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Nutritional Deficiencies and Requirements during Pregnancy

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ABSTRACT

Pregnancy is a complex process that requires a healthy diet to ensure the proper growth and development of the fetus. The nutrient requirements vary depending on the stage of pregnancy, physical activity level, and body mass index. During pregnancy, the body undergoes significant changes, including weight gain, hormonal changes, and changes in cardiac and hematological functions. The fetus overgrows, and the placenta and uterus expand to hold it. The increased blood volume and oxygen demand also require more nutrients. A healthy diet during pregnancy includes a variety of foods, such as fruits, vegetables, whole grains, lean proteins, and healthy fats. The nutrient requirements during pregnancy vary depending on the stage of pregnancy. In the first trimester, the energy requirements are minimal, but they increase significantly in the second and third trimesters. The essential nutrients during pregnancy include Protein, carbohydrates, fats, vitamins, and minerals. Protein is necessary for fetal growth and development, while carbohydrates provide the mother and fetus energy. Fats are essential for brain development and hormone production. Folic acid, vitamin D, and iron are crucial for fetal growth and maternal health. Minerals such as Calcium, chromium, copper, iodine, iron, magnesium, manganese, molybdenum, selenium, sodium, zinc, potassium, chloride, vitamin B_1 (thiamine), vitamin B_2 (riboflavin), vitamin B_5 (pantothenic acid), vitamin B_6 (pyridoxine), vitamin B_9 (folic acid), and vitamin B_{12} (Cobalamin) are also essential for fetal growth and development.

Keywords: Pregnancy; High-risk pregnancy; Nutritional deficiencies; Dietary reference intakes (DRI); Dietary guidelines; Neural tube defects; Anaemia; Cretinism; Anencephaly; Hemorrhage; Toxaemia.

1. Introduction

Pregnancy is the term used to describe the period in which a fetus develops inside a woman's womb or uterus. This is one specific characteristic feature that can be observed in mammals. Due to the complex and large brain, the human fetus grows very slowly. The slow growth rate is vital to accrue the nutrients that must laid down in the fetus, uterus, placenta, extra maternal fat, expanded blood volume, and developed breasts. A healthy, balanced diet is essential to obtain the recommended intake during pregnancy. Usually, this diet can be exceeded slightly, about 10-15%, more than a diet that is recommended before pregnancy [1]. During pregnancy, micronutrients and omega-3 fatty acids are essential for cell differentiation, proliferation, production of hemoglobin, and oxygen transportation. Vitamin D and iron deficiencies are also mainly affected during pregnancy.

1.1. Study objectives

Pregnancy causes changes in the nutritional requirements due to the effect of the fetus and inadequate fulfillment of nutritional needs may become nutritional deficiencies. So that nutritional deficiencies can be avoided or/and controlled following recommended dietary guidelines specified for countries and regions. Importance of recommended nutritional requirements with their roles has been studied in this review.

1.2. Normal pregnancy and high-risk pregnancy

Normal pregnancy is defined as the condition of a pregnant woman who had no more than three previous births and absence of gestational diabetes, pre-eclampsia, kidney diseases, hypertension, and non-communicable diseases, and the age limit should be above 18 and below 34. A pregnant woman who has a high-risk pregnancy is defined as a

condition where the above disease or diseases have appeared. Then, nutrient requirements are different depending on normal pregnancy and high-risk pregnancy due to the utilization of nutrients. Nutritional requirements and deficiencies during normal pregnancy are studied [2].

1.3. Changes observed during pregnancy

Weight gain is the first change that can be observed during pregnancy. Due to the fetus's weight, the placenta, uterus, amniotic fluid, mammary gland, blood, and adipose tissue, a physiological gestational weight gain occurs. Then, hormonal changes are a critical factor during pregnancy. By the synthesis of chronic gonadotropin (hCG) in the placenta, an increase in the production of pre-existing hormones such as progesterone, estrogens, and prolactin can be identified. As cardiac and hematological changes, plasma volume increases, hemoglobin concentration decreases, and red blood cell count decreases. A decrease in systemic vascular resistance occurred, and platelet count at the end of pregnancy was reduced to the standard limit. As another essential change, oxygen demand increases by 20–30% in pregnant women. The respiratory rate is increased, and hyperventilation can be observed. During pregnancy, alveoli prepare for lactation with the growth and development of lactiferous ducts. So, these changes cause an increase in the nutritional needs during pregnancy to ensure the proper growth of the fetus [1].

2. Nutritional Requirements during Pregnancy

Dietary habits during pregnancy are essential to ensure maternal well-being and a favorable pregnancy outcome. Usually, caloric restrictions are not recommended, and consumption of fiber-rich food, a minimum of five portions per day of vegetables and fruit, is recommended. High-fat and sugar food (ex, fried foods, high-sugar drinks, and confectioneries) should be avoided [3].

2.1. A healthy diet during pregnancy

The nutrient requirements of the diet vary with the level of physical activity and the Body Mass Index (BMI) at the beginning of activity. Nutrient needs are also different with the different stages (trimesters). For example, there is only a smaller increment in nutrient requirements in the first trimester.

2.2. Energy requirements

Energy requirements during pregnancy depend on individual women, and the guidelines vary for different countries. The basal metabolic rate, pre-pregnancy weight, composition and amount of weight gain, stage of pregnancy, and level of physical activities are the factors that must be considered for energy requirements during pregnancy. It is recommended that a pregnant woman requires 2855 calories per day, and needs for energy in the first trimester are minimal because there is no high energy-intensive related maternal basal metabolic rate for rapid development of fetal organs in the first trimester. After the first trimester, the development of the uterus, mammary glands, placenta, and fetus happens, and blood volume is increased, which is caused by significant energy needs [4].

2.3. Carbohydrates and fiber

Carbohydrates and fiber are essential for the functions of fetal organs, cell biosynthesis, structural components, and the primary substrate for fetal growth and coenzymes. At least 75% of the energy needed for the functions of the

fetus and brain is provided by the utilization of glucose from carbohydrates. Fiber delays the absorption of nutrients due to postprandial insulin response, and fiber helps to provide bulk for stool and absorb water to relieve transit time. Fibers are essential for maternal digestive health and beneficial due to changes in progesterone levels that can be caused by constipation [3].

2.4. Protein

In this period, dietary Protein is used additionally for fetal and placental growth, development of internal tissues, production, and increment of blood volume and amniotic fluid. From early pregnancy, the requirement for protein increases gradually. Over the last half of gestation, about 82% of total Protein is used to fulfill the maternal and fetal protein requirements. Low birth weight may happen due to inadequate maternal Protein. Also, the increment of Protein during pregnancy compared to nonpregnancy is more remarkable than other increments of nutrients. Especially protein intake for vegan pregnant women and multiple fetus incidents should need more attention.

2.5. Lipids and fats

A mother's diet should include an adequate amount of fat to meet a growing baby's needs. Sterols, phospholipids, and triglycerides are fundamental building blocks of body tissues, and these lipids can be integrated into body functioning. Also, lipids are essential for building up cell membranes and hormones. The essential fatty acids and chlorine that play key roles in healthy brain functioning are provided via the fat intake of a pregnant woman.

2.6. Essential fatty acids

As essential fatty acids, omega-6 (linoleic acid) and omega-3 (linolenic acid) play a key role and are crucial precursors of hormones. The optimal formation of the eyes and brain of a fetus occurs with the essential fatty acids.

2.7. Minerals

Calcium: During the third trimester, Calcium can cause mineralization of the fetal skeleton. Approximately 30g of Calcium is contained in a full-term baby's skeleton, and the maternal calcium needs are increased from the third trimester (1000-1200 mg per day). So, intestinal absorption of Calcium is increased in early pregnancy, and vitamin D is recommended as a supplement in the seventh month, which is vital for promoting intestinal calcium absorption. Lack of calcium intake, like bone loss and pre-eclampsia, can be severely affected in the last trimester. The WHO ensures that calcium supplements can reduce the risk of pre-eclampsia and leg cramps in pregnant women.

Chromium: During pregnancy, chromium is vital to regulate blood glucose along with insulin. Also, it helps break down carbohydrates, fats, and proteins so that gestational diabetes can be prevented and stimulates fatty acids and cholesterol synthesis. Most fruits and vegetables, meat, and grains are rich in chromium.

Copper: The requirement for copper is increased during pregnancy due to the critical growth of the fetus. Though severe copper deficiency is rare, copper deficiencies can be induced via excessive intake of iron and zinc, particularly drugs. Also, copper deficiency is caused by premature and low birth weight. The suboptimal copper is negatively affected by the brain, heart, vessels, tissues such as lungs, skin, and hair, and systems, including the skeletal and blood systems, during the development of the fetus (Uriu-Adams et al., 1997).

Iodine: Iodine requirements during pregnancy can be fulfilled by consuming iodized salts. This is essential for thyroid hormone synthesis, and thyroid hormones are necessary for developing the central nervous system via cell migration and myelination regulation. So, the iodine requirement is increased by 50% during pregnancy until the fetal thyroid can deliberate iodine and produce thyroid hormones, and maternal thyroxin production should be ensured as an adequate supply.

Iron: Hemoglobin production for oxygen transportation is the most critical role of iron. The daily iron requirement for pregnant women is very high (22-27 mg per day) due to increased blood mass and fetal growth. So, the intestinal absorption capacity of iron is increased from 40% to 10%, and Vitamin C helps increase iron absorption. Also, with the presence of polyphenols, tea, and coffee are affected adversely by this absorption. However, anemia is common during pregnancy due to iron deficiency in 2-5% of women in the first trimester and 10-20% in the third trimester. Iron deficiency anemia is considered severe when the Hemoglobin level is less than $7gdl^{-1}$. The threshold values for iron deficiency anemia are given below:

First and third trimester - Hemoglobin level should not be less than $11gdl^{-1}$.

Second trimester - Hemoglobin level should not be less than $10.5gdl^{-1}$.

Maternal iron intake reduces the risks of low birth weight and premature births, increasing the average birth weight.

Magnesium: The serum magnesium decreases gradually during pregnancy, and the magnesium level is increased after childbirth. About 50% of the average amount of magnesium is absorbed through the placenta, and the requirement for magnesium is increased due to the needs of the fetus. Usually, a pregnant woman's magnesium requirement is around 350 mg per day.

Manganese: Manganese is an essential micronutrient that helps break down carbohydrates, amino acids, and cholesterol, and the formation and development of fetus bones that occurs with the use of manganese during pregnancy.

Molybdenum: Molybdenum is a micronutrient that is important for eliminating toxic substances. Also, molybdenum is essential as a cofactor for enzyme activities, and the deficiency of molybdenum is rare due to the low amount required during pregnancy. The richest resources are beans, lentils, and grains.

Selenium: A multivariable role is played as a micronutrient, and selenium is essential for a healthy pregnancy. Inadequate intake of selenium causes a decrease in serum selenium that is associated with poor pregnancy outcomes, such as poor fetal growth [6]. Maternal and fetal oxygen demand is increased during pregnancy due to the formation of new oxygen-reactive species and products of lipid peroxidation. The ability of antioxidant defense and limit oxidative damage are related to these changes in oxygen demand [7].

Zinc: Relative to the nonpregnancy state, zinc is required during pregnancy, as high as 11 mg per day. Also, zinc is essential to prevent premature delivery and favorable neurological development of the fetus. Approximately 100 mg of zinc is required to synthesize maternal and fetal tissues. Without increased dietary intake, additional needs for zinc cannot be fulfilled because the absorption efficiency of zinc does not change significantly during pregnancy. Legumes, cheese, milk, and egg yolk are rich sources of zinc [4],[8].

Potassium: During pregnancy, it is vital to consume the recommended potassium intake to maintain the fluid and electrolyte balance due to increased blood volume and transfer of nerve impulses. Also, mineral imbalance is caused by leg cramping during pregnancy, and potassium, Calcium, and magnesium are essential to prevent this.

Sodium: Sodium plays a key role in maintaining increased blood volume and fluid balance. Inadequate sodium intake causes a reduction in blood volume and impacts the growth and function of the placenta. The recommended sodium intake can ensure optimal fetal nervous and other systems development, proper metabolic function, and adequate birth weight.

Chloride: It is essential to maintain fluid balance, and chloride affects blood volume and pressure and the ratio of acid/base of fluids as an electrolyte. Adequate consumption of salt provides the sodium and chloride requirements during pregnancy.

2.8. Vitamins

Vitamin A (Retinol): Vitamin A plays a key role in the development of gastrointestinal and respiratory mucous membranes and the skin and skeletal systems during pregnancy. Excess intake of vitamin A can be affected adversely. Because of that, it is recommended that fish oil and retinol-containing food supplements should be avoided during pregnancy. Vitamin A is abundant in animal-originated food (ex, seafood, eggs, milk). Also, plant-derived foods (Ex, pumpkin, apricots, carrots) are rich in pro-vitamins of vitamin A, which are no risk during pregnancy [9].

Vitamin B_1 (Thiamine): Vitamin B_1 is essential for placental function, fetus growth, and proper utilization of carbohydrates. Cereals and whole grain products, fortified bread, salmon, and lentils are rich in vitamin B_1.

Vitamin B_2 (Riboflavin): Vitamin B_2 plays a key role in bone development, iron absorption, and function of the nervous system and muscles in the womb. Vitamin B_2 deficiency is caused by pre-eclampsia and congenital disabilities. As a water-soluble vitamin, riboflavin cannot be stored in the body, and daily intake is recommended. Usually, whole grains, carrots, broccoli, and leafy greens are rich sources of vitamin B_2.

Vitamin B_5 (Pantothenic acid): Intake of vitamin B_5 is necessary to metabolize carbohydrates, proteins, and fats. Also, pantothenic acid is needed to produce red blood cells, and this vitamin helps to secrete stress-relieving hormones and avoid muscle cramps during pregnancy. Milk, egg yolk, bran, and avocado are rich in vitamin B_5, and vitamin B_5 deficiency is rare due to the natural availability of vitamin B5 in most foods.

Vitamin B_6 (Pyridoxine): Protein metabolism and the other 100 reactions are mainly involved in vitamin B_6 as a coenzyme. Vitamin B_6 is associated with improved pregnancy outcomes as it reduces the risk of toxemia. Vitamin B_6 cannot be stored at a significant level, and increased intake is not applicable in early pregnancy before the predominant requirements of vitamin B_6 in the last half of pregnancy, so it is recommended that a 1.9 mg/day of intake is needed for pregnant women [9].

Vitamin B_9 (Folic acid): Folic acid has more bioavailability and chemical stability than folate, and there are differences in the bioavailability of folic acid. Considering the bioavailability, dietary folate equivalents (DFEs) are

used. High folic acid intakes may be caused to promote cancer, interact with medications, and impair fetal development.

Vitamin B_{12} (Cobalamin): For various reasons, vitamin B_{12} is essential during pregnancy and helps maintain the reproductive system's health and immune system. Also, it is vital to be involved in most enzymatic reactions. Vitamin B_{12} and folic acid are essential for the cognitive development of the fetus. Milk, dairy products, and fish are rich in Cobalamin, and large amounts are available in oysters [9].

Table 1. Role of nutrients during pregnancy

Nutrient	Role during pregnancy
Energy	Growth and production of maternal and fetal tissues
Carbohydrate	Non-protein energy needs
Protein	Fluid balance, maternal and fetal tissue production [10]
Fat	Growth, development, and function of fetal nerve and brain tissue, cell membranes, and organs
Folate	Fetal neural tube formation [11]
Pyridoxine (Vitamin B_6)	Coenzyme for maternal energy metabolism [12]
Cobalamin (Vitamin B_{12})	DNA and RNA synthesis [13]
Retinol (Vitamin A)	Fetal tissue development [14]
Calcium	Fetal skeleton mineralization [15]
Iron	Maternal blood volume expansion through hemoglobin synthesis [16]
Zinc	DNA and RNA synthesis
Potassium	Nerve impulses transmission [17]
Sodium	Nerve impulses transmission
Chloride	Part of hydrochloric acid in the stomach [18]

Vitamin C (Niacin): Vitamin C can enhance iron absorption and reduce the risk of infections. Daily vitamin C requirements can be fulfilled by three or four food commodities that contain Vitamin C.

Vitamin D (Calciferol): Vitamin D is essential to maintaining bone health and some non-skeletal functions such as immune function, non-communicable disease-related functions, and fetal development.

3. Role of Nutrients during Pregnancy

Energy requirements, minerals, and vitamins play essential roles in pregnancy. The roles of selected key nutrients during pregnancy are listed in Table 1. According to Table 1, energy is required to grow and produce maternal and fetal tissues, and carbohydrates fulfill the non-protein energy needs. Folic acid is essential for the formation of the fetal neural tube. Calcium is vital for mineralizing the fetal skeleton, and iron is required to synthesize hemoglobin. Potassium and sodium are essential for nerve impulse transmission. Chloride is considered a part of hydrochloric acid in the stomach.

4. Dietary Reference Intakes (DRI)

Dietary Reference Intakes of most macronutrients and micronutrients are deferred with the pregnancy compared to the nonpregnancy period. According to Table 2, nutrient requirements are categorized under four categories: energy

and macronutrients, minerals, vitamins, water, and electrolytes. Due to pregnancy requirements, most of them have increments of recommended intakes. As percentages, the need for carbohydrates, fiber, Protein, iron, iodine, zinc, folate, vitamin B_6, riboflavin, and thiamin can be observed as the most required dietary intakes.

Table 2. Dietary Reference Intakes for Women 19–30 Years of Age [4]

Nutrient	Nonpregnancy	Pregnancy	Increase %
Energy and macronutrients			
Energy (kcal/day)	2403	2855	19
Carbohydrate (g/day)	130	175	35
Total fiber (g/day)	25	28	12
Protein (g/day)	46	71	54
Minerals			
Calcium (mg/day)	1100	1100	0
Fluoride (mg/day)	3	3	0
Phosphorus (mg/day)	700	700	0
Chromium (mcg/day)	25	30	20
Copper (mcg/day)	900	1000	11
Iodine (mcg/day)	150	220	47
Iron (mg/day)	18	27	50
Magnesium (mg/day)	310	350	13
Manganese (mg/day)	1.8	2	11
Molybdenum (mcg/day)	45	50	11
Selenium (mcg/day)	55	60	9
Zinc (mg/day)	8	11	38
Vitamins			
Folate (mcg/day)	400	600	50
Niacin (mg/day)	14	18	29
Pantothenic acid (mg/day)	5	6	20
Riboflavin (mg/day)	1.1	1.4	27
Thiamin (mg/day)	1.1	1.4	27
Vitamin A (mcg/day)	700	770	10
Vitamin B_{12} (mcg/day)	2.4	2.6	8
Vitamin B_6 (mg/day)	1.3	1.9	46
Vitamin C (mg/day)	75	85	13
Biotin (mcg/day)	30	30	0
Vitamin D (mcg/day)	5	5	0
Vitamin E (mg/day)	15	15	0
Vitamin K (mcg/day)	90	90	0
Water and Electrolytes			
Water (l/day)	2.7	3	11
Chloride (l/day)	2.3	2.3	0
Potassium (g/day)	4.7	4.7	0
Sodium (g/day)	1.5	1.5	0

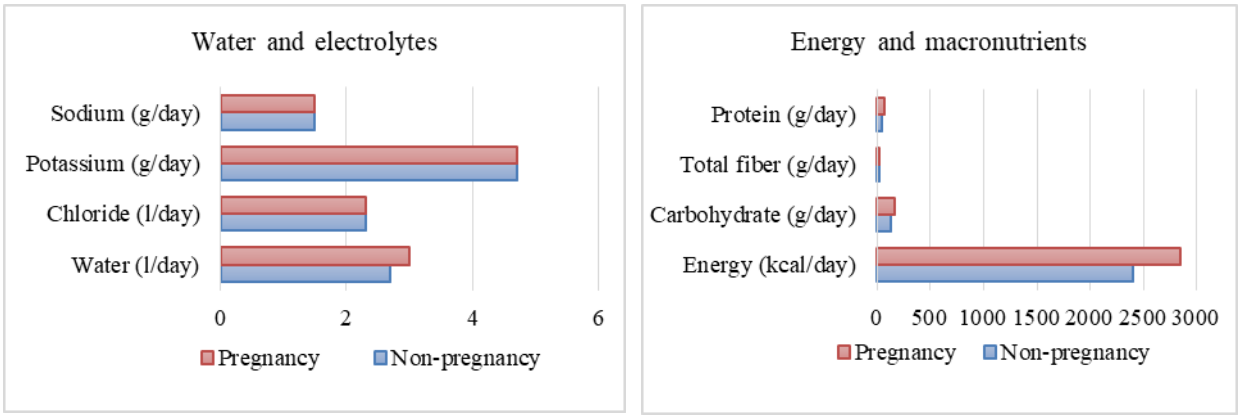

Figure 1. Nutrient requirements in pregnancy and non-pregnancy
(a) water and electrolytes, (b) energy and macronutrients

Due to the total energy requirement, attention should be given to the composition of nutrient-dense meals. It is essential to reduce the intake of empty calories in food that provides some energy except micronutrients so that excess intake of micronutrients higher than recommended values can be regulated. Physical and hormonal changes during pregnancy are caused by loss of water and electrolytes during pregnancy. So, the lack of less than required fluids can dehydrate the body. Water is the majority of the maternal weight, and during pregnancy, this required amount is increased from 2.7 liters to 3 liters per day, according to Figure 1 above.

5. Recommended number of servings from each food group during pregnancy (food-based dietary guidelines for Sri Lankans)

According to the BMI (Body Mass Index) and level of physical activity, the portion of food recommended for consumption may change. Also, nutritional needs during the first-trimester increase slowly. However, the highest number of dietary needs can be identified in the third trimester. All the nutritional requirements during pregnancy should be fulfilled for optimum pregnancy outcomes. A collection of food that can provide similar nutritional properties is referred to as a food group. According to food-based dietary guidelines for Sri Lankans published by the Nutrition Division, Ministry of Health (2011), recommended servings in six food groups are illustrated in Figure 2 below.

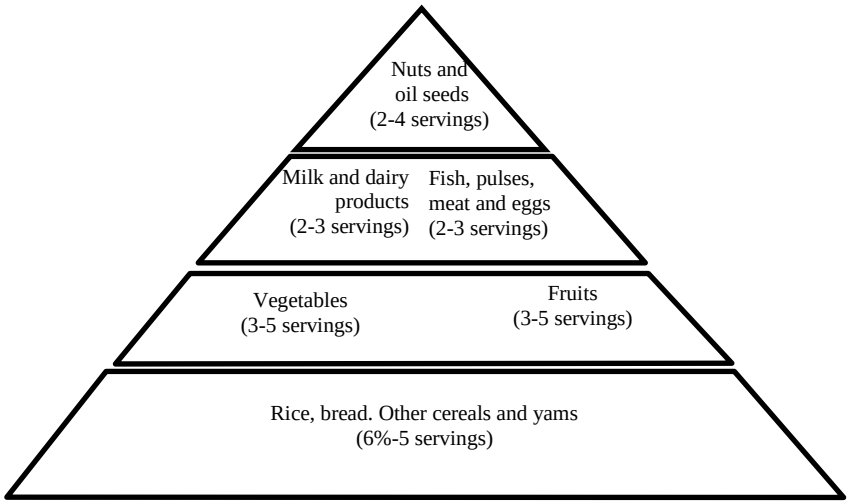

Figure 2. Recommended number of servings from each food group during pregnancy

According to Figure 2, various nutritious foods from 5 food groups can be consumed as a recommended number of servings during pregnancy. These five food groups consist of cereal, vegetables, fruits, milk and dairy products, lean meats and poultry, fish and eggs, nuts, and oil seeds. Vegetables, legumes, fruits, and beans are rich in vitamins, minerals, and dietary fibers. The protein food group consists of lean meat, fish, and poultry. Also, beans (legumes) are plant-based protein sources and meat alternatives. Milk and dairy products are also rich sources of Protein and Calcium.

6. Nutritional Deficiencies and Pregnancy

Women manifesting nutritional deficits can benefit from a balanced energy/protein supplementation. Micronutrient deficiencies are associated with adverse pregnancy outcomes. Adverse outcome(s) of some selected nutrients such as folic acid, iron, iodine, Calcium, zinc, vitamin A, vitamin D, and K, copper, selenium, and magnesium are listed below in Table 3.

According to Table 3, folic acid, zinc, and selenium may cause neural tube defects (NTD), and iron, vitamin A, zinc, and copper deficiency can cause anemia. Anencephaly can occur due to folic acid, zinc, and copper deficiencies.

6.1. Neural tube defects

A failure of the neural tube during the 3rd and 4th weeks of pregnancy is referred to as a neural tube defect (NTD). Also, the development of the neural tube is completed within 28 days after conception, and many pregnant women are not aware of that early stage. A neural tube defect can be easily identified using maternal serum alpha fetoprotein level or ultrasound scanning.

Folic acid supplementation can be recognized as a primary protective factor for neural tube defects during early pregnancy (Also, x-ray exposures to pesticides may cause neural tube defects) [36],[37].

6.2. Anaemia

During pregnancy, different types of anemia may develop, and a lack of healthy blood cells is caused by inadequate carriage of oxygen to tissues of the mother and fetus. During pregnancy production, more blood is needed for the growth of the fetus. So, deficiency of iron and other certain nutrients is directed to the failure of this additional blood production in this period. Then, a severe anemia condition may occur due to a lack of iron and vitamin levels. It can increase the risk of preterm delivery.

Iron deficiency anemia, folate deficiency anemia, and vitamin B_{12} deficiency anemia are anemia types developed during pregnancy [38]. Iron deficiency anemia can be caused by inadequate production of hemoglobin, a protein in red blood cells that helps carry oxygen from the lungs to body tissues. So that blood cannot carry enough oxygen to tissues. Folate can be identified as a vitamin found naturally in green leafy vegetables and is essential for producing red blood cells [39]. During pregnancy, the folate requirement is increased, and folate is recommended as folic acid so that additional requirements for folate can be fulfilled as a food supplement. There is a relationship between low birth weight and certain types of birth defects with folic acid deficiency [40]. Also, vitamin B_{12} is required to produce red blood cells. Vegetarian pregnant women tend to have vitamin B_{12} deficiency. So, consuming dairy

products, eggs, and meat during pregnancy is essential. Vitamin B_{12} deficiency contributes to congenital disabilities and preterm delivery [41],[42].

6.3. Cretinism

Thyroxine and tri-iodothyronine are essential hormones for normal growth with necessary neurodevelopment, and iodine is a fundamental part of thyroid hormones. Usually, the fetal thyroid generates hormones with a low reservation in the fetal gland in the first trimester. So, maternal thyroid hormones are affected by the total fetal thyroid hormone concentrations until birth. Due to the requirement of iodine, a 50% increase in intake is recommended [43]. A lack of iodine intake contributes to an iodine deficiency in mother and fetus. Then, hypothyroxmia can occur with damage to the developing brain as a result. Cretinism is referred to as an inborn disease due to the absence or deficiency of normal thyroid secretion, characterized by physical deformity, mental retardation, and often goiter. However, cretinism is the most severe case of iodine deficiency. Adequate iodine status is essential for maternal and fetal health [44].

6.4. Anencephaly

This is a severe congenital disability due to a baby being born without some portions of the skull, scalp, and brain. As a key important risk factor related to Anencephaly, folic acid deficiency can be a concern [45]. Anencephaly and spina bifida are sometimes categorized under subtypes of neural tube defects described previously. Fetuses that have Anencephaly may cause Abortion or death after birth, and this risk can be minimized with folic acid supplements and diet changes. Other than this, exposure to environmental toxins and high temperatures during pregnancy can be caused by anencephaly [46].

6.5. Hemorrhage

A relatively common type of blood clot formed by abnormal accumulation of blood between the placenta and the uterus wall is called sub-chronic hemorrhage. Also, antepartum hemorrhage is defined as bleeding from or into the genital tract after the 22nd week of pregnancy [47]. Vitamin K deficiency can be a severe health issue because babies may tend to hemorrhage. Blood coagulation occurs with prothrombin and vitamin K. Vitamin K deficiency slows down blood coagulation and causes excessive bleeding. This condition is referred to as vitamin K deficiency bleeding (which is classified with the presentation time after birth as early, classical, and late. Neonatal oral or parental vitamin K prophylaxis is recommended to prevent hemorrhage [48].

6.6. Toxaemia (pre-eclampsia)

A mild to severe condition of high blood pressure, Protein in urine, and swelling in the legs and hands is referred to as toxemia. These symptoms appeared most often in the third trimester. During gestation, approximately 30g of Calcium is needed for the fetus due to the high demand for Calcium [49]. However, bone turnover and internal calcium absorption are increased, and then the recommended dietary calcium intake is the same for a pregnant and non-pregnant woman of the same age. The World Health Organization guidelines state that adequate calcium intake is essential to prevent pre-eclampsia during pregnancy. Other than that, problems with the placenta and issues in the immune system and genes are caused by pre-eclampsia [50].

Table 3. Nutritional deficiencies and pregnancy

Nutrient	Outcome(s) due to deficiency
Folic acid	Neural tube defects, Anencephaly [19]
Iron	Anaemia, Haemorrhage [20]
Iodine	Cretinism [21]
Calcium	Hypertension, Pre-eclampsia [22],[23]
Zinc	Anaemia, Neural tube defects, Low birth weight, Anencephaly [24]
Vitamin A	Vertical transmission of HIV, Maternal anemia, Infection, Maternal mortality [25],[26],[27]
Vitamin D	Neonatal hypocalcemia [28]
Vitamin K	Hemorrhage [29]
Copper	Anaemia, Anencephaly, Low birth weight [30],[31],[32]
Selenium	Neural tube defects, Dysfunction of the brain and cardiovascular system, Abortion [33]
Magnesium	Increased blood coagulability, Toxaemia, Preterm birth [34], [35]

7. Conclusion

Many metabolic changes lead to the increments of nutritional requirements during pregnancy. Overcoming the recommended dietary intake during pregnancy is essential to delivering a healthy newborn birth and maintaining the mother's health status. Deficiencies of nutrients may cause different adverse outcomes such as neural tube defects, anemia, cretinism, Anencephaly, hemorrhage, and toxemia. In Sri Lanka, deficiencies of folic acid, iron, iodine, and vitamin A can be identified commonly among pregnant women due to inadequate dietary intakes and increased nutritional requirements. It can be suggested to get adequate iron and caloric intake, incorporate protein for food during pregnancy, consume enough calcium and Vitamin D and fiber, consider for hydration.

8. Recommendations

It is essential to follow the recommended dietary guidelines of Sri Lanka for pregnancy and be conscious of the need for more food and nutrients during pregnancy. Under the supervision of an obstetrician, it is better to use dietary supplements (folic acid, iron tablets, etc.) if recommended.

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Competing Interests Statement

The authors declare no competing financial, professional, or personal interests.

Consent for publication

The authors declare that they consented to the publication of this study.

Authors' contributions

Both the authors made an equal contribution in the Conception and design of the work, Data collection, Drafting the article, and Critical revision of the article. Both the authors have read and approved the final copy of the manuscript.

Availability of data and material

Authors are willing to share data and material according to the relevant needs.

References

[1] Robson, J. (1975). Nutrition and Pregnancy. In D. Raphael (Eds.), Being Female: Reproduction, Power, and Change, Pages 49–54, New York: De Gruyter Mouton. https://doi.org/10.1515/9783110813128.49.

[2] Barnes, M.D., Hanson, C.L., Novilla, L.B., Magnusson, B.M., Crandall, A.C., & Bradford, G. (2020). Family-Centered Health Promotion: Perspectives for Engaging Families and Achieving Better Health Outcomes. Inquiry: A Journal of Medical Care Organization, Provision and Financing, 57: 46958020923537. https://doi.org/10.1177/0046958020923537.

[3] Ho, A., Flynn, A.C., & Pasupathy, D. (2016). Nutrition in pregnancy. Obstetrics, Gynaecology & Reproductive Medicine, 26(9): 259–264. doi: 10.1016/j.ogrm.2016.06.005.

[4] Bendich, A., & Deckelbaum, R.J. (2015). Nutrition and Health. Springer Cham. https://doi.org/10.1007/978-3-319-22431-2.

[5] Uriu-Adams, J.Y., Scherr, R.E., Lanoue, L., & Keen, C.L. (2010). Influence of copper on early development: prenatal and postnatal considerations. BioFactors, 36(2): 136–152. https://doi.org/10.1002/biof.85.

[6] Duntas L.H. (2020). Selenium and at-risk pregnancy: challenges and controversies. Thyroid Research, 13: 16. https://doi.org/10.1186/s13044-020-00090-x.

[7] Biswas, K., McLay, J., & Campbell, F.M. (2022). Selenium Supplementation in Pregnancy-Maternal and Newborn Outcomes. Journal of Nutrition and Metabolism, 2022: 4–7. https://doi.org/10.1155/2022/4715965.

[8] Oh, C., Keats, E.C., & Bhutta, Z.A. (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. Nutrients, 12(2): 491. https://doi.org/10.3390/nu12020491.

[9] Meija, L., & Rezeberga, D. (2017). Proper Maternal Nutrition during Pregnancy Planning and Pregnancy. World Health Organization.

[10] Elango, R., & Ball, R.O. (2016). Protein and Amino Acid Requirements during Pregnancy. Advances in Nutrition (Bethesda, Md.), 7(4): 839s–44s. https://doi.org/10.3945/an.115.011817.

[11] Ami, N., Bernstein, M., Boucher, F., Rieder, M., Parker, L., & Canadian Paediatric Society, Drug Therapy and Hazardous Substances Committee (2016). Folate and neural tube defects: The role of supplements and food fortification. Paediatrics & Child Health, 21(3): 145–154. https://doi.org/10.1093/pch/21.3.145.

[12] Salam, R.A., Zuberi, N.F., & Bhutta, Z.A. (2015). Pyridoxine (vitamin B6) supplementation during pregnancy or labour for maternal and neonatal outcomes. The Cochrane Database of Systematic Reviews, 2015(6): CD000179. https://doi.org/10.1002/14651858.CD000179.pub3.

[13] Moreno-Garcia, M.A., Rosenblatt, D.S., & Jerome-Majewska, L.A. (2013). Vitamin B12 Metabolism during Pregnancy and in Embryonic Mouse Models. Nutrients, 5(9): 3531–3550. https://doi.org/10.3390/nu5093531.

[14] Schubert, M., & Gibert, Y. (2020). Retinoids in Embryonic Development. Biomolecules, 10(9): 1278. https://doi.org/10.3390/biom10091278.

[15] Young, B.E., McNanley, T.J., Cooper, E.M., McIntyre, A.W., Witter, F., Harris, Z.L., & O'Brien, K.O. (2012). Maternal vitamin D status and calcium intake interact to affect fetal skeletal growth in utero in pregnant adolescents. American Journal of Clinical Nutrition, 95(5): 1103–1112. https://doi.org/10.3945/ajcn.111.023861.

[16] Mégier, C., Peoc'h, K., Puy, V., & Cordier, A.G. (2022). Iron Metabolism in Normal and Pathological Pregnancies and Fetal Consequences. Metabolites, 12(2): 129. https://doi.org/10.3390/metabo12020129.

[17] Otoikhila, O., & Seriki, S. (2023). A Comparative Study of Serum Sodium and Potassium Levels across the Three Trimesters of Pregnancy. Clinical Journal of Obstetrics and Gynecology, 6(3): 108–116. https://doi.org/10.29328/journal.cjog.1001137.

[18] Mohammed, M.I., & Inuwa, Y. (2012). Determination of serum chloride ion concentration in pregnant women from Minjibir local government area, Kano State Nigeria. Chem Search J., 3(1): 19–23.

[19] Wald, N.J. (2022). Folic acid and neural tube defects: Discovery, debate and the need for policy change. Journal of Medical Screening, 29(3): 138–146. https://doi.org/10.1177/09691413221102321.

[20] Glonnegger, H., Glenzer, M.M., Lancaster, L., Barnes, R.F.W., & von Drygalski, A. (2023). Prepartum Anemia and Risk of Postpartum Hemorrhage: A Meta-Analysis and Brief Review. Clinical and Applied Thrombosis/Hemostasis: Official Journal of the International Academy of Clinical and Applied Thrombosis/Hemostasis, 29: 10760296231214536. https://doi.org/10.1177/10760296231214536.

[21] Pearce, E.N., Lazarus, J.H., Moreno-Reyes, R., & Zimmermann, M.B. (2016). Consequences of iodine deficiency and excess in pregnant women: an overview of current knowns and unknowns. The American Journal of Clinical Nutrition, 104(s3): 918s–23s. https://doi.org/10.3945/ajcn.115.110429.

[22] Gomes, F., Ashorn, P., Askari, S., Belizan, J.M., Boy, E., Cormick, G., Dickin, K.L., Driller-Colangelo, A.R., Fawzi, W., Hofmeyr, G.J., Humphrey, J., Khadilkar, A., Mandlik, R., Neufeld, L.M., Palacios, C., Roth, D.E., Shlisky, J., Sudfeld, C.R., Weaver, C., & Bourassa, M.W. (2022). Calcium supplementation for the prevention of hypertensive disorders of pregnancy: current evidence and programmatic considerations. Annals of the New York Academy of Sciences, 1510(1): 52–67. https://doi.org/10.1111/nyas.14733.

[23] Woo Kinshella, M.L., Sarr, C., Sandhu, A., Bone, J.N., Vidler, M., Moore, S.E., Elango, R., Cormick, G., Belizan, J.M., Hofmeyr, G.J., Magee, L.A., von Dadelszen, P., & Precise Network (2022). Calcium for pre-eclampsia prevention: A systematic review and network meta-analysis to guide personalised antenatal care.

BJOG: An International Journal of Obstetrics and Gynaecology, 129(11): 1833–1843. https://doi.org/10.1111/1471-0528.17222.

[24] Li, H., Zhang, J., & Niswander, L. (2018). Zinc deficiency causes neural tube defects through attenuation of p53 ubiquitylation. Development (Cambridge, England), 145(24): dev169797. https://doi.org/10.1242/dev.169797.

[25] Wiysonge, C.S., Ndze, V.N., Kongnyuy, E.J., & Shey, M.S. (2017). Vitamin A supplements for reducing mother-to-child HIV transmission. The Cochrane Database of Systematic Reviews, 9(9): CD003648. https://doi.org/10.1002/14651858.cd003648.pub4.

[26] Hamdy, A.M., Abdel Aleem, M.M., & El-Shazly, A.A. (2013). Maternal Vitamin A Deficiency during Pregnancy and Its Relation with Maternal and Neonatal Hemoglobin Concentrations among Poor Egyptian Families. ISRN Pediatrics, 2013: 652148. https://doi.org/10.1155/2013/652148.

[27] Costello, A., & Osrin, D. (2010). Vitamin A supplementation and maternal mortality. Lancet (London, England), 375(9727): 1675–1677. https://doi.org/10.1016/S0140-6736(10)60443-6.

[28] Adán Lanceta, V., Martín Ruiz, N., Benito Costey, S., Alijarde Lorente, R., & Martínez de Zabarte Fernández, J.M. (2022). A neonatal hypocalcemia due to maternal vitamin D deficiency. Reviewing supplementation. Anales de pediatria, 96(2): 153–154. https://doi.org/10.1016/j.anpede.2020.09.015.

[29] Lee, S., Kim, H.M., Kang, J., Seong, W.J., & Kim, M.J. (2022). Fetal intracranial hemorrhage and maternal vitamin K deficiency induced by total parenteral nutrition: A case report. Medicine, 101(1): e28434. https://doi.org/10.1097/md.0000000000028434.

[30] Keen, C.L., Uriu-Hare, J.Y., Hawk, S.N., Jankowski, M.A., Daston, G.P., Kwik-Uribe, C.L., & Rucker, R.B. (1998). Effect of copper deficiency on prenatal development and pregnancy outcome. The American Journal of Clinical Nutrition, 67(5s): 1003s–1011s. https://doi.org/10.1093/ajcn/67.5.1003s.

[31] Fenichel, G. (2007). Disorders of Cerebral Morphogenesis. Neonatal Neurology, Pages 167–186. https://doi.org/10.1016/b978-044306724-2.50010-2.

[32] Sutton, A.M., Harvie, A., Cockburn, F., Farquharson, J., & Logan, R.W. (1985). Copper deficiency in the preterm infant of very low birthweight. Four cases and a reference range for plasma copper. Archives of Disease in Childhood, 60(7): 644–651. https://doi.org/10.1136/adc.60.7.644.

[33] Shimada, B.K., Alfulaij, N., & Seale, L.A. (2021). The Impact of Selenium Deficiency on Cardiovascular Function. International Journal of Molecular Sciences, 22(19): 10713. https://doi.org/10.3390/ijms221910713.

[34] Tonai, K., Katayama, S., Koyama, K., Sata, N., Tomioka, Y., Imahase, H., & Nunomiya, S. (2022). Association between hypomagnesemia and coagulopathy in sepsis: a retrospective observational study. BMC Anesthesiology, 22(1): 359. https://doi.org/10.1186/s12871-022-01903-2.

[35] Zhang, Y., Xun, P., Chen, C., Lu, L., Shechter, M., Rosanoff, A., & He, K. (2021). Magnesium levels in relation to rates of preterm birth: a systematic review and meta-analysis of ecological, observational, and interventional studies. Nutrition Reviews, 79(2): 188–199. https://doi.org/10.1093/nutrit/nuaa028.

[36] Avagliano, L., Massa, V., George, T.M., Qureshy, S., Bulfamante, G.P., & Finnell, R.H. (2019). Overview on neural tube defects: From development to physical characteristics. Birth Defects Research, 111(19): 1455–1467. https://doi.org/10.1002/bdr2.1380.

[37] Atlaw, D., Tekalegn, Y., Sahiledengle, B., Seyoum, K., Solomon, D., Gezahegn, H., Tariku, Z., Tekle, Y., & Chattu, V.K. (2021). Magnitude and determinants of neural tube defect in Africa: a systematic review and meta-analysis. BMC Pregnancy and Childbirth, 21(1): 426. https://doi.org/10.1186/s12884-021-03848-9.

[38] Soundarya, N. (2015). A review on anaemia – types, causes, symptoms and their treatments. Journal of Science and Technology Investigation.

[39] Kumar, D., Kumar, S., & Shekhar, C. (2020). Nutritional components in green leafy vegetables: A review. Journal of Pharmacognosy and Phytochemistry, 9: 2498–2502.

[40] Fekete, K., Berti, C., Trovato, M., Lohner, S., Dullemeijer, C., Souverein, O.W., Cetin, I., & Decsi, T. (2012). Effect of folate intake on health outcomes in pregnancy: a systematic review and meta-analysis on birth weight, placental weight and length of gestation. Nutrition Journal, 11: 75. https://doi.org/10.1186/1475-2891-11-75.

[41] Haider, B., et al. (2013). Anaemia, prenatal iron use, and risk of adverse pregnancy outcomes: Systematic review and meta-analysis. BMJ (Clinical Research Eds.), 346: f3443. https://doi.org/10.1136/bmj.f3443.

[42] Karaoglu, L., Pehlivan, E., Egri, M., Deprem, C., Gunes, G., Genc, M.F., & Temel, I. (2010). The prevalence of nutritional anemia in pregnancy in an east Anatolian province, Turkey. BMC Public Health, 10: 329. https://doi.org/10.1186/1471-2458-10-329.

[43] Ren, A.G. (2015). Prevention of neural tube defects with folic acid: The Chinese experience. World Journal of Clinical Pediatrics, 4(3): 41–44. https://doi.org/10.5409/wjcp.v4.i3.41.

[44] Skeaff, S.A. (2011). Iodine deficiency in pregnancy: the effect on neurodevelopment in the child. Nutrients, 3(2): 265–273. https://doi.org/10.3390/nu3020265.

[45] Butterworth, C.E., & Bendich, A. (1996). Folic acid and the prevention of birth defects. Annual Review of Nutrition, 16: 73–97. https://doi.org/10.1146/annurev.nu.16.070196.000445.

[46] Auger, N., Fraser, W.D., Arbour, L., Bilodeau-Bertrand, M., & Kosatsky, T. (2017). Elevated ambient temperatures and risk of neural tube defects. Occupational and Environmental Medicine, 74(5): 315–320. https://doi.org/10.1136/oemed-2016-103956.

[47] Shahrook, S., Ota, E., Hanada, N., Sawada, K., & Mori, R. (2018). Vitamin K supplementation during pregnancy for improving outcomes: a systematic review and meta-analysis. Scientific Reports, 8(1): 11459. https://doi.org/10.1038/s41598-018-29616-y.

[48] Ijland, M.M., Pereira, R.R., & Cornelissen, E.A. (2008). Incidence of late vitamin K deficiency bleeding in newborns in the Netherlands in 2005: evaluation of the current guideline. European Journal of Pediatrics, 167(2): 165–169. https://doi.org/10.1007/s00431-007-0443-x.

[49] Almaghamsi, A., Almalki, M.H., & Buhary, B.M. (2018). Hypocalcemia in Pregnancy: A Clinical Review Update. Oman Medical Journal, 33(6): 453–462. https://doi.org/10.5001/omj.2018.85.

[50] Purswani, J.M., Gala, P., Dwarkanath, P., Larkin, H.M., Kurpad, A., & Mehta, S. (2017). The role of vitamin D in pre-eclampsia: a systematic review. BMC Pregnancy and Childbirth, 17(1): 231. https://doi.org/10.1186/s12884-017-1408-3.