, and much of the evidence is based on indirect findings rather than direct testing. Therefore, while these explanations are reasonable, they are not yet fully proven in clinical settings.

Table 2: Summary of included studies.

Author (year)	Country	Sample size	Study design	Vitamin D exposure (timing/dose/ measurement)	Follow-up duration	Key findings (critical insight)
Sasan et al, (2017)[3]	Iran	n=142	Randomized controlled trial	50,000 IU vitamin D3 every 2 weeks until 36 weeks of gestation	Until 36 weeks	Significant reduction in recurrent preeclampsia (RR≈1.94 in control). Strong evidence in the high-risk population supports the supplementation benefit.
Mirzakhani et al, (2016)[17]	USA	n=881 (816 analyzed)	Randomized controlled trial+cohort analysis	4,400 IU vs 400 IU/day from 10-18 weeks; serum 25(OH)D measured early and late pregnancy	Up to delivery (32-38 weeks assessment)	No effect in RCT analysis, but higher serum vitamin D (≥30 ng/ml) linked to lower risk (AOR 0.28). Highlights the importance of baseline levels vs supplementation alone.
Singla et al, (2012)[18]	India	n=200	Randomized controlled trial	60,000 IU vitamin D every 2 weeks from 28 to 36 weeks of gestation	Until 36 weeks	Reduced incidence of preeclampsia (10% vs 4%), but CI crosses significance. Suggests benefit in late pregnancy, but the effect may depend on calcium metabolism interaction.
Yap et al, (2014)[19]	Australia	n=179	Double-blind RCT	5,000 IU vs 400 IU/day from <20 weeks	Until delivery	No major effect on metabolic outcomes; benefit mainly in correcting deficiency → suggests supplementation alone may not influence clinical endpoints.
Corcoy et al, (2019)[20]	Europe (multicenter)	n=154	RCT	1600 IU/day from ≤20 weeks; vitamin D sufficiency ≥50 nmol/l	Up to 35-37 weeks	Achieved sufficiency but minimal clinical impact → indicates limited benefit in already sufficient populations.
Jiang and yanling, (2021)[21]	China	n=450	RCT	Low, medium, high-dose vitamin D3 during pregnancy	Not clearly specified (antenatal period)	Dose-dependent reduction in preeclampsia; high-dose most effective → supports dose-response relationship.
Naghshineh et al, (2016)[22]	Iran	n=140	RCT	600 IU/day from 16 weeks until delivery	Until delivery	Reduced cases (2 vs 7) but not significant low-dose supplementation insufficient.

Continued.

Author (year)	Country	Sample size	Study design	Vitamin D exposure (timing/dose/ measurement)	Follow-up duration	Key findings (critical insight)
Kabuyanga et al, (2024)[23]	Dr Congo	n=1300	RCT	60,000 IU monthly from ≤16 weeks for 6 months	Until delivery	Significant reduction (RR=0.36) strong evidence for early, high-dose intervention.
Bener et al, (2013)[24]	Qatar	n=1873	Cohort	Serum vitamin D levels assessed (>24 weeks)	Cross-sectional follow-up	Deficiency strongly associated with preeclampsia supports risk association.
Asemi and Esmaillzade (2015)[25]	Iran	n=46	RCT	Multimineral+ 400 IU vitamin D (27 weeks, 9 weeks duration)	9 weeks	Improved BP but no direct PE outcome confounding due to combined supplementation.
Alkhalaf et al, (2026)[26]	USA (multisite)	552	Cohort (secondary RCT analysis	Preconception and 8-week serum 25(OH)D	Early pregnancy follow-up	Preconception deficiency increased risk (RR 2.32); effect attenuated by BMI, indicating confounding by metabolic factors.
Ashraf et al, (2023)[27]	Pakistan	250	RCT	50,000 IU every 2 weeks during pregnancy	Until delivery	Significant reduction in preeclampsia (24.8%→18.4%); supports effectiveness in high-risk populations.
Karamali et al, (2015)[28]	Iran	60	RCT	50,000 IU every 2 weeks (20-32 weeks)	12 weeks	Improved metabolic and oxidative stress markers; indirect evidence supporting mechanistic pathways rather than direct clinical outcome.
Lee et al, (2025)[29]	South Korea	5,169	Retrospective cohort	Serum 25(OH)D measured in 1st and 2nd trimester (deficiency <10 ng/ml)	Pregnancy +long-term child follow-up	No significant association with preeclampsia, but persistent early deficiency linked to adverse outcomes; suggests timing (early pregnancy/preconception) is more critical than later correction.
Das et al, (2021)[30]	India	2,000	Case-control	Serum 25(OH)D measured at term	At delivery	Strong association between deficiency and preeclampsia (OR≈11); also, a dose-response relationship with severity, supporting biological plausibility.

High-risk populations

The literature shows that vitamin D deficiency has a stronger clinical impact in high-risk populations, particularly women with prior preeclampsia, obesity, or baseline deficiency. Studies such as Sasan et al and Ashraf et al demonstrated significant risk reduction in women with previous preeclampsia, indicating a clear benefit in secondary prevention settings.[3,27] Similarly, Kabuyanga et al showed strong effects in populations with widespread deficiency, highlighting the importance of baseline nutritional status.[23] In contrast, Corcoy et al and Mirzakhani et al suggested limited benefit in vitamin D-sufficient or metabolically low-risk populations,

reinforcing the effect modification by baseline status.[17,20] Alkhalaf et al further emphasized the role of confounding comorbidities such as BMI, which attenuated observed associations.[26]

Evidence from Bener et al also highlighted socioeconomic and lifestyle factors influencing deficiency prevalence, indirectly shaping risk distribution.[24] Findings showed that vitamin D appears most effective in high-risk or deficient populations, supporting a targeted rather than universal supplementation strategy.

DISCUSSION

Vitamin D status during pregnancy has been progressively studied as a modifiable factor in the prevention of preeclampsia, a major contributor to maternal and foetal morbidity worldwide. The findings of this systematic review showed that low maternal vitamin D levels are consistently associated with an increased risk of preeclampsia, although the strength of this relationship varies across study designs. Observational studies, such as those by Das et al and Bener et al, reported strong associations, suggesting that deficiency may play a meaningful role in disease development.[24,30] However, randomized trials produced mixed results. High-dose supplementation, particularly in studies like Sasan et al, Kabuyanga et al, and Ashraf et al, demonstrated a clear reduction in preeclampsia risk, especially in high-risk or deficient populations.[3,23,27] For instance, Kabuyanga et al provided strong evidence showing a significant reduction in preeclampsia risk (RR=0.36, p=0.001) with early and sustained supplementation.[23] Similarly, Ashraf et al reported a statistically significant decrease in preeclampsia incidence (18.4% vs. 24.8%, p<0.001) among supplemented women.[27] These findings support the hypothesis that timely and adequate vitamin D supplementation during pregnancy may reduce preeclampsia risk.

In contrast, trials using low to moderate doses or conducted in relatively sufficient populations, such as Corcoy et al and Naghshineh et al, showed minimal or no clinical benefit.[20,22] Naghshineh et al found a non-significant reduction in preeclampsia incidence, although fewer cases were observed in the supplemented group. This inconsistency may be attributed to small sample size, lower dosage (600 IU/day), and later initiation of supplementation, highlighting the importance of dose and timing.[22] Supporting this, Kabuyanga et al initiated supplementation early in pregnancy with higher doses, which may explain its stronger effect.[23]

Furthermore, observational studies also reinforce the association between vitamin D deficiency and increased preeclampsia risk. Bener et al reported significantly higher rates of preeclampsia among vitamin D-deficient women, while another study demonstrated a marked association with an 11-fold increased risk in deficient individuals.[24,30] These findings indicate a strong epidemiological link; however, causality cannot be established due to potential confounding factors such as socioeconomic status, BMI, and lifestyle.

Moreover, the timing of vitamin D exposure appears to be critical. Alkhalaf et al highlighted that preconception vitamin D deficiency was associated with increased preeclampsia risk, although this association weakened after adjusting for BMI.[26] Similarly, Lee et al suggested that early pregnancy deficiency may have long-term adverse effects, even if corrected later, emphasizing that early or preconception intervention may be more effective than supplementation initiated later in pregnancy.[29]

Intervention studies combining vitamin D with other micronutrients and high-dose supplementation trials showed improvements in blood pressure, metabolic parameters and antioxidant status, which are biologically relevant to preeclampsia pathophysiology.[25,28] However, these studies did not demonstrate direct reductions in preeclampsia incidence, indicating that vitamin D may exert indirect protective effects through metabolic and vascular pathways rather than as a standalone intervention.

Despite these promising findings, several limitations must be considered. The included studies show heterogeneity in supplementation dose (400 IU to 60,000 IU), frequency (daily vs. monthly), timing (preconception vs. late pregnancy), and population characteristics, making direct comparison difficult. The conflicting results across studies can be explained by several factors. First, the timing of the intervention is critical. Studies such as Alkhalaf et al and Lee et al suggest that early pregnancy or even preconception vitamin D status is more important than later correction.[26,29] Second, dose variation plays a major role, with higher doses showing more consistent benefits. Third, baseline vitamin D sufficiency influences outcomes; supplementation in already sufficient populations may not provide additional benefit, as seen in Corcoy et al.[20] Finally, confounding variables such as obesity and metabolic health may mask or modify the effect of vitamin D.

The findings suggest that vitamin D supplementation may be most beneficial when used in a targeted manner rather than universally. Early initiation, particularly in the first trimester or before pregnancy, appears to offer greater protection compared to late supplementation. Routine screening of pregnant women, especially those at high risk (e.g., prior preeclampsia, obesity, limited sun exposure), may help identify individuals who would benefit most from supplementation. Several biological mechanisms support the observed association. Vitamin D plays a role in regulating immune response, reducing inflammation, and supporting normal placental development. It may also influence blood vessel function and blood pressure regulation. Studies such as Karamali et al showed improvements in oxidative stress and metabolic markers, while Mirzakhani et al highlighted changes in gene expression related to immune pathways.[28,17] These

findings provide indirect but consistent support for a mechanistic link between vitamin D and preeclampsia. Current evidence supports considering vitamin D status as part of antenatal care, particularly in high-risk populations. However, universal high-dose supplementation cannot yet be recommended due to inconsistent evidence. Clinical guidelines may benefit from incorporating targeted screening and individualized supplementation strategies rather than a one-size-fits-all approach.

Future studies should focus on large, well-designed randomized trials with standardized dosing regimens and clearly defined deficiency thresholds. There is also a need for research exploring preconception supplementation and long-term maternal and neonatal outcomes. Additionally, studies should aim to control for confounding factors such as BMI and diet to better establish causality. Understanding the optimal dose, timing and target population will be essential for translating these findings into effective clinical practice.

Strengths and limitations

This review has several strengths, including the inclusion of both randomized controlled trials and observational studies, which enhances the robustness of findings, along with a relatively large pooled sample size. However, certain limitations should be acknowledged. There was notable heterogeneity among the included studies, particularly in terms of study design, population characteristics, and outcome measures. Additionally, variability in vitamin D dosage and timing of supplementation may have influenced results. The presence of potential bias in some studies and the possibility of publication bias may also affect overall conclusions.

CONCLUSION

This review showed that low vitamin D levels in pregnancy are linked with a higher risk of preeclampsia. Supplementation may help reduce this risk, especially when started early and given in adequate doses, mainly in women who are deficient or at high risk. However, results are not consistent across all studies due to differences in dose, timing and population. Vitamin D appears helpful but should be used in a targeted way. More large and well-designed studies are needed to confirm clear guidelines.

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