Effectiveness of vitamin D intake on postpartum depressive symptoms: a systematic review

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Effectiveness of vitamin D intake on postpartum depressive symptoms

Abstract

Background: Postpartum depression (PPD) is a prevalent worldwide problem, with multiple adverse effects on mother and infant. Research has already indicated a link between vitamin D levels and mental health disorders, such as depression. In this systematic review we aim to investigate all the existing evidence about vitamin D intake during pregnancy or in the postpartum period and its effect on postpartum depressive symptoms.

Methods: PubMed, Cochrane and Embase were searched from February 2023 until February 2024. In total, 205 studies were reviewed, and 8 studies were included after assessment for eligibility.

Results: We identified 4 randomized controlled trials (RCT) studying vitamin D supplements, two observational studies studying dietary vitamin D intake and two reviews. Three out of four RCT's showed a significant reduction of postpartum depressive symptoms after intake of vitamin D supplements. Both observational studies found lower odds ratio's for PPD with higher intake of vitamin D. The two included reviews found inconclusive results, due to multiple observational studies with varying results. Only one of the studies we included had a low risk of bias, the other studies had some concerns, due to small sample sizes, deviation from intended interventions, blinding procedures, …

Conclusion: The real effect of vitamin D on PPD stays indecisive, since there's a lack of high-quality studies and evidence. A grade 2B recommendation for screening of vitamin D levels in prenatal, pregnant and postpartum women, may be feasible because of our study, since lower levels of vitamin D should be supplemented for the health benefits of their own and the fetus.

Abstract (Nederlands)

Achtergrond: Postpartum depressie (PPD) is wereldwijd een frequent voorkomend probleem, met nadelen voor zowel moeder als kind. Studies wijzen op een link tussen vitamine D inname en psychische stoornissen, zoals depressie. Het doel van onze systematische review is het huidige bewijs verzamelen over het effect van vitamine D inname op depressieve symptomen in het postpartum. Deze inname vindt plaats voor, tijdens of na de zwangerschap.

Methoden: We zochten naar studies van februari 2023 tot februari 2024 in Pubmed, Cochrane en Embase. We beoordeelden in totaal 205 studies, waarvan we er 8 includeerden in onze review na kwaliteitsbeoordeling en toetsing aan onze in- en exclusiecriteria.

Resultaten: We includeerden vier RCT's die het gebruik van vitamine D supplementen onderzochten. Drie van de vier RCT's toonden een significante daling van postpartum depressieve symptomen na inname van vitamine D. Daarnaast vonden we twee observationele studies die het effect van vitamine D inname in de voeding op postpartum depressieve symptomen onderzochten. Deze gaven beide een lagere odd's ratio bij hogere inname van vitamine D. Tenslotte includeerden we twee reviews waarvan de resultaten niet eenduidig zijn omwille van inclusie van meerdere observationele studies met wisselende resultaten. Slechts één van onze geïncludeerde studies is van zeer goede kwaliteit met een laag risico op bias. De andere studies botsten op een kleine steekproefomvang, selectie bias,…

Conclusie: Het reële effect van vitamine D op PPD blijft onzeker, omwille van gebrek aan studies van hoge kwaliteit. Een GRADE 2B aanbeveling om te screenen voor vitamine D deficiëntie bij prenatale vrouwen, zwangere vrouwen of vrouwen in het postpartum lijkt redelijk, gezien supplementatie bijdraagt tot voordeel van zowel de eigen gezondheid, als die van het kind.

1. Introduction

Postpartum depression (PPD) is an important worldwide problem, with an estimated global prevalence of 17.7%(1). It is classified as a major depressive disorder (MDD) which occurs during pregnancy or within four weeks postpartum, according to the Diagnostic and Statistical Manual of Mental Disorders (DSM-5). At least one of the symptoms include depressed mood or loss of interest or pleasure. Weight loss or weight gain, irrational fears, fatigue, insomnia, indecisiveness are also associated symptoms (2). Since a lot of these symptoms of MDD are not specific for PPD further screening tests have been developed to recognize women at risk. The Edinburgh Postnatal Depression Scale (EPDS) is one of the most common screening tools to identify these women(3).

Postpartum depression is shown to have adverse effects on mother, infant, and the surrounding environment. As for the mother, poorer maternal responsiveness to the infant, with an impact on breast-feeding, sleep and health care utilization are seen (4,5). Preterm delivery and low birth weight are most frequently reported as adverse effects on newborns (5). Furthermore, the child risks insecure attachment, which can impact long-term emotion regulation and distress tolerance. The child's cognitive, social, and behavioral functioning also suffers an impact (6). As for the environment, PPD increases paternal depression and parenting stress (4,5).

Multiple risk factors for developing postpartum depression have been identified, such as low education and low income, low social support, acute stressful events, marital strain, chronic health problems and smoking (7). Also unintended pregnancy and partner violence were recognized (5). A history of depression or psychiatric disorders is predictive for developing PPD with a 20-fold increased risk (8).

Treatment for PPD is mostly derived from major depressive disorder. This indicates a use for pharmacotherapy, typically with a Selective Serotonin Reuptake Inhibitor (SSRI). Anyhow, psychotherapy is often found to be more acceptable than pharmacotherapy, especially during pregnancy (10). Psychotherapy is shown to have a moderate effect on postpartum depression and on social support, anxiety, functional impairment, parental stress, and marital stress, with a number needed to treat of four (11). A recent review of Brown J.V.E. et al. (2022) studied the effect of antidepressants, especially of SSRIs in the treatment of PPD, compared to placebo. They found that SSRIs are likely to be as safe as placebo, with no significant reports of more adverse effects in the SSRI-group (12). However, they found limited evidence regarding the effectiveness of antidepressants in the management of postnatal depression, particularly for those with more severe depression**.**

Other interventions such as physical activity and dietary supplements are less investigated. A meta-analysis of Nakamura et al. showed only a small, but significant positive effect of physical activity during pregnancy on postpartum depressive symptoms (13). Another study found protective effects of vitamins, fish, polyunsaturated fatty acids, calcium, zinc, and possible selenium, but concluded a lack of evidence (14)
Vitamin D, however, can affect brain function in multiple ways. Research has indicated a link between vitamin D levels and mental health conditions, including depression. The biological reason for the role of vitamin D in depression may be due to the presence of 1,25 dihydroxyvitamin D receptors and alpha-1-hydroxylase (the enzyme which activates this vitamin) in the central nervous system, especially in the hypothalamus and the substantia nigra. This indicates a possible autocrine and/or paracrine function of vitamin D in the human brain (15). Also, inflammatory mechanisms

would play a crucial role in the pathological mechanisms of depression. Studies show an increase in pro-inflammatory cytokines and other inflammation-related proteins in plasma and cerebrospinal fluid during depression (16). However, vitamin D, might act as an anti-inflammatory agent in the brain. These suggest a relationship between vitamin D deficiency and depression, as well as other autoimmune and inflammatory diseases (17).

Until now, multiple studies propose a link between vitamin D deficiency during pregnancy and in the puerperal period, and the prevalence of post-partum depressive symptoms, but often with inconclusive results. In this systematic review, reported according to the PRISMA-Scr guidelines, we aim to assemble and analyze the evidence of vitamin D intake and its effects on postpartum depressive symptoms (18,19).

2. Methods

Search strategy and selection criteria

We searched PubMed, Cochrane and Embase from February 2023 until February 2024 to identify relevant articles for this study. English studies published from 1973 until January 2024 were reviewed. Our search strategy consists of 3 main concepts: postpartum, depression and vitamin D, with postpartum depression defined as a major depressive disorder (MDD) which occurs during pregnancy or within four weeks postpartum, according to the Diagnostic and Statistical Manual of Mental Disorders (DSM-5)(2).

First, to identify vitamin D, we used the following keywords and Mesh terms: “Vitamin D” [Mesh] OR “cholecalciferol” OR “25-hydroxyvitamin D” OR “vitamin D”. Next, to find pregnancy-related outcomes we used the following keywords and Mesh terms: “Pregnancy” [Mesh] OR “Postpartum Period” [Mesh] OR “pregnancy” OR “postpartum” OR “perinatal” OR “puerperal” OR “maternal”. Finally, to identify depression, we used the next keywords and Mesh terms: “Depression, Postpartum” [Mesh] OR “depression” OR “postpartum depression” OR “antenatal depression” OR “maternal depression” OR “puerperal depression”. We used “AND” to combine the keywords of the three concepts (postpartum, depression and vitamin D) in our search.

To find extra articles, we examined the references of our found studies. However, relevant articles in the references were already included in our search. All articles were screened based on title and abstract by two independent reviewers. Next, the full text was read and assessed for eligibility. In case of doubt, we assessed the full article for bias.

Eligibility

Articles were included if they investigated vitamin D intake (before, during or after pregnancy until 1 year postpartum) and its effect on postpartum depressive symptoms. Randomized controlled trials, observational studies, clinical trials and systemic reviews or meta-analysis were eligible for inclusion.

Exclusion criteria were studies out of pregnancy context (women not in postpartum period or women with no aspiration for pregnancy), other study designs than mentioned above, no online availability of the article, as well as a history for psychiatric disorders, use of antidepressants and use of vitamin D supplementation prior to the study.

Research using multivitamin supplements or other supplements than vitamin D were also excluded. Studies that explored the relationship between serum vitamin D levels and postpartum depressive

symptoms were also excluded, as our focus is on examining the impact of vitamin D intake on postpartum depressive symptoms, rather than serum vitamin D levels.

Risk of bias assessment

To determine the quality of every article, each study was assessed independently by two reviewers using specific risk of bias tools. The RoB 2 tool from Cochrane, a revised tool for assessing risk of bias in randomized trials, was used for the randomized trials (20). For the observational studies and cohort studies, the risk of bias in non-randomized studies- of Exposure (ROBINS-E) tool was used (21). The ROBIS tool was used for evaluating the risk of bias in systemic reviews(22).

Data extraction

Overall results and study characteristics were extracted from the eligible studies and are presented in Table 1. Data contains information about study design, study population, inclusion and exclusion criteria, used supplementation and doses, used depression scales and conclusions of the studies.

3. Results

3.1. Study selection

We found 205 articles to be possible eligible for this study **(Figure 1)**. No studies were excluded based on study design. After the removal of duplicates, we were left with 180 possible studies for inclusion. Twenty-two studies remained after selection by title and abstract. They underwent a full text review and bias assessment. At the end of our search, we included a total of 8 studies: 4 RCT's, 2 observational studies, 1 narrative review and 1 systematic review.

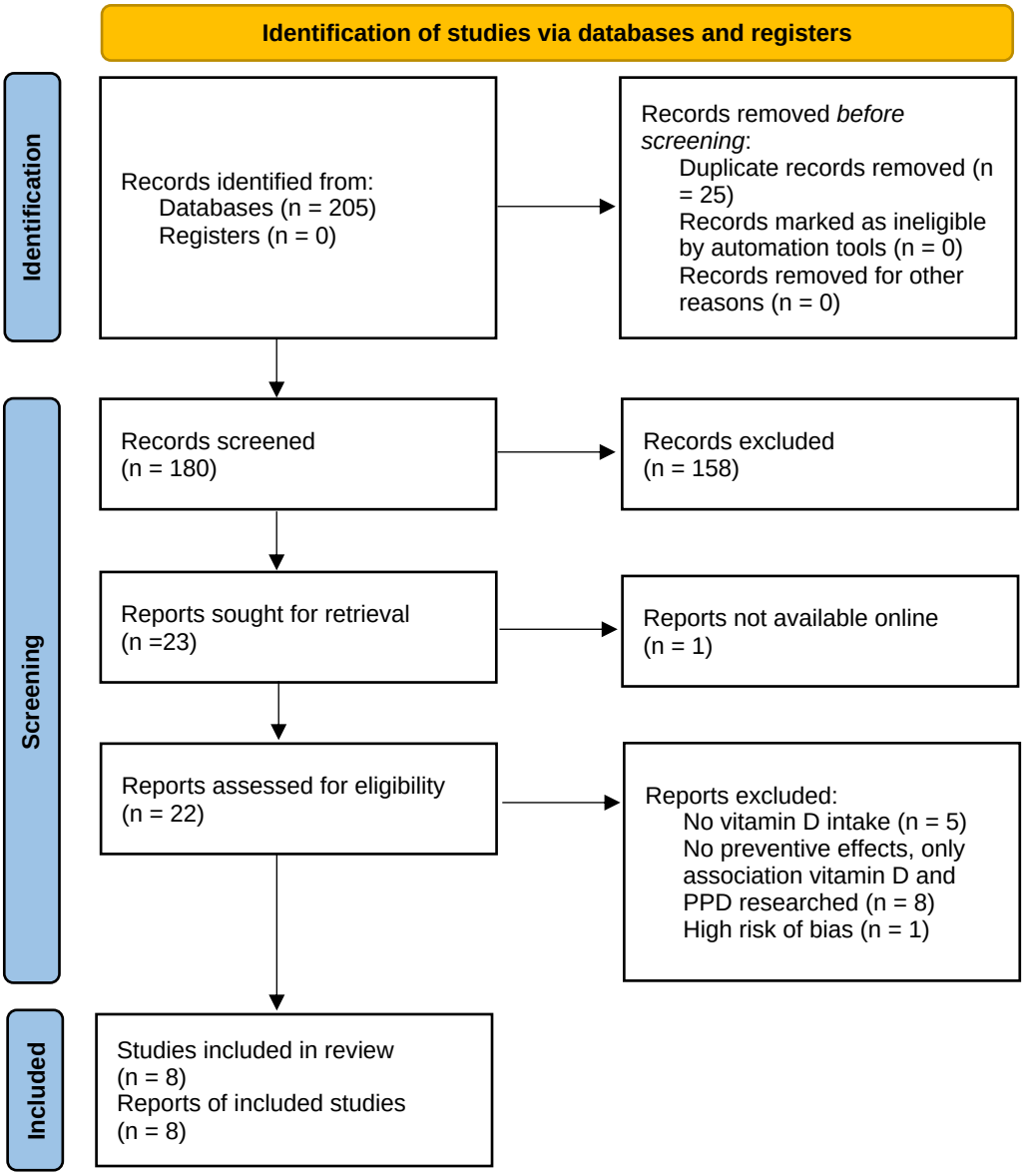


Figure 1. Flow diagram reporting the selection of studies for this review.

Source: Page MJ, et al. BMJ 2021;372: n71. doi: 10.1136/bmj. n71.
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3.2. Trials of Vitamin D supplementation and Postpartum Depressive Symptoms

We included 4 randomized controlled trials, shown in Table 1 and Table 2.

3.2.1. Design of the randomized controlled trials

Participants

Three studies recruited women from Iran: Vaziri et al. included 169 women from Hafez Hospital in Shiraz(23) and Dabbaghmanesh et al. included 120 women also from this hospital(24), whereas Amini et al. included 81 women from the Clinic of Ahvaz (25). The fourth study recruited 552 women from the Department of Obstetrics and Gynecology of the University of Cagliari, in Italy(26). The most typical inclusion criteria included: age over 18 years, no history of mental illness or chronic diseases, no addiction to narcotics, an uncomplicated singleton pregnancy, and a gestational age between 26 and 28 weeks (23,24). Two studies recruited women in the postpartum period, ranging from 1-6 months for Amini et al, with a body mass index below 35(25), whereas for Paoletti inclusion happened after spontaneous delivery between 37-41 weeks with healthy babies and a body mass index between 22-26 was necessary(26).

Amini et al. is the only study that only included women with a score of more than 12 on the Edinburgh questionnaire, and thus with a positive screening for postpartum depression(25).

Intake of vitamin D prior to the study was found to be an exclusion criterion for three out of four studies(23–25). All four studies used the Edinburgh postnatal depression scale (EPDS) for the screening of postpartum depressive symptoms(23–26), yet for two out of four, an Iranian version of this tool was used(23,25).

Interventions

Two out of four studies used 2.000 IU vitamin D3 daily as intervention, from week 26-28 of gestation until birth (23,24). The other two studies used a combination of vitamin D and calcium (25,26).

For Amini et al. 50.000 IU vitamin D3 fortnightly in combination with 500mg calcium daily was used for 8 weeks during the 1–6-month postpartum period(25). Paoletti et al. however used 400 IU vitamin D in combination with 500mg calcium daily starting from day three after delivery until one month postpartum(26).

Only Vaziri et al. had a single blind study design for the interventions(23). The other three studies were double blind, whereas one used a block randomization technique(24), one used a single computer-generated list of randomizations(26), and the third one used a random block allocation method using a computer-generated blocked randomization (1:1:1), random blocks of six subjects were used. To prevent bias, they also used two-digit unique codes for everyone, to conceal allocation(25).

Comparators

Vitamin D intake was compared to placebo in two studies(23,24). Amini et al. used two comparator groups: one containing the intake of 50.000 IU vitamin D3 fortnightly with a placebo of calcium daily and the other group containing the intake of placebo of vitamin D3 fortnightly in combination with placebo of calcium daily(25). Paoletti et al. used Elevit vitamins for the control group(26).

Outcomes

The primary outcome for these four RCT's is the severity of depressive symptoms, all measured by the EPDS. Secondary outcomes are mostly hematological parameters (such as thyroid stimulating hormone, free thyroxin, estradiol and others), which are not further relevant to our systematic review(23–26).

EPDS scores were measured at baseline and at 4 weeks postpartum for Dabbaghmanesh et al, and at 38-40 weeks of gestation, 4 and 8 weeks after delivery for Vaziri et al.(23,24).
For the studies conducted in the postpartum period, Amini et al measured EPDS-scores at baseline and after the one-month intervention period. They used text messages to remind the participants about the intake of their pills. Compliance was measured at 80% by unused pills that were returned to the researcher(25). Participants for Paoletti et al. were included at day 3 after delivery, with measurements at baseline and at day 15 and 30 after delivery(26).

3.2.2. Results of the randomized controlled trials

Vaziri et al. showed a significant impact of vitamin D intake on EPDS-scores. Depression scores at baseline for vitamin D group were 8.44±3.89, as for the control group a score of 8.64±3.81 was seen, with no difference between the groups (p-value 0.747). After intervention for the vitamin D group, there was a significant difference starting at 38-40 weeks of gestation. The EPDS scores at 38-40w gestation were 6.17±3.47 for the vitamin D group, in comparison to 7.77±3.92 for the control group (p-value 0.01). At 4 weeks postpartum a score of 4.59±3.29 in comparison to 7.36±4.27 (p-value <0.001) and at 8 weeks postpartum a score of 4.19±3.76 in comparison to 7.18±3.99 (p-value <0.001)(23).

Dabbaghmanesh et al. also showed a significant impact of vitamin D intake. At baseline, at 26-28weeks of gestation, an EPDS score of 8.52±3.61 was seen for the vitamin D group, and 8.00±3.69 for the control group (p-value 0.47). After intake of 20.000 IU of vitamin D from baseline until delivery, a significant difference was seen between both groups, whereas the vitamin D group had a score of 4.48±3.30 at 4 weeks postpartum, and the control group showed a score of 7.07±4.52 at that time (p-value 0.002). A significant reduction for the vitamin D group, with a p-value of 0.000, as to where the control group showed no difference, with a p-value of 0.15 (24).

Amini et al. used 3 groups for comparison. The highest reduction in EPDS scores was seen in the vitamin D + calcium placebo group (17.50±3.97 at baseline, 13.33±6.38 after intervention, a change of -4.16±5.90, with a p-value of 0.004), followed by the vitamin D + calcium group (17.41±4.10 at baseline, 15.70±5.15 after intervention, a change of -1.70±3.44, with a p-value of 0.042, a significant reduction). Only the vitamin D placebo + calcium placebo group showed no difference after the intervention period (16.43±3.07 at baseline, 16.68±5.99 after intervention, with a difference of 0.25±2.81 and a p-value of 0.586)(25).

Our fourth included RCT, of Paoletti et al. showed a significant difference in the reduction of EPDS scores between the intervention group and the Elevit group, with more reduction for the Elevit groups. The overall women included in the control group had an EPDS score of 6.3±4.1 at visit 1 (3rd day after delivery), 4.1±3.4 at visit 2 (15 days after delivery), and 3.2±2.8 at visit 3 (30 days after delivery). In comparison to the intervention group with vitamin D supplements, a score of 6.1±4.2 was seen at visit 1, 4.9±3.8 at visit 2 and 4.5±3.8 at visit 3. A p-value of <0.05 was seen for the difference between these groups. Paoletti et al. also made a sub analysis for women with an EPDS-score <12 at visit 1 and women with an EPDS-score ≥12 at visit 1. The sub analysis of both groups showed the same results, whereas the scores of women with an EPDS score of <12 at visit 1 in the control group (5.0±2.8 at visit 1, 3.3±2.6 at visit 2, 2.7±2.5 at visit 3) compared to the women in the intervention group (4.8±2.9 at visit 1, 4.0±3.1 at visit 2, 3.5±3.2 at visit 3), showed a p-value of <0.005. For the women with an EPDS score of ≥12, the control group (14.3±2.8 at visit 1, 8.7±4.0 at

visit 2, 6.8±3.8 at visit 3) compared to the intervention group (14.3±2.9 at visit 1, 10.6±3.5 at visit 2, 9.9±3.8 at visit 3) also had a significant difference with a p-value of 0.005, with more reduction for the Elevit groups.

3.2.3. Bias of the randomized controlled trials

The bias-assessment of the randomized controlled trials included in this study is shown in **Table 3**. Amini et al. was found to have the least risk of bias (25). The other studies showed missing data, with a risk for attrition bias (24,26), as well as a lack of blinding in the process (single blind or no information provided), which could lead to performance bias(23). Some studies also allowed the use of other supplementations outside the study protocol(23,24).

3.3. Observational Studies reporting vitamin D intake and their effect on PPD symptoms

A summary of the included observational studies can be found in Table 4 and 5.

3.3.1. Design of the observational studies

Two observational studies are included in this review, which were both conducted in Japan(27,28). Tsunoda et al. included 74.840 women in their study, who were enrolled through fetal records registered in the longitudinal Japan Environment and Children's Study, an ongoing national epidemiological study on children's health and environment(27). The second study included 1745 women with a mean age of 31.2±4.3years, with data from the Kyushu Okinawa Maternal and Child Health Study (KOMCHS).

Inclusion criteria were no difficulty for participating in the study (understanding Japanese language), singleton pregnancies and having an expected delivery date between first of August 2011 and mid 2014 (27), or women who recently became pregnant (28). No exclusion criteria were mentioned (27,28).

3.3.2. Measurements of the observational studies

Both studies used different measurement scales for the collection of data. Tsunoda et al.(27) used the Edinburgh Postnatal Depression Scale (EPDS) and the food frequency questionnaire (FFQ). The FFQ is a semi-quantitative tool that has been validated for use in epidemiologic studies and was used to collect data on dietary vitamin D intake during mid to late pregnancy (27.7±6.3 weeks of gestation), but only at one timepoint.

Miyake et al.(28) used a Japanese version of the Center for Epidemiologic Studies Depression Scale (CES-D) for the measurement of depressive symptoms at various timepoints between 5-39 weeks of gestation. To evaluate dietary intake of vitamin D, they used the Diet History Questionnaire (DHQ), which assesses the dietary habits of the preceding month.

3.3.3. Results of the observational studies

Tsunoda et al. divided vitamin D intake into five quintiles based on the intake questionnaires and used odds ratios for postpartum depressive symptoms, based on the intake of vitamin D.

The first quintile had a median vitamin D intake of 1.2µg/d, which contained 12.643 women with an EPDS score <9 and 2.321 women with an EPDS score ≥9. The adjusted OR was set at 1.00 for this group. The second quintile had a median vitamin D intake of 2.6µg/d, with 12.555 women with an EPDS score <9 and 1.967 women with an EPDS score ≥9, which gave an adjusted OR of 0.88 (95% confidence interval: 0.82-0.94). The third quintile had a median vitamin D intake of 3.9µg/d, with 13.813 women with an EPDS score <9 and 2.016 women with an EPDS score ≥9, which gave an adjusted OR of 0.83 (95% confidence interval: 0.78-0.89). The fourth quintile had a median vitamin D intake of 5.5µg/d, with 12.745 women with an EPDS score <9 and 1.966 women with an EPDS

score ≥9, which gave an adjusted OR of 0.87 (95% confidence interval: 0.81-0.93). The fifth quintile had a median vitamin D intake of 9.3µg/d, with 12.627 women with an EPDS score <9 and 2.187 women with an EPDS score ≥9, which gave an adjusted OR of 0.90 (95% confidence interval: 0.83-0.97).
This showed that the adjusted OR were lower from the second until the fifth quintile, with a P-value of 0.004, which means a significant association between vitamin D intake and postpartum depressive symptoms. Yet, there also seemed to be a dose-dependent risk reduction effect. *The adjusted odds ratio (aOR) was calculated after accounting for factors such as age, energy intake, pre-pregnancy body mass index, highest level of maternal education, annual household income, alcohol consumption, smoking status, morning sickness, physical activity, employment status, history of anxiety and depression, major congenital anomalies, time spent outdoors during pregnancy, study location, the season when the questionnaire was completed, and vitamin D supplementation use.*(27).

Miyake et al. used quartiles to divide the vitamin D intake of the 1745 pregnant women. They also used adjusted odds ratios for the risk of depressive postpartum symptoms based on vitamin D intake.
The first quartile had a median intake of 3.1µg/d, with 24.1% prevalence of depressive symptoms. An adjusted odds ratio of 1.00 was given to the first quartile. The second quartile had a median intake of 4.6µg/d, with 20.2% prevalence of depressive symptoms. The adjusted OR was 0.79 (95% confidence interval: 0.55-1.11). The third quartile had a median intake of 5.9µg/d, with 18.8% prevalence of depressive symptoms. The adjusted OR was 0.73 (95% confidence interval: 0.49-1.07). The fourth quartile had a median intake of 8.5µg/d, with 14.0% prevalence of depressive symptoms. The adjusted OR was 0.52 (95% confidence interval: 0.30-0.89). The adjusted odds ratios showed a significant reduction with increasing vitamin D intake (P-value 0.02), shown as an inverse linear trend. *The adjusted odds ratio (aOR) was adjusted for age, gestation, region of residence, number of children, family structure, history of depression, family history of depression, smoking, secondhand smoke exposure at home and at work, employment, household income, education, body mass index, intake of saturated fatty acids, and intake of eicosapentaenoic acid plus docosahexaenoic acid*(28).

3.3.4. Bias of the observational studies
Different sources of bias are present in these observational studies, as shown in Table 6.
First, FFQ has not yet been validated for use in pregnant women(27), and FFQ as well as DHQ can facilitate recall bias or measurement bias. Another source of measurement bias is found in Mikaye et al., since data was collected from 5 weeks until 39 weeks of gestation ((28). Tsunoda et al. shows risk for attrition bias due to missing data, and selection bias due to the exclusion of 30.000 women based on the inclusion criteria(27) and the absence of exclusion criteria.

3.4. Reviews

3.4.1. Design of the included reviews
We included two reviews: one systematic review(29) and one narrative review(30). Overall characteristics are visible in Table 7.

Gould et al (2022), searched PubMed until October 2021, for RCT's and observational studies regarding vitamin D in the antenatal or postpartum period and the effect on symptoms of postpartum depression(29). The narrative review of Ibrahim et al, evaluated vitamin D as well as

other nutrient supplementation to prevent perinatal depressive symptoms(30). PubMed, Scopus and USW Library were searched until the 1st of May 2023.

Both reviews applied predefined inclusion and exclusion criteria. The systematic review included studies that focused on vitamin D supplementation during the antenatal or postpartum period, as well as observational studies examining vitamin D (25OH) status, intake, or exposure, provided they also measured depressive symptoms (such as diagnosis, antidepressant treatment, or depression questionnaires). Excluded were animal studies and those not published in English. (29).
For the narrative review, they included peer reviewed analytical studies, original research published within the last 10-20 years in English with a quantitative research design to examine the relationship between perinatal depression and dietary intake, use of a researcher- or clinician- administered or self-report validated depression screening instrument or clinical diagnosis by a specialist, use of validated food frequency, food recalls, eating habits and behavior questionnaires. They excluded research with food insecurity, hormone levels, chemical analysis of nutrients or used nutritional biomarkers, women with comorbidities or already diagnosed with depression, letters to editors, abstracts and conference papers(30).

3.4.2. Outcomes of the included reviews
Gould et al. (29) included 21 studies, of which two RCT's and 20 observational studies (of which 1 study was included as both RCT and observational). The two RCT's(23,25) of Gould et al. are also included separately in this review, as well as one observational study(28).
Both trials showed a decrease in EPDS-scores in the vitamin D treatment groups compared to the control group. Observational studies were inconclusive, whereas one large case-control study found an increased likelihood of having postpartum depression when vitamin D status fell into one of the higher categories (>80nmol/L) and smaller case-control studies found more postpartum depression in women with a deficient vitamin D status. Among the other observational studies, seven identified a higher risk of depressive symptoms as vitamin D status declined, five found no significant association, one study reported contradictory results, and one cohort study noted both a negative association and no association, depending on when the outcome was measured.

As for Ibrahim et al. (30) 14 studies met the eligibility criteria, of which 8 RCT's, 3 cohort studies and 3 cross-sectional studies, concerning all nutrient supplements. Only 4 of these included vitamin D intakes. One RCT showed a significant association between dietary vitamin D intake and postpartum depressive symptoms(23), with significantly lower scores in het vitamin D group versus the control group. The other three included studies were observational studies, of which two studies showed an association between higher vitamin D intake and lower postpartum depressive symptoms, as well as depressive symptoms during pregnancy(27,28). One study showed no significant association between postpartum intake of vitamin D and postpartum depression.

3.4.3. Bias of the included reviews
As shown in **Table 8,** Gould et al (2017) will be excluded from further analysis, due to an overall high risk of bias, and due to the inclusion of Gould et al. (2022)(29). The highest risk of bias in these studies is the lack of bias control, since there is no mentioning of the used bias-tools, no written summary or table of the risks of bias in each study.

Ref.	Authors, year	Studied population	Period of study	Number of participants	Age (Mean with SD)	Inclusion Criteria	Exclusion criteria
(23)	Vaziri et al. 2016	Nulliparous as well as multiparous women who underwent prenatal care in Iran.	November 2014 until early October 2015.	136 (out of 169 included) finished the study	26.31 ± 4.59	Age >18, no history of mental illness and internal diseases, no addiction to narcotic drugs, a singleton live fetus, living with a husband, no pregnancy complications, no previous cesarean sections, gestational age of 26-28 weeks based on ultrasounds	Edinburgh postnatal depression scale at baseline > 13, refusing blood sample at beginning of the study, and < 8 weeks consumption of vitamin D3 supplements, no regular consumption.
(24)	Dabbaghmanesh et al., 2019	Nulliparous as well as multiparous females who underwent antenatal care Iran.	January 2014 to December 2015	98 (out of 120 included) finished the study	Intervention group: 26.04 ±5.07 Control group: 26.6 ±4.01	Age >18, no history of medical problems, no dependence on any types of narcotic substances or alcohol, no gestational complications, a singleton pregnancy with live fetus, and being at the week 26-28 of gestation	<8 weeks before consumption of vitamin D3 supplement
(25)	Amini S. et al., 2022	Clinic of Ahvaz Jundishapur University of Medical Sciences, Ahvaz, Iran.	June to September 2017	76 (out of 81 included) finished the study	28.35 ± 1.43	Age 18-45, scores of > 12 from the EDPS questionnaire, in the postpartum period ranging from 1-6 month and body mass index less than 35.	Sufficient vitamin D (serum value > 75nmol/L), birth abnormalities, taking contraceptives, endocrine disorders, previous history of depression, using antidepressants, serum calcium >2.65mmol/L, intake of vitamin D and calcium supplements during the last six months, having a history of chronic diseases.
(26)	Paoletti et al. 2013	Department of Obstetrics and Gynecology of the University of Cagliari, Italy	January 2009 until December 2011	552	Group A: 33.4 ± 4.8 Group B: 33.2 ± 4.9	Healthy puerperal women, 20-40years old, body mass index between 22-26, first full-term pregnancy, spontaneous delivery between 37-41weeks pregnancy with healthy babies.	Hemoglobin values <10.0g/dL after delivery, delivery by caesarean section, history of premenstrual dysphoric symptoms or affected by psychiatric illness, thyroid disease, drugs intake interfering with psychological status, family history of psychiatric disorders

Table 1. Descriptions of the randomized controlled trial studies and participants within studies included in this systematic review.

Ref.	Intervention	Control	Duration of supplementation	Depression-scale	Conclusion
(23)	2000 IU of vitamin D3 daily	Placebo	Week 26-28 of gestation until birth	The Edinburgh postnatal depression scale (Iranian version, interview)	The vitamin D group had statistically significant higher 25-hydroxyvitamin D concentrations at childbirth and a significant higher reduction of depression scores at 38-40weeks ($p=0.01$), 4 weeks ($p<0.01$) and 8 weeks ($p<0.01$) postpartum than the control group.
(24)	2000 IU of vitamin D3 daily	Placebo	Week 26-28 of gestation until birth	The Edinburgh postnatal depression scale	Significant lower depression scores at 4th week postpartum in the vitamin D group ($p=0.002$)
(25)	50.000 IU vitamin D3 fortnightly + 500 mg calcium daily	1) 50.000 IU vitamin D3 fortnightly + placebo of calcium daily 2) placebo of vitamin D3 fortnightly + placebo of calcium daily	8 weeks during the postpartum period, exact timing of supplementation not mentioned	The Iranian Edinburgh postnatal depression scale	Vitamin D supplements could reduce the score of postpartum depression. This was significant between the three groups. A 25% reduction was seen in the vitamin D + placebo calcium group. The reduction was higher in vitamin D alone (-4.16, $p=0.004$), compared to vitamin D + calcium (-1.70, $p=0.042$). The difference between both groups was significant ($p=0.008$)
(26)	vitamin D3 (400IU) + calcium (500mg) daily	Elevit vitamins	1 month postpartum: supplementation started on day 3 after delivery, with measurements at 15 days and 30 days after delivery.	The Edinburgh postnatal depression scale	An increase was seen in hematological parameters at 15 and 30 days postpartum, significantly, without difference between the two groups. A significant decrease in EPDS score was seen at day 15 and 30 postpartum for all groups at visit 2 and 3 in comparison to visit 1, with a significant larger decrease in group A than B (p-value <0.05). This was also seen for women with a basal EPDS score <12 and >/=12.

Table 2. Descriptions of the intervention versus control group, depression-scale and conclusion of each randomized controlled trial study included in this systematic review.

Ref.	Domain 1	Domain 2	Domain 3	Domain 4	Domain 5	Overall bias
(23)	!	+	-	!	-	!
(24)	!	!	+	-	-	!
(25)	-	-	!	-	-	-
(26)	+	+	+	+/-	-	!

Table 3. The risk of bias assessment for the randomized controlled trial studies included within this systematic review, using the Cochrane risk-of-bias tool (14). Domain 1 – bias arising from the randomization process; Domain 2 – bias due to deviations from intended interventions; Domain 3 – bias due to missing outcome data; Domain 4 – Bias in measurement of the outcome; Domain 5 – bias in selection of the reported result.
'+': high risk of bias; '!': some concerns in risk of bias; '- ': low risk of bias.

Ref.	Authors, year	Studied population	Period of study	Number of participants	Age (Mean with SD)	Inclusion Criteria	Exclusion criteria
(27)	Tsunoda K. et al 2023	15 regions in Japan	January 2011 until March 2014	74.840	/	Living in the study areas at the time of recruitment and expecting to live uninterrupted in Japan for the near future, an expected delivery date between 1 August 2011 and mid 2014, being proficient in the Japanese language. Singleton pregnancies.	Non-residents of the study areas.
(28)	Miyake Y. et al 2015	Pregnant women who lived in one of seven provinces in southern Japan or in Okinawa province.	April 2007 and March 2008	1745	31.2±4.3	Women who have recently become pregnant and lived in one of seven provinces in southern Japan or in Okinawa province (31).	No exclusion criteria mentioned.

Table 4. Descriptions of general characteristics of the observational studies and cohort studies included within this systematic review.

Ref.	Study design	Depression-scale	Conclusion
(27)	Assessment of vitamin D intake with the Food Frequency Questionnaire, during mid-late pregnancy (27.7±6.3weeks). Assessment of postpartum depression symptoms with the EPDS at 1 month after delivery. Vitamin D intake was divided into 5 quintiles. Logistic regression was used to calculate odd ratios.	The Edinburgh Postnatal Depression Scale	Dietary vitamin D intake during pregnancy was associated with a significant reduction of postpartum depressive symptoms 1 month after delivery (p-value 0.004). A dose-dependent risk reduction effect was seen, with the lowest risk of postpartum depressive symptoms in the third quintile (0.83 OR (0.78-0.89)). This suggests an inverted J-shape relation between vitamin D intake and the odds ratio for PPD. The highest group of vitamin D intake also had the highest intake of calcium. Further research concerning calcium intake may be required.
(28)	Diet History Questionnaire (DHQ) for assessing the dietary habits during the preceding months, taken at different points between week 5 and 39 of pregnancy.	A Japanese version of the Center for Epidemiologic Studies Depression Scale (CES-D)	Higher vitamin D intake was independently associated with a lower prevalence of depressive symptoms during pregnancy (p-value OR trend 0.02), with an OR of 0.52 for an intake of 8.5µg/d (340IU) compared to an OR of 1.0 for an intake of 3.1µg/d (124IU).

Table 5. Descriptions of the used measurements, depression-scale and conclusion of the observational studies and cohort studies included within this systematic review

Ref.	Domain 1	Domain 2	Domain 3	Domain 4	Domain 5	Domain 6	Domain 7	Overall bias
(27)	!	!	!	!	!	-	-	!
(28)	!	!	!	!	-	-	-	!

Table 6. The risk of bias assessment for the included observational and cohort studies within this systematic review, using the Risk of Bias in Non-randomized Studies– of Exposure tool (ROBINS-E) ((17) *for studies* (23) *and* (24)*.*

Domain 1 – bias due to confounding; Domain 2 – bias arising from measurement of the exposure; Domain 3 – bias in selection of participants into the study (or into the analysis); Domain 4 – Bias due to post-exposure interventions; Domain 5 – bias due to missing data; Domain 6 – Bias arising from measurement of the outcome; Domain 7 – Bias in selection of the reported result.

'+': high risk of bias; '!': some concerns in risk of bias; '- ': low risk of bias.

Ref.	Authors, year	Database, included articles	Period of study	Inclusion Criteria	Exclusion criteria	Conclusion
(29)	Gould FJ et al. (2022)	PubMed, 2 randomized controlled trials, 20 observational studies.	Included articles until October 2021	Trials of vitamin D supplementation during the antenatal or postpartum period. Observational studies of vitamin D (25OH) status, vitamin D intake or vitamin D exposure and with measurement measure of depressive symptoms (diagnosis, treatment with antidepressants or questionnaires measuring depressive symptoms).	Studies in other languages than English or executed on animals.	Randomized controlled trials showed a decrease in depressive symptoms with vitamin D intake. Observational studies were inconclusive, where some studies detected an inverse relation between vitamin D and depressive symptoms and other studies detected no association at all (no results of relevance for our aim).
(30)	Ibrahim Aly HJ. et al (2023)	PubMed, Scopus and USW Library. Included 14 studies, of which 2 RCT's of importance to our scope.	Included articles until May 2023	Peer reviewed analytical studies, original research published within the last 10-20years in English with a quantitative research design to examine the relationship between perinatal depression and dietary intake, use of a researcher- or clinician-administered or self-report validated depression screening instrument or clinical diagnosis by a specialist, use of validated food frequency, food recalls, eating habits and behavior questionnaires.	Research with food insecurity, hormone levels, chemical analysis of nutrients of used nutritional biomarkers, already diagnosed with depression or comorbidities, letters to editors, abstracts, conference papers.	2 studies included showed evidence in favor of the utilization of vitamin D supplements. The consumption of >2800IU of vitamin D daily for a minimum of 8 weeks is highly likely to be successful. Vaziri et al. Observed a higher intake of calcium in the group with highest vitamin D intake, further investigation for dietary intake might be necessary.
(32)	Gould 2017	Cochrane not specifically mentioned. For the part of vitamin D: 7 observational studies.	Not mentioned	No inclusion criteria mentioned	No exclusion criteria mentioned	Two cohort studies reported associations between postpartum depression and low maternal serum vitamin D in mid-pregnancy, one cohort study reported an association shortly after birth and one vitamin D intervention trial found an association between low maternal serum vitamin D and postpartum depressive symptoms from 4-6 weeks to seven months postpartum. One cohort study and the two largest studies showed no association.

Table 7. Descriptions of general characteristics of the reviews included within this systematic review.

Ref.	Domain 1	Domain 2	Domain 3	Domain 4	Overall bias
(29)	-	+	+	-	!
(30)	-	-	+	-	!
(32)	+	+	+	+	+

Table 8. The risk of bias assessment for the included systematic reviews within this systematic review, using The Risk of Bias in Systematic Reviews tool (ROBIS)(22).

Domain 1 – bias in study eligibility criteria; Domain 2 – bias in identification and selection of studies; Domain 3 – bias in data collection and study appraisal; Domain 4 – Bias in synthesis and findings;

'+': high risk of bias; '!': some concerns in risk of bias; '- ': low risk of bias.

DISCUSSION

In this review, we investigated the effects of vitamin D intake on post-partum depressive symptoms. The evidence we found was of relatively poor quality and rather indecisive. Three out of four included RCT's showed beneficial effects of vitamin D supplementation for depressive symptoms, with significant results (23–25). In contrast to these results, the RCT of Paoletti et al. showed a significant reduction in EPDS scores for both the vitamin D groups, as well as the control group (with Elevit vitamins), yet a higher reduction was seen for the control group (26).
The observational studies showed a dose-dependent result, with lower adjusted odds ratios for postpartum depressive symptoms with higher vitamin D intake. However, both studies had different cut-offs, which makes it difficult to find the right cut-off for beneficial effects of vitamin D intake(27,28).

The reviews were also indecisive. The observational studies of Gould et al.(29) were inconclusive, where some studies detected an inverse relation between vitamin D and depressive symptoms while other studies detected no association at all. Anyhow, these association studies are of no relevance to our aim. The narrative review (30) showed two included studies with evidence in favor of the utilization of vitamin D supplements. The consumption of >2800IU of vitamin D daily for a minimum of 8 weeks is highly likely to be successful. Another study from this review observed a higher intake of calcium in the group with highest vitamin D intake, which may mean that further investigation for dietary intake might be necessary. Overall, we can say that most of our included studies do show a positive effect of vitamin D intake on postpartum depression symptoms.

Our findings are consistent with the current literature. Lots of studies are trying to show the association between vitamin D and depression, by measuring serum levels of vitamin D. Some find positive associations, where a higher risk for depression is seen with lower serum levels of vitamin D (33–35), but other studies find indecisive results, or no association(36–38). Anyhow, there are not enough interventional or observational trials to determine the real effect of vitamin D intake on depressive symptoms, hence the results stay indecisive (33,39–43). Most of the studies examine depressive disorders, but the number of studies that examine postpartum depressive disorders are lacking(12,36–38,44).
At this moment, guidelines about routine screening and supplementation for vitamin D during pregnancy are inconsistent. The WHO recommends a daily supplementation for women during pregnancy and lactation from 400 IU – 800 IU daily depending on the individual's risk of deficiency (45). Unlike the WHO, The American College of Obstetricians and Gynecologists does not recommend routine screening and supplementation of vitamin D in pregnant women. However, they published that for pregnant women thought to be at increased risk of vitamin D deficiency, maternal serum25-OH-D levels can be measured and should be interpreted in the context of the individual clinical circumstance (46). Based on these highly regarded sources, even though the quality of evidence is moderate to low, we dare cautiously to make a weak recommendation (GRADE 2B) that healthcare providers should consider screening for vitamin D levels in prenatal, pregnant and postpartum women, especially those at higher risk for PPD, since lower levels of vitamin D should be supplemented for their own health benefits, as well as the health benefits for the fetus. This supplementation should be tailored to individual needs, considering dietary intake, sun exposure and baseline vitamin D levels. Experts agree that supplemental vitamin D is safe in dosages of 1000-2000 IU per day during pregnancy and lactation (46). Moreover, vitamin D supplementation should not be viewed as a standalone treatment for PPD. A holistic approach that includes psychosocial support, therapy, and, if necessary, pharmacological interventions is essential.

Our included studies showed quite a few limitations, such as small sample size, short period of intervention, inappropriate exposure or outcome measures, lack of adjustment for confounders, particularly seasonal. As mentioned above, the included studies all showed different forms of bias, most common recall bias by using the FFQ/DHQ(27,28), attrition bias due to the missing data(27) and performance bias due to the lack of blinding in RCT's(23). The reviews mentioned no use of bias tools(29,30). However, the overall quality of the included studies is acceptable, and therefore a positive effect of vitamin D on postpartum depressive symptoms may be present. Further research is still needed, with a preference of RCT's with higher power and better bias control.

CONCLUSION

The link between vitamin D intake and postpartum depression (PPD) is still a complex and developing field of study. More high-quality research is needed to clarify whether vitamin D plays a role in preventing or treating depression during the postpartum period.

REFERENCES

1. Hahn-Holbrook J, Cornwell-Hinrichs T, Anaya I. Economic and Health Predictors of National Postpartum Depression Prevalence: A Systematic Review, Meta-analysis, and Meta-Regression of 291 Studies from 56 Countries. Vol. 8, Frontiers in Psychiatry. Frontiers Media S.A.; 2018.

2. Langan RC, Goodbred AJ. Identification and Management of Peripartum Depression. Vol. 93. 2016.

3. Smith-Nielsen J, Matthey S, Lange T, Væver MS. Validation of the Edinburgh Postnatal Depression Scale against both DSM-5 and ICD-10 diagnostic criteria for depression. BMC Psychiatry. 2018 Dec 20;18(1).

4. Kroska EB, Stowe ZN. Postpartum Depression: Identification and Treatment in the Clinic Setting. Vol. 47, Obstetrics and Gynecology Clinics of North America. W.B. Saunders; 2020. p. 409–19.

5. Field T. Prenatal Depression Risk Factors, Developmental Effects and Interventions: A Review. J Pregnancy Child Health. 2017;04(01).

6. Goodman JH. Perinatal depression and infant mental health. Arch Psychiatr Nurs. 2019 Jun 1;33(3):217–24.

7. Oliveira TA, Luzetti GGCM, Rosalém MMA, Mariani Neto C. Screening of Perinatal Depression Using the Edinburgh Postpartum Depression Scale. Revista Brasileira de Ginecologia e Obstetricia. 2022;44(5):452–7.

8. Field T. Prenatal Depression Risk Factors, Developmental Effects and Interventions: A Review. J Pregnancy Child Health. 2017;04(01).

9. Silverman ME, Reichenberg A, Savitz DA, Cnattingius S, Lichtenstein P, Hultman CM, et al. The risk factors for postpartum depression: A population-based study. Depress Anxiety. 2017 Feb 1;34(2):178–87.

10. Frieder A, Fersh M, Hainline R, Deligiannidis KM. Pharmacotherapy of Postpartum Depression: Current Approaches and Novel Drug Development. Vol. 33, CNS Drugs. Springer International Publishing; 2019. p. 265–82.

11. Cuijpers P, Karyotaki E. The effects of psychological treatment of perinatal depression: an overview. Vol. 24, Archives of Women's Mental Health. Springer; 2021. p. 801–6.

12. Brown JVE, Wilson CA, Ayre K, Robertson L, South E, Molyneaux E, et al. Antidepressant treatment for postnatal depression. Vol. 2021, Cochrane Database of Systematic Reviews. John Wiley and Sons Ltd; 2021.

13. Nakamura A, van der Waerden J, Melchior M, Bolze C, El-Khoury F, Pryor L. Physical activity during pregnancy and postpartum depression: Systematic review and meta-analysis. Vol. 246, Journal of Affective Disorders. Elsevier B.V.; 2019. p. 29–41.

14. Sparling TM, Henschke N, Nesbitt RC, Gabrysch S. The role of diet and nutritional supplementation in perinatal depression: a systematic

review. Vol. 13, Maternal and Child Nutrition. Blackwell Publishing Ltd; 2017.

15. Eyles DW, Smith S, Kinobe R, Hewison M, McGrath JJ. Distribution of the Vitamin D receptor and 1α-hydroxylase in human brain. J Chem Neuroanat. 2005 Jan;29(1):21–30.

16. Raedler TJ. Inflammatory mechanisms in major depressive disorder. Vol. 24, Current Opinion in Psychiatry. 2011. p. 519–25.

17. Guillot X, Semerano L, Saidenberg-Kermanac'h N, Falgarone G, Boissier MC. Vitamin D and inflammation. Vol. 77, Joint Bone Spine. 2010. p. 552–7.

18. Amini S, Jafarirad S, Amani R. Postpartum depression and vitamin D: A systematic review. Vol. 59, Critical Reviews in Food Science and Nutrition. Taylor and Francis Inc.; 2019. p. 1514–20.

19. Aghajafari F, Letourneau N, Mahinpey N, Cosic N, Giesbrecht G. Vitamin D deficiency and antenatal and postpartum depression: A systematic review. Vol. 10, Nutrients. MDPI AG; 2018.

20. Sterne JAC, Savović J, Page MJ, Elbers RG, Blencowe NS, Boutron I, et al. RoB 2: A revised tool for assessing risk of bias in randomised trials. The BMJ. 2019;366.

21. Higgins J, Morgan R, Rooney A, Taylor K, Thayer K, Silva R, et al. Risk of Bias in Non-randomized Studies-of Exposure (ROBINS-E). Version [Internet]. 2023. Available from: https://www.riskofbias.info/welcome/robins-e-tool.

22. Whiting P, Savović J, Higgins JPT, Caldwell DM, Reeves BC, Shea B, et al. ROBIS: A new tool to assess risk of bias in systematic reviews was developed. J Clin Epidemiol. 2016 Jan 1;69:225–34.

23. Vaziri F, Nasiri S, Tavana Z, Dabbaghmanesh MH, Sharif F, Jafari P. A randomized controlled trial of vitamin D supplementation on perinatal depression: In Iranian pregnant mothers. BMC Pregnancy Childbirth. 2016 Aug 20;16(1).

24. Dabbaghmanesh MH, Vaziri F, Najib F, Nasiri S, Pourahmad S. The effect of vitamin D consumption during pregnancy on maternal thyroid function and depression: A randomized, placebo-controlled, clinical trial. Jundishapur J Nat Pharm Prod. 2019 May 1;14(2).

25. Amini S, Amani R, Jafarirad S, Cheraghian B, Sayyah M, Hemmati AA. The effect of vitamin D and calcium supplementation on inflammatory biomarkers, estradiol levels and severity of symptoms in women with postpartum depression: a randomized double-blind clinical trial. Nutr Neurosci. 2022;25(1):22–32.

26. Paoletti AM, Orrù MM, Marotto MF, Pilloni M, Zedda P, Fais MF, et al. Observational study on the efficacy of the supplementation with a

preparation with several minerals and vitamins in improving mood and behaviour of healthy puerperal women. Gynecol Endocrinol. 2013 Aug;29(8):779–83.

27. Tsunoda K, Hamazaki K, Matsumura K, Kasamatsu H, Tsuchida A, Inadera H. Dietary Intake of Vitamin D during Pregnancy and the Risk of Postpartum Depressive Symptoms: The Japan Environment and Children's Study. J Nutr Sci Vitaminol (Tokyo). 2023;69(1):14–20.

28. Miyake Y, Tanaka K, Okubo H, Sasaki S, Arakawa M. Dietary vitamin D intake and prevalence of depressive symptoms during pregnancy in Japan. Nutrition. 2015;31(1):160–5.

29. Gould JF, Gibson RA, Green TJ, Makrides M. A Systematic Review of Vitamin D during Pregnancy and Postnatally and Symptoms of Depression in the Antenatal and Postpartum Period from Randomized Controlled Trials and Observational Studies. Nutrients. 2022 Jun 1;14(11).

30. Ibrahim Aly HA, J. New K. The Role of Nutrient Supplementation to Prevent Perinatal Depression. A Narrative Review. J Psychiatry Psychiatr Disord. 2023;07(06).

31. Miyake Y, Tanaka K, Okubo H, Sasaki S, Arakawa M. Fish and fat intake and prevalence of depressive symptoms during pregnancy in Japan: Baseline data from the Kyushu Okinawa Maternal and Child Health Study. J Psychiatr Res. 2013;47(5):572–8.

32. Gould JF, Best K, Makrides M. Perinatal nutrition interventions and post-partum depressive symptoms. J Affect Disord. 2017 Dec 15; 224:2–9.

33. Musazadeh V, Keramati M, Ghalichi F, Kavyani Z, Ghoreishi Z, Alras KA, et al. Vitamin D protects against depression: Evidence from an umbrella meta-analysis on interventional and observational meta-analyses. Vol. 187, Pharmacological Research. Academic Press; 2023.

34. Anglin RES, Samaan Z, Walter SD, Sarah DM. Vitamin D deficiency and depression in adults: Systematic review and meta-analysis. Vol. 202, British Journal of Psychiatry. 2013. p. 100–7.

35. Ju SY, Lee YJ, Jeong SN. SERUM 25-HYDROXYVITAMIN D LEVELS AND THE RISK OF DEPRESSION: A SYSTEMATIC REVIEW AND META-ANALYSIS. Vol. 17, The Journal of Nutrition. 2013.

36. Gould JF, Anderson AJ, Yelland LN, Smithers LG, Skeaff CM, Gibson RA, et al. Association of cord blood Vitamin D at delivery with postpartum depression in Australian women. Australian and New Zealand Journal of Obstetrics and Gynaecology. 2015 Oct 1;55(5):446–52.

37. Nielsen NO, Strøm M, Boyd HA, Andersen EW, Wohlfahrt J, Lundqvist M, et al. Vitamin D status during pregnancy and the risk of subsequent

postpartum depression: A case-control study. PLoS One. 2013 Nov 27;8(11).

38. Tan Q, Liu S, Chen D. Poor vitamin D status and the risk of maternal depression: A dose-response meta-analysis of observational studies. Vol. 24, Public Health Nutrition. Cambridge University Press; 2021. p. 2161–70.

39. Spedding S. Vitamin D and depression: A systematic review and meta-analysis comparing studies with and without biological flaws. Vol. 6, Nutrients. MDPI AG; 2014. p. 1501–18.

40. Gowda U, Mutowo MP, Smith BJ, Wluka AE, Renzaho AMN. Vitamin D supplementation to reduce depression in adults: Meta-analysis of randomized controlled trials. Vol. 31, Nutrition. Elsevier Inc.; 2015. p. 421–9.

41. Cheng YC, Huang YC, Huang WL. The effect of vitamin D supplement on negative emotions: A systematic review and meta-analysis. Depress Anxiety. 2020 Jun 1;37(6):549–64.

42. Li G, Mbuagbaw L, Samaan Z, Falavigna M, Zhang S, Adachi JD, et al. Efficacy of vitamin D supplementation in depression in adults: A systematic review. Vol. 99, Journal of Clinical Endocrinology and Metabolism. Endocrine Society; 2014. p. 757–67.

43. Hernández-Viadel M. Efficacy of vitamin D in the treatment of depression: a systematic review and meta-analysis. Actas Esp Psiquiatr. 2021;49(1):12–23.

44. Wang J, Liu N, Sun W, Chen D, Zhao J, Zhang W. Association between vitamin D deficiency and antepartum and postpartum depression: a systematic review and meta-analysis of longitudinal studies. Vol. 298, Archives of Gynecology and Obstetrics. Springer Verlag; 2018. p. 1045–59.

45. Hoge Gezondheidsraad [Internet]. 2016. Available from: www.hgr-css.be

46. Vitamin D Screening and Supplementation During Pregnancy.