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(REVIEW ARTICLE)

The Role of Micronutrients in Maternal Health and Child Development: A literature review

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Abstract

Maternal and child undernutrition remains a major global public health concern, particularly in low- and middle-income countries. Pregnancy represents a critical period characterized by increased nutritional requirements to support maternal physiological adaptation, placental function, and fetal growth and development. Inadequate intake of essential micronutrients during this period may lead to adverse maternal outcomes and long-term consequences for child health. This literature review aims to synthesize current evidence on the role of key micronutrients in maternal health and child development and to identify research gaps relevant to clinical nutrition practice. The review highlights that deficiencies in iron, folate, iodine, zinc, vitamin A, and vitamin D are associated with maternal anemia, pregnancy complications, impaired fetal growth, and suboptimal physical, immune, and neurocognitive development in children. While iron–folic acid supplementation remains a cornerstone of antenatal care, emerging evidence suggests that multiple micronutrient supplementation may offer broader benefits in populations with a high burden of concurrent deficiencies. In conclusion, optimizing micronutrient intake during pregnancy is essential to improve maternal and child health outcomes. Comprehensive and context-specific micronutrient interventions integrated into antenatal care are crucial to reducing the long-term burden of undernutrition.

Keywords: Micronutrients; Pregnancy; Maternal health; Child development; Clinical nutrition

1. Introduction

Maternal and child undernutrition remains a major global public health concern and continues to contribute substantially to morbidity and mortality worldwide, particularly in low- and middle-income countries (LMICs) [1, 2]. Pregnancy represents a critical period characterized by increased nutritional demands to support maternal physiological adaptations, placental function, and fetal growth and development. Inadequate intake of essential micronutrients during this period may result in adverse maternal outcomes as well as impaired fetal development with long-term consequences for child health [3, 4].

Micronutrients such as iron, folate, iodine, zinc, vitamin A, and vitamin D play indispensable roles in hematopoiesis, neurodevelopment, immune competence, and cellular growth [5, 6]. Despite global efforts to improve maternal nutrition, micronutrient deficiencies remain highly prevalent among pregnant women and young children, particularly in resource-limited settings [7]. Understanding the role of micronutrients in maternal and child health is therefore essential to inform effective clinical and public health interventions.

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This literature review aims to synthesize current evidence on the role of micronutrients in maternal health and child development, critically appraise existing studies, relevant to clinical nutrition practice.

2. Material and Methods

A literature search for this review was conducted using PubMed, ScienceDirect, and SpringerLink. Relevant studies were selected and key findings were extracted and organized into thematic categories. The review synthesized evidence from systematic reviews, observational studies, cross-sectional studies.

3. Review Content

3.1. Micronutrients and Maternal Health

During pregnancy, physiological changes such as increased blood volume, hormonal alterations, and accelerated fetal growth lead to a substantial increase in maternal micronutrient requirements [1, 3]. When these demands are not adequately met, micronutrient deficiencies may occur and disrupt normal maternal and fetal physiological processes.

Iron deficiency impairs hemoglobin synthesis, resulting in reduced oxygen-carrying capacity of the blood. In pregnant women, this condition may lead to maternal anemia, decreased oxygen delivery to the placenta, and impaired fetal growth [8, 9]. increasing the risk of maternal fatigue, infection, preterm delivery, and low birth weight. Chronic iron deficiency during critical periods of brain development can interfere with myelination, neurotransmitter synthesis, and neuronal metabolism, which may contribute to long-term cognitive and behavioral impairments in children [10-13].

Folate deficiency disrupts DNA synthesis and cell division, processes that are essential during rapid embryonic development. Inadequate folate availability during early pregnancy may result in failure of neural tube closure, leading to neural tube defects [10, 11]. At the molecular level, folate deficiency also affects methylation pathways that play a role in gene expression and normal fetal development [7].

Vitamin D deficiency has been increasingly recognized as a contributor to adverse pregnancy outcomes, including preeclampsia, gestational diabetes, and impaired fetal skeletal development [14]. Collectively, these findings underscore the importance of adequate micronutrient status for maintaining maternal health during pregnancy.

3.2. Micronutrients and Child Development

Micronutrient adequacy during fetal life and early childhood is essential for optimal physical growth, immune function, and neurocognitive development [1, 15]. Iron deficiency in early life has been associated with long-term deficits in cognitive performance, motor development, and behavior, even after iron repletion [16]. Iodine deficiency affects the synthesis of thyroid hormones, which are critical regulators of metabolism and neurodevelopment. During pregnancy, insufficient iodine intake may cause maternal hypothyroxinemia, thereby reducing the availability of thyroid hormones required for fetal brain maturation [12, 13]. This condition has been associated with impaired cognitive development and reduced intellectual potential in offspring [13].

Zinc deficiency interferes with cellular growth, immune function, and protein synthesis. In children, inadequate zinc status may impair linear growth, weaken immune responses, and increase susceptibility to infections [17]. Zinc also plays an important role in neurodevelopment through its involvement in synaptic transmission and neuronal signaling [5].

Vitamin A deficiency remains a major cause of preventable childhood morbidity and mortality, particularly due to its role in immune competence and epithelial integrity and increasing vulnerability to infections in both mothers and children [17]. Meanwhile, vitamin D deficiency affects calcium and phosphate metabolism, which are essential for fetal skeletal development and may contribute to adverse pregnancy outcomes [14].

These findings highlight that micronutrient deficiencies during critical developmental periods may have irreversible consequences, emphasizing the need for early prevention.

3.3. Micronutrient Supplementation and Public Health Implications

Micronutrient supplementation during pregnancy has been shown to reduce the prevalence of anemia, low birth weight, and certain congenital anomalies. While iron–folic acid supplementation is widely recommended, evidence suggests

that multiple micronutrient supplementation may offer additional benefits in populations with high nutritional vulnerability [18, 19]. However, the effectiveness of supplementation strategies varies across settings due to differences in baseline nutritional status, dietary patterns, and health system capacity [19]. Furthermore, most studies focus on single micronutrients, limiting understanding of nutrient interactions and long-term outcomes.

4. Conclusion

Adequate micronutrient intake during pregnancy is essential for maintaining maternal health and supporting optimal fetal growth and child development. Evidence summarized in this review demonstrates that deficiencies in key micronutrients, including iron, folate, iodine, zinc, vitamin A, and vitamin D, are associated with adverse maternal outcomes, impaired fetal development, and longterm consequences for child growth, immune function, and neurocognitive development. These effects are particularly pronounced when deficiencies occur during critical periods of pregnancy and early life, where biological processes such as organogenesis and brain development are highly sensitive to nutritional inadequacy. Iron and folic acid supplementation remains a cornerstone of antenatal nutrition programs, emerging evidence suggests that multiple micronutrient supplementation may provide broader benefits in populations with a high burden of concurrent deficiencies. However, variations in baseline nutritional status, study design, and outcome assessment highlight the need for context-specific and evidence-based approaches. Strengthening maternal nutrition strategies through comprehensive micronutrient interventions, alongside improved dietary quality and antenatal care, is crucial to improving maternal and child health outcomes and reducing the long-term burden of undernutrition.

Compliance with ethical standards

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Disclosure of conflict of interest

There is no conflict of interest.

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