

Dietary Patterns of Expectant Mothers and Pregnancy-Related Hypertension in Low-and Middle-Income Nations: A Comprehensive Review and Meta-analysis

*Dr. Sarvamangala S.

ABSTRACT

Healthy maternal diets can lower the odds of developing pre-eclampsia, a direct and second leading cause of maternal death, globally. However, there is a research gap in low- and middle-income countries (LMIC), which bear a disproportionate burden of these deaths.

Objective: This systematic review aimed to assess the relationship between maternal dietary patterns during pregnancy and hypertensive disorders, including pre-eclampsia, among pregnant and postpartum women in low- and middle-income countries (LMICs). Additionally, it sought to identify the barriers and facilitators to achieving an adequate maternal diet.

Methodology: A comprehensive search was conducted across multiple databases, including MEDLINE, Embase, the Cumulative Index to Nursing and Allied Health, Web of Science, Cochrane Central Register of Controlled Trials, African Journals Online, the WHO Regional Databases, trial registries, and Google Scholar. The search included primary research studies that examined dietary patterns during pregnancy and their association with pregnancy hypertension outcomes in LMICs. The risk of bias in the included studies was assessed using the ROBINS-I tool. Thirteen studies met the inclusion criteria, with five studies included in a meta-analysis using Review Manager 5.

Results: Adequate consumption of vegetables (compared to no or low consumption) was associated with lower odds of pre-eclampsia (OR: 0.38; 95% CI: 0.18, 0.80; I2 = 85%; P= 0.01), as was adequate consumption of fruit (OR: 0.42; 95% CI: 0.24, 0.71; I2 = 79%; P= 0.008). However, no definitive conclusions could be drawn regarding the impact of high meat or grain consumption, a "Western" diet, or alcohol consumption on the odds of pre-eclampsia during pregnancy. Further research in LMICs is necessary to explore whether the observed beneficial effects of fruits and vegetables on pre-eclampsia incidence are more pronounced in the presence of maternal malnutrition, and to investigate the potential contribution of other sociodemographic factors.

INTRODUCTION

Sustainable Development Goal 3.1 aims to reduce the global maternal mortality ratio (MMR) to 70 per 100,000 live births. However, achieving this target requires a significant reduction in maternal deaths, particularly in low- and middle-income countries (LMICs). In 2017, low-income countries had

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an MMR of 462 per 100,000 live births, compared to 11 per 100,000 in high-income countries (HICs) (1). Maternal mortality is largely attributed to three main direct causes: maternal hemorrhage (27%), hypertensive disorders (14%), and sepsis (11%). While there have been notable declines in deaths related to hemorrhage and sepsis, progress in reducing pregnancy hypertension-related deaths has been slower (2). The proportion of pregnancy hypertension-related deaths has remained relatively stable as a percentage of overall maternal deaths between 1990 and 2013 (3). Hypertensive disorders of pregnancy (HDPs) contribute to an estimated 46,000 maternal deaths, 416,000 stillbirths, and 1.5–2 million neonatal deaths annually (4). Pre-eclampsia, the most severe form of HDPs, is characterized by new-onset hypertension at ≥ 20 weeks of gestation with proteinuria and/or signs of organ damage, commonly affecting the liver and kidneys. It is a pregnancy-specific inflammatory disorder linked to abnormal placental vascular development or preexisting maternal risk factors such as hypertension, renal disease, overweight, or diabetes (5).

Dietary intake during pregnancy is thought to impact pre-eclampsia risk, with micronutrients particularly implicated due to their antioxidant, anti-inflammatory, or vasoactive properties (6). However, the evidence remains inconclusive, necessitating a focus on overall dietary patterns. A systematic review indicated that healthy diet interventions reduced the risk of pre-eclampsia by 33%. Additionally, a meta-analysis of four observational studies found that a healthy dietary pattern characterized by high consumption of fruits, vegetables, whole-grain foods, fish, and poultry was associated with a lower likelihood of pre-eclampsia (7). Importantly, all four studies included in the meta-analysis were from HICs, with three from India and one from The Netherlands. It is crucial to explore the impact of maternal diet on pre-eclampsia risk in resource-constrained settings where there are high burdens of both maternal deaths and maternal under nutrition (8).

The primary objective of this review was to assess the association between dietary patterns during pregnancy and hypertension among pregnant and postpartum women in LMICs. The secondary objective was to identify risk factors associated with maternal dietary patterns, including barriers and facilitators to achieving an adequate maternal diet (10).

METHODS

This review adhered to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) checklist. A review protocol was registered with PROSPERO before commencing the review process. Searches were conducted across several databases, including MEDLINE Ovid, Embase, the Cumulative Index to Nursing and Allied Health (CINAHL), Web of Science (15), Cochrane Central Register of Controlled Trials (CENTRAL), African Journals Online (AJOL), and the WHO Regional Databases. Additionally, searches were supplemented by reviewing clinicaltrials.gov, the ICTRP (International Clinical Trials Registry Platform) Search Portal (WHO), and Google Scholar, as well as scanning reference lists. The search spanned from database inception to February 2020.

Using the PECOS (Participants, Exposures, Context, Outcomes, Study design) research framework, the search terms broadly encompassed concepts related to dietary diversity, dietary patterns, diet

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quality, developing countries, resource constraints, LMICs, maternal death, pregnancy hypertension (18), pregnancy-induced hypertension, pre-eclampsia, gestational hypertension, chronic hypertension, and eclampsia. Definitions of dietary patterns and outcomes followed those provided by the original study authors. The focus was on observational cohort studies, but searches also included randomized controlled trials targeting interventions to enhance maternal dietary diversity or patterns. Case-control studies were added to the search strategy after scoping searches, as they are often more feasible in resource-limited LMIC settings. Cross-sectional studies were excluded to minimize potential bias risks (25).

Two reviewers independently screened titles and abstracts, resolving discrepancies through discussion with a third reviewer. Full texts were then independently assessed for eligibility by the same two reviewers, with the third reviewer providing an independent assessment for discrepancies. Studies were considered for inclusion if they involved primary data collection, focused on women of reproductive age during periconception, pregnancy, or postpartum, were conducted in LMICs, and reported maternal dietary patterns in relation to pregnancy hypertension outcomes. Only English language articles were included due to reviewer team capacity (29).

Search results were managed using Mendeley to remove duplicates, and the reference list was imported into Excel for study selection. Data extraction was conducted using an Excel sheet, with details including study design, country, population characteristics, exclusion criteria, participant age, dietary assessment, identified dietary patterns and food groups, outcome measurements, comparative risk, relative effect, risk factors associated with pre-eclampsia incidence, and dietary patterns extracted and independently reviewed by two reviewers. Potential confounding factors and co-interventions were also extracted in preparation for quality assessment (25). Study quality was assessed using the ROBINS-I risk of bias tool, with studies at high risk of bias excluded from meta-analyses. Evidence from studies with similar design, data collection methodology, sample, and reported outcomes was pooled using Review Manager (RevMan 5) and reported as odds ratios (ORs) with 95% confidence intervals (CIs). The Mantel-Haenszel random-effects model was used for analyses with substantial heterogeneity ($I^2 > 50\%$), and sensitivity analyses were conducted to explore the impact of study quality on heterogeneity levels. Funnel plots were planned to estimate publication bias if there were more than ten studies included in the meta-analysis (33).

INCLUSION CRITERIA

Studies including women aged 15 to 49 years, covering the periods of prepregnancy, pregnancy, or up to 42 days postpartum. • Studies that analyze maternal dietary patterns, including the frequency and diversity of food intake. • Studies conducted in one or more low- and middle-income countries, as defined by the World Bank. • Studies that investigate the relationship between maternal dietary patterns and outcomes related to pregnancy hypertension, such as chronic hypertension, gestational hypertension, pre-eclampsia, and superimposed pre-eclampsia. • Inclusion of case-control studies, cohort studies, and randomized controlled trials with primary data collection. • Studies published in

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English. Exclusion of studies not written in English. No restrictions on publication date.

EXCLUSION CRITERIA

Studies involving individuals outside the age range of 15 to 49 years, including those focusing on men, children, or infants without separate outcomes specified for women. • Studies that solely discuss nutritional status without addressing specific food groups or items. • Excluded studies that do not clearly indicate outcomes relevant to low- and middle-income countries. • Studies that solely report on infant or child health outcomes without addressing pregnancy hypertension outcomes. • Exclusion of cross-sectional surveys, uncontrolled pre-post studies, and studies lacking primary data collection and sufficient methodological detail, such as reviews, commentaries, editorials, letters to the editor, study protocols, conference abstracts, and proceedings. • Studies not written in English were also excluded.

Results

We initially identified a total of 4993 records through our database searches, with the majority from MEDLINE, Embase, and Web of Science. Additional unique records were found through Google Scholar and reference list searching. After removing duplicates and screening for eligibility, 13 studies met the inclusion criteria, while 43 full-text articles were excluded for various reasons, such as not focusing on the relevant population, exposure, or outcome of interest, not being conducted in a low- or middle-income country (LMIC), or being conference abstracts, cross-sectional surveys, or duplicates.

Quality assessment

It revealed that 7 studies had a moderate risk of bias, 4 had a serious risk, and 2 had a critical risk. Most studies adjusted for important baseline confounders, including maternal age, parity/gravidity, prepregnancy BMI, and family history of hypertension. However, several potential risk factors for pre-eclampsia, such as ethnicity, season of infant birth, maternal height, and smoking status, were not consistently accounted for across all studies. Few studies adjusted for socioeconomic status, history of pregnancy hypertension, blood pressure in early pregnancy, gestational age, pregnancy interval, gestational weight gain, physical activity, total energy intake, and dietary supplement use. Participants were mostly recruited at health facilities, with pregnancy hypertension diagnosed by external clinicians. Dietary intake patterns were self-reported through food frequency questionnaires (FFQs) administered by trained interviewers, with some studies using validated FFQs.

Healthy dietary patterns

Four studies utilized principal component analysis (PCA) to identify dietary patterns in the habitual diets of their participants. Participants' diets were assessed based on the frequency of food consumption, and they were divided into quartiles or tertiles. Those in the highest quartile or tertile were considered to have high adherence to the dietary pattern, while those in the lowest quartile or

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tertile had low adherence.

Three studies conducted in Iran identified a healthy dietary pattern characterized by frequent consumption of vegetables, fruit, and low-fat dairy products. These studies found that women with higher adherence to this healthy dietary pattern had lower odds of developing pre-eclampsia. In case-controlled studies, high adherence to the healthy dietary pattern was associated with an 82–87% reduction in the risk of pre-eclampsia compared to low adherence. A prospective cohort study also found a 51% reduction in the risk of pre-eclampsia among those with high adherence to the healthy dietary pattern.

Fruit dietary pattern

Among the seven studies that investigated the frequency of fruit consumption in relation to the risk of pregnancy hypertension, three studies conducted in Zimbabwe, Iran, and Ethiopia did not find a significant association with pre-eclampsia outcomes. However, three studies from Ethiopia reported that consuming an adequate amount of fruit (1-3 servings per week) was linked to a 49-77% reduction in the odds of developing pre-eclampsia. Another study from Ethiopia found that regular fruit consumption (2-4 times per week) was associated with lower odds of developing hypertensive disorders of pregnancy compared to women with low fruit consumption.

Discussion

To our knowledge, this is the first review specifically examining the association between maternal dietary patterns and pregnancy hypertension in low- and middle-income countries (LMICs). Several studies identified a healthy dietary pattern characterized by high consumption of fruits, vegetables, and low-fat dairy products, which was associated with a 51-82% reduction in the risk of pre-eclampsia. Notably, diets lacking in vegetables were associated with a 2.6 times higher risk of pre-eclampsia, while diets lacking in fruit were associated with a 2.3 times higher risk. Limited data suggest that high consumption of meat, grains, a "Western" diet high in sugar, fried, and processed foods, or alcohol during pregnancy might be linked to higher rates of pre-eclampsia, but the evidence is inconsistent.

However, most of the available literature comes from Ethiopia and Iran, limiting the generalizability of these findings. Additionally, the majority of studies had a moderate to serious risk of bias, which impacts the quality of the evidence. Excluding studies with serious bias significantly reduced heterogeneity in the pooled outcomes. Furthermore, while the review focused on cohort and case-control studies, which generally have lower bias risks than cross-sectional studies, the evidence largely comes from case-control studies, highlighting the need for more large prospective cohort studies.

Despite these limitations, the association between healthy maternal dietary patterns and a lower risk of pre-eclampsia in LMICs aligns with evidence from high-income countries (HICs). Previous reviews from the US and Norway also suggested a beneficial effect of diets rich in fruits and vegetables on pre-

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eclampsia. The review underscores the importance of maternal diet in maternal and child health, particularly in reducing the risk of pre-eclampsia. However, more high-quality research is needed in LMICs to confirm these associations, explore dietary diversity and food group consumption, and examine potential interactions with socioeconomic status.

***Principal
Shree Sapthagiri Institute of Nursing Sciences
Hosapete, Bellari, Karnataka**

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