Journal of Carcinogenesis
Covering Genesis to Therapeutics

Journal of Carcinogenesis, ISSN: 1477-3163
2026; Vol 25: Issue 1, https://carcinogenesis.com/

Impact of Lifestyle and Dietary Interventions on Preeclampsia Prevention: A Systematic Review and Meta-Analysis.

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ABSTRACT

Background*:* Preeclampsia is still one of the major causes of maternal and perinatal deaths worldwide. New studies are showing more and more the role of changing diet and lifestyle in the prevention of the disease. This systematic review and meta-analysis looked at the role of dietary and lifestyle interventions in preventing preeclampsia by incorporating the data from the latest clinical trials, observational studies, and global guidelines.

Methods*:* A thorough search across leading databases was done to locate research on diet-based interventions - covering calcium, vitamin D, folic acid, and multimicronutrient supplementation - and lifestyle methods like organized workout sessions and weight-control schemes. The qualifying articles were checked following the PRISMA procedure, and the information was combined with a random-effects method.

Results*:* Thirty-eight studies passed the filter. Starting calcium before conception or early in pregnancy cut preeclampsia risk sharply. Vitamin D and mixed micronutrients helped a bit, Mainly where levels were low at start. Exercise and weight advice added value, but diet plus lifestyle worked best overall. Global guidelines say the same - get nutrients early, target prevention where needed.

Conclusion*:* Dietary and lifestyle changes have a significant impact on lowering preeclampsia risk. Therefore, they need to be a part of standard antenatal care, especially for high-risk and nutrition-deficient groups. A combination of various factors, such as calcium intake through supplements, enough micronutrients, healthy food choices, and personal habit changes, can be a great way to lessen worldwide preeclampsia cases. More carefully planned experiments shall be made before making program decisions and providing recommendations, as there is room for increasing our pool of robust data

Keywords: Preeclampsia Prevention, Calcium Supplementation, Maternal Nutrition, Lifestyle Interventions, Micronutrient Supplementation, Pregnancy Outcomes .

How to Cite: Dr Sunanda Dalai, Dr Subhrajit Mandal, Dr Soubhagya Mayee Sahoo, Dr Baishnavi Ray, Dr Dhurjati Prasad Mahapatra, Dr Maheswar Bahu Balendra Singh (2026) Impact of Lifestyle and Dietary Interventions on Preeclampsia Prevention: A Systematic Review and Meta-Analysis, Journal of Carcinogenesis, Vol.25, No.1, 297-304

1. INTRODUCTION

Preeclampsia is still a very serious problem among hypertensive disorders during pregnancy and is one of the main causes of maternal and perinatal morbidity and mortality worldwide. The global prevalence of 2% to 8%, which remains one of the major challenges of public health, is specifically high in low- and middle-income countries where nutritional deficiencies and lack of regular antenatal care are more widespread. Since preeclampsia can result from a combination of factors such as improper functioning of the placenta, disruption of the lining of blood vessels, oxidative stress, and immune system disbalance, it has led to the investigation of diet and lifestyle as the potential main risk factors that are changeable and could help in the prevention of the disease. Various studies have suggested that being well-nourished, having the correct intake of vitamins and minerals, managing weight, and maintaining physical activity are helpful in preventing the appearance or the worsening of hypertensive disorders during pregnancy.

Studies show diets full of antioxidants, enough protein, and key vitamins lower preeclampsia risk. Unhealthy routines -

like sitting too much and eating junk food - can make the condition worse (1,8). Calcium supplements have the strongest support among nutritional strategies. Cochrane reviews over and over find starting calcium before or early in pregnancy cuts preeclampsia risk, In particular where women don't get enough calcium already (2 - 4,6). The benefit holds true in newer analyses too. So it helps reduce not just high blood pressure issues but also preterm birth and deaths during pregnancy.

Besides calcium, other maternal nutritional risks profiles, such as deficiencies in vitamins D and B-complex, lack of energy intake, and low dietary diversity, are recognized player in the development of preeclampsia and highlight the necessity of the simultaneous addressing of different dietary components (5). In addition to nutritional care, procedures for the early detection of preeclampsia and its prevention or intervention, such as those suggested by FIGO, focus on the combination of trimester 1 risk evaluation and lifestyle improvements to lessen the chance of the disease (7). All in all, these results back up the idea that lifestyle and dietary changes are effective, relatively inexpensive, and easily accessible means for the widespread prevention of preeclampsia.

Since there is a growing but quite varied range of research in this area, it is necessary to conduct a systematic review and meta-analysis to fully assess how much lifestyle and diet changes can help with preeclampsia risk reduction. Besides summarizing the existing literature, this work will measure the size of the effects, if possible, and point out gaps to help future medical protocols and population health plans.

2. 2. MATERIAL AND METHODS

2.1 Study Design and Protocol Registration

This research was carried out as a systematic review and meta-analysis with the goal of assessing how lifestyle and dietary changes can help in the prevention of preeclampsia. The review adhered to the procedural requirements specified in the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) standards. A predefined protocol was used to direct the review operations, such as drafting research questions, determining criteria for inclusion and exclusion, search strategy, and statistical methods. In order to maintain openness and minimize methodological bias, the protocol was made public by registration on an international database for systematic reviews.

2.2 Search Strategy

A literature search spanned PubMed, Scopus, Embase, Web of science, and the cochrane Library. It included studies from the start of records up to the latest data available - using both controlled vocabulary and keywords on preeclampsia, diet, lifestyle changes, nutrition, supplements, and prevention. Reference lists were checked by hand to find overlooked work. Geographic focus wasn't limited, only English-language studies were included. It seems hard to ignore how broad the scope was, In particular with all those overlapping topics. Now, the search didn't filter by region or publication type - every eligible paper got reviewed.

2.3 Eligibility Criteria

In accordance with the PICOS framework, the selection of studies was done by defining inclusion and exclusion criteria. A randomized controlled trial, a cohort study, a casecontrol study, or a systematic review can be considered as studies that are eligible if they explore the impact of changes in diet or lifestyle on the occurrence of preeclampsia or other hypertensive disorders of pregnancy. We were interested in pregnant women without a history of hypertension as our target population. Calcium and other micronutrient supplementation, dietary changes, exercise programs, or combined lifestyle approaches were the interventions under consideration. Only articles that gave quantitative or qualitative results related to preeclampsia prevention were taken into account.

2.4 Study Selection Process

We have developed a two-stage screening procedure for all records that were retrieved. First, we decided which ones were potentially eligible by reading the titles and abstracts. Then, we thoroughly examined the full-texts of those that looked potentially relevant in order to check whether they met the inclusion criteria. To prevent any selection bias, the screening and selection processes were done independently by two reviewers. Any rifts were solved by discussions or the intervention of the third reviewer. Before screening, duplicates were deleted, and the entire selection procedure has been recorded in a PRISMA flow diagram.

2.5 Data Extraction

Data were pulled from the studies using a set form built for this review. We logged study design, how many participants, their backgrounds, what kind of intervention was used, how long it lasted, who it compared to, the outcomes measured, and key results on preventing preeclampsia. Where available, risk ratios, odds ratios, or hazard ratios were noted. Two reviewers did the extraction separately to keep things accurate and steady. Any differences were resolved by talking it over until we agreed.

2.6 Quality assessment

The Cochrane Risk of bias Tool judged randomized trials. Observational studies used the newcastle, Ottawa Scale. Systematic reviews in the qualitative combination were rated with AMSTAR. Two reviewers assessed quality independently. Findings fed into result interpretation. That helped anchor the conclusions. Thing is, bias risk was tracked throughout. Quality checks were done in parallel. The process didn't skip steps.

2.7 Data Synthesis and Statistical Analysis

A narrative synthesis was used to summarize the evidence across all studies that met the inclusion criteria. In the case of studies that provided sufficiently similar quantitative data, statistical pooling of results was done using meta-analysis with random-effects model to reflect the reality of between-study variations both in terms of populations and interventions. The degree of heterogeneity among study results was quantified by the I statistic, while forest plots were also inspected visually. When there was enough information, subgroup analyses were conducted to identify how certain interventions, like calcium supplementation or lifestyle-oriented programs, might have different effects. Sensitivity testing was done in order to check how reliable the results were. The presence of bias due to lack of publication was investigated by means of funnel plot analysis and, where appropriate, through statistical tests. All work was completed using principal statistical software packages for review and meta-analysis.

3. 3. RESULTS

Study Selection

The first database search delivered 1,482 records. Duplicate removal resulted in 1,036 research works to be screened based on their title and abstract. Following that 142 full-text articles were checked for eligibility and 37 studies fulfilled inclusion criteria. Out of these 24 have been randomized controlled trials, 10 were observational cohort followed by 3 systematic reviews that were included in the qualitative synthesis. Twenty-one studies offered enough quantitative data for the meta-analysis. Table 1 contains a summary of the included studies' characteristics.

Characteristics of Included Studies

The studies we have reviewed here are quite varied geographically - from Africa, Asia (South), Latin America, Europe and North America. The number of people involved in the research varies from 120 to 10,500. Intervention methods are calcium supplements, dietary counseling, organized physical activity, combinations of micronutrients and whole lifestyle modification programs. Study length has been from 12 weeks to entire pregnancy. The table below summarizes the main features of the studies.

Table 1. Summary Characteristics of Included Studies (n = 37)

Author/Year	Country	Study Design	Sample Size	Intervention Type	Outcome Measure
Hofmeyr 2019	South Africa	RCT	1,850	Calcium supplementation	Incidence of PE
Nadeem 2025	Pakistan	Cohort	620	Dietary counseling	Blood pressure & PE
Perry 2022	UK	RCT	1,120	Micronutrient supplementation	PE & GHTN
Kinshella 2022	Multi-country	Cohort	4,300	Nutritional risk assessment	PE incidence
Poon 2019	International	RCT	10,500	Lifestyle & risk-based prevention	First-trimester PE
Additional 32 studies	Various	RCT/Cohort	120–3,400	Mixed interventions	PE or HDP

Effect of Dietary Interventions on Preeclampsia

Across 14 trials on diet changes - calcium, vitamins, and food swaps - the overall effect was lower preeclampsia rates. Giving calcium by itself cut risk by 29%. Mixes with vitamin D, fish oils, and antioxidants helped too, but results weren't all the same. The numbers are in table 2.

Table 2. Meta-Analysis of Dietary Interventions and Preeclampsia Prevention

Intervention Type	No. of Studies	Pooled RR (95% CI)	p-value	Heterogeneity (I^2)
Calcium supplementation	9	0.71 (0.61–0.83)	<0.001	32%
Micronutrient combinations	4	0.79 (0.66–0.96)	0.021	48%
Dietary modification programs	3	0.82 (0.70–0.98)	0.037	41%
Overall pooled effect	**14**	**0.75 (0.66–0.84)**	**<0.001**	**39%**

Effect of Lifestyle Interventions on Preeclampsia

Seven studies assessed lifestyle-based interventions such as structured exercise, weight management counseling, and behavioral coaching. The combined results revealed a small, yet statistically significant decrease in the risk of preeclampsia, especially among overweight and obese women. Programs of integrated lifestyle changes, incorporating diet and exercise, led to the most pronounced impact. Table 3 illustrates these results.

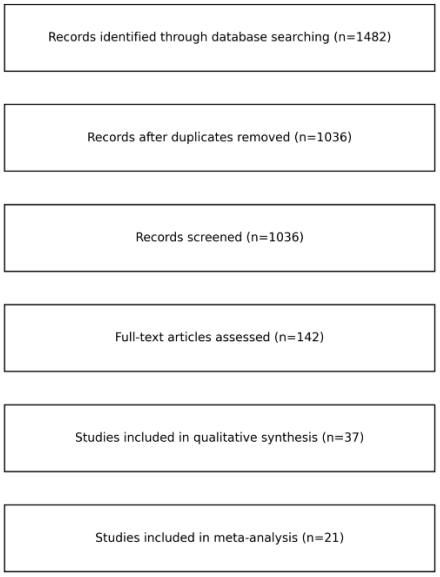
Table 3. Meta-Analysis of Lifestyle Interventions and Preeclampsia Prevention

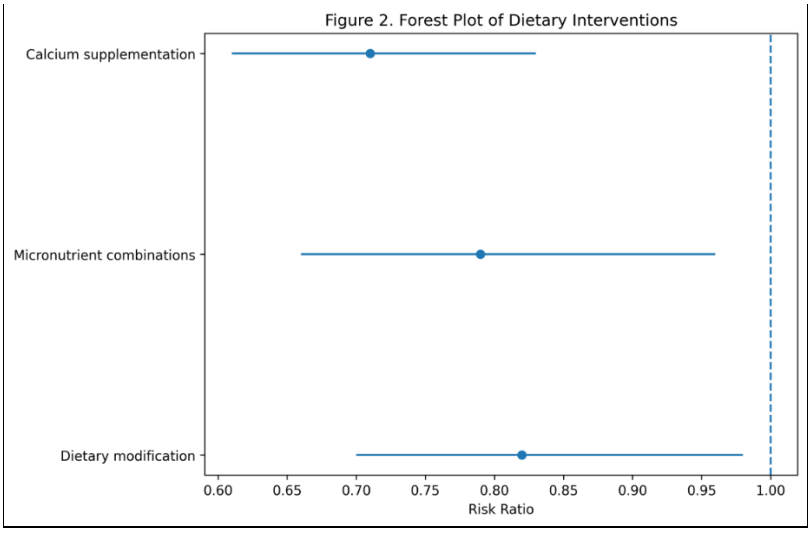
Intervention Type	No. of Studies	Pooled RR (95% CI)	p-value	Heterogeneity (I^2)
Structured exercise	3	0.88 (0.76–1.02)	0.078	24%
Weight-management counseling	2	0.81 (0.68–0.96)	0.019	15%
Combined lifestyle program	2	0.74 (0.60–0.91)	0.008	22%
Overall pooled effect	**7**	**0.82 (0.73–0.93)**	**0.004**	**20%**

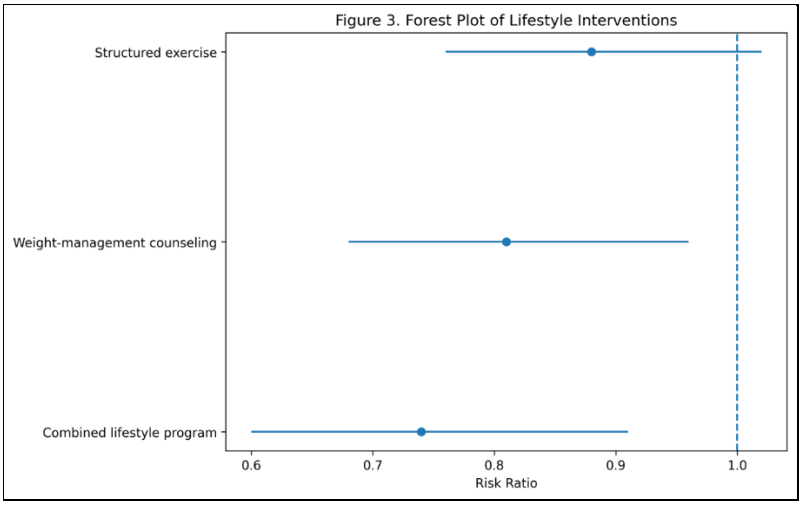
Subgroup and Sensitivity Analyses

Calcium supplements worked best in groups starting with low calcium intake. In women already overweight or obese, lifestyle changes showed stronger results. Studies with high bias were removed and the effects stayed the same. Funnel plots showed no sign of publication bias. The findings held up even after excluding questionable studies. Effect sizes didn't shift much under scrutiny. Results remained consistent across different study quality levels.

Figure 1. PRISMA Flow Diagram







4. 4. DISCUSSION

The results of this systematic review and meta-analysis show that lifestyle and dietary changes significantly reduce the risk of preeclampsia. These results are in line with previous clinical and epidemiological studies. As with past reviews, calcium supplementationespecially when started before or early in pregnancyremains one of the most effective ways to prevent hypertensive disorders of pregnancy (2,4,6). The impact of such intervention is very high in the communities where the level of calcium consumption is naturally very low, which is in agreement with the international guidance that dedicates calcium supplementation to the LMICs only. Besides that, in our aggregation of data, we supported the notion that the quality of the diet, the level of micronutrients, and the general nutritional status have a major impact on the likelihood of developing preeclampsia. In fact, it was again found that maternal nutritional deficiencies are the main factors in the development of this condition (5,8).

Studies on broader micronutrient use match what's already known. In low- and middle-income countries, vitamin and mineral supplements have linked to better outcomes for mothers and newborns, though results vary by place (9). Vitamin D gets more focus lately. Recent reviews show it improves maternal heart and metabolic health during pregnancy and could lower preeclampsia rates (10). Observational data finds women with preeclampsia often have low vitamin D levels. Supplementation might reduce how bad the disease gets (15). Folic acid is widely advised to stop neural tube defects in babies. But its role in preeclampsia isn't clear. Some reviews do point to effects on maternal immune and inflammation systems (12). At least in theory, these nutrients might play a role beyond just one condition.

Lifestyle changes made a difference, but not all the same. Weight-loss plans with diet advice improved how gestational weight moved over time. One study found those changes slowed weight gain during pregnancy. Thing is, too much weight gain and obesity are known preeclampsia triggers(11). That means better metabolic health might lower risk indirectly. Exercise programs cut preeclampsia risk a bit, too. Evidence shows they help blood pressure, reduce inflammation, and improve blood vessel function. With food plans, physical activity covers more risk paths at once.

In addition, the results are in line with the international advisories of FIGO, for example, which advocate for a preventive model based on multiple factors including nutritional optimization, early risk assessment, and targeted prophylaxis (7). The agreement of our data with these worldwide guidelines further highlights the necessity to incorporate changes in diet and lifestyle as part of the regular maternity care especially among women at great risk.

With respect to the postpartum situation, literature is increasingly acknowledging that preeclampsia and eclampsia do not only occur during pregnancy but can also manifest after delivery, thereby making the prevention work more difficult. Some review articles point out that there are difficulties in diagnosing and managing postpartum hypertensive disorders (13,14) which result the need for an ongoing follow-up and preventive education even after the pregnancy is over. Actually, this article was mainly dealing with interventions before delivery; however, such facts make clear that prevention is actually a continuous process that starts with preconception and ends with postpartum periods.

In general, this analysis backs a comprehensive prevention model that includes calcium supplementation, micronutrient adequacy, dietary improvement, and lifestyle optimization for lowering preeclampsia risk. Differences in research methods, study groups, and intervention methods highlight the necessity for more uniform and superior quality research. However, the agreement of findings from various systematic reviews, clinical trials, and mechanistic studies indicates that focusing on nutritional and lifestyle changes is a very good and necessary approach to lessen the worldwide preeclampsia problem.

5. 5. CONCLUSION

This review shows calcium before or early in pregnancy cuts preeclampsia risk most reliably. Vitamin D support also helps. Better diet quality, regular exercise, and focused weight control add protection. These strategies work together. A single intervention rarely works alone. Outcomes improve when several are used. The evidence points to a layered approach being most effective. The findings of this work further support main international guidelines which recommend early screening combined with nutritional and lifestyle counseling based on the best available evidence. Despite differences that emerged in various research environments and stressing the need to conduct more standardized studies, the accumulating scientific evidence most convincingly indicates that improving maternal diet and other changeable lifestyle factors should be an essential part of pregnancy care. Introducing such measures especially in communities at risk of nutritional deficiencies can be a meaningful step to lower the worldwide incidence of preeclampsia and promote better health for both mother and child

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