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Literature review paper

Teenage Pregnancy and Micronutrient Deficiency: A Critical Review

Embarazo adolescente y deficiencia de micronutrientes: Una revisión crítica

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Abstract
Adolescence is a critical stage where growth is at its peak and when a pregnancy occurs in this period, it represents a greater nutritional risk for both the mother and the growing fetus. Young pregnant adolescents are more likely to give birth to babies with certain congenital anomalies, lower birth weight, and higher chances of infant mortality. Insufficient micronutrients in maternal nutrition during pregnancy can increase the risk of birth defects in newborns. This can be attributed to the fact that the developing fetus depends on the mother's nutrition for its proper growth, metabolic processes, and proper development. Malnutrition during pregnancy can lead to a variety of birth defects, including neural tube closure defects, cleft lip and palate, congenital heart defects, and increased fetal mortality. Iron deficiency early in pregnancy in the first and second trimesters could lead to premature birth or decreased birth weight and negatively impact the health of newborns. Most spontaneous abortions observed in adolescents during the first trimester could be attributed to nutritional deficiency of the mothers prior to conception. Few of the miscarriages observed in adolescents during the first trimester could be attributed to the nutritional deficiency of the mothers prior to conception.

Keywords: **anaemia, teenagers, pregnancy, micronutrients.**

Resumen

La adolescencia, etapa crítica donde el crecimiento está en su punto máximo y cuando un embarazo ocurre en este período, representa un mayor riesgo nutricional tanto para la madre como para el feto en crecimiento. Las jóvenes adolescentes embarazadas tienen una mayor tendencia de dar a luz a bebés con ciertas anomalías congénitas, menor peso al nacer y mayores posibilidades de mortalidad infantil. La insuficiencia de micronutrientes en la nutrición materna durante la gestación puede aumentar el riesgo de defectos congénitos en los recién nacidos. Esto se puede atribuir a que el feto en desarrollo depende de la nutrición de la madre para su adecuado crecimiento, procesos metabólicos y adecuado desarrollo. La desnutrición durante el embarazo puede provocar una variedad de anomalías congénitas, como defectos de cierre del tubo neural, labio y paladar hendido, defectos cardíacos congénitos y mayor mortalidad fetal. La deficiencia de hierro al inicio del embarazo en el primer y segundo trimestre podría provocar un parto prematuro o una disminución del peso al nacer y un impacto negativo en la salud de los recién nacidos. Pocos de los abortos espontáneos observados en adolescentes durante el primer trimestre podrían atribuirse a la deficiencia nutricional de las madres antes de la concepción.

Palabras clave: **anemia, adolescentes, embarazo, micronutrientes.**

1. Introduction

Malnutrition refers to an imbalance in nutrition within the human body, either in excess or deficit. This term is most associated with the latter form of malnutrition in the context of low and middle-income countries (LMICs) [Yimer and Wolde, 2022]. The high prevalence and serious implications of malnutrition including micronutrient deficiencies make the nutrition of teenage girls and young women in LMICs particularly crucial (Keats *et al*., 2022). Malnutrition can manifest in different ways resulting in infections, noncommunicable diseases, disability, or death. It becomes a significant issue when observed in adolescents, who have specific nutritional requirements for their bodies, especially during pregnancy. Micronutrient deficiencies affect two billion people living in (LMICs). Micronutrient deficits deteriorate during pregnancy and have long-term effects on both the mother and the fetus. Women who receive micronutrient supplements throughout pregnancy and breastfeeding may be able to lessen these effects (Shinde *et al*., 2022).

Supplementing with micronutrients during pregnancy is essential for promoting good growth and development and guarding against preterm birth and low birth weight (Bekele *et al*., 2024). Depletion may result from the fetus' rapid growth and development throughout pregnancy as well as its enlarged vascular volume (Georgieff *et al*., 2020). Research has indicated that inadequate intake of certain micronutrients during pregnancy can heighten the likelihood of low birth weight and premature deliveries (Georgieff *et al*., 2020). The World Health Organization (WHO) advises all pregnant women to take a daily supplement of iron throughout their pregnancy to lessen these effects (WHO, 2016). The deficits of certain micronutrients such as iodine, selenium, iron, zinc, calcium, magnesium, and folate that are germane in the proper fetus formation in pregnancy and their effects on adolescent pregnancies are the main topics of this narrative review.

Firstly, the development of the cranium is one of the most intricate processes in the human body (Babai and Irving, 2023). Birth deformities that affect the mouth and face include cleft lip and palate.

When the tissues that make up the lip and palate don't fuse correctly during development, these abnormalities happen. Although the exact cause of cleft lip and palate is unknown, inadequate nutrition for expectant mothers has been associated with an increased incidence of the condition. Another birth issue that may be connected to inadequate nourishment for the mother is heart defect. The structure and function of the heart may be impacted by several disorders, which can range in severity. According to research, women who consumed more folic acid both before and throughout their first pregnancy were less likely to give birth to a baby who had a congenital heart abnormality. Pregnant women have long utilized folic acid (FA), a synthetic version of folate, as a dietary supplement. It has been established that supplementing with FA can prevent fetal neural tube abnormalities (NTDs) from occurring and from recurring. On the other hand, congenital heart disease (CHD) incidence has been rising globally in tandem (Cheng *et al*., 2022).

Furthermore, micronutrient deficiencies during pregnancy can have long-term effects on the developing fetus. A prolonged period of severe nutrient shortage can result in several crises, including weakened immune function, redox signaling, wounds scarring, and the expression of genes that regulate the development of diseases (Zemrani and Bines, 2020). Moreover, iodine and iron deficits have been linked to harm to the fetus' neurodevelopment (Zemrani and Bines, 2020).

The fetus has a store of nutrients during the second and third trimesters of adolescent pregnancy that can be used after birth; as a result, children's growth during the first two years of life defined as the child's first 1000 days is accelerated in comparison to children without adequate store of nutrients (Beluska, 2019). This time frame is necessary for growth and development and is remarkably the result of the dietary standards provided; if these standards are not met, the baby may experience deficiencies in development, including brain function (Beluska, 2019). Most reviews on pregnancy that were done on adults concentrated on vitamin D and folate (Wilson *et al*., 2018; Palacios *et al*., 2019; Rajwar *et al*., 2020).

Pregnant teens should be provided with a choice of nutrient-dense foods that will support their growth and their increased requirement for many nutrients should be highlighted. The months of pregnancy are crucial because during this time, the mother's and the fetus' growth and development depend more on several nutrients. The body requires the greatest amount of micronutrients at this time to support several functions, such as bone formation and metabolic functions. Women who start menstruating have considerably higher iron needs, and these needs only grow when they get pregnant. Also, their need for magnesium, vitamin A, and folate rises and resembles those of adults. Deficiencies of iron, iodine, and zinc are often neglected despite their major role in the health of pregnant adolescents. Thus, this review focuses on the effects of selected micronutrients that are vital to teenage pregnancy

2. Methods

This is a narrative review of studies published prior to August 2024 using "Pregnancy and Micronutrient Deficiency / Adolescent Pregnancy and Micronutrient Deficiency" in biomedical databases. The main inclusion criterion was that articles needed to have systematic reviews and meta-analyses of the micronutrient status of pregnant women, teenage pregnancy, and micronutrient deficiency. The following search strategy was applied: articles were extracted from PubMed, google scholar, web of Science, and grey literature using the terms "Pregnancy", "Adolescent pregnancy", "micronutrients", "micronutrients deficiency", and in combination with ''Teenage pregnancy micronutrients efficiency". The most relevant and essential literature in the field was identified using expert knowledge on nutrition and incorporated into the article. These articles' titles and abstracts were screened to determine if they fulfilled the eligibility criteria. The articles included had to be related to pregnancy, teenage pregnancy, micronutrients, importance and deficiencies of micronutrients. Studies were excluded if: 1) subjects did not have micronutrients deficient status reported; 2) micronutrients status was not reported quantitatively using primary micronutrient markers; 3) the micronutrients status was not reported in association with prenatal/maternal/intrauterine; 4) full - length text was not available; 7) specific study types, including, dissertations, animal studies, correspondences, editorials, conference proceedings, and health letters.

3. Effects of minerals on teenage pregnancy and fetal development

3.1. Iodine (I)

This is a crucial part of the thyroid hormones thyroxine (T4) and triiodide-thyronine (T3), which regulate the thyroid gland and the immune system in several biological processes (Shahid *et al*., 2024). Iodine deficiency exists throughout all life cycle but is more severe in pregnant teenagers, lack of iodine leads to hypothyroidism and other disorders, classified as iodine deficiency disorders (IDDs) [Zhou *et al*., 2019]. Iodine supplementation can be recommended to fulfill individual needs, especially for juvenile expectant mothers, to prevent the potential impacts that its deficiency can have on the neural development of the fetus (Zhou *et al*., 2019).

Teenagers who are pregnant need more nutrients during their pregnancy to meet the needs of both the mother and the developing fetus. In addition to giving the fetus iodine, the mother's thyroid hormones must be maintained at normal levels, especially during the first trimester. Furthermore, especially in the first trimester of pregnancy, this increase is necessary to supply iodine clearance by the kidneys (Zimmermann, 2016). Likewise, iodine deficiency can manifest in other forms such as oxidative stress, causing disturbances in trophoblastic cell function and the placental vascular net, and weakened redox balance since it can compete with free radicals or induce the action of enzymes with antioxidant activity (Olivo-Vidal *et al*.,2016).

Due to its irreversible effects, iodine deficiency is particularly risky for teenage pregnancies, reproductive-age women, and women who are pregnant or nursing. This mineral increases the risk of irreparable damage because it is essential for neuron migration and myelination in the brain and causes hypothyroxinemia when levels are low (Olivo-Vidal *et al*.,2016). The primary cause of the unavoidable mental delay during the embryonic phase is iodine deficiency, which can cause an IQ (Intelligence Quotient) decline of up to 20 points (Olivo-Vidal *et al*.,2016).

3.2. Selenium (Se)

A mineral with antioxidant properties is selenium. It is an integral component of the antioxidant enzyme GSH-Px, which balances free radicals and prevents the body from producing more of them. It also maintains the body's natural defenses, controls growth and development, activates the immune system, and guards against cancer and heart disease (Hofstee *et al*., 2020). Foods high in selenium include cereals, vegetables, meat, and oilseeds such as nuts, but the amount of selenium in the diet varies depending on the climate. Selenium is easily absorbed from diets because of its high bioavailability (Olivo-Vidal *et al*., 2016). For people aged 19 to 50, the recommended daily consumption quantities are 45 to 50 μg, 60 μg for women, and 70 μg for adults and for men and nursing moms, it is 75 μg (Stoffaneller and Morse, 2015). Selenium levels below 0.9 μmol/L have been associated with reduced thyroid hormone balance; this effect is more pronounced in older persons over 65 and youngsters. Significant amounts of selenium have been found in the thyroid gland, indicating that the mineral is necessary for regular biological activity.

More specifically, there has been a stronger correlation shown between decreased innate and adaptive immune system activity and the activity of selenium-containing proteins in the oxidative system, which eliminates free oxygen radicals produced during the synthesis of thyroid hormones. Selenium insufficiency is also associated with the development of cretinism because of its direct linkage with iodine during the body's conversion of hormones (Stoffaneller and Morse, 2015; Mao *et al*., 2016; Nogales *et al*.,2017).

A shortage in selenium during pregnancy can impact the T cells, leading to an increase in oxidant substance production and other issues that impact both the mother and the developing fetus. Pre-eclampsia, glucose intolerance, changes in the lipid profile, mental and psychomotor delay, and other diseases are some of the associated issues (Mao *et al*., 2016; Amorós *et al*., 2018; Jiang *et al*., 2019).

3.3. Iron (Fe)

Iron is a necessary mineral for several biological processes, such as the production of erythrocytes and the transport of oxygen. It also co-occurs in the transport of enzymes, primarily those involved in the metabolism of lipids, and is vital for the immune system's upkeep (WHO, 2017; Rees *et al*., 2019). When a pregnant teenager's iron requirements are out of balance and insufficient to maintain homeostasis, iron deficiency results (Georgieff, 2020). This is a global public health issue that mostly affects women of reproductive age, nursing mothers, and infants (Harvey and Boksa 2014; Saydam *et al*., 2017; WHO, 2017).

Anemia is highly prevalent in several continents such as Africa, Asia, South America, and even Eastern Europe, especially in women of reproductive age (WHO, 2017, Saydam *et al*., 2017). Anemia has been associated with inadequate ingestion of iron, deficiency of folate and vitamin B12, problems of low absorption, inefficient iron transport, parasite infections, and diseases, such as HIV, for example. The condition is characterized by a low level of hemoglobin in the blood, which interferes with the body's ability to transport oxygen (WHO, 2017). Anemia can be thought of as the last stage of iron deficiency (Georgieff, 2020). It is possible to notice symptoms like exhaustion and trouble completing everyday tasks. Measurements of serum ferritin and/or transferrin receptor levels, as well as hemoglobin concentration, are advised for diagnosis. Moreover, types of anemia: normocytic, macrocytic, and microcytic, each of which has a different etiology (WHO, 2017). When a teenager needs iron for proper development and growth is pregnant, one of the observed problems is the reduced activity of the immune system, especially a significant reduction in the number of T cells produced and available for use.

Thus, both innate and adaptative immune systems are weakened, exposing the mother and the fetus-to bacteria, viruses, and other pathogens attacks. The immune system whose foremost function is to protect the mother and fetus from infections caused by several sorts of pathogens becomes weakened and compromised. Iron deprivation at the beginning of pregnancy can lead to premature birth or low birth weight and threaten the health of the newborn (Harvey and Boksa, 2014; WHO, 2017). Gestational anemia is related to a higher maternal mortality rate as well as interferes with the weight and health of the neonatal (Chikakuda *et al.*, 2018). It also can lead to miscarriage during the first trimester (Guo *et al*., 2019).

3.4. Zinc (Zn)

One of the several metallic ions that are frequently present in the human brain is zinc. In the body, this mineral is essential. Approximately 90 % of this oligo element is found in the bones and skeleton muscles. It is absorbed in the small intestine through a mechanism mediated by transporters. Studies have indicated that different population groups absorb it at different rates depending on the type of diet and the molar proportion of phytate. The concentration of zinc in the gastrointestinal tract is the only factor that determines its absorption; it has been shown that people who consume high levels of zinc in their diet also tend to absorb zinc less readily (Galetti *et al*., 2016). Teenagers who are pregnant may lose zinc through their gastrointestinal tract, urine, or skin, hair, or perspiration. Hexa and pentaphosphate of inositol should not be consumed simultaneously with phytic acid for optimal absorption. Phytic acid is the main dietary component that is known to impede zinc binding to transporter cells.

More than 50 % of preterm and severely premature neonates have cerebral white matter damage (WMI), the main component of the premature brain, which can be brought on by a zinc shortage (Volpe, 2019). Since the pre-oligodendrocyte (pre-OL), the progenitor of OLs that create mature myelin, is the target in the cellular core area of WML, its morphologic effects are subjacent to most documented future neurological impairments. Hypomyelination results from the preterm brain's pre-OL failing due to lesions (Volpe, 2019).

3.5. Calcium (Ca)

The mineral calcium (Ca), which depends on a number of genetic and environmental factors, is responsible for the development and upkeep of bone tissue. One of the most important indicators of bone health, bone mineral density (BMD), has a phenotypic manifestation that is known to be influenced by genetics to a degree of 60 % to 70 %. Furthermore, between 30 % and 40 % of BMD is influenced by environmental variables, including nutrition and lifestyle. The likelihood of changing these environmental elements and, therefore, improving bone tissue becomes crucial when describing their impact on the skeleton. Of these, the dietetic Ca content is the most pertinent to bone health (Bromage *et al*., 2016).

The mother's and the fetus's bone health are greatly impacted by calcium deficiency. Severe Ca deficiency during adolescent pregnancy can be fatal to the mother, raising the possibility of pre-eclampsia, and detrimental to the fetus by increasing the likelihood of spontaneous preterm. Pre-eclampsia raises the risk of infant mortality by causing miscarriage or drug-induced preterm birth

(Weaver *et al*., 2014). When it comes to preterm delivery, a shortage in calcium can limit intrauterine growth, cause low birth weight, and eventually have several physical and cognitive effects, such as greater atrophy. Pre-natal Ca ingestion can reduce the risk of premature birth and can be associated with its function in supporting fetal growth and maturity (Mosha *et al*., 2017).

3.6. Magnesium (Mg)

This is the fourth cation present in the human body universally and it is the second most commonly found cation inside human cells. About 53 % of it is found in bones, approximately 27 % in muscles, 19 % present in soft tissues that are not muscles, and only 1 % in the extracellular liquid; the majority of it is bonded to different chelators in the intracellular space, including ATP, adenosine diphosphate, protein, RNA, DNA, and citrate (Altura *et al*., 2016).

The parathyroid hormone (PTH) and vitamin D both affect its absorption. When calcitriol was given to uremic patients, the amount of magnesium absorbed through the jejunum returned to normal; in patients who were also malpositioned and had insufficient vitamin D, this absorption decreased (Conlon and Bird, 2015). This nutrient is widely available in all food sources; deficiencies in it are uncommon under normal circumstances and are typically associated with the presence of a concomitant illness (Altura *et al*., 2016).

Magnesium deficiency manifests with diverse symptoms such as severe reduction in cognitive capacity, processing, and in particular decreased attention span, increased aggression, weariness, and lack of focus and concentration (Elbaz *et al*., 2017). Other prevalent symptoms may include frequent irritation, anxiety, and fluctuating humor (Viktorinova *et al*., 2016). Magnesium deficiency has been adversely implicated in maternal and perinatal settings, as it has been associated with risks, such as hypertensive pregnancy syndrome, leg cramps, and premature birth. Mg deficiency has also been associated with the highest Apgar scores among newborns and reduced occurrence of hypoxic-ischemic encephalopathy; however, as only 2 of the 10 randomized clinical trials were considered of the highest quality, the authors concluded that there was insufficient evidence to support oral Mg supplementation during pregnancy as beneficial for the mother and/or the fetus (Farias *et al*., 2020).

Magnesium aids in the production of ATP and energy, the removal of ammonia from the brain associated with inattention, and the conversion of important fatty acids into DHA (docosahexaenoic acid), which is necessary for the healthy construction and operation of brain cells. It can help lessen oxidative stress associated with the physiopathology of attention deficit hyperactivity disorder (ADHD) due to its antioxidant properties. Magnesium can also help with sleep disturbances associated with ADHD, which can negatively impact attention (de Araújo *et al*.,2020).

3.7. Folate

Folate (vitamin B9) is one of the thirteen essential vitamins, present in food items, but folic acid is a synthetic supplement that is added to food for fortification. Metabolically inert, vitamin B9 (natural dietary folate) is sometimes referred to as folic acid which is the synthetic form (Jouanne *et al*., 2021). Folic acid has a higher bioavailability and is chemically more stable than folate. Although there are differences in data on the bioavailability of food folate, food is thought to comprise 50 % of total bioavailable folic acid. Considering this variation in bioavailability, the notion of dietary folate equivalents (DFEs) is employed: 0.6 μg of folic acid in fortified foods, 0.5 μg in supplements, or 1 μg of dietary folate are all comparable to 1 μg of DFE (Argyridis, 2019; Jouanne *et al*., 2021). Folate deficiency is frequently caused by pregnancy, particularly in cases of multiple pregnancies or complex pregnancies with vomiting. Certain pregnancy issues, such as congenital heart disease, preeclampsia, intrauterine growth restriction, and neural tube abnormalities (NTD), such as spina bifida and anencephaly, can be caused by a folate shortage (Argyridis, 2019). It is also critical to stress that women with pregestational diabetes should take 5 mg of the medication daily (Jouanne *et al*., 2021).

4. Conclusion

The effects of the micronutrients on teenage pregnancy are so crucial to the extent that if deficiency occurs in the juveniles, it causes congenital abnormalities, affects the mother's health, and the unborn babies and may eventually lead to maternal mortality and deaths of the fetus. If the babies survive the gestational period, the baby may develop diverse metabolic syndromes. Policymakers, physicians, nutritionists, and other health workers should focus more attention on the micronutrient status of adolescents. Therefore, it becomes paramount that proper education should be given to pregnant teenagers and more research should be focused on nutritional intervention for these vulnerable groups.

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Conflict of interest

There is no conflict of interest in the publication of these research notes.

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