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Effect of Prenatal Malnutrition on Fetus and Newborn Baby: A Comprehensive Review

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Abstract: ***Maternal nutrition plays a crucial role in influencing fetal growth and birth outcomes. Early finding of health risk associated with Malnutrition and Micronutrient deficiency during pregnancy provides the best possible result. Maternal malnutrition increases the risk of gestational anemia, hypertension, miscarriages and fetal deaths during pregnancy, pre-term delivery and maternal mortality. In newborn, it can cause low birth weight, fetal intrauterine growth retardation that may have long life consequences ondevelopment, quality of life and health care costs. Malnutrition also has an adverse effect on the development of the immune system of the newborn. There was identifying the relationship between maternal malnutrition and fetal development outcomes. Prenatal Malnutrition should be treated during pregnancy by healthy diet or supplements.Nutritional counseling needs to be an integral part of antenatal care in order to reduce the risk of maternal-fetal and newborn complications.***

Keywords: Prenatal Malnutrition, Micronutrient deficiency, Low Birth Weight, Preconception, Premature Birth

1. Introduction

Nutrition plays a major role in the maturation and functional development of the central nervous systemchild and maternal health. Lack of adequate nutrition of good quality and quantity during pregnancy can cause health problems for both the mother and her fetus [1]. Maternal nutrition show a positive connection with infant birth weight, maternal prepregnancy body mass index (BMI) and weight gain during pregnancy. Women with low prepregnancy BMI are at increased risk for preterm birth and intrauterine growth retardation (IUGR) only if they fail to gain adequate weight [2].

The nutritional status of the mother at conception is a key factor for development and fetal growth for a healthy. It is essential before and during pregnancy give balanced diet to mother provides energy and nutrients to herself and foetus growth and for the future lactation. Many adverse health effects associated with maternal under-nutrition. It can affect both the pregnant woman and developing baby in the short and long-term. Under-nutrition can be classified as either:

- Malnutrition
- Micronutrient deficiency

Malnutrition occurs when an individual consistently consumes less energy obtained from proteins and carbohydrates and measured in calories. Malnutrition results in the individual being underweight and experiencing greater ill-health.

Micronutrient deficiency is a condition which occurs when an individual consumes enough food overall, but does not consume enough of the specific micronutrients they need to maintain the growth and function of specific body parts and systems. For example, calcium deficiency can affect the growth of bones and teeth. [3]

During pregnancy, maternal weight gain affects foetal growth. Small neonate size at birth is attributable to poor growth and shortened gestation, and the most unfavourable outcomes occur in the most immature infants. Low rate of pregnancy weight gain is associated with increased risk of preterm birth, whereas low second- or third-trimester weight gain has been shown to be associated with spontaneous preterm delivery risk. [4]

Poor maternal nutritional status has been related to adverse birth outcomes. The association between maternal nutrition and birth outcome is complex and is influenced by many biologic, socioeconomic, and demographic factors, which vary widely in different populations. Understanding the relation between maternal nutrition and birth outcomes may provide a basis for developing nutritional interventions that will improve birth outcomes and long-term quality of life and reduce mortality, morbidity, and health-care costs. [7]

Low birth weight (LBW) Low birth weight is a major determinant of mortality, morbidity and disability in infancy and childhood and also has a long-term impact on health outcomes in adult life. Low birth weight is defined as a birth weight less than 2,500 g. It can result from premature delivery, intrauterine growth failure or disruption. Low birth weight is an important secondary factor in 40%–80% of neonatal deaths, 98% of which occur in developing countries. In both developed and developing countries, low birth weight is strongly associated with perinatal morbidity and increased risk of long-term disability. [5]

Preterm birth, which is defined as a gestational age less than 37 completed weeks, contributes substantially to the incidence of low birth weight and is the leading underlying cause of infant mortality among infants with congenital anomalies. The costs of postpartum hospitalization and treatment are extremely high for low birth weight and preterm infants.

The role of inter-generational effects in determining maternal preconceptual nutritional status indicates the need for continued investment in strategies that improve women nutrition and health throughout the life cycle, especially during the early years. Half of the children with a LBW were born in South Asia and among these countries India and Bangladesh has the highest prevalence of LBW 30%. Consequently, strategies to reduce prevalence of LBW is important in order to achieve the forth Millennium Development Goals -reduce child mortality. The 30 million low-birth-weight babies had born annually 23.8% of all births short- and long-term health consequences. The consequences of poor nutritional status and inadequate nutritional intake for women during pregnancy not only directly affects women health status, but may also have a negative impact on birth weight and early development. [13] Contributing Factors such as maternal age, poor maternal nutritional status, and non-pregnant weight, gestational age, intervals between pregnancies, parity, educational status, violence during pregnancy, lack of antenatal care and very low socio-economic status. In India, low body mass index (BMI), short stature, anaemia and other micro-nutrient deficiencies are known to increase the risk of giving birth to a baby with LBW. For example, low BMI is a reliable indicator for protein-energy malnutrition, which affects fetal growth during pregnancy. [11, 14, 15]

2. Health Risks Associated With Malnutrition During Pregnancy

a) Health risks for the mother

Pregnant women who receive inadequate nutrition experience greater maternal morbidity and have a higher risk of poor pregnancy outcomes e.g. premature birth, miscarriage. They also have an increased risk of developing the following conditions: [8]

- Anemia
- Infection
- Lethargy and weakness
- Lower productivity.

b) Health risks for the fetus and newborn baby

Under-nutrition in pregnant women is associated with a range of harmful effects to the developing fetus, including intrauterine growth retardation and low-birth weight. Maternal under-nutrition during pregnancy, IUGR and low birth weight are in turn associated with a range adverse outcomes for the developing fetus and/or newborn baby, including an increased risk of:

- Stillbirth – some 50% of stillbirths in normally formed fetuses are attributable to IUGR
- Premature birth
- Perinatal mortality (death of the infant within seven days of birth) -infants who weigh <2.5kg are 5 to 30 times more likely to die within the first seven days of life compared to normal weight infants (≥2.5kg).
- Infants who weigh <1.5kg have a 70 to 100 times increased risk of dying within seven days of birth
- Infant neurological, intestinal, respiratory and circulatory disorders
- Birth defects
- Underdevelopment of some organs
- Cretinism (a congenital condition affecting the thyroid gland which results in lack of coordination, dull facial expression and dry skin)
- Brain damage. [1]

c) Health risks for the child in the long-term

Maternal under-nutrition causes metabolic and other changes in the fetus following birth. For example, a fetus that is malnourished adapts by reducing insulin and glucose production. Permanently alter the individual's glucose and insulin metabolism throughout their life and increase the risk of chronic nutritional disorders including type 2 diabetes mellitus, metabolic syndrome and obesity. For example, one study showed that the lower the birth weight of an infant, the higher the risk of developing type 2 diabetes. Men who were born at a very low weight were seven times more likely to develop diabetes compared to men born at a high weight.

The effects of maternal under-nutrition vary depending on the stage of pregnancy at which under-nutrition is experienced. For example, one study reported that exposure to maternal malnutrition in the first trimester of pregnancy was associated with an increased risk of obesity and coronary heart disease, while malnutrition in the second or third trimester was associated with poor glucose metabolism.

The fetus of mother who experienced under-nutrition during pregnancy have an increased risk of developing:

d) Metabolic disorders including:

- Type 2 diabetes mellitus
- Dyslipidaemia (abnormal concentration of lipids in the blood)
- Glucose intolerance (a pre-diabetes condition in which the body is unable to metabolize glucose normally)
- Impaired energy homeostasis (when the body does not function as it should to regulate its energy levels)
- Obesity
- Mitochondrial dysfunction (dysfunction of the mitochondria, which is found in the cell nucleus and provides the cell energy)
- Oxidative stress (a state in which the body has too many reactive molecules which can cause cell damage)
- Ageing

Cardiovascular disorders including:

- Hypertension;
- Atherosclerosis (narrowing of the blood vessels);

- Stroke andCoronary heart disease
- Osteoporosis
- Breast cancer
- Chronic obstructive lung disease
- Chronic kidney failure
- Polycystic ovarian syndrome

Psychiatric disorders including:

- Organ dysfunction or abnormal development of organs including the testes, ovaries, brain, heart, liver, small intestine and mammary gland;
- Reduced adolescent health, especially for females
- Reduced health during adulthood
- Infectious disease.

Individuals who are born at a low birth weight have a greater risk of poor development outcomes during infancy and childhood. The mother's nutritional intake before, during and after pregnancy influences their child's immediate and long-term mental development and performance.

The greatest brain growth occurs between the 3 months before birth and 2 years of age. It is at these stages that the development of the brain's nerve system and the connection between nerves is at its peak and so the brain requires the most energy to maintain its growth. The nerve system made during this time impacts the way the brain is structurally and functionally organized throughout life.

7Poor fetal development has been associated with the following adverse health and development outcomes later in life:

- Poor performance at school, learning and developing skills
- Reduced ability to perform physical work
- Reduced economic productivity. [2]

3. Health Risks Associated with Micronutrient Deficiency During Pregnancy

There are also numerous maternal and fetal health risks associated with micro-nutrient deficiency during pregnancy, that is, deficiency in particular micro-nutrients such as folate, and vitamin B12.

1) Health risks for the mother

Maternal health risks which may arise as a result of deficiency in particular micro-nutrients include:

Vitamin B12 deficiency is associated with the following risks for pregnant women:

- Anemia and its symptoms
- Neurological complications

a) **Vitamin K deficiency** is associated with blood clotting disorders, including increased clotting time which presents particular risks during delivery when women lose substantial amounts of blood, even when blood clotting functions normally

b) **Iron deficiency** during pregnancy is associated with iron deficiency anemia

c) **Iodine deficiency** is associated with poor pregnancy outcomes including:

- Miscarriage
- Stillbirth

d) **Zinc deficiency is associated with:**

- Pre-eclampsia (high blood pressure and urinary protein concentrations during pregnancy)
- Premature rupture of membranes (when a woman's amniotic sac or pregnancy waters break before she experiences contractions)
- Preterm delivery.

e) **Magnesium deficiency increases the risk of:**

- Pre-eclampsia
- Pre-term delivery

f) **Health risks for the baby**

A woman's deficiency in particular micronutrients while she is pregnant has harmful effects on particular aspects of fetal development. Fetal health risks which arise as a result of deficiency on particular micronutrients include:

1) **Maternal vitamin D deficiency** is associated with fetal rickets (a condition which weakens the bones)
2) **Maternal folate deficiency** is associated with an increased risk of neural tube defects in the infant
3) **Maternal iodine deficiency** is associated with the following complications in the infant:
   - Congenital abnormalities
   - Increased risk of infant mortality
   - Neurological cretinism (a congenital condition of poor thyroid hormone secretion which impairs cognitive development)
   - Mental deficiency
   - Spastic diplegia (spastic paralysis of the limbs) and squint
   - Myxoedymateous cretinism (a type of cretinism in which physical development is impaired) and dwarfism (very short stature)
   - Psychomotor effect (affected movement)
4) **Maternal zinc deficiency is associated with**
   - Fetal growth retardation
   - Congenital abnormalities. [1]

4. Factors Associated with Deterioration in Maternal Nutritional Status

There are number of well-established risk factors for adverse birth outcomes, such as over eating and obesity,

maternal infections, and a history of preterm birth, food supplementation and socio economic status. [17]

a) Emerging problems of overeating and obesity

During preconception counselling to educate women planning pregnancy about the risks of maternal obesity and encourage healthy lifestyles. Effective gestational weight management strategies are of high priority since they can reduce the likelihood of complications and reduce the risk of further development of obesity in mothers and their babies.

b) Effect of food supplementation during pregnancy

The high prevalence of low-birth weight is less than or equal to 2,500 gm babies in many poor communities is a major public health problem. Studies in humans in situations of acute starvation suggest an effect of maternal nutrition on birth weight, but less clear results appear under situations of moderate maternal malnutrition. We concluded that caloric supplementation during pregnancy produced the observed increase in birthweight.

c) Effect of socio-economic status

Low socioeconomic status can increase the risk of adverse pregnancy outcomes, but it remains unclear whether this negative association is attributed to inadequate prenatal care. Socioeconomic status (SES) is one of the most important factors associated with medical outcomes. When SES is low, medical care is inadequate and it has been attributed to adverse outcomes. In pregnant women, low SES can increase the risk of adverse pregnancy outcomes. Previous studies have revealed that low SES is associated with pregnancy complications such as abortion, preterm delivery, preeclampsia, eclampsia, and gestational diabetics. [16, 17]

5. Role of Nutrition

A healthy and accurate diet during pregnancy plays the most important role for both the unborn baby and the mother. It is directly affects the weight of the baby at the time of birth. It also helps to prevent the child from developing diseases such as heart disease and obesity later in life. [1]

Study showed that women with poor diets before pregnancy are more likely to give birth prematurely than women who have healthy diets. Therefore, it is always recommended to maintain a healthy diet, remain active, and drink lots of fluids. All of this is important for the health of the mother and the unborn baby. [7]

Nutritional counseling needs to be an integral part of antenatal care in order to reduce the risk of maternal-fetal and newborn complications. [2]

1) Nutritional requirement during pregnancy and birth outcomes

Maternal pregnancy outcomes are dependent upon the intake of sufficient nutrients to meet maternal and foetal requirements. Malnutrition results from inadequate dietary intake that is growth failure, protein-energy malnutrition especially during the rapid growth phases during gestation. It was subsequently recognized that poor growth results not only from a deficiency of protein and energy but also from inadequate intake of micro-nutrients that are vital during rapid growth phases. [4]

2) Dietary intake, nutritional status and outcomes of pregnancy

A complete balanced diet to support healthy foetal growth and development is required for the nutritional demands of pregnancy. Maternal nutrition determines birth weight outcomes as well. Low-protein diets should be avoided. Breast-feeding women also have increased nutritional needs and Energy requirements are actually higher during breast-feeding than pregnancy. Pregnant and breast-feeding women should eat a healthy diet, including multiple nutritious foods for proper nutrition as well as for best outcomes. [6]

6. Prevention and Management of Micronutrient Deficiency

The most desirable approach to prevent micronutrient deficiencies in pregnancy is to assure a sustained diet of various micronutrient dense foods. As such a diet plan is often difficult to attain for preventing adverse birth outcomes due to micronutrient deficiencies through supplementation represents a sound and effective sources. One of the most commonly adopted by many low-income countries is that of daily Iron-folic Acid (IFA) supplementation as part of routine antenatal care to reduce the risk of low birth weight and maternal anaemia where iron deficiency is a public health problem. [3, 12] The WHO recommended daily dosage of iron is 30–60 g of elemental iron and 400 µg of folic acid beginning as early as possible in pregnancy. For low-income countries where the prevalence of anaemia among women of reproductive age 15-45 years is ≥20%, intermittent IFA for menstruating women is also recommended. The International Federation of Gynecology and Obstetrics recommends the use of iodized salt to prevent gestational iodine deficiency disorders prevent by iodine supplementation 250 µg per day is recommended for pregnant women in countries where there is limited access to iodized salt. [6] Where the prevalence of vitamin A deficiency (hyporetinolemia) is 5% or more among pregnant women or in children aged 2 to under 5 years, WHO recommends gravida be supplemented with up to 10,000 IU daily or 25,000 IU weekly of vitamin A to prevent maternal night blindness. Even with evidence-based recommendations, implementation of these strategies is extremely challenging due to reasons of low rates of antenatal care, inadequate supply and poor adherence. For example, in one review, only 8% of women reported taking a full course of 180 or more iron-folic acid tablets during pregnancy. [3]

A balanced and nutritious diet is universally recommended to meet nutritional needs and maintain health during pregnancy. Daily antenatal multiple vitamin and mineral supplements are commonly taken prophylactically by women in the USA and other high-income countries, where there are few formal medical society recommendations. [12] More common are recommendations for individual micronutrients, such as in Germany, where pregnant women are advised to take folic acid and iodine supplements. In low-income countries, where evidence of fetal health benefit is increasing in support of multiple micronutrient

supplement use during pregnancy. WHO/UNICEF policy recommends that pregnant and lactating women to take a daily multiple micronutrient supplement in emergency settings. The beneficial effects of antenatal multiple micronutrient supplementation on birth outcomes compared with IFA alone support change in global policy to promote this intervention in low-income and middle-income countries, no such broad WHO/UNICEF policy current exists for this purpose. Programmatic platforms, especially antenatal care visits, through which IFA supplements are distributed already exist although with variable success. Demographic and Health Survey data show any supplement use during pregnancy varies from 10% to 90% of women across low-income countries. Nutritional interventions that successfully increase birth size should be accompanied by adequate intrapartum care, via facility-based delivery or skilled birth attendants, especially where adolescent pregnancy to reduce potential risks of intrapartum and birth asphyxia-related complications. [9]

The preconceptional period is increasingly seen as a period of great influence in the life course, yet intervention efforts at this time are fewer than in pregnancy. In 53 countries worldwide, ranging from low-income to high-income, folic acid fortification of flour is mandatory. Other strategies currently being tested but with potential impact on pregnancy outcomes include dual fortified salt (iron and iodine), iron-fortified flour, and bio fortification of staple crops such as rice and maize. Overall, fortification is a promising strategy for improving micronutrient status during pregnancy, but data on health outcomes is less. Improving diets and the adequate intake of various food groups continues to be a long-term goal for enhancing maternal micronutrient status, regardless of geographical location or income status [13]

7. Anaemia in pregnancy

Maternal anaemia during pregnancy than mother need to start taking an iron supplement and folic acid supplement in addition to the prenatal vitamins to the diet. Ask to mother for another blood test after a specific period of time for check hemoglobin and haematocrit levels are improving. Aim for at least three servings a day of iron-rich foods such as: [10]

- Lean red meat, poultry, and fish
- Leafy, dark green vegetables (such as spinach, broccoli, and kale)
- Iron-enriched cereals and grains
- Beans, lentils, and tofu
- Nuts and seeds
- Eggs

Foods that are high in vitamin C can help the body absorb more iron. These include:

- Citrus fruits and juices
- Strawberries
- Kiwis
- Tomatoes
- Bell peppers
- Try eating those foods at the same time that you eat iron-rich foods. For example, you could drink a glass of orange juice and eat an iron-fortified cereal for breakfast. Also choose foods that are high in folate to help prevent folate deficiency. These include:
- Leafy green vegetables
- Citrus fruits and juices
- Dried beans
- Breads and cereals fortified with folic acid

Vitamin A deficiency in pregnancy

Vitamin A is important for visual health, immune function and fetal growth and development. It can cause visual impairment in the form of night blindness and, in children, may increase the risk of illness and death from childhood infections, including measles and those causing diarrhoea. If pregnant women are susceptible to vitamin A deficiency throughout gestation, susceptibility is at its highest during the third trimester of pregnancy due to accelerated fetal development and the physiological increase in blood volume during this period.

Some indication that low doses of vitamin A supplements given to pregnant women on a daily or weekly basis, starting in the second or third trimester, can reduce the severity of decline in maternal serum retinol levels during late pregnancy and the symptoms of night blindness, current evidence indicates that vitamin A supplementation during pregnancy does not reduce the risk of illness or death in mothers their infants. Pregnant women should be encouraged to receive adequate nutrition, which is best achieved through consumption of a healthy balanced diet.

Vitamin B 12 deficiency

Vitamin B12 is important for maintaining the health of your nervous system, but it's also believed that when combined with folic acid during pregnancy, B12 supplements around 2.6 micrograms per day can help to prevent spina bifida and other spinal and central nervous system birth defects in your baby.

Benefits

- Essential for baby's neural tube formation, brain and spine development
- Together with Folate (B9), it works to produce DNA synthesis and red blood cells
- Aids the development and functioning of your brain, nerves and blood cells
- Helps improve your energy, mood and stress levels by aiding the metabolization of fats, carbohydrates, and proteins.
- Helps maintain the normal central nervous system and neurological functions by regulating the synthesis of myelin and fatty acids.

Natural Food Sources of Vitamin B12:

- Eggs
- Soy Milk or Soy Products (fortified with B12 on the label)
- Fish and poultry
- Grass-fed Beef Liver
- Yogurt
- Fortified Cereals
- Red Meat

- Swiss Cheese
- Milk
- Cottage Cheese

8. Discussion and Conclusions

As we analysed in this narrative review hypothesis is supported by evidence showing that during pregnancy maternal under and over-nutrition can lead to anomalies in metabolism and body composition in adulthood. Nowadays, it is believed that in the early stages of life could be important in the etiology of diseases such as obesity, type 2 diabetes and cardiovascular disease, suggesting that these common diseases can be prevented through optimal development of both foetus and newborn. The nutritional needs of the foetus depend on the intake of nutrients of the mother, their metabolism, and their distribution through maternal circulation and on the placental transport mechanism. Malnourished mothers may be limited in their ability to adequately support the foetus. Vitamin D helps gastrointestinal absorption of several nutrients, including calcium, phosphate, magnesium, iron, and zinc. Vitamin D is present in many foods although most of vitamin D is synthesized in the skin after exposure to ultraviolet light (sunlight). Antioxidants, such as vitamin E and C, help to protect cells by acting as free radical. Antioxidant enzymes depend on essential nutrients such as magnesium, riboflavin and niacin for their activation. [10] The vitamin B complex is essential for cellular function, synthesis of neurotransmitters and metabolism of glucose, lipids, proteins and alcohol. Phosphate and magnesium ions are essential components of the nucleic acids and a lot of enzymes require magnesium as a catalytic agent. Selenium is a co-factor for antioxidant enzymes and thyroid hormones. Potassium helps to maintain osmotic balance. The docosahexaenoic acid (DHA) is particularly important in cognitive development and the eicosapentaenoic acid (EPA) promotes the development and function of the brain, its mechanisms on development processes reflect those of DHA. Foetal nutrition is influenced by size and composition of the mother's body and by her diet.

The nutritional status of a pregnant woman can be affected by many factors including low socio-economic status, higher parity and short inter-pregnancy interval. Women with low socio-economic status are more likely to have inadequate food intake, unhygienic housing and lack of sanitation, reduced ability to seek medical care and purchase medicine/supplements, which then affects the birth weight of their infants. The incidences of placenta previa and malpresentation increases with high parity and these complications may predispose a women to give birth to an infant with LBW.

Researcher has been observed clinically in humans the use of new knowledge to reduce the onset of many diseases. Therefore, it is necessary to know both the factors that determine foetal growth and the conditions that limit the maternal foetal supply of nutrients and oxygen to the foetus. Even if much has already been done, further investigations are necessary in order to better understand how the foetus adapts to a limited supply of nutrients from the mother, how these adaptations could influence structure and physiology of the body, and what are the molecular mechanisms by which nutrients and hormones could alter gene expression. We believe that it is necessary to develop dietary plans of optimize nutrition to improve the outcomes of pregnancy and promote growth and healthy child development and also reduce the risk of chronic diseases, and slow down the metabolic decline associated with aging. Maternal nutrition plays a crucial role in influencing fetal growth and birth outcomes. It is a modifiable risk factor of public health importance in the effort to prevent adverse birth outcomes, particularly among developing/low-income populations.

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