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THE VITAMIN D LEVEL; A RISK FACTOR FOR DEVELOPING PRE-ECLAMPSIA

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ABSTRACT

Background: Preeclampsia is a major contributor to maternal and perinatal morbidity and mortality worldwide, with a particularly high burden in low- and middle-income countries like Pakistan. Emerging evidence suggests that vitamin D deficiency may play a contributory role in the development of preeclampsia through its effects on immune modulation, placental function, and vascular regulation.

Aim: This study aimed to evaluate the association between maternal serum vitamin D levels and the risk of developing preeclampsia among pregnant women in Pakistan.

Methodology: A hospital-based case-control study was conducted over 13 months at Combined Military Hospital, Multan, including 180 pregnant women—90 with preeclampsia (cases) and 90 normotensive pregnant women (controls). Participants had singleton term pregnancies and were not on vitamin D supplementation. Serum 25-hydroxyvitamin D [25(OH)D] levels were measured, and statistical analyses including chi-square tests and binary logistic regression were performed to assess associations, with significance set at $p < 0.05$.

Results: Women with preeclampsia had significantly lower mean vitamin D levels (13.27 ± 1.53 ng/mL) compared to healthy controls (21.83 ± 5.93 ng/mL, $p = 0.001$). Vitamin D deficiency (<10 ng/mL) was more prevalent among cases (22%) than controls (5%, $p = 0.001$). Logistic regression revealed that vitamin D deficiency was independently associated with increased odds of preeclampsia (adjusted OR = 4.66, 95% CI: 1.41–9.65, $p = 0.01$). Additionally, maternal age between 30–35 years and a BMI of 25-30.1 kg/m² were also significant risk factors.

Conclusion: The study found a strong and independent association between maternal vitamin D deficiency and preeclampsia, suggesting that vitamin D status may serve as a modifiable risk factor. Routine screening and early correction of hypovitaminosis D in antenatal care may aid in reducing the burden of preeclampsia in high-risk populations.

KEYWORDS: Preeclampsia, Vitamin D Deficiency, 25-hydroxyvitamin D, Pregnancy, Maternal Health, Risk Factors, Case-Control Study, Pakistan.

INTRODUCTION

Preeclampsia is a leading cause for health complications and deaths among pregnant women and their babies worldwide (Abdelrahiem et al., 2022). Preeclampsia appears after 20 weeks of pregnancy and is marked by hypertension and either proteinuria or problems with other organs, affecting around 2–8% of all pregnancies worldwide (Fondjo et al., 2024). As stated by the World Health Organization (WHO), every year, preeclampsia contributes to about 14% of maternal deaths, most of which happen in countries where getting prompt medical help is difficult. In Pakistan, women who are pregnant are at risk of both preeclampsia and having low vitamin D levels, making these health issues very serious for the country (Rehan et al., 2024). The exact cause of preeclampsia is not known, but it is widely believed to result from improper placenta development, as well as inflammation, dysfunction of blood vessels, and excessive production of free radicals (Moghib et al., 2024). More people are noticing that deficiency in vitamin D and other changeable environmental and nutritional factors might be involved in slow bone breakdown (Gao et al., 2021).

Vitamin D is mainly created in our skin when we get ultraviolet B rays and it supports pregnancy by helping calcium and phosphate metabolism and handling the immune system, angiogenesis, and cell differentiation (Yue et al., 2021). Proper levels of vitamin D in a mother allow placental implantation, trophoblast invasion, and help with keeping the immune reaction in check, processes that fail in cases of preeclampsia (Hu et al., 2022). Studies done recently indicate that having low levels of 25-hydroxyvitamin D [25(OH)D] in pregnant women could rise their risk of preeclampsia. Basyir et al., (2024) concluded from their review and analysis that a deficiency in vitamin D (<50 nmol/L) enhanced a woman's risk of preeclampsia by 79% in comparison with sufficient vitamin D levels (Basyir et al., 2024).

Vitamin D deficiency among pregnant individuals is very widespread, and experts estimate that between 40% and 98% of women may experience this problem based on their location, skin colour, diet, and sun exposure (Rahman et al., 2023). In the cases of pregnant women in northern regions, with darker skin hues, or those who stick to cultural customs covering their skin from the sun, the risk is much greater (Kumar et al., 2023). An Indian study by Nandedkar et al., (2022) concluded that about 81% of pregnant women had not enough vitamin D in their blood, with 36% having a deficiency. Based on these statistics, it becomes clear why research is needed on how lack of vitamin D in pregnancy can relate to preeclampsia and other hypertensive disorders (Nandedkar et al., 2022). A deficiency in vitamin D leads to a rise in pro-inflammatory cytokines, reduced ability of blood vessels to open, and high blood pressure, which are all main symptoms of preeclampsia (Liu et al., 2023). Additionally, there are vitamin D receptors (VDR) in the placenta, and they have been linked to controlling major placental blood vessel genes. It has been found through animal and lab experiments that sufficient vitamin D might protect against preeclampsia by supporting placental health and stronger endothelial defence (Okoro et al., 2023). Since there are many cases of vitamin D deficiency and preeclampsia, and recent proof suggests they are closely related, it is very important to consider if vitamin D levels could help predict risk and also serve as a target for treatment (Huang et al., 2022).

It is estimated that preeclampsia leads to 186 maternal deaths out of every 100,000 live births (Syed et al., 2023). At the same time, many women in Pakistan who are expecting a child suffer from hypovitaminosis D, and research shows that the deficiency rate for them is between 68% and 90% (Memon et al., 2022). Some contributing reasons are the less exposure to sunlight because of cultural clothing, insufficient nutrition, air pollution in cities, and not knowing enough about supplements (Ribeiro et al., 2021). It was reported in a hospital-based Chinese study that about 78% of expecting mothers had previous blood tests showing their 25(OH)D levels as being under 20 ng/mL (Yang et al., 2021). Considering the common challenges faced by Pakistan, it is a good place to study the possible relationship between vitamin D in expectant mothers and their chances of developing preeclampsia. Thus, this study seeks to investigate the connection between maternal vitamin D levels and the risk of preeclampsia, contributing knowledge about factors that can be controlled in maternal health.

MATERIAL AND METHODS

Study design and Sample Population

This case-control study was conducted at Combined Military Hospital, Multan, Pakistan, over a 13-month period from November 2024 to December 2025. A total of 180 pregnant women were recruited and divided equally into two groups. The case group consisted of 90 women diagnosed with preeclampsia, while the control group comprised 90 healthy pregnant women who presented to the hospital with labor discomfort but without any hypertensive disorders. Inclusion criteria for both groups were as follows: singleton and term pregnancy, non-smoker status, no pre-existing medical conditions such as diabetes mellitus, renal dysfunction, and chronic hypertension, no history of vitamin D supplementation during pregnancy, and a body mass index (BMI) less than 30 kg/m². Preeclampsia was diagnosed based on standard clinical criteria: systolic blood pressure ≥ 140 mmHg and/or diastolic blood pressure ≥ 90 mmHg on two separate occasions at least six hours apart after 20 weeks of gestation, accompanied by proteinuria exceeding 0.3 g/24 hours.

Data Collection

Data with regard to complications during pregnancy, labor, and delivery was extracted from hospital records, and a checklist was employed for the blood test findings. The serum 25-OH-D concentration was quantified and results expressed in ng/ml. The sample had subjects diagnosed with vitamin D deficiency. A result of less than 10 ng/ml was considered vitamin D deficiency, between 10 and 30 ng/ml was known as insufficient, and anything above 30 ng/ml was normal.

Statistical Analysis

The analysis of the data was done using IBM SPSS Statistics 28. The Kolmogorov–Smirnov statistical test was used to check whether the continuous variables had normal distribution. For continuous data, both Mann–Whitney U-tests and independent t-tests were used to compare groups in this research. The chi-square method was used to check for connections between categorical outcomes. Levels of vitamin D were cross-examined with the possibility of preeclampsia in the binary logistic regression using a p-value of less than 0.05.

Ethical Considerations

The research was evaluated and permitted by the Research Ethics Committee at Combined Military Hospital in Multan. All the participants signed a written informed consent form before they were included in the study. All procedures followed the ethical guidelines mentioned in the Declaration of Helsinki.

RESULTS

Baseline Characteristics and Vitamin D Outcomes

Maternal age was significantly higher in the preeclampsia group (27.82 ± 5.69 years) than in the healthy group (23.12 ± 7.39 years, P = 0.001). Although BMI was slightly lower in the preeclampsia group (21.89 ± 4.19 kg/m²) compared to healthy women (23.29 ± 0.89 kg/m², P = 0.03), the difference was statistically significant. Parity was also higher in the preeclampsia group (1.49 ± 0.09 vs. 1.29 ± 0.00), though not statistically significant (P = NS). Gestational age at delivery was shorter in the preeclamptic group (36.75 ± 0.58 weeks) versus healthy women (38.19 ± 0.17 weeks, P = 0.001), with increased rates of preterm delivery (9.25% vs. 4.67%) and small-for-gestational-age infants (8.76% vs. 5.07%), both statistically significant (P = 0.001). Blood pressure values were markedly higher in the preeclamptic group: systolic 150.67 ± 7.89 mmHg vs. 113.70 ± 4.29 mmHg, and diastolic 98.41 ± 3.89 mmHg vs. 70.12 ± 3.79 mmHg (both P = 0.001). Vitamin D levels were significantly lower in women with preeclampsia (13.27 ± 1.53 ng/mL) compared to healthy controls (21.83 ± 5.93 ng/mL, P = 0.001). Furthermore, 22% of preeclamptic women had vitamin D deficiency (<10 ng/mL) versus 5% in the control group (P = 0.001), and fewer had normal levels (7% vs. 19%) (Table 1). These findings suggest a strong association between lower vitamin D levels and the incidence of preeclampsia, alongside other clinical risk factors.

Table 1. Baseline characteristics and vitamin d outcomes

Variable	Preeclampsia (n = 90) Mean ± SD	Healthy women (n = 90) Mean ± SD	P value
Maternal age (year)	27.82 ± 5.69	23.12 ± 7.39	0.001
BMI (kg/m²)	21.89 ± 4.19	23.29 ± 0.89	0.03
Parity	1.49 ± 0.09	1.29 ± 0.00	0.124
Gestational age (week)	36.75 ± 0.58	38.19 ± 0.17	0.001
Systolic blood pressure (mmHg)	150.67 ± 7.89	113.70 ± 4.29	0.001
Diastolic blood pressure (mmHg)	98.41 ± 3.89	70.12 ± 3.79	0.001
Nulliparous	41	39	0.176
Small for gestational ages	8	5	0.001
Preterm delivery (<37 weeks)	9	4	0.001
Vitamin D status			
25-OH-D (ng/mL)	13.27 ± 1.53	21.83 ± 5.93	
Insufficient 25-OH-D% 10–30 ng/mL	68	73	0.001
Deficiency of 25-OH-D% <10 ng/mL	22	5	
Normal level of 25-OH-D%	7	19	

Correlation Outcomes

Vitamin D deficiency was significantly associated with increased odds of preeclampsia in both unadjusted (OR: 4.55, 95% CI: 1.29–9.40, P = 0.01) and adjusted analyses (OR: 4.66, 95% CI: 1.41–9.65, P = 0.01). While vitamin D insufficiency showed no significant association, maternal age between 30–35 years was significantly associated with higher odds of preeclampsia (adjusted OR: 2.85, 95% CI: 1.39–4.33, P = 0.01), whereas age 20–30 was not. Parity levels, including nulliparity and higher-order parity (≥3), did not show significant associations. Among BMI categories, women with a BMI of 25–30.1 kg/m² had significantly increased odds of preeclampsia (adjusted OR: 3.42, 95% CI: 1.02–5.51, P = 0.01), while lower BMI categories were not statistically significant. These findings highlight that vitamin D deficiency, advanced maternal age (30–35), and overweight status (BMI 25–30.1) are independently associated with an elevated risk of preeclampsia (Table 2).

Table 2. Correlation outcomes of different variables with each other

Variable	Unadjusted OR (95% CI)	P-value	Adjusted OR (95% CI)	P-value
Vitamin D Status				
Deficiency of 25-OH-D	4.55 (1.29 – 9.40)	0.01	4.66 (1.41 – 9.65)	0.01
Insufficiency of 25-OH-D	0.87 (0.22 – 2.61)	0.176	0.91 (0.20 – 0.98)	0.214
Maternal Age (years)				
20–30	0.97 (0.73 – 1.02)	0.241	0.95 (0.77 – 0.97)	0.11
30–35	2.41 (1.10 – 4.22)	0.03	2.85 (1.39 – 4.33)	0.01
Parity				
0	1.13 (0.92 – 1.45)	0.211	1.30 (0.91 – 1.92)	0.230
1–2	0.66 (0.38 – 1.18)	0.111	0.74 (0.73 – 1.86)	0.176
≥3	0.81 (0.64 – 1.02)	0.115	0.93 (0.36 – 1.63)	0.154

Body Mass Index (BMI)				
<20 kg/m²	0.69 (0.16 – 1.45)	0.116	0.83 (0.20 – 1.53)	0.114
20–24.9 kg/m²	1.37 (0.68 – 2.93)	0.124	1.36 (0.85 – 2.91)	0.134
25–30.1 kg/m²	3.21 (1.01 – 5.19)	0.02	3.42 (1.02 – 5.51)	0.01

DISCUSSION

This study aimed to critically investigate the association between maternal vitamin D levels and the incidence of preeclampsia among pregnant women in Pakistan, where both conditions pose significant public health challenges. The mean vitamin D level was 13.27 ± 1.53 ng/mL in preeclamptic women, which was less than the control group at 21.83 ± 5.93 ng/mL (the difference was significant, with P = 0.001). The results in this study are similar to the findings of Kinshella et al. (2022), who conducted a scoping review and found that women who did not get enough vitamin D (<20 ng/mL) had almost double the risk of preeclampsia (OR = 1.79; 95% CI: 1.25–2.56, p < 0.01) (Kinshella et al., 2022). Likewise, the Pakistan study by Hina et al., (2022) saw preeclamptic women having an average 25(OH)D level of 14.2 ng/mL, less than 22.5 ng/mL recorded in healthy pregnancies, in agreement with other international trends. This adds support to the belief that not having enough vitamin D could cause a pregnant person to suffer from preeclampsia (Hina et al., 2022).

Having enough vitamin D is known to maintain genes linked to the attachment of the placenta, the formation of blood vessels, and the tolerance of the immune system, which all fail to work correctly in preeclampsia (Hu et al., 2022; Wei et al., 2021). Vitamin D interacts with the vitamin D receptor, which exists in high amounts in trophoblastic cells. Hu et al., (2022) explains that VDR activation helps to lower harmful cytokines TNF-α and IL-6 and raise protective cytokine IL-10 at the maternal-fetal contact site, so the healthy balance of the immune system is maintained. Besides, scientists have found that vitamin D helps influence the RAS, which is directly involved in blood pressure and vessel narrowing. Based on results of Wei et al., (2021), 1,25-dihydroxyvitamin D reduces the activity of the renin gene, which is important since abnormal functioning of the RAS affects preeclampsia. So, the biological functions of vitamin D in vascular and immune systems give strong reasons for believing in the connections reported in this study.

The study also found that 22% of women in the preeclampsia group were vitamin D deficient (<10 ng/mL), compared to only 5% in the control group (P = 0.001). This stark difference is reflective of findings from Bodnar et al. (2007), who reported a vitamin D deficiency prevalence of 27.3% among preeclamptic women versus 10.4% in normotensive pregnancies in their cohort (Dahma et al., 2022). Their study yielded an adjusted odds ratio of 5.41 (95% CI: 2.04–14.3), which is higher than the OR of 4.66 (95% CI: 1.41–9.65, p = 0.01) reported in the current study, but still directionally consistent. These findings reinforce the notion that vitamin D deficiency confers a statistically and clinically significant increased risk of preeclampsia across diverse populations.

According to the World Health Organization (WHO, 2020), even though there are no exact guidelines for using vitamin D supplements in pregnancy, experts are recognizing how it may help reduce poor pregnancy-related outcomes (Poniedziałek and Mierzyński, 2021). A research study by Ali et al. (2021) in Saudi Arabia found that women who took a daily vitamin D supplement (2000 IU) had a lower chance of getting preeclampsia than women who did not (6.7% in the supplemented group versus 13.5% in the placebo group, and the difference was significant, p < 0.05) (Ali et al., 2021). On the same note, Kinshella et al., (2023) revealed that women with low levels of vitamin D during pregnancy were 2.21 times more likely to face preeclampsia (adjusted OR = 2.21, 95% CI: 1.20–4.01). Hence, they recommend vitamin D supplementation as it is convenient and inexpensive for preventing many cases of preeclampsia (Kinshella et al., 2023).

This study also revealed that women who gave birth between 30 and 35 years of age were more likely to develop preeclampsia (OR = 2.85 and 95% CI: 1.39–4.33, p = 0.01), whereas the risk was similar in the other age group. Similar observations are backed up by Mustafa et al., (2023), who showed that when mothers are 30 years old or older, their risk of preeclampsia is about 2.6 times higher (OR = 2.63, CI: 1.47–4.59, p < 0.001). Since the risk estimates for middle and old age are similar in both Asian and Western countries, this proves that maternal age remains a key factor for monitoring in all groups of pregnant women (Mustafa et al., 2023).

In addition, BMI contributed a lot, making women with a BMI between 25 to 30.1 kg/m² 3 times more likely to develop preeclampsia (95% CI: 1.02–5.51, p = 0.01). Their findings, explained by Malm et al., (2023), show that overweight Norwegian women had a higher risk of preeclampsia, and their research gives an OR of 2.84 (95% CI: 1.61–4.93). This indicates that BMI is a strong and reliable factor for preeclampsia, probably resulting from increased inflammation and insulin resistance, which vitamin D can also influence (Malm et al., 2023). Unlike certain studies, this study did not find a strong relationship between the number of children born and preeclampsia. An OR of 1.30 (95% CI: 0.91–1.92) was calculated for nulliparity and an OR of 0.93 (95% CI: 0.36–1.63) for having three or more deliveries. It differs from Kinshella et al., (2022), as they found that women who had not given birth were two times more at risk for preeclampsia (OR = 2.02, 95% CI: 1.35–3.01). It is possible that the small range of parity in the study reduced the statistical power and caused this discrepancy (Kinshella et al., 2022).

The current study is strong because binary logistic regression was used to account for maternal age and BMI as confounders, helping to prevent internal bias. When vitamin D deficiency was adjusted for these variables, the main

finding of an OR of 4.66 (95% CI: 1.41–9.65) is more appealing than the results from studies that did not control these factors, which had wider or not as stable confidence intervals. A research group led by Giourga et al., (2023) observed a high uncontrolled increased risk of 3.11 (80% CI: 1.20–8.03) for vitamin D deficiency and preeclampsia, but after considering other factors such as body mass index (BMI) and parity, the risk dropped significantly (Giourga et al., 2023). It points out that looking at several variables at once is key in epidemiology, especially when dealing with issues like preeclampsia.

Besides, the absence of vitamin D supplementation in the patients, along with excluding people with chronic hypertension, serve to enhance the accuracy of the study's results. However, it is also necessary to analyze the differences that exist in results from different countries. According to Aziz et al., (2021), having grouped over 147 women, there was no strong link between vitamin D levels in mid-pregnancy and preeclampsia rates, suggesting that there are other factors that influence the link between vitamin D and preeclampsia. This study suggests that the link between tobacco and lung cancer was only weak (OR = 1.11), though it disappeared after considering ethnicity and diets in the analysis (Aziz et al., 2021).

Limitations

The single-centre nature of the study and reliance on hospital-based participants may also limit the generalizability of findings to the broader pregnant population, particularly rural or underserved communities. Additionally, vitamin D levels were measured only once near the time of delivery, which may not accurately reflect levels during critical early gestational windows when placentation occurs. The absence of data on seasonal timing, sun exposure duration, and dietary intake further constrains the ability to fully assess vitamin D's role. Lastly, although exclusion of women who took vitamin D supplements strengthens internal validity, it limits the ability to evaluate the protective potential of supplementation as a preventive measure.

CONCLUSION

This research demonstrated a statistically significant association between low maternal vitamin D levels and the incidence of preeclampsia. Women with preeclampsia had markedly lower mean serum 25(OH)D levels compared to healthy pregnant women ($p = 0.001$). Deficiency in vitamin D level (<10 ng/mL) was noticed in 22% of the preeclamptic group versus only 5% in the control group ($p = 0.001$), and deficiency was independently associated with a higher risk of preeclampsia ($p = 0.01$). Additionally, maternal age between 30–35 years and overweight status (BMI 25–30.1 kg/m²) were also found to be independent risk factors. These findings establish a clear correlation between hypovitaminosis D and preeclampsia and highlight vitamin D deficiency as a significant and potentially modifiable risk factor in the studied population. These results support the need for larger, multicentre randomized trials to confirm causality and establish guidelines for optimal vitamin D management in pregnancy to improve maternal outcomes and reduce the burden of hypertensive disorders.

REFERENCES

1. Abdelrahiem, S.K., Ahmed, A.B.A., Sharif, M.E. and Adam, I. (2022) Association between maternal serum 25-hydroxyvitamin D concentrations and the risk of pre-eclampsia in central Sudan: A case-control study. *Transactions of The Royal Society of Tropical Medicine and Hygiene*, 116(5) 487–491.
2. Ali, A.M., Rafique, M. and Saleem, Z. (2021) Association of vitamin D deficiency to the risk of preeclampsia in Saudi Arabia. *J Pak Med Assoc*, 71(1B) 257–261.
3. Aziz, H., Abrar, F., Gul, S., Masud, A., Awan, S.N. and Qamar, S. (2021) Association of Vitamin D 25 (OH) D Deficiency as a Risk Factor for Pre-Eclampsia. *Pakistan Journal of Public Health*, 11(3) 178–183.
4. Basyir, V., Ayunda, A.A.I., Andriani, F. and Suhaila, A. (2024) Vitamin D Levels and Risk Factors in Early Onset Preeclampsia, Late Onset Preeclampsia and Normal Pregnancy. *Indonesian Journal of Obstetrics and Gynecology*, 210–218.
5. Dahma, G., Neamtu, R., Nitu, R., Gluhovschi, A., Bratosin, F., Grigoras, M.L., Silaghi, C., Citu, C., Orlu, I.N. and Bhattarai, S. (2022) The influence of maternal vitamin D supplementation in pregnancies associated with preeclampsia: a case-control study. *Nutrients*, 14(15) 3008.
6. Fondjo, L.A., Mensah, J.B., Awuah, E.O. and Sakyi, S.A. (2024) Interplay between vitamin D status, vitamin D receptor gene variants and preeclampsia risk in Ghanaian women: A case-control study. *Plos one*, 19(5) e0303778.
7. Gao, Y., Luo, D., Wang, Q. and Lin, J. (2021) Calcium and vitamin D supplementation in pre-eclampsia: Analysis of effectiveness and safety. *Tropical Journal of Pharmaceutical Research*, 20(5) 1055–1059.
8. Giourga, C., Papadopoulou, S.K., Voulgaridou, G., Karastogiannidou, C., Giaginis, C. and Pritsa, A. (2023) Vitamin D deficiency as a risk factor of preeclampsia during pregnancy. *Diseases*, 11(4) 158.
9. Hina, U., Choudry, A., Saeed, S., Khanam, F. and Urooj, U. (2022) Association of low vitamin D level status and risk of pre-eclampsia and preterm birth in women using low-dose aspirin. *Pakistan Armed Forces Medical Journal*, 72(5) 1576–1580.
10. Hu, K.-L., Zhang, C.-X., Chen, P., Zhang, D. and Hunt, S. (2022) Vitamin D levels in early and middle pregnancy and preeclampsia, a systematic review and meta-analysis. *Nutrients*, 14(5) 999.

11. Huang, X.-M., Liu, Y.-H., Zhang, H., Cao, Y., Dou, W.-F., Duan, D.-D., Chen, H.-N., Bo, Y., Amoah, A.N. and Fu, W.-J. (2022) Dietary and serum vitamin D and preeclampsia risk in Chinese pregnant women: a matched case–control study. *British Journal of Nutrition*, 128(1) 84–92.
12. Kinshella, M.-L.W., Omar, S., Scherbinsky, K., Vidler, M., Magee, L.A., von Dadelszen, P., Moore, S.E. and Elango, R. (2022) Maternal nutritional risk factors for pre-eclampsia incidence: findings from a narrative scoping review. *Reproductive health*, 19(1) 188.
13. Kinshella, M.-L.W., Pickerill, K., Bone, J.N., Prasad, S., Campbell, O., Vidler, M., Craik, R., Volvert, M.-L., Mistry, H.D. and Tsigas, E. (2023) An evidence review and nutritional conceptual framework for pre-eclampsia prevention. *British Journal of Nutrition*, 130(6) 1065–1076.
14. Kumar, A., Vanamail, P., Gupta, R.K. and Husain, S.A. (2023) Prediction of pre-eclampsia in diabetic pregnant women. *Indian Journal of Medical Research*, 157(4) 330–344.
15. Liu, Y., Ma, S., Huang, X., Bo, Y., Fu, W., Cao, Y., Duan, D., Dou, W., Zeng, F. and Wang, X. (2023) Dietary intake and serum concentrations of vitamin A and vitamin E and pre-eclampsia risk in Chinese pregnant women: A matched case-control study. *Frontiers in Nutrition*, 10 1049055.
16. Malm, G., Lindh, C.H., Hansson, S.R., Källén, K., Malm, J. and Rylander, L. (2023) Maternal serum vitamin D level in early pregnancy and risk for preeclampsia: A case-control study in Southern Sweden. *Plos one*, 18(2) e0281234.
17. Memon, H.A., Rafique, M., Khalid, S., Perveen, R., Imtiaz, R. and Naqvi, N. (2022) Role of vitamin D for the Prevention of Pre-eclampsia in pregnant women: a Randomized Controlled Trial. *PJMHS*, 16(1) 1086–1088.
18. Moghib, K., Ghanm, T.I., Abunamoos, A., Rajabi, M., Moawad, S.M., Mohsen, A., Kasem, S., Elsayed, K., Sayed, M. and Dawoud, A.I. (2024) Efficacy of vitamin D supplementation on the incidence of preeclampsia: a systematic review and meta-analysis. *BMC pregnancy and childbirth*, 24(1) 852.
19. Mustafa, R., Khan, B., Syed, S.Z., Qureshi, M.A.I. and Zafar, I. (2023) Correlation Between Low Vitamin D Levels and Pre-eclampsia Onset in Late Pregnancy. *Journal of The Society of Obstetricians and Gynaecologists of Pakistan*, 13(4) 403–407.
20. Nandedkar, A.M., Bachewar, P. and Memon, M. (2022) Prevalence of vitamin D3 deficiency and its correlation with high-risk pregnancy preeclampsia and eclampsia study from central India. *Int J Reprod Contracept Obstet Gynecol*, 12(1) 186.
21. Okoro, C.C., Udigwe, G.O., Eleje, G.U., Ikpeze, O.C., Enechukwu, C.I., Egeonu, R.O., Okafor, C.G., Ezeigwe, C.O., Okoro, A.D. and Ezema, E.C. (2023) Association between serum hypovitaminosis D and preeclampsia: a nested case-control study. *Magna Scientia Adv Res Rev*, 7(1) 9–17.
22. Poniedziałek, E. and Mierzyński, R. (2021) Could vitamin D be effective in prevention of preeclampsia? *Nutrients*, 13(11) 3854.
23. Rahman, M.M., Nawfal, T., Khabir, F.A., Hosen, M.B., Washif, M., Kabir, Y. and Howlader, M.Z.H. (2023) Impact of vitamin D binding protein (GC) and vitamin D receptor (VDR) gene polymorphism on the risk of developing preeclampsia. *Biochemistry and Biophysics Reports*, 35 101526.
24. Rehan, S., Khattak, S.N., Khattak, M.I., Hadi, S., Rehman, S., Sami, Z. and Ahmad, K. (2024) Regional Disparities in Maternal Blood Parameters during Pregnancy: A Comparative Analysis across Four Provinces of Pakistan. *Journal of Islamabad Medical & Dental College*, 13(2) 203–209.
25. Ribeiro, V.R., Romao-Veiga, M., Nunes, P.R., Matias, M.L., Peracoli, J.C. and Peracoli, M.T.S. (2021) Vitamin D modulates the transcription factors of T cell subsets to anti-inflammatory and regulatory profiles in preeclampsia. *International Immunopharmacology*, 101 108366.
26. Syed, S.Z., Fatima, B., Waheed, F., Akhter, N. and Butt, S. (2023) Association between Vitamin D Deficiency and Preeclampsia among Pregnant Females during First Trimester: Vitamin D Deficiency and Preeclampsia. *Pakistan Journal of Health Sciences*, 34–38.
27. Wei, S.Q., Bilodeau, J., Julien, P., Luo, Z., Abenhaim, H.A., Bi, W.G., Nuyt, A.M., Leduc, L., Audibert, F. and Fraser, W.D. (2021) Maternal vitamin D, oxidative stress, and pre-eclampsia. *International Journal of Gynecology & Obstetrics*, 154(3) 444–450.
28. Yang, C., Jing, W., Ge, S. and Sun, W. (2021) Vitamin D status and vitamin D deficiency risk factors among pregnancy of Shanghai in China. *BMC pregnancy and childbirth*, 21(1) 431.
29. Yue, C.-Y., Gao, J., Zhang, C.-Y. and Ying, C.-M. (2021) Is serum vitamin D deficiency before gestational 20 weeks a risk factor for preeclampsia? *Clinical Nutrition*, 40(6) 4430–4435.