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Management of Maternal Nutrition and Dietary Habits to Prevent Pre-Eclampsia in High-Risk Pregnant Women: A Systematic Review

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ABSTRACT

Background. Numerous correlational studies suggest a significant relationship between nutrition, dietary patterns, and the incidence of hypertension in pregnancy or preeclampsia. Accordingly, there has been a rise in intervention studies aimed at reducing the risk of preeclampsia. However, the growing number of intervention studies and reviews has yet to establish the most reliable and effective approaches with certainty.

Aim. This systematic review aims to evaluate nutritional interventions and dietary habits in pregnant women for the prevention of preeclampsia.

Metode. The search utilized databases including PubMed, Embase, Cochrane Library, and Wiley Online Library. Each study relevant to the topic was assessed for bias by an independent researcher. The included studies focused on dietary interventions, nutrition education, and eating behavior education.

Results. Thirteen studies were deemed eligible and were then reviewed narratively. In general, these studies analyzed the effectiveness of nutritional interventions such as the restriction of trans fatty acids (TFAs) or those that can increase high-density lipoprotein (HDL) sourced from animal (fish oil) and vegetable oils (olive oil, palm oil, etc.), as well as the restriction of salt and sugar intake. Education, consultation, and monitoring of nutritional needs during pregnancy in all analyzed studies showed very satisfactory results.

Conclusion. During pregnancy, it is crucial for mothers to pay full attention to proper food intake. Therefore, strict monitoring and increased maternal knowledge of the risk of preeclampsia are necessary.

Keywords: Diet, Food, Nutrition; Hypertension, Gestational weight; Pre-eclampsia

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1. INTRODUCTION

Gestational hypertension (GH) and preeclampsia (PE) are the most common hypertensive disorders of pregnancy [1–3]. GH is a significant cause of maternal mortality worldwide, with an average incidence rate of 6.3% [4,5]. PE increases the risk of perinatal mortality and accounts for approximately 15% of preterm births and 10% of stillbirths [6–10]. GH is defined as an increase in systolic blood pressure (SBP) to ≥140 mmHg and/or diastolic blood pressure (DBP) to ≥90 mmHg detected after 20 weeks of gestation, while PE is defined by the combination of GH and proteinuria (protein output ≥300 mg every 24 hours) [11–17].

Although the etiology of gestational hypertension and preeclampsia remains largely unclear, evidence suggests that diet may play a role [18–21]. Hypertensive disorders in pregnancy (HDP) are characterized by metabolic disorders similar to those found in cardiovascular disease [22–25] and type 2 diabetes mellitus (T2DM), including endothelial dysfunction,

inflammation, oxidative stress, insulin resistance, and dyslipidemia [22–25]. Diet is a well-known risk factor for cardiovascular disease and T2DM [28]. Additionally, serum nutrient levels (such as increased polyunsaturated fatty acids and decreased vitamins C and E, zinc, and iron) are associated with increased inflammation, oxidative stress, and dyslipidemia [29,30]. Nutritional status is directly associated with an increased risk of preeclampsia, including elevated serum triglycerides and fatty acids, and decreased levels of serum calcium, vitamin D, magnesium, and zinc [29]. Intervention trials have examined the effects of single nutrient supplementation in pregnant women on HDP risk, and recently, several systematic reviews and meta-analyses have synthesized the results [31,32].

Researchers have shown that diet is associated with hypertensive disorders in pregnancy (HDP). For example, a cohort study found that higher consumption of saturated fat in the first trimester and lower intake of manganese, vitamins C and E, fiber, and carbohydrates in the third trimester increased the risk of preeclampsia (PE). Additionally, a case-control study reported an inverse association between adherence to the Dietary Approaches to Stop Hypertension (DASH) diet and the risk of PE. Randomized controlled trials (RCTs) have demonstrated that gestational hypertension (GH) and PE can be effectively controlled with nutritional interventions during pregnancy [31,33,34]. However, some RCTs did not find these interventions effective for GH or PE [35].

A systematic review summarized the correlation between nutrient intake and the incidence of gestational hypertension (GH) and/or preeclampsia (PE) in observational studies, concluding that greater energy intake, along with lower magnesium and calcium intake during pregnancy, is closely associated with the incidence of hypertensive disorders of pregnancy (HDP) [36–39]. Moreover, higher consumption of fish, whole grains, legumes, vegetables, and fruits is linked to a reduced risk of HDP [40]. This systematic review aims to evaluate nutritional interventions and dietary habits of pregnant women to prevent preeclampsia during pregnancy.

2. METHOD

Review Protocol

This systematic review was conducted through systematic steps based on the PRISMA Statement [41], which included developing research questions using PICO, searching for relevant articles, assessing article eligibility, extracting data, assessing quality, documenting results, and summarizing results in a narrative analysis. This review evaluates nutritional interventions and dietary habits of pregnant women in order to prevent the incidence of preeclampsia.

The participant, intervention, comparator, outcome, and study design (PICOS) criteria outlined in Table 1 were used to select studies for inclusion in this review.

Table 1. PICOS statement

Criteria	Statement
Problem	Preeclampsia, Hypertension
Intervention	Nutrition Based, Nutrition Education, Counseling
Comparisons	Placebo, usual care
Outcomes	Weight, lipid profile, dietary pattern
Study Design	Experimental

Literature Search

This systematic review was reported with a prospective protocol in accordance with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) and PICO guidelines. Databases used included Cochrane, Pubmed, Embase, and Wiley online library. In the first step of the electronic search, we selected RCTs related to the following search terms found in the title, abstract, or keywords: (["nutrition*education" OR "intervention*nutrition" OR "intervention*education" OR "counseling*nutrition"] AND ["Pre-Eclampsia" OR "Hypertension, caused by pregnancy" OR "Gestational Hypertension"]). Then, the reference lists of eligible RCTs were searched to find other studies not found in the electronic search, which reported the effect of nutritional interventions on GH or/and PE. At the next stage, the full texts of the selected papers were assessed for compliance with the inclusion criteria and reporting the effects of dietary interventions on GH or/and PE, compared with control or placebo interventions.

Eligibility

The target population for this search included pregnant women regularly visiting healthcare facilities or residing in the community. The inclusion criteria for the database search were: (a) Experimental studies meeting the specified keywords and terms, (b) Availability of full-text articles, (c) Original articles, and (d) Articles written in English. Exclusion criteria were based on: (a) Case study articles, (b) Review articles with an odd narrative ratio (OR), (c) Articles not peer-reviewed or published as theses, and (d) Articles focusing on outcomes unrelated to the risk of preeclampsia events. Abstracts of

identified articles were screened against these criteria, and full-text articles meeting eligibility were included in the qualitative synthesis.

Data Extraction

The researcher independently extracted information for each article into a spreadsheet. The data was organized by (a) Number (b) Author, Title, and Journal (c) Method (e) Intervention (f) Participants (g) outcomes, and (h) Main findings.

Risk of Bias

The risk of bias of each study was assessed using the RoB2 tool [42]. This instrument assesses each study into five assessment domains consisting of Risk of bias arising from the randomization process, Risk of bias due to deviation from the intended intervention, Missing outcome data, Risk of bias in outcome measurement, and Risk of bias in the selection of reported outcomes. The decision for each domain consists of several options including High, Low, Some concerns, and No information.

3. RESULT

From the four databases used, a total of 610 articles were collected. After removing duplicates and those deemed ineligible by title, 322 articles remained. During the screening process, after reviewing detailed titles and abstracts, 289 articles were excluded, leaving 33 studies. Ultimately, only 13 studies met the eligibility criteria for inclusion in this review.

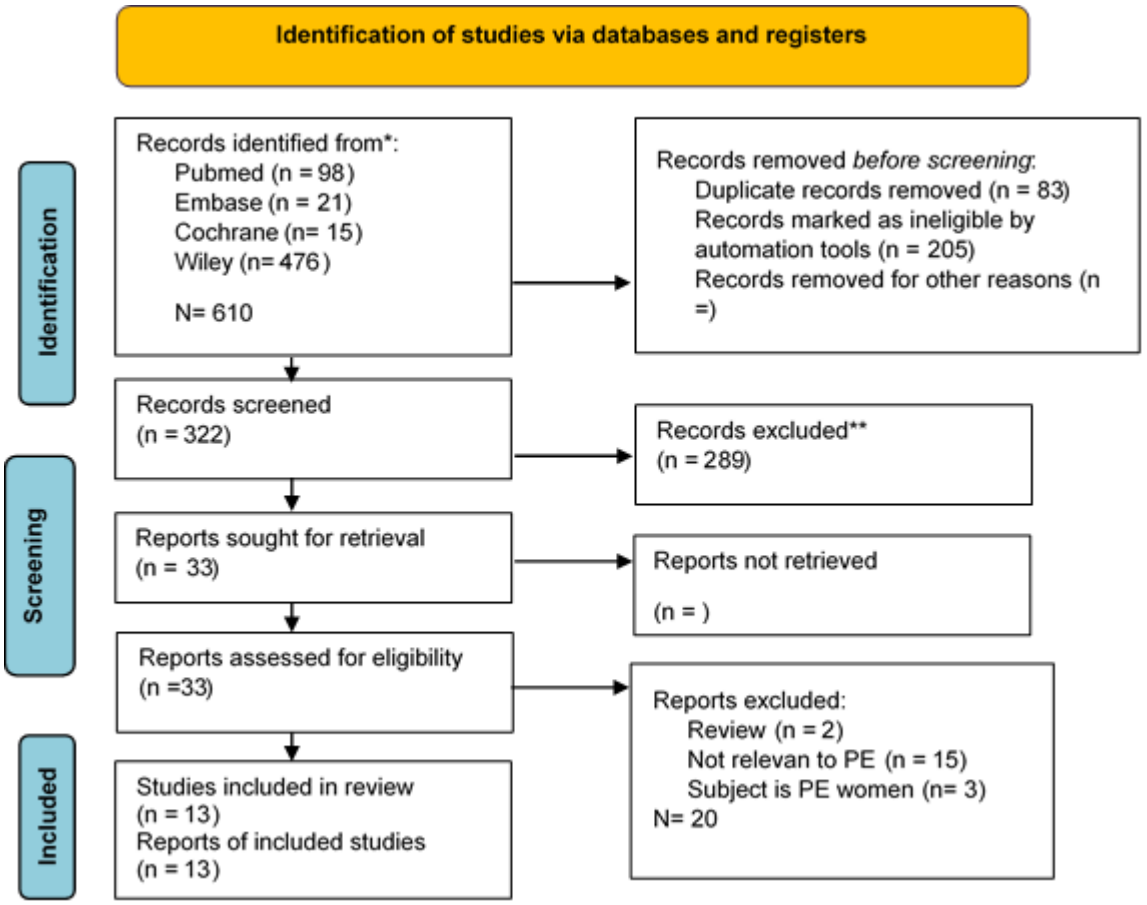


Table. Data extraction from eligible studies

Author, Country	Study design	Participants	Interventions	Outcome	Main Findings
[43], Iran	RCT	IG= 393 CG= 407	**IG:** individualized dietary patterns with TFA content <1% of total daily energy intake. **CG:** individualized dietary patterns without any focus on TFA content.	BP BMI Proteinuria	- There was decreased of PE risk about 50% in IG. - Incidence of PE in IG: 6%, and CG: 11%
[44], Malaysia	RCT	IG= 151 CG= 148	**IG:** palm oil vitamin E capsules **PG:** was prescribed super olein capsules	PE incidence	Palm oil in the form of TRF reduced the incidence of PE (p=0.052)
[45], Belgium	RCT	AG= 42 PG= 37 CG= 43	**PG:** a brochure designed for the purpose **AG:** brochure plus guided intensively by a nutritionist **CG:** lifestyle intervention	GWG BP	Both lifestyle interventions improved the nutritional habits of obese women during pregnancy.
[46]	quasi-experimental	IG= 30 CG= 30	Health promotion: taking rest, dietary salt restriction, calcium supplementation, and vitamin D supplementation	- Knowledge - Dietary practice	Knowledge, and dietary practice Significantly improved.
[47], Norway	RCT	IG: 127 CG: 142	**IG:** fatty fish, vegetable oils, especially olive oil and rapeseed oil, nuts, nut butters, margarine based on olive- or rapeseed oil, and avocado to replace meat, butter, cream, and fatty dairy products **CG:** Usual diet based on Norwegian foodstuffs	- Cholesterol level	- Total and low-density lipoprotein cholesterol levels were lowered in the IG (P < .01)
[48], Iran	RCT	IG= 53 CG= 53	**IG:** - 2-h individualized motivational interview - Counseling sessions with a nutritionist in the 15–20 weeks and 20–24 weeks of pregnancy **CG:** - Routine prenatal care	PE incidene	Significant decrease in edema (20.4% and 47.3%), proteinuria (5.6% and 30.9%), BP =140/90 mmHg (3.7% and 14.5%), and preeclampsia (1.9% and 12%) n IG
[49], US	RCT	NW: IG= 90 CG= 92 OW/OB IG= 81 CG= 86	**IG:** Standard care + behavioral lifestyle (face-to-face visit; Automated postcards that prompted healthy eating, 3 brief supportive phone calls from the dietitian and exercise habits were mailed weekly) **CG:** Standard care	GWG	- The behavioral intervention reduced GWG in NW and OW/OB (P=0.02)
[50], US	RCT	IG= 116 CG= 116	**IG:** prescribed a balanced nutritional regimen and were asked to record in a diary all of the foods eaten during each day (monitored) **CG:** conventional prenatal dietary management (unmonitored)	GWG	- There were statistically significant differences in the groups maternal last weight before delivery (p < .001)

[51], Australia	RCT	IG= 1197 CG= 1202	**IG:** three 500-mg capsules of DHA-rich fish oil concentrate daily, providing 800 mg DHA (Incromega 500TG; Croda Chemicals), **CG:** were asked to take three 500-mg vegetable oil capsules without DHA	PE incidence	- DHA supplementation of 800 mg/d in the second half of pregnancy does not reduce the risk of preeclampsia
[52], Brazil	RCT	IG= 33 CG= 35	**IG:** DASH **CG:** Standard diet	PE incidence BP Lipid level	- PE incidence was 22·9 % in the CG and 12·1 % in the IG (P =0·25)
[53], Spain	RCT	IG= 143 CG= 142	**IG:** MedDiet, supplemented with ExtraVirgin Olive Oil/pistachios **CG:** Standard diet (Limit fat intake	BG BP	- The GDM rate was lower in IG: p = 0.021, than in CG
[54], Korea	RCT	IG= 98 CG= 44	**IG:** Nutrition Education off and online, phone call (diet guideline; practicing method of low-salt and low-sugar diet) **CG**: 2 times (1st, 4th) offline education	BP Knowledge Eating habits	- Reduction on sodium and sugar intake (p<.05)
[55], Denmark	RCT	IG= 23 CG= 27	**IG:** 10 consultations of 1 h each; eat a healthy diet according to the official Danish dietary recommendations **CG:** no consultations; no restrictions on energy intake or gestational weight gain	BG BP Anthropometry GWG	- Reduced on GWG (p=0.002) - Reduced on BG (p= 0.04)

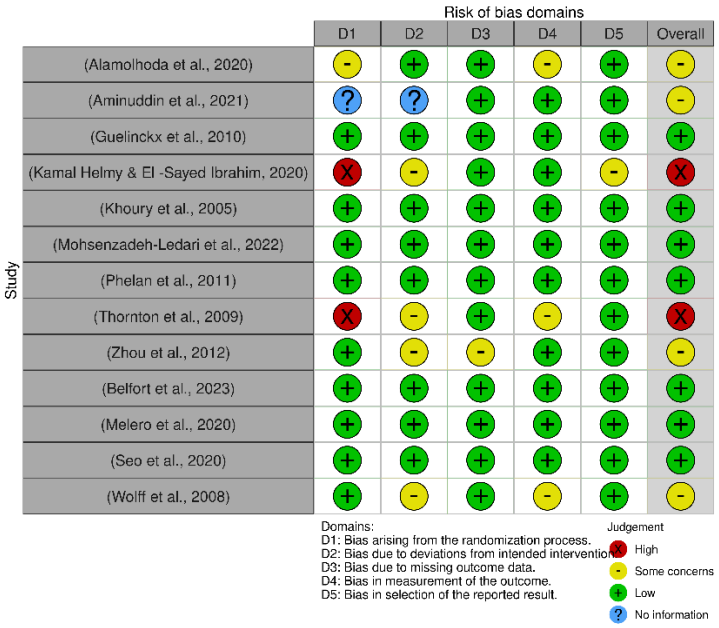
*IG: Intervention Group; CG: Control Group; BP: Blood Pressure; BMI: Body Mass Index; PE: Preeclampsia; TFA: Trans-Fatty Acids; GWG: Gestasional Weight Gain; TRF: Tocotrienol-Rich Fraction; DASH: Dietary Approaches to Stop Hypertension; MedDiet: Mediterranean Diet; NW: Normal Weight; OW/OB: Overweight/ Obese; GDM: Gestational Diabetes Mellitus.

Overview of eligible studies

The database search yielded studies from eleven countries across four continents. These countries included Iran (n=2), the US (n=2), Malaysia, Denmark, Egypt, Norway, Australia, Spain, Korea, Brazil, and Belgium (each contributing one study). Most of the studies were randomized controlled trials (RCTs), with one study classified as quasi-experimental [46]. Participant numbers ranged from 50 to just under 1400 pregnant women, mostly were in the first trimester.

Summary of Risk of Bias assessment results

Two studies were categorized as having a high risk of bias [46,50]. In one study, the randomization process was not adequately explained due to study design constraints [46], while the other study exhibited bias in participant allocation to interventions [50]. Four studies fell into the "Some Concerns" category, primarily due to uncertainties in the second domain of the Risk of Bias (RoB) assessment [43,44,51,55]. Seven studies were classified as having a low risk of bias, demonstrating strengths across all assessment domains [45,47–49,52–54].



Nutritional and dietary interventions to reduce the risk of preeclampsia

In general, restriction of salt, sugar and fat consumption was part of the intervention in eligible studies. However, it is not enough if done without close monitoring of the participants (pregnant women). A study in Iran found a 50% reduction in the risk of pre-eclampsia through dietary fat <1% of total energy intake per day [43]. Meanwhile, in other studies, maternal fat intake during pregnancy was obtained from fish fat [47,51], palm oil [44], vegetable oil [47], to replace fat from meat, butter, cream, and fatty dairy products.

A study conducted in Belgium focused on using brochures and group discussions to emphasize that 9–11% of energy intake should come from proteins, 30–35% from fats, and 50–55% from carbohydrates [45]. This intervention aimed to reduce gestational weight gain by encouraging the substitution of consumption habits with low-fat diet products and whole grains, and by reducing saturated fatty acids [45]. Similarly, in Iran, a study used motivational interviews to analyze participants' unhealthy behaviors and collaboratively develop plans for a healthier lifestyle with expert guidance. Participants were provided booklets and CDs explaining essential nutrition types during pregnancy, such as fruits, vegetables, whole grains, meats, dairy products, and water [48]. Phelan et al. [49] employed face-to-face visits with nutritionists to alter participants' diets and eating habits to achieve ideal gestational weight gain, focusing on low-fat intake combined with physical activity. In Korea, educational interventions via offline, online, and telephone calls aimed to enhance participants' knowledge of low-salt diets and nutritional management while modifying unhealthy eating habits. Participants also underwent tests to assess preferences for salty and sweet tastes, providing crucial initial data on the participants' risk of developing preeclampsia [54]. Wolff et al. conducted an intervention involving consultations and energy intake restrictions, recommending a maximum of 30% energy from fats, 15-20% from proteins, and 50-55% from carbohydrates, adjusted to maternal daily energy requirements considering fetal growth [55].

Effects of nutritional interventions and dietary habits

The studies included in this review analyzed interventions aimed at reducing risk factors for preeclampsia (PE) among participants, with the goal of preventing its incidence during pregnancy. Gestational weight gain is a known risk factor for elevated blood pressure in pregnant women, underscoring the importance of targeted interventions to manage maternal weight. For instance, a study in Iran emphasized limiting trans fatty acid (TFA) intake to <1% of total daily energy intake, resulting in a 50% reduction in PE risk compared to the control group [43]. Interventions involving palm oil [44] also successfully reduced PE risk by significantly lowering LDL cholesterol levels. Similarly, studies using olive oil and rapeseed oil [47] demonstrated significant LDL reduction with a P value <.01. In Norway, fish oil supplementation aimed at reducing LDL levels showed significant efficacy [47,51]. In contrast, Australian studies using fish oil did not significantly impact PE risk factors such as blood pressure and proteinuria. The composition of interventions may explain Norway's success, as participants received a combination of fish oil and other vegetable oils, potentially enhancing effectiveness.

Two dietary programs were conducted in studies from Brazil and Spain: DASH (Dietary Approaches to Stop Hypertension) [52] and MedDiet (Mediterranean Diet) [53]. The DASH diet in the Brazilian study included consumption of whole grains, breads, cereals, nonfat or low-fat dairy products, daily servings of whole grains and legumes, and encouraged foods rich in

fiber, potassium, magnesium, and calcium. Results from the intervention group showed a significant difference compared to the control group, with incidence rates of 12.1% and 22.9%, respectively [52]. Similarly, participants in the MedDiet program in Spain experienced a significant decrease in blood pressure by the end of the intervention [53].

Other interventions of equal importance and concern in this study include PE prevention through consultations [48,55], motivational interviews [49], nutrition education [54], nutrition brochures [45], and intensive monitoring by health staff, such as midwives [50]. Overall, each of these interventions yielded highly significant results.

4. DISCUSSION

This review aims to evaluate the effectiveness of nutrition and dietary interventions for pregnant women by analyzing the outcomes of these interventions across multiple countries. A total of 13 studies were gathered from various reputable databases and through manual searches on platforms like Google Scholar and ResearchGate. The majority of these studies exhibited a high risk of bias. However, despite some studies showing a high bias, the majority of them demonstrated a low risk of bias.

Dietary and lifestyle interventions, such as dietary patterns during pregnancy, have been shown to reduce the risk of preeclampsia [56–58]. Among these interventions, dietary-based approaches appear more effective in risk reduction compared to mixed interventions or essential fatty acid supplementation during pregnancy. For instance, an Australian study found no significant effect of fish oil supplementation on preeclampsia incidence [51], consistent with findings from a meta-analysis that emphasized the importance of dietary control in maternal health care practices [59]. Additionally, emphasizing family support, particularly from spouses, during prenatal visits at clinics or other healthcare facilities is crucial for pregnant women [56,60–68].

Overall, the pooled studies assessed the effects of interventions on conditions experienced by pregnant women in relation to preeclampsia. Based on the outcomes of the analyzed studies, several conditions were found to be associated with the incidence of preeclampsia, including BMI [43], gestational weight gain (GWG) [45,49,50,55], blood pressure (BP) [43,45,52–55], proteinuria [43,48], and LDL levels [47,52]. Additionally, two other conditions indirectly related to preeclampsia were identified: diet and knowledge [54]. Therefore, even if some studies did not explicitly mention interventions for preventing preeclampsia, if their interventions led to outcomes related to the risk of preeclampsia, they were included in this review.

Essential fatty acids vs Restriction of salt and sweet intake

Essential fatty acids have long been recognized for their numerous benefits to the body, such as increasing High Density Lipoprotein (HDL) levels [69–71] and supporting fetal brain development [72,73]. In Iran, a study implemented an intervention that reduced trans fatty acid (TFA) intake to less than 1% per day, resulting in a 50% reduction in the risk of preeclampsia [43]. These findings were corroborated by a meta-analysis, which demonstrated that reducing TFA intake significantly decreases the incidence of gestational diabetes mellitus (GDM) and lowers the risk of preeclampsia [74–80]. Studies consistently show that essential fatty acids from both animal and vegetable sources effectively lower cholesterol levels, thereby reducing the risk of preeclampsia. Many studies have utilized vegetable oils, such as soybean oil, to target cardiovascular disorders by lowering circulating cholesterol levels [81]. However, caution is advised regarding vegetable fats, as some oils, like coconut oil, may elevate LDL levels. A meta-analysis concluded that consuming coconut oil can significantly increase LDL levels compared to oils from non-tropical vegetables [82–87].

Unlike essential fatty acids, consumption of salt and sugar, even within ideal limits, may have adverse effects on the body, particularly during pregnancy [88,89]. Changes in taste buds during pregnancy significantly contribute to increased salt and sugar intake [90]. Seo and colleagues in Korea conducted a pre-test to assess perceived taste preferences, which served as crucial baseline data before implementing nutrition education interventions essential during pregnancy. Their study involved comprehensive monitoring through offline, online, and telephone calls, yielding significant results in modifying pregnant women's behaviors regarding salt and sugar consumption [54]. Previous studies have also noted behavioral changes in pregnant women's eating habits, such as a preference for sweet foods like bread spreads [91]. Excessive consumption of sugary foods during pregnancy is linked to negative outcomes, including obesity and gestational diabetes mellitus (GDM) [92]. Therefore, education [93–97], monitoring [98–102], scheduled diet plans [103,104], and strong family support are crucial to mitigate pregnancy complications, especially preeclampsia.

5. LIMITATION

Some limitations of this review include the lack of access to reputable databases, which restricted our ability to obtain higher-quality literature; consequently, we identified only thirteen intervention studies that met our inclusion criteria. Studies with a high risk of bias were still included, underscoring the importance for readers and future researchers to

exercise caution when interpreting the findings of this review.

6. CONCLUSION

Interventions aimed at maternal nutrition and dietary habits during pregnancy to prevent the incidence of preeclampsia include restricting salt, sugar, and fat intake to reduce risks such as obesity, gestational diabetes mellitus (GDM), hypertension, and high cholesterol levels. Key interventions involve nutrition education, monitoring, and counseling to guide pregnant women in adhering to a nutrition-focused maternal health program.

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