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DAMPAK SUPLEMENTASI MIKRONUTRIEN IBU HAMIL TERHADAP LUARAN KEHAMILAN: A *LITERATURE REVIEW*

The Effect of Micronutrient Supplementation on the Pregnancy: A Literature Review

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ABSTRAK

Selama kehamilan, kebutuhan nutrisi meningkat dibandingkan dengan wanita yang tidak hamil. Makanan bergizi selama hamil meliputi asupan energi, protein, vitamin dan mineral. Namun di negara-negara berpenghasilan rendah-menengah. Pemenuhan kebutuhan asupan makanan ibu hamil menjadi tantangan yang menyebabkan terjadinya defisiensi mikronutrien sehingga diperlukan suplementasi mikronutrien. Tinjauan pustaka ini bertujuan untuk mendeskripsikan pengaruh suplementasi mikronutrien terhadap dampak pada kehamilan. Artikel ini disusun menggunakan Preferred Reporting Items for Systematic Review and Meta Analysis (PRISMA). Database diambil dari Science Direct, PubMed, Cochrane, dan SAGE Journal dengan kata kunci "Micronutrient during Pregnancy" OR "Micronutrient Supplementation of Pregnancy" OR "Micronutrient of Pregnant Women" OR "Supplementation of Pregnancy". Sepuluh artikel dianalisis mengenai desain tujuan, hasil serta kesimpulan. Hasil tinjauan pustaka ini menjelaskan bahwa suplementasi mikronutrien untuk ibu hamil yang penting yaitu zat besi (Fe), asam folat, kalsium (Ca), magnesium (Mg), tembaga (Mg), seng (Zn) dan vitamin A, vitamin B, vitamin C, vitamin D. Suplementasi ini dapat dikonsumsi sesuai apa yang dibutuhkan tubuh. Dampak konsumsi suplementasi selama hamil yaitu dapat mencegah terjadinya anemia, gizi buruk, dan preeklamsia/eklampsia pada ibu hamil, bayi lahir pendek, prematur, berat badan lahir rendah dan kematian.

***Kata kunci**: kehamilan, mikronutrien, neonatal, PRISMA, suplementasi*

ABSTRACT

During pregnancy, nutritional needs increase compared to women who are not pregnant. Nutritious food during pregnancy includes energy, protein, vitamin and minerals intake. However, in low- and middle-income countries, it is challenging to meet the food intake needs of pregnant women, which causes micronutrient deficiencies, so micronutrient supplementation is needed. This literature review aimed to describe the effect of micronutrient supplementation on the impact of pregnancy. This article employed the Preferred Reporting Items for Systematic Review and Meta Analysis (PRISMA). Databases were taken from Science Direct, PubMed, Cochrane, and SAGE Journals with the keyword is micronutrients during pregnancy" OR "micronutrient supplementation for pregnancy" OR "micronutrient for pregnant women" OR "Supplementation During Pregnancy". Ten articles were analyzed in terms of design, objectives, results, and conclusions. The results of this literature review explained that micronutrient

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supplementation for pregnant women is essential the micronutrients include iron (Fe), folic acid, calcium (Ca), magnesium (Mg), copper (Mg), zinc (Zn), vitamin A, vitamin B, vitamin C, and vitamin D which are consumed according to the body's need consumed based on the body's need. Consuming supplementation during pregnancy can prevent malnutrition anemia, and preeclampsia/eclampsia in pregnant women, short birth babies, premature birth, low birth weight, stillbirths.

Keywords: micronutrients, neonatal, pregnancy, PRISMA, supplementation

INTRODUCTION

Pregnancy is a condition where women experienes fertilization and fetal development in the womb. Thus, it is crucial to maintain a diet to improve the health of the mother and fetus. Therefore, it is important to maintain a diet in order to boost maternal and fetal health. A healthy diet includes good nutrition for pregnancy which consist of energy, protein, vitamin, and mineral intake. These nutrients aim to promote maternal and fetal health[3]. Nutritional needs increase 2-3 times during pregnancy compared to non-pregnant women[4]. Nevertheless, many pregnant women require adequate intake food such as fruits, vegetables, meat, and dairy are not fulfilled, which can lead to micronutrient deficiencies, this can lead to micronutrient deficiencies in low- and middle-income countries[5]. Micronutrient deficiencies are common public health problems in several low- and middle-income countries, for example, anemia caused by iron deficiency or increased infection and death (exacerbated by vitamin A and zinc deficiencies)[6], [7], [8].

Other minerals also need to be considered, as mineral levels tend to decrease during pregnancy if not supplemented adequately, such as calcium, magnesium, selenium, zinc, and iodine. Based on reviews, optimal mineral supplementation significantly reduced several pregnancy complications including anemia, gestational hypertension, gestational diabetes, hyperthyroidism, preeclampsia/eclampsia, and miscarriage. Meanwhile, infant illness such as anemia, asthma, autism, cerebral palsy, hypothyroidism, intellectual disabilities, low birth weight, neural tube defects, and premature birth can be mitigated [9].

Iron deficiency in pregnant women is one of the iron deficiency in pregnant women is one of the most common micronutrient deficiencies that leads to anemia. According to the World Health Organization (WHO), the highest prevalence of anemia is in Southeast Asia (49%)[10]. Indonesia is one of the countries of Southeast Asia that has the highest prevalence of anemia in pregnant women in 2020 in the age group of 15-24 years (84.6%)[11]. Anemia in pregnancy is caused by malnutrition, infections, parasites, blood loss, chronic diseases and chronic hemolysis, as well as several risk factors such as multiple pregnancies unhealthy lifestyles, menstrual disorders, smoking, and alcohol. Anemia in pregnancy has serious consequences for mother and baby, including an increased risk of intrauterine growth retardation, premature birth, and bleeding during labor and postpartum[11], [12].

Prevention and control of anemia in Indonesia has been implemented for all pregnant women by providing 90 Fe tablets during pregnancy, and a particular intervention is conducted by community health centers (PHC) or hospitals to anemic pregnant women (Hb <11 g / dl). However, these activities have not yielded satisfactory results due to low compliance in taking iron tablets associated with unfavorable taste, indigestion may occur even after taking the tablets[13]. Supplementation has been an effective strategy to prevent the adverse effects of micronutrient deficiencies during pregnancy[15]. Some of the strategies that have been implemented are food diversification, large-scale and targeted fortification, biofortification of staple crops, and micronutrient supplementation[16]. Fortification is undertaken because, generally, the diet during pregnancy may not necessarily meet the nutritional needs of pregnant women.[17]

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Based on this explanation, a literature review was conducted to examine and summarize the impact of micronutrient supplementation in pregnant women on pregnancy outcomes in accordance with previous studies.

METHODS

The systematic review article utilized the Preferred Reporting Items for Systematic Review and Meta Analysis protocol which focuses on the micronutrient supplementation of pregnant women on pregnancy outcomes. The systematic review search focused on essential literature based on electronic data. Electronic databases sourced from Pubmed, Science Direct, SAGE Journal, and Cochrane were combined. The search process used keywords such as “Micronutrients during Pregnancy” OR “Micronutrient Supplementation for Pregnancy” OR “Micronutrient for Pregnant Women” OR “Supplementation During Pregnancy.”

The analysis included original articles and review articles published in English within the last 6 years (2018-2023). Online search results using electronic data obtained 905 articles. All articles obtained were then analyzed in depth so 10 articles were selected as the basis for analysis in this paper. The inclusion criteria for this literature review consist of studies with the following samples: for mothers: pregnant women in the third trimester, pregnant women receiving antenatal care at healthcare facilities, primigravida or multigravida. For infants: infants born to these mothers, alive infants, and infants with measurable anthropometric data. Additionally, this review focused on research addressing the maternal and neonatal effects of micronutrient supplementation consumed by third-trimester pregnant women.

Articles retrieved through the database amounted to 905 articles. The article selection process involved examining titles, irrelevant abstracts, and filtering full texts, resulting in 870 articles. Further refinement of the search was conducted by excluding 20 articles that did not meet the outcome criteria regarding the maternal and neonatal effects caused by micronutrient supplementation. 5 articles were removed due to duplication. The flow of the review analysis process, from identification to screening and selection of articles for review, can be seen in Figure 1 below.

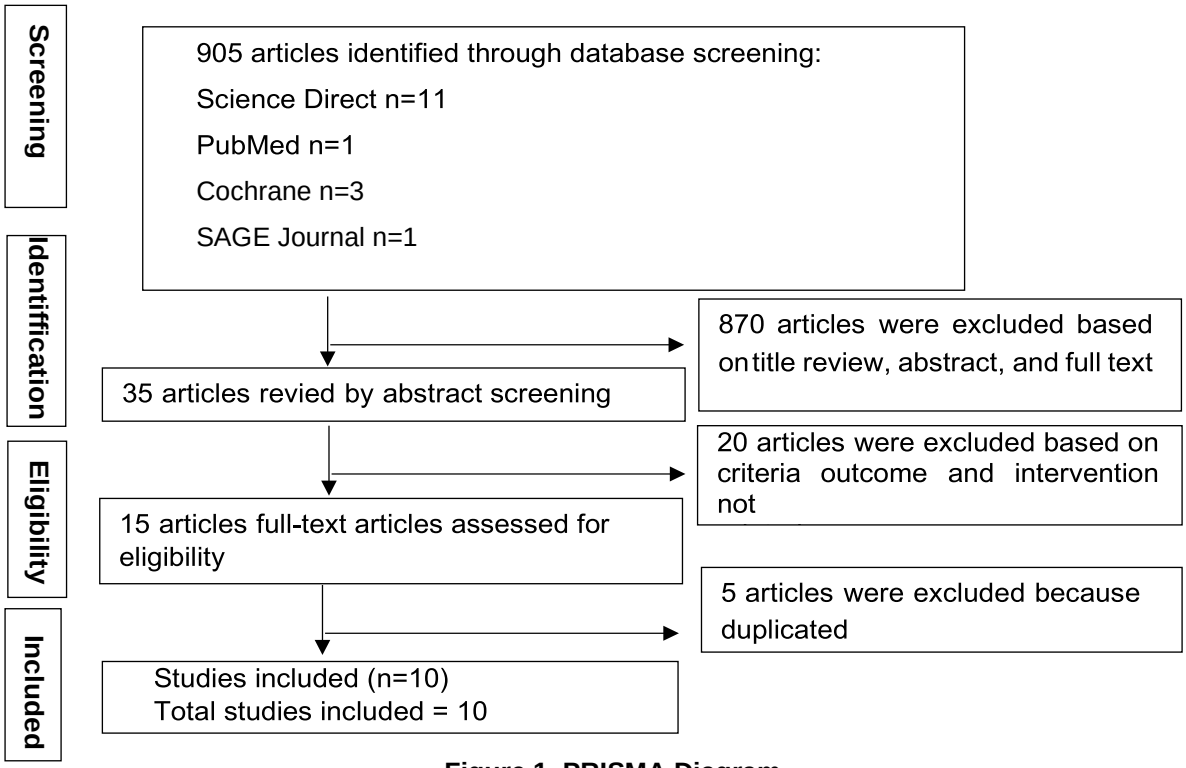

Figure 1. PRISMA Diagram

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RESULT

Based on articles selected from 905 articles in Figure 1, each article was taken from several databases.

Table 1. Results

Database	Keywords	Results
Science Direct	Micronutrient during Pregnancy, Micronutrient Supplementation of Pregnancy, Micronutrient of Pregnant Women, Supplementation of Pregnancy	585
PubMed	Micronutrient during Pregnancy, Micronutrient Supplementation of Pregnancy, Micronutrient of Pregnant Women, Supplementation of Pregnancy	240
Cochrane	Micronutrient during Pregnancy, Micronutrient Supplementation of Pregnancy, Micronutrient of Pregnant Women, Supplementation of Pregnancy	54
SAGE Journal	Micronutrient during Pregnancy, Micronutrient Supplementation of Pregnancy, Micronutrient of Pregnant Women, Supplementation of Pregnancy	26

Based on Table 1, search by using keywords such as "*Micronutrient during Pregnancy" OR "Micronutrient Supplementation of Pregnancy" OR "Micronutrient of Pregnant Women" OR "Supplementation of Pregnancy"* in 4 databases, there were 585 articles obtained from Science Direct, 240 articles of PubMed, 54 articles from Cochrane, and 26 articles from SAGE Journal. After the filtering process illustrated in Figure 1, there were 10 articles analyzed in Table 2.

Table 2. Research Article Summary about the Effect of Micronutrient Supplementation on the Impact of Pregnancy

No	Authors, year, Title	Objective	Design, sample, research location, year of research	Results	Conclusions
[1]	Gu et al., 2024 Assessment of Individual and Mixed Effects of Six Minerals on Thyroid Hormones in Chinese Pregnant Women.	To explore the relationship of the six mineral elements to thyroid function during pregnancy	Design: a cross-sectional study Sample: 489 participants with non-probability sampling Research location: three hospitals of major countries (Chunan, Qujiang, and Putuo) in Zhejiang Province, China Year of research: March 2020 to October 2021	Yodium is negatively related to the stimulant hormone TSH and has a positive relationship with FT3 and FT4	Six minerals (Ca, Mg, Fe, Zn, Se, and Iodine) contribute to thyroid function. Iodine deficiency in pregnancy has the potential to damage the neurocognitive development of the fetus and neonates.
[2]	Rak et al., 2024 Some Immune Parameters of Term Newborn at Birth Are Associated with the Concentration of Iron, Copper, and Magnesium	To distinguish the relationship between the concentration of Mg, Ca, Zn, Fe, and Cu in maternal serum and the concentration of IgG antibodies	The sample consisted of 98 pregnant women and their newborn children (46 boys and 52 girls) who checked into the Obstetrics and Gynecology Ward of the Provincial	The concentration of IgG antibodies in umbilical rope serum was adversely connected with the concentrations of Mg (p 0.002) and Fe (p 0.001) in maternal serum. Emphatically connected with Cu concentration in	Mineral components within the sustenance of pregnant women, most likely can increment the insusceptibility of newborns and diminish the hazard of neonatal contaminations an unfavorable wellbeing impacts heredity.

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No	Authors, year, Title	Objective	Design, sample, research location, year of research	Results	Conclusions
	in Maternal Serum	and antineutrophil cytoplasmic auto-antibodies against lactoferrin in umbilical rope serum.	Specialist Hospital, Poland. Year of research: April-December 2016 Design: cross-sectional with non-probability sample.	maternal serum (p 0.001).	
[3]	Domínguez et al., 2023 Micronutrients in Food Supplements for Pregnant Women: European Health Claims Assessment.	To assess the substance and ampleness of micronutrients contained in pregnant women's dietary supplements commercialized in Spain	The experimental design evaluated the adequacy of health claims related to micronutrients in 10 national food supplements marketed in Spain.	Vitamin C for pregnant women helps maintain the function of the immune system and improves iron absorption. Vitamin B9 functions for tissue growth in the mother during pregnancy. Iron is for the formation of red blood cells and hemoglobin, and oxygen transportation in the body. Copper provides protection for cells from oxidative stress. Manganese is for the formation of connective tissue and bone maintenance. Zinc is for the cell division process. Calcium is for the maintenance of the fetal bones.	All outcomes about of micronutrient examination (vitamin C, vitamin B9, iron, copper, manganese, zinc, calcium and or magnesium) contained in dietary supplements chosen from the Spanish advertisement were compared to the values expressed within the label and are inside the desired limits.
[4]	Adelo et al., 2023 Dietary Supplements Intake During Pregnancy Among Pregnant Women in Ethiopia.	To assess the prevalence and use of common dietary supplements during pregnancy in referral hospitals in Ethiopia	A cross-sectional study conducted from November 2020 to January 2021 in Ethiopia, with a total sample of 253 participants selected through a systematic random sampling technique.	Higher educational attainment enhances pregnant mothers' awareness and acceptance of the importance of nutrition. Mothers' compliance with consuming food supplements and regular prenatal check-ups can help prevent anemia and fetal growth restriction.	Despite the increasing prevalence of dietary supplement use, the duration of supplement use is often less than what the WHO recommends. Pregnant women are aware of the importance of taking folic acid and iron supplements to prevent anemia and low birth weight in their babies.
[5]	Uddin, et al., 2023 Analysis of serum calcium, sodium, potassium, zinc, and iron in	To discover the serum level of following components Such as micronutrients (zinc and iron) and macro-	The design was cross-sectional study, involving 192 pregnant women recruited from Department of Obstetrics and	The linkage between macrominerals. In expansion, systolic blood pressure was emphatically connected with sodium and contrarily related to	Pregnant women with preeclampsia were found to have lower levels of calcium, potassium, zinc, and iron than healthy pregnant women. In contrast,

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No	Authors, year, Title	Objective	Design, sample, research location, year of research	Results	Conclusions
	patients with pre-eclampsia in Bangladesh: A case-control study.	minerals (sodium, calcium, potassium) and their potential association with pre-eclampsia	Gynecology, Noakhali Medical College Hospital from August 2019 to November 2019.	potassium within the control group.	sodium concentration was higher in pregnant women with preeclampsia. Thus, it is recommended that the higher intake of calcium, potassium, iron, zinc as an important therapeutic intervention, while restricting sodium intake, in order to help prevent complications associated with pre-eclampsia
[6]	Jaisamrarn, et al., 2023 Vitamins and minerals, education, and self-care need during preconception to 1000 days of life in Southeast Asia: An expert panel opinion	Summarizing key clinical learnings and evidence-based conclusions from specialists to get the require for vitamin and mineral supplementation, instruction, and self-care from preconception to the first 1000 days of life	The opinions of nine Southeast Asian experts were used to evaluate the available literature on the importance of vitamin and mineral supplementation during preconception, pregnancy, and lactation. An expert panel meeting was conducted virtually on 13th July 2021. The multidisciplinary expert panel consisted of nine experts across specialties, including obstetrics and gynecology, dietetics, and epidemiology from the Philippines, Malaysia, and Thailand	- The predominance of the inadequacies and wholesome focal points of the mother - Fitting mediation starts bias and proceeds until the first 1000 days of life. - Multi-micronutrient supplementation can progress maternal and child wellbeing - Execution of national nourishment procedures and activity plans.	Malnutrition sustenance may be an issue that happens in Southeast Asia during preconception, pregnancy and breastfeeding, requiring contact from health workers to encourage women of childbearing age to follow good calorie counting and utilize appropriate multi-micronutrient supplementation for themselves and their children.
[7]	Tyagi et al., 2023 Assessment of maternal dietary intake during pregnancy and its relation with nutritional status of infants at birth	Assessing the mother's food intake during pregnancy was associated with the nutritional status of the baby at birth	The participant were 144 pregnant women during the third semester. This study used a longitudinal follow-up study with a non-probability technique done from October 2014 to July 2016 through door to door survey from West Delhi.	The mother's intake of nutrients (energy, protein, micronutrients such as riboflavin, niacin, B6, and zinc) during pregnancy was found to correlate significantly with anthropometric measurements of the baby at birth.	Poor food intake is obtained from pregnant women living in slums. The mother's food intake was significantly related to the nutritional status of the baby at birth.

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No	Authors, year, Title	Objective	Design, sample, research location, year of research	Results	Conclusions
[8]	Vazquez et al., 2023 Nutrient Intake among Pregnant Women in Spain and Poland: A Comparative Analysis	Comparing nutritional intake and adequacy against the recommendations of pregnant women	This study was a longitudinal study with a total of 583 pregnant women included in the first trimester (453 from Spain and 130 from Poland), and 465 were included in the third trimester (414 from Spain and 51 from Poland). This study included data from Tarragona , Spain 2013-2017 and Poznan, Poland 2016-2018.	Adequate protein intake by pregnant mothers significantly influences fetal growth and development, while fiber intake can lower cholesterol levels and the risk of insulin resistance. Iron deficiency can lead to anemia and low birth weight. Vitamin D supplementation can increase the risk of gestational diabetes, preeclampsia, and premature birth and can affect calcium metabolism, causing bone health problems in both mothers and children. Vitamin B9 supplementation during pregnancy can result in prematurity, increased risk of neural tube defects, and cognitive impairments in children.	Emphasizing the importance of addressing insufficient nutrient intake (iron, vitamin D, and vitamin B9) can be obtained from daily foods and additional supplementation to reduce adverse effects on pregnancy for both mother and child.
[9]	Keats et al., 2021 Effects of vitamin and mineral supplementation during pregnancy on maternal, birth, child health and development outcomes in low- and middle-income countries: A systematic review.	Evaluate and summarize the evidence on the impact of micronutrient supplementation	The design was a systematic review that searched papers published from 1995 to October 31, 2019 in CAB Abstracts, CINAHL, Cochrane Central Register of Controlled Trials, Embase, International Initiative for Impact Evaluations, LILACS, Medline, POPLINE, Web of Science, WHOLIS, ProQuest Dissertations & Theses Global, R4D, and WHO International Clinical Trials Registry Platform. Non-indexed grey literature searches were conducted using Google, Google	Greater multi-micronutrient supplementation lowers the risk of low birth weight. Vitamin D supplementation may reduce the risk of premature birth. Calcium supplementation can reduce the occurrence of preeclampsia/eclampsia.	Multi-micronutrient and vitamin supplementation improve maternal and child health outcomes and reduces the risk of maternal anemia, low birth, premature birth, stillbirth, micronutrient deficiency, preeclampsia/eclampsia, and diarrhea in children.

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No	Authors, year, Title	Objective	Design, sample, research location, year of research	Results	Conclusions
			Scholar, and web pages of key international nutrition agencies.		
[10]	Oh et al., 2020 Vitamin and Mineral Supplementation during Pregnancy on Maternal, Birth, Child Health, and Development Outcomes in Low and Middle-Income Countries: A Systematic Review and Meta-Analysis	To know the effectiveness and evaluation of different supplementation interventions on birth outcomes, child health, and development	A Systematic Review design using RCTs with a control arm was used, with 314 papers (451.723 women) collectively. The databases were CAB Abstracts, CINAHL, Cochrane Library, Embase, International Initiative for Impact Evaluations, LILACS, Medline, Popline, Web Science, and WHO library database. The final research date was 31 October, 2019.	- MMN supplementation provides more results in reducing the incidence of premature birth and low birth, compared to IFA. - The benefits of MMN (Multiple-Micronutrient) supplementation are more beneficial in children with diarrhea and retinol concentration - MMN supplementation doesn't have a major effect in reducing maternal and neonatal mortality.	Specific micronutrient supplementation must be tailored to specific needs in order to get maximum results.

From the conducted search, it was found that there were 905 articles relevant to the keywords. These articles were then analyzed thoroughly to select 10 articles for inclusion in this literature review. The analyzed articles encompass publications from the last six years (2018 to April 2024) and are sourced from databases such as Science Direct, PubMed, Cochrane, and SAGE Journal. This study focused on the maternal and neonatal effects of micronutrient supplementation during pregnancy. There were 4 articles employing a cross-sectional design, 1 article with an experimental design, 3 articles conducting systematic reviews, and 2 articles utilizing a longitudinal study design.

DISCUSSION

There are a few micronutrients contained in certain articles, including iron (Fe), calcium (Ca), folic acid, magnesium (Mg), copper (Cu), zinc (Zn), vitamin A, vitamin B6, vitamin B9, vitamin C, and vitamin D. Typical micronutrient supplement provided to pregnant women in Indonesia includes iron, calcium, and folic acid.

Gu et al. (2024) conducted research highlighting the importance of six minerals (calcium, magnesium, iron, zinc, selenium, and iodine) in supporting thyroid health during pregnancy. Iodine plays a crucial role in the synthesis of thyroid hormones. If iodine deficiency occurs, this can have a negative effect on the neurocognitive development of the fetus from pregnancy to birth or during the neonatal period[18]. Typically, in line with research by Megier et al.(2023), that the oxidation state of iodine could be a main component of the thyroid, even though this is also supported by several other minerals. The require for 50% iodine increments quickly amid pregnancy in arrange to preserve the homeostasis of the maternal and fetus. Pregnant women who experience thyroid disorders will affect the condition of their fetus, such as congenital heart defects in the fetus, disorder of brain development, low birth weight, disorder of fetal bone growth, fetal hyperthyroidism, fetal hypothyroidism, intellectual disabilities, and neurological diseases

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in the fetus[19], [20]. Apart from iodine, it is essential to ensure and enhance the fulfillment of other micronutrients. The research of Rak et al.'s (2024) explained, that achieving optimal and balanced levels of mineral elements is important to maintain the nutritional status of pregnant women. This balance is critical because it impacts fetal immunity during pregnancy, reduces the likelihood of neonatal infections, reduces future health problems, and decreases the risk of neonatal mortality[21], [22].

Pregnant women may also experience the effects of essential nutrient deficiencies. According to Adelo et al. (2023), pregnant women may experience anemia and low birth weight (LBW) due to iron deficiency. Therefore, it is important for mothers to receive of iron and folic acid supplements[23]. Furthermore, according to Uddin et al. (2023), pregnant women diagnosed with preeclampsia exhibit decreased levels of calcium, potassium, zinc, and iron compared to healthy pregnant women. Conversely, they have higher sodium levels. Thus, it is imperative to implement effective interventions to enhance calcium, potassium, iron, and zinc intake while minimizing sodium intake to prevent preeclampsia[24][25]. Interventions by giving iron and folic acid to pregnant women can reduce the risk of hypertension in pregnancy, with folic acid alone[26].

Recommendations for reducing the adverse effects of inadequate nutritional intake include multi-micronutrient supplementation[27]. Keats et al., (2021) stated that multi-micronutrient supplementation is highly recommended for consumption by pregnant women with maternal nutritional deficiencies. It comprehensively enhances both maternal and child health compared to iron-folic acid supplementation alone[28], [29]. Pregnant women who take iron-folic acid supplements have a decreased chance of premature birth, low birth weight, and neonatal passing compared to those who expand as if it were one supplement (either iron or folic acid).[30] Following research conducted by Domínguez et al. (2023) in Spain, they have introduced food supplements containing multiple micronutrients to the market. The marketed products align with the values stated on their labels and meet the specified recommendations, as confirmed by research findings. Certain multi-micronutrient supplements available on the market contain essential elements such as copper (Cu), which support the immune system of the mother and fetus. Zinc (Zn) contributes to fertility, reproduction, and immune system function, which is particularly important during the first trimester of pregnancy. Manganese (Mn) serves a protective role against oxidative stress at the cellular level, while calcium (Ca) aids in the maintenance, growth, and development of fetal and child bones.[31], [32] By ensuring adequate intake of micronutrients through these supplements, various pregnancy complications can be mitigated. These complications may include but are not limited to anemia, gestational hypertension, gestational diabetes, and neural tube defects. Additionally, proper nutrition during pregnancy can also contribute to the prevention of preterm birth, low birth weight, and other adverse outcomes for both the mother and the baby.

It is strongly recommended to provide multi-micronutrient supplementation to pregnant women to complement their daily food intake. In the research of Tyagi et al. (2023), most of pregnant women who live in slum areas tend to have poor food intake. According to statistical analysis, maternal food intake has a significant relationship with the nutritional status of the baby at birth [32],[33],[34]. Multi-micronutrient supplementation should not only be given to pregnant women but also during the preconceptional, postpartum, and breastfeeding periods o prevent malnutrition.

Likewise, folic acid supplementation amid previously established inclination and early pregnancy is very important. It contributes to anticipating neural tube abandons, such as spina bifida, by as much as 40-80%.[36] Calcium is basic for bone mineralization, which functions as the main intracellular component in maintaining cell membranes [37]. Low maternal calcium admissions can cause osteopenia, paresthesia,

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muscle issues, lockjaw, maternal tremors, delayed fetal growth, low birth weight babies, and poor fetal mineralization.[38] Zinc is an important catalytic useful in protein union, nucleic acid metabolism, cell division, gene expression, antioxidant defense, wound mending, vision, and neurological and resistant capacities. Zinc is found in meat, fish, milk, and nuts. In cases of zinc deficiency, it can cause immune disorders, prolonged labor, premature birth, preterm labor, intrauterine growth restriction, low birth weight, and hypertension.[39]

In addition, vitamin A is important during pregnancy because it can improve vision, fetal growth, bone metabolism, immunity, and antioxidant activity. It also supports the growth and maintenance of fetal tissues and aids in maternal metabolism.[40] Synthesis of vitamin A occurs either from retinoids or provitamin carotenoids, which are precursors. Retinoids like retinoic acid and retinoate are sourced from foods such as eggs, milk, liver, and fish liver oil. Carotenoids like beta-carotene are found in vegetables such as water spinach, sweet potatoes, and carrots.[41], [42]

Vitamin B complex includes vitamin B1 (thiamine), vitamin B2 (riboflavin), vitamin B3 (niacin), vitamin B6 (pyridoxine), and vitamin B12 (cyanocobalamin), consisting of water-soluble vitamins which are essential for the metabolism proteins, fats, and carbohydrates. Vitamin B complex is obtained from animal sources such as fish, meat, poultry, dairy, nuts, and green leafy vegetables[43]. Several studies showed that thiamine deficiency can interfere with fetal brain development [43],[44]. Deficiencies in riboflavin and niacin have been associated with conditions such as preeclampsia, congenital heart defects, and low birth weight.[46] A deficiency in cyanocobalamin causes complications such as placental abruption, stillbirth, low birth weight, and premature birth.[43], [47]

Vitamin C is a vital vitamin found in fruits and vegetables such as guavas, oranges, tomatoes, and broccoli. Vitamin C aims to increase antioxidant defenses and prevent oxidative stress by inhibiting the formation of free radicals. Vitamin C supplementation in pregnant women can reduce the risk of various pregnancies, including the birth of babies with low birth weight.[48]

Vitamin D is vital in keeping calcium balance and bone health. Vitamin D is synthesized subcutaneously through exposure to ultraviolet-B radiation (sunlight) found in foods such as fish, dairy products, and supplements in the form of cholecalciferol (vitamin D3) or ergocalciferol. Vitamin D deficiency in mothers can cause rickets in newborns. However, giving vitamin D supplements during pregnancy can diminish the hazard of preeclampsia, low birth weight, and premature birth and can optimize maternal and fetal bone health.[47],[48]

This intervention should be implemented optimally by professional health workers to ensure that mothers can maintain a healthy and balanced diet containing appropriate multi-micronutrient supplements.[50], [51] On the other hand, pregnant women who are aware of their nutritional needs must be monitored, evaluated, and given regular counseling during antenatal care (ANC) visits. This approach aims to increase pregnant women's compliance with nutritional recommendations and address any problems effectively by contributing to the birth of healthy babies and minimizing the risk of complications and related diseases.[51],[52]

CONCLUSION

Multi-micronutrient supplementation is highly recommended to enhance maternal outcomes and well-being. Some micronutrient supplements include iron, calcium, magnesium, zinc, copper, folic acid, vitamin A, vitamin B6, vitamin B9, vitamin C, and vitamin D. Multi-micronutrient supplements play a crucial role in supporting maternal and fetal health and immunity during pregnancy. Adequate intake of micronutrients through these supplements can prevent various pregnancy complications. Complications that

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may occur in mothers include maternal and neonatal anemia, gestational hypertension, gestational diabetes, and neural tube defects. Furthermore, proper nutrition during pregnancy can also contribute to preventing preterm birth, low birth weight, and other adverse outcomes for both the mother and her baby.

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