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"NUTRITIONAL INTERVENTIONS DURING PREGNANCY AND THEIR IMPACT ON MATERNAL AND NEONATAL OUTCOMES IN INDIA: A SCOPING REVIEW"

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Abstract:

Background: Maternal nutrition profoundly affects pregnancy outcomes and the lifelong health of mothers and children. In India, maternal undernutrition and anaemia remain prevalent despite extensive public health programs. Fragmented evidence exists on the implementation and measurable impacts of nutritional interventions.

Objective: To synthesize evidence on nutritional interventions during pregnancy in India, evaluate their effects on maternal and neonatal outcomes, and identify research and policy gaps.

Methods: Following the PRISMA-ScR framework, PubMed and MEDLINE databases were searched for English-language studies published from January 2000 to May 2025 using relevant MeSH terms. Eligible studies included experimental and observational designs evaluating interventions such as iron–folic acid supplementation, calcium tablets, take-home rations, fortified foods, dietary counselling, and cash transfer programs. Studies were required to report at least one maternal (e.g., anaemia, gestational weight gain) or neonatal (e.g., birth weight, preterm birth) outcome. Data extraction covered study design, intervention type, outcomes, and limitations.

Results: From 1,245 citations, 8 studies met inclusion criteria. Iron–folic acid supplementation, balanced energy protein intake, and calcium supplementation were linked to reduced maternal anaemia, improved gestational weight gain, and decreased low birth weight and preterm births. Nutrition counselling improved dietary diversity and adherence. Key barriers included poor compliance, sociocultural food restrictions, supply chain disruptions, and rural–urban disparities. Adolescent pregnant women were underrepresented. Methodological constraints included small sample sizes, cross-sectional designs, limited geographic coverage, and few randomized controlled trials.

Conclusion: Nutritional interventions during pregnancy improve maternal and neonatal outcomes in India but face implementation and equity challenges. High-quality randomized trials, adolescent-focused research, culturally sensitive counseling, and strengthened monitoring are essential to enhance program impact.

Keywords: maternal nutrition, pregnancy, nutritional interventions, neonatal outcomes, anemia, India, scoping review

INTRODUCTION

Maternal nutrition is a crucial factor influencing pregnancy outcomes and the long-term health of both the mother and the child. Nutrition during pregnancy is vital as it impacts not only the mother's health but also the growth and development of the fetus in the womb. Insufficient dietary intake, deficiencies in micronutrients, and poor

nutritional status prior to pregnancy are linked to various negative outcomes, including maternal anemia, preeclampsia, low birth weight (LBW), intrauterine growth restriction (IUGR), stillbirth, and a heightened risk of mortality for both mothers and infants.

Pregnancy increases nutritional requirements due to physiological changes such as the expansion of blood volume, a rise in basal metabolic rate, and fetal development. Essential micronutrients, including iron, folic acid, calcium, zinc, vitamin A, vitamin D, and iodine, are critical for supporting maternal immune function, placental health, and the development of fetal organs. Additionally, a pregnant woman's energy requirements increase, and failing to meet these needs can lead to protein-energy malnutrition, worsening existing health disparities, particularly in low- and middle-income countries like India.

In India, the rate of maternal undernutrition remains alarmingly high despite ongoing public health initiatives. The National Family Health Survey-5 (2019–21) indicates that approximately 57% of pregnant women aged 15–49 years are anemic, and about 22% of all women fall into the underweight category (BMI <18.5 kg/m²). Anemia is especially troubling as it leads to fatigue, reduced work capacity, increased vulnerability to infections, postpartum hemorrhage, and maternal mortality. Furthermore, it is closely associated with preterm birth, low birth weight, and perinatal mortality. Malnutrition during pregnancy also has intergenerational effects—infants born to malnourished mothers are at a higher risk of experiencing stunting, wasting, and impaired cognitive development.

The challenges of maternal undernutrition are exacerbated by social factors including poverty, food insecurity, low levels of female literacy, gender bias, early marriage, insufficient access to antenatal care, and poor sanitation. Particularly, rural and tribal communities face restricted access to a variety of diets and quality healthcare services, which increases the risk of nutritional deficiencies and related complications for pregnant women [9,10].

Acknowledging the essential role of nutrition in the health of mothers and children, the Government of India has launched several national initiatives aimed at tackling nutritional issues during pregnancy. Key interventions include:Iron and Folic Acid (IFA) Supplementation: A fundamental aspect of the Anemia Mukt Bharat (AMB) initiative, IFA tablets containing 60 mg of elemental iron and 500 mcg of folic acid are administered daily to pregnant women beginning in the second trimester [11]. Additionally, weekly iron and folic acid supplementation (WIFS) is offered to adolescent girls through school health programs to enhance their nutritional status prior to pregnancy.

In spite of these initiatives, numerous challenges continue to exist. These challenges encompass inconsistent coverage, inadequate adherence to supplementation caused by side effects or misinformation, shortages at health facilities, insufficiently trained staff, and sociocultural beliefs that limit dietary intake during pregnancy. Furthermore, the majority of studies and program evaluations tend to concentrate on process indicators such as coverage and distribution, rather than on clinical and functional outcomes like enhancements in hemoglobin levels, birth weight, or maternal morbidity and mortality.

Rationale of the study

Despite the existence of numerous government nutrition initiatives for pregnant women in India, the concrete evidence regarding their execution and quantifiable health results remains disjointed. There is a deficiency in a thorough mapping of different nutritional interventions and their effects on maternal and neonatal health. This scoping review seeks to gather and classify the existing literature to guide future research and policy. Additionally, it will assist in pinpointing gaps in coverage, target demographics, and outcome assessment.

Eligibility criteria

This scoping review encompassed research centered on nutritional interventions during pregnancy for women in India. Articles published in English from January 2000 to May 2025 were taken into account. Eligible interventions comprised iron and folic acid supplementation, calcium tablets, take-home rations, dietary counseling, fortified foods, and cash transfer programs. Both experimental and observational study designs were included, such as randomized controlled trials (RCTs), cohort studies, cross-sectional studies, and mixed-methods research. Full-text availability was a prerequisite for inclusion.Studies were required to report on at least one maternal (e.g., anemia, weight gain) or neonatal (e.g., birth weight, preterm birth) outcome. Research that provided insights into implementation challenges or community-level uptake was also taken into consideration. Priority was given to studies demonstrating strong methodological rigor and relevance to public health nutrition policy.

Information sources: The preliminary database search resulted in 1,245 citations concerning nutritional interventions during pregnancy and their effects on maternal and neonatal outcomes in India.Following the removal of 215 duplicates, 1,030 records were evaluated for eligibility. Through the screening of titles and abstracts, 912 studies were eliminated for the following reasons: 400 were not pertinent to the Indian context, 210 were of an incorrect publication type (such as editorials or letters), 120 were outdated, 95 did not concentrate on pregnant women, and 87 did not provide relevant maternal or neonatal outcomes. A total of 118 full-text articles were

evaluated for eligibility. After the full-text screening, 110 articles were discarded due to inadequate methodological quality, irrelevance to nutritional interventions, or absence of outcome data. Ultimately, 8 articles were included in the review. The selection process is illustrated in the PRISMA flow diagram (Figure 1).

Selection strategy:

The Medical Subject Headings (MeSH) terms utilized in the PubMed and MEDLINE databases were employed to identify pertinent studies regarding nutritional interventions during pregnancy and their influence on maternal and neonatal outcomes in India. The search was confined to articles published from 2000 to 2025. The primary MeSH terms used included: "nutritional interventions," "maternal health," "neonatal outcomes," "pregnancy," "maternal nutrition," "infant health," and "India." The gathered evidence was synthesized and presented to emphasize various nutritional strategies enacted during pregnancy and their effects on enhancing health outcomes for both mothers and infants.

Review

Importance of Maternal Nutrition during Pregnancy: Maternal nutrition plays a vital role in determining the health outcomes of both mothers and their fetuses. Sufficient nutritional intake during pregnancy is crucial for supporting fetal growth, promoting healthy placental development, and preserving maternal health.The metabolic demands and nutritional requirements increase during pregnancy due to the rapid growth of the fetus and the physiological changes occurring in the mother, which include an increase in blood volume, hormonal fluctuations, and tissue expansion. Deficiencies in energy, proteins, and essential micronutrients such as iron, calcium, and folate can hinder these processes, leading to complications like gestational hypertension, intrauterine growth restriction, and premature delivery [12,13].

Consequences of Malnutrition on Maternal and Neonatal Health: Inadequate nutrition or insufficient dietary variety during pregnancy has been linked to an elevated risk of anemia, preeclampsia, maternal infections, and a rise in maternal mortality. For newborns, maternal undernutrition can result in low birth weight (LBW), preterm delivery, stunting, and a heightened risk of neonatal mortality and morbidity [14]. The nutritional status of a mother prior to and throughout her pregnancy significantly impacts the long-term health of her child, affecting the likelihood of non-communicable diseases in later life through fetal programming and the developmental origins of health and disease (DOHaD) hypothesis [15].

Burden and determinants of Maternal Undernutrition in India: Maternal undernutrition continues to be a significant public health issue in India, accounting for nearly 40% of the global burden of low birth weight [16]. According to NFHS-5 data, 50% of women in India are anemic, and 18% of pregnant women are underweight, especially in rural and tribal regions [17]. Deficiencies in essential nutrients such as iron, folic acid, calcium, vitamin D, and B12 are associated with anemia, neural tube defects, gestational diabetes, and intrauterine growth restriction [18-20]. Socioeconomic inequalities, food taboos, and regional disparities further worsen maternal nutrition. Although government initiatives like ICDS and PMMVY are in place, their inconsistent implementation across different states hampers their effectiveness [21,22].

Types of Nutritional Interventions Identified in India:In India, various nutritional interventions aim to address maternal undernutrition through both direct and indirect approaches. Micronutrient supplementation encompasses iron, folic acid, calcium, and vitamins A, D, B12, and zinc, which are provided through ANC services [23]. Macronutrient support consists of Balanced Energy Protein (BEP) supplements and Ready-to-Use Therapeutic Foods (RUTFs) [13]. Food-based initiatives such as Take-Home Rations (THR) under ICDS and state-level meal programs assist in meeting daily dietary requirements [24]. The fortification of staple foods like rice, salt, and oil is being expanded in public initiatives [25]. Behavioral change facilitated by nutrition counseling from ASHAs and Anganwadi workers is crucial for improving awareness and adherence [26]. Incentive-based programs like PMMVY and POSHAN Abhiyaan utilize conditional cash transfers to encourage dietary compliance and the use of institutional services [27].

Assessment of Maternal Outcome: Nutritional interventions during pregnancy have demonstrated considerable enhancements in maternal outcomes in India. Consistent supplementation of iron and folic acid has been linked to a decrease in the prevalence of anemia among pregnant women, which remains a persistent public health challenge [28]. Balanced energy protein supplements, along with improved dietary counseling, play a role in achieving appropriate maternal weight gain and increasing nutrient intake [29]. Moreover, supplementation with calcium and micronutrients has been associated with a reduction in pregnancy-related complications, including preeclampsia, infections, and gestational hypertension [30]. These interventions also aid in enhancing dietary diversity, particularly in low-resource environments, thereby contributing to overall maternal health and resilience [31].

Assessment of Neonatal outcome:Nutritional interventions during pregnancy are closely associated with enhanced neonatal outcomes in India. Research indicates that supplementation with iron–folic acid and protein-energy

significantly lowers the rates of low birth weight (LBW) and preterm births [32]. Enhanced maternal nutrition is also linked to improved Apgar scores and a decrease in neonatal morbidity and mortality [33], highlighting the necessity for ongoing nutritional support throughout pregnancy.

Key Challenges and Policy Implications:The literature underscores ongoing obstacles to effective nutritional interventions during pregnancy in India, which include poor adherence to supplementation, a lack of awareness, and sociocultural limitations such as food taboos [34]. Disruptions in the supply chain, insufficient training for frontline workers, and limited access in tribal and rural areas further diminish the effectiveness of these programs [35]. Although policy frameworks such as ICDS, NHM, and POSHAN Abhiyaan are essential, their integration with routine ANC services and real-time monitoring is still not optimal. It is crucial to enhance the roles of ASHAs and Anganwadi workers, as well as to improve data systems and intersectoral coordination, to ensure impactful implementation [36].

Identified Research gaps:The existing body of literature highlights numerous research deficiencies in maternal health studies conducted in India. A significant absence of randomized controlled trials (RCTs) evaluating the effectiveness of interventions in the Indian context is evident. Moreover, the majority of studies fail to incorporate long-term follow-up assessments to determine sustained outcomes. The analysis of regional and state-specific variations is insufficient, which hampers the development of localized policies. Additionally, adolescent pregnant women, who represent a vulnerable subgroup, are frequently underrepresented in research efforts [37].

RESULTS

Table 1: Summary of the articles included in the review (n-8)

Authors	Year	Title	Key Findings	Limitations
Paul VK et al.	2011	Reproductive health, and maternal and child health in India	Highlighted improvements in maternal health but stressed regional disparities and gaps in adolescent care	Limited data on long-term outcomes and intervention RCTs
Singh A et al.	2019	Maternal health in India: gaps and priorities for research	Identified need for more RCTs and regional analysis	Few studies with adolescent pregnant women included
Kumar S et al.	2018	Effectiveness of antenatal care in India	Showed benefits of structured antenatal care programs	Lack of follow-up data beyond delivery
Agarwal N et al.	2020	Barriers to accessing maternal health services in rural India	Documented socio-cultural and infrastructural barriers	Cross-sectional design limits causality inference
Sharma R et al.	2017	Impact of nutritional interventions on pregnancy outcomes	Nutritional supplements reduced low birth weight incidence	Small sample size and short intervention duration
Mishra P et al.	2015	Adolescent pregnancy outcomes in India	Higher risk of complications and poor neonatal outcomes	Limited geographic coverage and lack of longitudinal data
Gupta S et al.	2016	State-wise disparities in maternal mortality in India	Revealed significant variations by state and urban/rural divide	Did not assess intervention effectiveness
Rao S et al.	2021	Long-term follow-up of maternal health programs	Positive maternal health trends with sustained benefits	Limited sample size for follow-up and potential reporting bias

The table provides a summary of eight significant articles concerning maternal health in India, outlining their primary findings and limitations. The majority of the studies highlight advancements in maternal and child health while also identifying gaps, such as a scarcity of randomized controlled trials and insufficient long-term follow-up. Common issues include regional disparities and the underrepresentation of pregnant adolescents. Numerous studies examine obstacles to accessing care and the effects of nutritional interventions. Nevertheless, limitations such as small sample sizes, cross-sectional designs, and inadequate geographic coverage are noted, suggesting potential areas for future research.

Table 2: Summary of Assessed Parameters and Observed Changes in Indian Maternal Health Research

Authors	Year	Parameters Checked	Parameters Changed	Reason for the Change
Paul VK et al.	2011	Maternal mortality, child health indicators	Regional disparities in outcomes	Variations in healthcare access and socioeconomic factors
Singh A et al.	2019	Intervention effectiveness, adolescent care	Low RCT coverage, adolescent inclusion	Limited research focus and ethical challenges
Kumar S et al.	2018	Antenatal care coverage, birth outcomes	Improved antenatal visits and birth outcomes	Enhanced program implementation and awareness
Agarwal N et al.	2020	Access to maternal services, socio-cultural barriers	Reduced service utilization	Cultural taboos and infrastructural constraints
Sharma R et al.	2017	Nutritional status, birth weight	Reduced low birth weight incidence	Introduction of nutritional supplements
Mishra P et al.	2015	Pregnancy complications, neonatal outcomes	Increased complications in adolescents	Biological vulnerability and inadequate adolescent care
Gupta S et al.	2016	Maternal mortality rates by state and region	State-wise variations in mortality	Differences in healthcare infrastructure and policy execution
Rao S et al.	2021	Maternal health outcomes, program sustainability	Sustained improvement in some areas	Continued program support and follow-up

The table provides a summary of important maternal health research conducted in India, outlining the parameters evaluated, the changes observed, and the reasons behind those changes. It emphasizes regional disparities and differences in healthcare access as significant factors affecting outcomes. The lack of representation of adolescent pregnant women and cultural obstacles are identified as major challenges. Notable positive effects from nutritional interventions and enhanced antenatal care are apparent. Ongoing program support is demonstrated to be essential for achieving long-term improvements in maternal health.

Significance of the study: This research underscores significant deficiencies and advancements in maternal health studies throughout India. It stresses the necessity for region-specific approaches and focused interventions for at-risk populations, such as adolescent mothers. The results offer valuable information for policymakers aiming to enhance maternal health initiatives and service provision. Additionally, it highlights the critical role of ongoing monitoring and randomized controlled trials. In summary, the research provides essential evidence for fortifying maternal health systems in India.

Limitations: The research is constrained by its dependence on secondary data derived from previously published articles, which may exhibit diverse methodologies and sample sizes. The inconsistency in study designs complicates direct comparisons. The majority of articles emphasize short-term outcomes, with limited data on long-term follow-up. The representation of pregnant adolescents is notably low across the studies. Furthermore, while regional disparities are addressed, comprehensive district-level data is frequently lacking.

Implications of the study: Future studies should focus on implementing well-structured randomized controlled trials, particularly aimed at pregnant adolescents and underserved areas, to produce strong evidence for customized interventions. Increased attention to long-term outcome monitoring will aid in evaluating the sustainability of maternal health initiatives. Policymakers must confront socio-cultural obstacles and enhance healthcare infrastructure to improve service utilization. Bolstering health data systems at both state and district levels can enable more accurate, localized health planning. Incorporating adolescent-friendly services into maternal health programs may help mitigate complications for this at-risk demographic. Ultimately, ongoing funding and community engagement will be essential to ensure the persistence and effectiveness of maternal health programs, thereby supporting India's advancement towards meeting global maternal health objectives.

CONCLUSION

The studies that have been reviewed collectively highlight the intricate nature and variety of maternal health issues throughout India. There are notable regional and state-level differences in maternal mortality rates and health outcomes, which are largely shaped by inconsistent healthcare infrastructure and socioeconomic conditions. Although there has been advancement in antenatal care accessibility and nutritional programs, adolescent pregnant women continue to be a neglected and at-risk demographic that necessitates more concentrated efforts. Cultural and infrastructural obstacles persist, hindering access to vital maternal health services, particularly in rural regions.Additionally, the lack of randomized controlled trials and long-term follow-up studies limits the evidence required to develop effective policies. Ongoing program support and monitoring have been essential for achieving sustainable improvements. It is crucial to address these deficiencies through targeted research, inclusive policy-making, and community involvement to further decrease maternal morbidity and mortality rates in India.

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