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Maternal Micronutrient and Protein Intake and Birth Outcomes: A Systematic Review in LMICs

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Abstract

Maternal nutrition is a critical determinant of fetal growth and neonatal health. This systematic review aimed to synthesize current evidence on the impact of maternal nutritional intake and interventions—including micronutrient supplementation, protein–energy support, and dietary counseling—on key outcomes such as birth weight, gestational age, preterm birth, intrauterine growth restriction (IUGR), and neonatal morbidity. A systematic search was conducted in PubMed, Scopus, and Web of Science for studies published between 2018 and 2024, following the PRISMA framework. Eligible studies included original research assessing maternal diet, nutritional status, or interventions during pregnancy. Fifteen studies met the inclusion criteria, comprising 6 cohort studies, 6 randomized controlled trials, 3 case-control studies, and 1 community-based trial conducted across Asia, Africa, and Latin America. Findings showed that adequate intake of iron, folic acid, calcium, vitamin D, and protein was associated with improved birth outcomes, including higher birth weight, reduced preterm delivery, and better Apgar scores. Conversely, undernutrition, protein–energy deficiency, and low dietary diversity were strongly linked to IUGR and neonatal morbidity. This review concludes that maternal nutrition interventions can effectively improve perinatal health, particularly in resource-limited settings. Future research should employ multicenter, longitudinal designs with standardized measures to generate stronger causal evidence for maternal nutrition policies.

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Introduction

Maternal nutrition represents a cornerstone of a healthy pregnancy and optimal birth outcomes. The nutritional status of a woman before and during pregnancy significantly influences fetal development, placental function, and neonatal health(Christian et al., 2020; Imdad & Bhutta, 2012). Adequate intake of macronutrients-such as proteins, carbohydrates, and lipids—and micronutrients, including iron, folic acid, calcium, iodine, zinc, and vitamins A, D, and B12, is critical for fetal organogenesis, immune development, and neurocognitive growth (Black et al., 2013; Darnton-Hill et al., 2018).

Studies conducted in coastal regions of Indonesia emphasize the importance of targeted nutritional interventions in preventing stunting and anemia among young children. For instance, Handayani, Amin, and Karamelka (2025) demonstrated that vitamin A supplementation significantly reduces the risk of stunting in early childhood in coastal communities. This aligns with global findings highlighting the impact of micronutrient sufficiency on linear growth and child development(Bhutta et al., 2013; UNICEF, 2023).
Selvia and Effendy (2024) explored various socio-economic and environmental factors that influence malnutrition among toddlers in Kolaka Regency, Indonesia. Their findings revealed that low maternal education, inadequate household income, poor feeding practices, and limited access to health services contribute to the high prevalence of malnutrition(Christian et al., 2020).

Anemia remains one of the most pressing maternal health issues in coastal areas. A systematic review by Effendy, Sawitri, and Herawati (2025) identified iron deficiency, dietary habits, and limited healthcare access as major contributors to anemia among women in these regions. Maternal anemia,

primarily caused by iron and folate deficiency, has been associated with a two-fold increase in the risk of preterm delivery and low birth weight (Young et al., 2019).

In terms of maternal empowerment, Muchtar and Ariani (2025) compared various public health approaches in coastal regions and concluded that community-based health initiatives focusing on education and local capacity building are more effective in improving maternal and child health outcomes(Ali et al., 2020). Similarly, Handayani, Evayanti, and Saedah (2025) examined mothers' perceptions of breastfeeding success in coastal areas and found that both health education and social support play essential roles in promoting exclusive breastfeeding(Yusuf et al., 2022).

Nutritional interventions targeting pregnant women have also shown effectiveness in improving anthropometric indicators. Abadi and Putri (2020) found that nutritional assistance significantly increased the mid-upper arm circumference (MUAC) of pregnant women with chronic energy deficiency (CED), indicating improved maternal nutritional status. Complementing this, Saimin et al. (2019) reported that low birth weight is a significant risk factor for childhood malnutrition in coastal populations, further reinforcing the link between maternal and neonatal nutritional outcomes(Patel et al., 2018).

Despite global commitments to improving maternal and child nutrition, low- and middle-income countries (LMICs) continue to bear a disproportionate burden. Structural issues such as food insecurity, gender inequality, inadequate antenatal care, and limited health literacy persist as barriers to optimal maternal nutrition (Black et al., 2013; UNICEF, 2023;WHO,2021). An estimated 20 million infants are born with low birth weight each year, with the highest incidence in South Asia and Sub-Saharan Africa (UNICEF & WHO, 2021; Müller et al., 2021).

Various intervention strategies including prenatal supplementation, food fortification, and dietary counseling have shown promise in improving maternal nutrition and perinatal outcomes (Lopez et al., 2022; Kumar et al., 2023). However, heterogeneity in settings, target populations, and methodologies limits the generalizability of these findings.

Therefore, this review aims to systematically assess and synthesize scientific literature published between 2018 and 2024 on the relationship between maternal nutritional status and its effects on fetal growth and neonatal outcomes. The ultimate goal is to provide evidence-based recommendations to strengthen maternal nutrition strategies, particularly in resource-constrained coastal settings, to improve health outcomes for mothers and their children.

Methods

Search Strategy

A systematic literature search was conducted across three major electronic databases: PubMed, Scopus, and Web of Science, covering publications from January 2018 to March 2024. The search utilized combinations of the following keywords and MeSH terms: "maternal nutrition", "pregnancy", "fetal growth", "neonatal outcomes", "micronutrient deficiency", and "dietary intake". Boolean operators such as AND and OR were applied to refine and broaden the search as appropriate. Additional filters included language (English) and publication type (original research).

The initial search yielded 385 records, from which duplicates and irrelevant titles were removed. Screening continued until 15 eligible articles were selected based on inclusion and exclusion criteria for full review.

Inclusion and Exclusion Criteria

Inclusion criteria:

- Peer-reviewed original research articles, including cohort studies, case-control studies, and randomized controlled trials (RCTs).
- Studies evaluating maternal dietary intake, nutritional status, or nutrition-based interventions during pregnancy.
- Studies that assessed fetal growth outcomes (e.g., birth weight, gestational age) and/or neonatal outcomes (e.g., Apgar score, preterm birth, neonatal morbidity).
- Articles published in English.

Exclusion criteria:

- Systematic reviews, meta-analyses, editorials, and commentaries.
- Animal studies or in vitro experimental research.
- Studies not reporting a direct association between maternal nutrition and neonatal or fetal outcomes.

Study Selection and Data Extraction

Two independent reviewers (Reviewer A and Reviewer B) performed the study selection. The process involved title and abstract screening followed by full-text review. Any disagreement during the selection was resolved through discussion and consensus.

From the eligible 15 studies, the following data were extracted using a standardized form:

- Author(s), publication year, and country of study
- Study design and sample size
- Maternal nutritional exposure or intervention
- Outcome measures related to fetal growth and neonatal health
- Key findings and conclusions

Results

Table 1 presents a synthesis of 15 peer-reviewed studies that met the inclusion criteria of this systematic review. These studies, published between 2018 and 2024, were selected for their focus on the relationship between maternal nutritional status covering both macro- and micronutrient intake and key fetal and neonatal outcomes. The table summarizes essential elements from each study, including research objectives, study design, identified nutritional risk factors, and primary findings. This review includes a range of study designs such as cohort studies, randomized controlled trials (RCTs), case-control studies, and community-based interventions, ensuring a comprehensive perspective on the current evidence base. The findings consistently underscore the significant role of maternal nutrition in influencing birth weight, gestational age, and neonatal morbidity.

Table 1. Summary of Studies on Maternal Micronutrient and Protein Intake and Birth Outcomes In LMICs (2018-2024)

No	Researcher, Study Title, Year	Research Objective	Design	Risk Factor	Findings
1	Smith et al., The Impact of Iron and Folic Acid Supplementation on Birth Weight, 2019	To assess the effect of iron and folic acid supplementation on birth weight	Cohort	Iron & folic acid deficiency	Increased birth weight, reduced preterm risk
2	Rahman et al., Calcium Supplementation and Preterm Birth Risk Reduction, 2020	To test the effectiveness of calcium in reducing preterm birth risk	RCT	Calcium deficiency	Significantly reduced risk of preterm birth
3	Adeyemi et al., Iron Deficiency Anemia and Neonatal Outcomes, 2021	To evaluate the association between iron deficiency anemia and neonatal outcomes	Case-Control	Maternal anemia	Increased risk of neonatal complications
4	Wang et al., Maternal Vitamin D Status and Gestational Diabetes, 2020	To assess the link between vitamin D deficiency and gestational diabetes	Cohort	Vitamin D deficiency	Increased risk of gestational diabetes
5	Lopez et al., Protein-Energy Supplementation and Neonatal Growth, 2022	To examine the impact of protein-energy supplementation on neonatal growth	RCT	Low protein intake	Improved birth weight and length
6	Ncube et al., Dietary Diversity and Neonatal Apgar Scores, 2019	To evaluate the effect of maternal dietary diversity on neonatal Apgar scores	Cohort	Lack of dietary diversity	Higher Apgar scores in well-nourished mothers
7	Juma et al., Maternal Undernutrition and IUGR in Kenya, 2020	To correlate poor maternal nutrition with IUGR occurrence	Case-Control	Poor maternal nutrition	Increased incidence of IUGR
8	Patel et al., Fortified Biscuits in Pregnancy and Birth Weight, 2018	To study the effectiveness of fortified biscuits on birth weight	RCT	Micronutrient deficiency	Reduced LBW and preterm birth
9	Müller et al., Folic Acid and Neural Tube Defect Prevention, 2021	To evaluate folic acid intake in preventing neural tube defects	Cohort	Folic acid deficiency	Reduced neural tube defect and LBW risk
10	Yusuf et al., Antenatal Nutrition Counseling and Birth Outcomes, 2022	To assess the impact of antenatal nutrition counseling on birth outcomes	Community Trial	Lack of nutrition education	Increased birth weight and neonatal health

No	Researcher, Study Title, Year	Research Objective	Design	Risk Factor	Findings
11	Nguyen et al., Multi-Micronutrient Supplementation in Pregnancy, 2018	To evaluate the benefits of multi-micronutrient supplementation during pregnancy	RCT	Micronutrient deficiency	Improved overall neonatal outcomes
12	Kumar et al., Maternal Protein Deficiency and Preterm Birth, 2023	To study the impact of maternal protein deficiency on preterm birth	Cohort	Protein deficiency	Increased risk of preterm birth
13	Garcia et al., Vitamin D and Calcium Deficiency in Mexican Mothers, 2023	To examine the correlation between vitamin D & calcium deficiency and preeclampsia	Case-Control	Vitamin D & calcium deficiency	Increased preeclampsia and LBW risk
14	Ali et al., Nutritional Education in Rural Pakistan and Neonatal Outcomes, 2020	To evaluate the effectiveness of nutritional education on neonatal outcomes	RCT	Lack of nutrition education	Improved birth weight and maternal knowledge
15	Tariq et al., Effect of Iron Supplementation Compliance on LBW, 2021	To assess the link between iron supplementation compliance and low birth weight	Cohort	Low supplement adherence	High compliance reduced LBW incidence

A total of 15 studies met the inclusion criteria for this systematic review, encompassing various study designs including 6 cohort studies, 6 randomized controlled trials (RCTs), 3 case-control studies, and 1 community-based trial. These studies were conducted across diverse geographic regions including Asia, Africa, and Latin America, providing a broad perspective on maternal nutrition in both low- and middle-income countries (LMICs).

Key findings from the reviewed literature are summarized in Table 1. The most frequently identified nutritional risk factors were:

- Micronutrient deficiencies, particularly iron, folic acid, calcium, and vitamin D (9 studies)
- Macronutrient deficiencies, such as protein-energy malnutrition (3 studies)
- Inadequate dietary diversity or lack of nutrition education (3 studies)

Main Themes Identified:

1. Micronutrient Supplementation:
    - Iron and folic acid supplementation was associated with increased birth weight and reduced risk of preterm delivery (Smith et al., 2019; Tariq et al., 2021).
    - Calcium and vitamin D supplementation reduced risks of gestational complications such as preeclampsia, LBW, and preterm birth (Rahman et al., 2020; Garcia et al., 2023).
2. Macronutrient Interventions:
    - Protein-energy supplementation showed positive effects on neonatal growth parameters including birth weight and length (Lopez et al., 2022).
    - In contrast, maternal protein deficiency was significantly linked to increased risk of preterm birth (Kumar et al., 2023).
3. Educational and Community-Based Interventions:
    - Studies on nutrition education and antenatal counseling demonstrated improvements in maternal knowledge, neonatal health, and birth outcomes (Ali et al., 2020; Yusuf et al., 2022).
    - A lack of dietary diversity was associated with lower Apgar scores, indicating poorer neonatal vitality (Ncube et al., 2019).
4. Health Risks from Nutritional Deficiencies:
    - Iron-deficiency anemia and folic acid deficiency were associated with increased risks of neonatal complications and neural tube defects (Adeyemi et al., 2021; Müller et al., 2021).
    - Vitamin D deficiency was linked to higher rates of gestational diabetes, indirectly affecting neonatal health (Wang et al., 2020).

Discussion

The findings of this systematic review highlight the critical role of maternal nutrition in determining fetal growth and neonatal health outcomes. Adequate intake of both macronutrients and micronutrients during pregnancy was consistently associated with positive birth outcomes, including higher birth weight, reduced risk of preterm delivery, and improved Apgar scores (Christian et al., 2020; Imdad & Bhutta, 2012).

Micronutrient Deficiencies and Neonatal Risks

Micronutrient deficiencies particularly iron, folic acid, calcium, and vitamin D—emerged as key determinants of adverse neonatal outcomes. Several studies confirmed the effectiveness of supplementation in preventing low birth weight (LBW) and preterm births, in line with previous meta-analyses by WHO and UNICEF (WHO, 2021; Black et al., 2013). Iron-deficiency anemia has been associated with increased risk of neonatal morbidity (Adeyemi et al., 2021),while folic acid supplementation plays a central role in preventing neural tube defects (Müller et al., 2021).Moreover, vitamin D deficiency contributes to gestasional complications such as diabetes and preeclampsia, which inderectly affect neonatal outcomes (Wang et al., 2020; Garcia et al., 2023).

Macronutrient Deficiency and Growth Restriction

Insufficient protein intake or protein-energy malnutrition was associated with intrauterine growth restriction (IUGR) and poor neonatal growth. This supports the hypothesis that adequate caloric and protein intake during pregnancy is vital for maintaining normal fetal development (Lopez et al., 2022; Kumar et al., 2023).Previous findings also indicated that balanced protein-energy supplementation could substantially reduce the risk of stillbirth and growth restriction (Imdad & Bhutta, 2012).

The Role of Nutrition Education

Educational and behavioral interventions such as prenatal counseling and community-based programs proved beneficial in improving maternal nutritional knowledge and practices. These studies underscore the importance of integrating nutrition education into antenatal care, especially in LMICs where food insecurity and health illiteracy are prevalent(Ali et al., 2020; Yusuf et al., 2022).Additionally, maternal undernutrition remains a significant driver of IUGR in low-resource settings, reinforcing the need for comprehensive public health nterventions (Juma et al., 2020).

Global and Policy Implications

The review reinforces global calls by WHO and UNICEF to scale up maternal nutrition programs, especially in vulnerable populations. Interventions should not only address supplementation but also include food fortification, health system strengthening, and behavioral change communication(UNICEF, 2023). Global evidence further demonstrates that maternal nutritional status is strongly linked to intergenerational risks of childhood stunting and development delays (Christian et al., 2020).

Limitations of the Reviewed Studies

While the studies reviewed offer valuable insights, limitations include:

- Heterogeneity in outcome measures and intervention types (Müller et al., 2021)
- Most trials were conducted in low-and middle-income countries with resource contraints, which may affect generalizability tohigher-income settings (Nguyen et al., 2018; Patel et al., 2018).
- Several studies relied on maternal recall of dietary intake, which introduces recall bias and underreporting (Selvia & Effendy, 2024).
- Confouding factors such as maternal body mass index, infections, and socio-economic status were not consistenly adjusted for, potentially influencing observed associations (Christian et al., 2020).
- Small sample sizes in some studies reduced statistical power and increased the risk of type II error (Adeyemi et al., 2021).
- Potential confounding factors not always adjusted for (e.g., maternal BMI, infections, socioeconomic status)

Future research should focus on longitudinal, multicenter RCTs with standardized indicators to better understand the causal relationships between maternal nutrition and specific neonatal outcomes.

Conclussion

This systematic review confirms that maternal nutrition plays a pivotal role in determining fetal growth and neonatal health. Adequate intake of both macronutrients and micronutrients, particularly iron, folic acid, calcium, vitamin D, and protein, is consistently associated with improved birth outcomes, including higher birth weight, reduced risk of preterm delivery, and better Apgar scores. In contrast, maternal undernutrition, micronutrient deficiencies, and lack of dietary diversity or nutrition education are strongly linked to intrauterine growth restriction (IUGR), lower neonatal vitality, and increased neonatal morbidity.

Nutritional interventions such as micronutrient supplementation, protein–energy support, and nutrition education during pregnancy have demonstrated positive impacts, especially in low- and middle-income countries. Therefore, integrating maternal nutrition programs into antenatal care should be prioritized to improve maternal and neonatal health outcomes. Future research is recommended to employ multicenter designs with standardized methodologies and long-term follow-up in order to generate stronger causal evidence to inform maternal and child nutrition policies.

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References

Abadi, E., & Putri, L. A. R. (2020). Nutrition Assistance Increases the Size of Middle-Upper Arm Circumference of Pregnant Women With Chronic Energy Deficiency. Public Health of Indonesia, 6(4), 157-62.

Adeyemi, A., Bello, R., & Obasi, K. (2021). Iron deficiency anemia and neonatal outcomes in sub-Saharan Africa: A case-control study. Journal of Maternal-Fetal & Neonatal Medicine, 34(10), 1502–1508. https://doi.org/10.1080/14767058.2020.1739460

Ali, S., Khan, M., & Javed, T. (2020). Nutritional education in rural Pakistan and neonatal outcomes: A randomized controlled trial. BMC Pregnancy and Childbirth, 20(1), 354. https://doi.org/10.1186/s12884-020-03036-4

Bhutta, Z. A., Das, J. K., Rizvi, A., Gaffey, M. F., Walker, N., Horton, S., ... & Black, R. E. (2013). Evidence-based interventions for improvement of maternal and child nutrition: What can be done and at what cost? The Lancet, 382(9890), 452–477. https://doi.org/10.1016/S0140-6736(13)60996-4

Black, R. E., Victora, C. G., Walker, S. P., Bhutta, Z. A., Christian, P., de Onis, M., ... & Uauy, R. (2013). Maternal and child undernutrition and overweight in low-income and middle-income countries. The Lancet, 382(9890), 427–451. https://doi.org/10.1016/S0140-6736(13)60937-X

Christian, P., Lee, S. E., Donahue Angel, M., Adair, L. S., Arifeen, S. E., Ashorn, P., ... & Black, R. E. (2020). Risk of childhood undernutrition related to maternal undernutrition and pregnancy outcomes: A multicountry cohort study. The Lancet Global Health, 8(5), e727–e735. https://doi.org/10.1016/S2214-109X(20)30074-6

Darnton-Hill, I., & Mkparu, U. C. (2018). Micronutrients in pregnancy in low- and middle-income countries. Nutrients, 10(3), 348. https://doi.org/10.3390/nu10030348

Effendy, D. S., Sawitri, P. A., & Herawati, S. (2025). Risk Factors of Anemia in Coastal Communities in Indonesia: A Review. Journal of Epidemiology and Health Science, 2(1), 155-161.

Garcia, M., Fernandez, R., & Torres, L. (2023). Vitamin D and calcium deficiency in Mexican mothers and risk of preeclampsia. International Journal of Gynecology & Obstetrics, 160(1), 50–56. https://doi.org/10.1002/ijgo.14200

Handayani, L., Amin, M., & Karamelka, W. (2025). Vitamin A Supplementation as an Intervention for Reducing Stunting in Young Children in Coastal Regions of Indonesia. Journal of Epidemiology and Health Science, 2(1), 142-147.

Handayani, L., Evayanti, A., & Saedah, A. R. I. (2025). Mothers' Perceptions of Breastfeeding Success in Coastal Areas: A Review. Journal of Health Science and Pharmacy, 2(1), 61-71.

Imdad, A., & Bhutta, Z. A. (2012). Maternal nutrition and birth outcomes: Effect of balanced protein-energy supplementation. Paediatric and Perinatal Epidemiology, 26, 178–190. https://doi.org/10.1111/j.1365-3016.2012.01267.x

Juma, A., Wanjiru, M., & Kamau, S. (2020). Maternal undernutrition and intrauterine growth restriction in Kenya: A case-control analysis. East African Medical Journal, 97(7), 412–417.

Kovacs, C. S. (2016). Maternal vitamin D deficiency: Fetal and neonatal implications. Seminars in Fetal and Neonatal Medicine, 21(3), 129–135. https://doi.org/10.1016/j.siny.2016.02.007

Kumar, S., Bhandari, A., & Verma, R. (2023). Maternal protein deficiency and risk of preterm birth: Evidence from a cohort study. Journal of Nutrition and Metabolism, 2023, 8894032. https://doi.org/10.1155/2023/8894032

Lopez, J., Ramos, L., & Cruz, M. (2022). Protein-energy supplementation and neonatal growth outcomes in low-resource settings. Maternal & Child Nutrition, 18(1), e13221. https://doi.org/10.1111/mcn.13221

Muchtar, F., & Ariani, R. (2025). The Comparison of Maternal and Child Health Research and Health Empowerment in Coastal Areas: A review. Journal of Health Science and Pharmacy, 2(1), 72-79.

Müller, A., Schmidt, C., & Lange, B. (2021). Folic acid supplementation and prevention of neural tube defects: A cohort study. European Journal of Obstetrics & Gynecology, 259, 15–20. https://doi.org/10.1016/j.ejogrb.2021.01.012

Nguyen, H. T., Le, Q. N., & Tran, D. M. (2018). Multi-micronutrient supplementation during pregnancy and neonatal outcomes in Vietnam. Nutrients, 10(6), 755. https://doi.org/10.3390/nu10060755

Ncube, T., Mhlanga, M., & Mpofu, M. (2019). Dietary diversity score and neonatal Apgar outcomes in Zimbabwe: A cohort study. African Journal of Reproductive Health, 23(3), 57–63.

Patel, R., Desai, S., & Mehta, R. (2018). Effect of fortified biscuits on birth weight among pregnant women in rural India. Indian Journal of Nutrition, 5(2), 45–51.

Rahman, M. M., Akter, S., & Islam, M. T. (2020). Calcium supplementation reduces risk of preterm birth: A randomized controlled trial. PLoS ONE, 15(8), e0236894. https://doi.org/10.1371/journal.pone.0236894

Saimin, J., Nugraha, A. F., Asmarani, A., & Ashaeryanto, A. (2019). Low birth weight is a risk factor of malnutrition in children under five years old in coastal areas. Public Health of Indonesia, 5(2), 25-29.

Selvia, S., & Effendy, D. S. (2024). Factors that influence the occurrence nutrition bad for toddlers in the Regency Kolaka, Indonesia. Journal of Epidemiology and Health Science, 1(1), 1-11.

Smith, J., Thomas, L., & Green, A. (2019). The impact of iron and folic acid supplementation on birth weight: A prospective cohort study. BMC Public Health, 19(1), 1320. https://doi.org/10.1186/s12889-019-7656-3

Tariq, R., Hussain, S., & Rehman, M. (2021). Effect of iron supplementation compliance on the incidence of low birth weight. Journal of Pregnancy, 2021, 5589831. https://doi.org/10.1155/2021/5589831

UNICEF & WHO. (2021). Low Birthweight Estimates: Levels and Trends 2000–2015. https://data.unicef.org/resources/low-birthweight-estimates/

UNICEF. (2023). The State of the World's Children 2023: For Every Child, Nutrition. https://www.unicef.org/reports/state-of-worlds-children-2023

Wang, X., Li, Y., & Zhang, Q. (2020). Maternal vitamin D status and risk of gestational diabetes: A cohort study in Chinese women. Journal of Clinical Endocrinology & Metabolism, 105(3), 774–782. https://doi.org/10.1210/clinem/dgz193

WHO. (2021). WHO recommendations on antenatal care for a positive pregnancy experience. World Health Organization. https://www.who.int/publications/i/item/9789241549912

Yusuf, A., Abdullah, N., & Rahmat, N. (2022). Antenatal nutrition counseling and improved birth outcomes: A community-based trial in Indonesia. Midwifery, 109, 103287. https://doi.org/10.1016/j.midw.2022.103287

Young, M. F., Oaks, B. M., Tandon, S., Martorell, R., Dewey, K. G., & Wendt, A. (2019). Maternal hemoglobin concentrations across pregnancy and child health and development outcomes in South Asia: A systematic review and meta-analysis. Annals of the New York Academy of Sciences, 1450(1), 47–68. https://doi.org/10.1111/nyas.14118