Journal of Namibian Studies, 33 (2023): 4491–4513 ISSN: 2197-5523 (online)

Importance of Nutrition during the Gestation Period and Infant Development: A Nutrition Guide for Mother and Infant Health

Gunjan Khera[1], Rahemeen Yusuf[2], Aruna Janaki[3]

Abstract

The current narrative review highlights the importance of awareness of proper nutritional diets for pregnant mothers and their infants. Nutritional deficiencies are a major cause of concern globally which affects many expecting mothers who struggle with a lack of knowledge regarding their dietary intake, putting their health and also the health of the fetus or new-born at risk. Therefore, the current manuscripts help highlight the importance of certain nutrients, vitamins and micronutrients important for pregnant women and the daily recommended dosages to avoid pregnancy-related complications at maximum. The manuscript also highlights the importance of awareness and educational programs that may be helpful to create awareness to ensure infant and expecting mothers' nutrition. The review also tried to try to negate certain cultural norms and myths which become obstacles in making expecting mothers consume the right nutritious diet. The manuscript serves as a guide for the expecting mothers and their fetus development at different stages and their infants from the perspective of nutrition and cognitive development.

Key Words: Expecting mothers, pregnancy, vitamins, minerals, micronutrients, nutrition, infant, neuronal and cognitive development.

Introduction

According to the World Health Organization (WHO, 2016), malnutrition is defined as an imbalance in an individual's intake of nutrients and is a leading cause of global concern. Lack of awareness and fewer resources are the major risk factors for women exhibiting poor dietary habits. Financial constraints, natural calamities like drought, floods, earthquakes, and political instability in many developing countries have

[1] Assistant Professor of Psychology, Department of Cognitive Sciences, College of Humanities and Social Sciences, United Arab Emirates University, Al Ain, Abu Dhabi, UAE, khera.gunjan@gmail.com

[2] Research Assistant, Happiness Centre, United Arab Emirates University, Al Ain, Abu Dhabi, UAE, r.yusuf@uaeu.ac.ae

[3] Specialist Obstetrics and Gynaecology, NMC Speciality Hospital Al Ain, Abu Dhabi, UAE, arunajanaki05@gmail.com

reduced opportunities for people to access a proper nutritious diet (Leiber, Chin-Hong, Kelly, Dandu & Weiser, 2022). However, it cannot be ignored that although undernourishment is a major cause of concern, pregnant and lactating women yet remain to be at a high risk of malnutrition.

The nine months of pregnancy is not only a challenging time for the mother in terms of the physiological changes her body experiences, in terms of the changes in her digestive, cardiovascular and endocrine systems but also puts her at a major risk for deficiencies (Ballestín, Campos, Ballestín, & Bartolome, 2021). Amongst these deficiencies, Vitamin D deficiency is the most common which results in the development of gestational Diabetes and Anaemia (Al-Ajlan et al., 2018). Early pregnancy is another issue which puts the mother at risk as they are not physically mature to be able to meet the nutritional demands of the fetus (Shaikh, 2018). Also, it cannot be ignored that women struggle with lack of knowledge and information regarding their dietary intake during pregnancy. Much of the information they get is through family and friends which is hardly evidence based but more based on myths for example eating Saffron to have fair coloured children but in reality, during pregnancy high doses of Saffron could be a cause of miscarriages (Norain, Nor, Fazlinda & Faiz, 2019). Similarly, there are many instances where women struggle with having the right knowledge about what to eat and what to avoid during pregnancy.

A proper balanced diet full of multivitamins, nutrients is also very pivotal for the foetal growth and to avoid any chronic illnesses being developed later in life. An undernourished mother can not only put herself at risk of having hypertension, gestational weight gain and pre-eclampsia but also put the fetus at risk of preterm birth, various deficiencies and insulin resistance (Laitinen et al., 2012; Kominiarek & Peaceman, 2017).

Despite World Health Organization (WHO, 2008) guidelines for antenatal care still comprehensive implementable guidelines for the nutritional needs of women throughout pregnancy and lactation are lacking (Marshall et al., 2022). Understanding, creating awareness, and implementing proper maternal nutritional guidelines are extremely pivotal. This will not only help in healthy foetal development but also protect the mother against many diseases.

1. Method

The narrative review was written by searching scientific databases for articles defining the role of nutrition of the expecting mothers and their fetus and infant development. The topic has a greater valence because the paper serves as a nutrition and health guide for women in their gestation period. To investigate the phenomenon from the perspective of some important vitamins, micronutrients and minerals and their daily recommended dosage and food supplements an intensive review was

performed. Databases such as Medline, Cochrane Library, Web of Science, Google Scholar, SciELO, PuBMed from the year 2010 – 2023 and a total of 256 articles were reviewed. Following MeSH headings were used for the screening of the articles including all the keywords mentioned in the article. A total of 130 articles were excluded from the selected list because either they were older than the year 2008 or were unrelated to any of the keywords headings.

2. Cognitive development of Foetal through Maternal nutrition: Importance of Vitamin D

Vitamin D3 is an essential vitamin mainly obtained through sun exposure and limited food items such as wild mushrooms, oily fish, egg yolks and meat (Benedik, 2021) and also fortified foodstuff. Vitamin D is a fat-soluble vitamin essential for normal bone development and its deficiency can be a major cause of Osteoporosis (weakening of the bone) in adults and reduced immunity (Sizar, Khare, Goyal & Giveler, 2023). Although people tend to ignore the importance of vitamin D and the problems associated with its deficiency because of the lack of information about the importance of Vitamin D.

Vitamin D deficiency is very common in pregnant women having a strong relationship with adverse pregnancy outcomes. Studies have shown a high occurrence of vitamin D deficiency in expecting mothers in almost every pregnancy trimester (Xiao, Zang, Pei, Xu, Zhu & Liao, 2015; Karras et al., 2016; Lundqvist, Sandström, Stenlund, Johansson & Hultdin, 2016). Where the main source of this vitamin is through sunlight and a few food items, its deficiency is very prevalent, especially in the Middle East as women avoid going out much in Sun due to extremely hot temperatures (Wassia & Ouf, 2016). Worldwide it is estimated that 18-84 percent of pregnant women suffer from this deficiency depending on the country of residence and local clothing customs (Abbasian et al., 2016).

A recent meta-analysis done on pregnant women, vitamin D deficiency is one of the major causes of preterm birth in women's gestational period (Lian et al., 2021). A study also highlighted that Vitamin D supplementation during pregnancy could reduce the chances for reversible bone loss in mothers (Varbiro et al., 2022). Evidence was obtained from a Cochrane review which included 30 trials done on 7033 women highlighted the reduction of gestational Diabetes, pre-eclampsia, low birth weight and reduced the likelihood of post-partum haemorrhage (Palacios, Kostiuk, & Peña-Rosas, 2019).

Vitamin D also plays a salient role in foetal development and its deficiency may be seen to affect cognitive development in fetus. Cognitive development is an important milestone to be achieved by the infant which is defined as a set of higher mental functions including memory and learning (Pet & Brouwer-Brolsmauring, 2016;

Schwarzenberg& Georgieff, 2018). During pregnancy Vitamin D is transported to the placenta in the form of 25 Hydroxyvitamin D and its deficiency may also increase the chances of having Multiple sclerosis in fetus brain development (Nielson et al., 2017). Vitamin D is importance in early brain development but its deficiency also increases the chances of the offspring having Asthma in later life (Specht et al., 2020; Pierrot-Deseilligny & Souberbielle, 2017; Wagner & Hollis, 2018; Wolsk et al., 2017).

Moreover, infants born to mothers breastfeeding them with Vitamin D deficiency are shown to exhibit hypocalcemic seizures and dilated cardiomyopathy later in life (Munn et al., 2016). It also causes rickets and osteomalacia which may impair an infant's growth and health in later life span (Tan, Abram & Osborne, 2020). Therefore, it is advisable according to studies that pregnant women should take vitamin D supplements to improve their levels. It is advisable to take approximately 1000-2000 mg daily of Vitamin D in the form of tablets during pregnancy (Pérez-López, Pilz & Chedraui, 2020). It is also recommended Vitamin D3 supplement of approximately 400 IU daily recommended dosage for children between 0-18 years (Bacchetta et al., 2022). These steps are important so that the body has adequate reserve stores of Vitamin D required for expecting mothers and their fetus and infant development.

2.1 Neurodevelopment of fetus through Maternal nutrition: Importance of Iron

Iron deficiency is another leading cause of concern affecting billions of individuals around the world and its deficiency may have aversive health outcomes (Georgieff, Krebs, Cusick, 2019). Iron can be obtained through a balanced diet consisting of fresh and green vegetables, red meat, and rice (Adetola, Onabanjo & Stark, 2020).

Studies have highlighted Iron deficiency affects pregnant mothers, having adverse effects on the neurodevelopment of the child and the immunity of the mother (Georgieff et al., 2021). Research highlights that Iron deficiency in mothers is a risk factor for maternal illness and intrauterine growth restriction (Georgieff, 2020). A normal pregnancy requires 500-800mg of Iron and if pre-pregnancy that reserve is not available, the physiological increase in demand of iron for foetal development becomes very hard putting the mother at high risk of having Anemia (Milman, Taylor, Merkel & Brannon, 2017). Anemia is a condition characterised by low levels of red blood cells causing fatigue and tiredness caused due to less iron concentration in the blood (Turner, Parsi & Badireddy, 2023).

According to a study 2 to 5 percent of women are diagnosed with iron deficiencies during the first trimester and 10 to 20 percent during their third trimester (Jouanne, Oddoux, Noel & Voisin-Chiret, 2021).

According to a systematic review and meta-analysis, high prevalence of Anaemia was seen in pregnant women, especially in the third trimester and it was seen to be higher in developing countries than in developed countries (Karami, Chaleshgar, Salari, Akbari & Mohammadi, 2022). A study was conducted to assess Iron deficiency and its adverse effect of perinatal outcomes in southern India highlighted, that Anaemia and Iron deficiency were higher in early pregnancy days and increased risk for the infant (Finkelstein, Kurpad, Bose, Thomas, Srinivasan & Duggan, 2020).

Studies also highlighted that infants and preeschoolers (1 years to 5 years) are at a high risk of having Iron deficiency. This is primarily attributed because infants/toddlers being fed with a diet which is not rich in iron nutrients, or the body absorption may not be sufficient. Another prominent reason for Iron deficiency is the transition of the infant to unmodified cow milk or other food sources which do not have higher Iron concentrations (Thane, Walmsley, Bates, Prentice & Cole, 2000; McCarthy et al., 2017). Iron also plays an important role in the neuronal function of the fetus and growing infant. Myelin is a fatty sheath found on the neurons that is related to speed of processing behavioural related tasks (Lynch et al., 2018). Iron plays a major role in the neurodevelopment of the fetus by facilitating the neuronal process of myelination however, its deficiency can disrupt the foetal maternal Iron balance resulting in abnormal neuronal development (Lynch et al., 2018). Its deficiency can not only disrupt these neurological processes but also put the fetus at a high risk of developing cognitive deficient which in later life exhibit in the form of difficulty in memory recognition, low verbal intelligence, inattentive and sluggish cognitive symptoms in childhood and poor educational outcomes in later adulthood (East, Doom, Blanco, Burrows, Lozoff, Gahagan, 2021; Lynch et al., 2018). Also, maternal Iron deficiency was seen to cause slower processing speed and issues in memory and recognition in infants (Georgieff, 2020).

According to research during the third trimester iron need of the body increases from 0.8mg/day to 7.5mg/day therefore 1000 mg of Iron must be consumed to maintain the maternal iron balance and to support the fetoplacental development (Fisher & Nemeth, 2017). Dietary allowance for children under 5 years should be approximately 2 mg/kg body weight (Man, Xu, Adhikari, Zhou, Wang & Wang, 2022). There is also an urgent requirement to spread adequate awareness about the importance of iron and daily dosage for expecting mothers to have adequate iron supplements to improve maternal and infant development (Finkelstein, Kurpad, Bose, Thomas, Srinivasan, & Duggan, 2020). Prevention of iron-related deficiency and the consumption of iron-fortified food and production requires to be conducted as public awareness programs. Overall, health will be improved by a continuous supplement for people with deficient and expecting mother and their infants. The upcoming section will discuss the role of vitamin C and Zinc essential for mothers' and infants' nutritional health.

2.2 Immunity building in mothers and infants: Essential role of Vitamin C and Zinc

Vitamin C is a water-soluble vitamin which helps in many biological processes in the body (Hansen, Tveden-Nyborg & Lykkesfeldt, 2014). Obtained largely through citrus fruits and vegetables it is seen to play a pivotal role in building an individual's immunity, reduces joint pains and reduces the likelihood of bone and connective tissue disorder. Also, it acts as an important antioxidant and helps in promoting health and improving immunity and preventing the contraction of upper respiratory infections (Shahbaz, Fatima, Basharat, Bibi, Yu, Hussain & Nasrullah, 2022). During Covid-19, Vitamin C which is a water-soluble vitamin was helpful in reducing mortality rates because it helps in enhancing the body's immune system to fight against such infections (Shahbaz et al., 2022). The daily dosage of Vitamin C is recommended to be 90 mg for males and 75 mg for females and 85mg for expecting mothers (National Institute of Health, 2021).

However, environmental, and cultural factors like traditional diets and cooking methods including staple foods, geographic region, climate, and pollution all are reasons for having Vitamin C deficiency, especially in expecting mothers (Carr & Rowe, 2020).

Pregnant women struggle with having a balanced level of Vitamin C which is essential to reduce any pregnancy complication and foetal development, especially in the last trimester. It is also seen to reduce pregnancy complications such as pre-eclampsia, intrauterine growth reduction and also reduces the chances of Anaemia (Rumbold, Ota , Nagata , Shahrook & Crowther, 2015). According to studies Vitamin C supplementation are seen to improve the milk production from 40 to 60mg/l in breastfeeding mothers (Drug and Lactation database, 2021) According to another study conducted by Zarban, Toroghi, Asli, Jafari, Vejdan & Sharifzadeh (2015), it was seen that sixty healthy women between 1 to 6 months of breastfeeding infants were given Vitamin C supplements for thirty days reported increased biochemical markers of antioxidant activity in the urine samples of their infants. Therefore, it is advisable for mothers to take vitamin C supplementation due to its antioxidant properties in helping in reduction of contraction of diseases and illnesses (Carr & Rowe, 2020). Studies from the year 2017-2018 have reported the average daily recommendation of Vitamin C for women aged 20-39 years is approximately 71mg (Adams, Kirby, Sorensen, Pollard & Audhya, 2022). The recommended daily dosage for pregnant women is approximately 85 mg with an upper limit of 2000 mg (Adams, Kirby, Sorensen, Pollard & Audhya, 2022). Further, daily recommended dosage for infants may range between 40-50 mg (Maggini, Wenzlaff & Hornig, 2010).

Vitamin C and Zinc are the essential vitamins and minerals needed by the body for good health, especially during pregnancy. Both the vitamins

and minerals support the immunity of the pregnant woman and the growing fetus. Zinc has a salient role which assists with the process of protein synthesis and for reproductive health, growth and development.

Zinc is also very important micronutrient essential due to its anti-inflammatory and anti-oxidant properties. It can be obtained through food items like liver, red meat, whole wheat rice, bread, cereals and peanut butter, sunflower seeds, pecans etc (Sandstead & Freeland-Graves, 2014; Gibson, Heath & Szymlek-Gay, 2014). It plays a pivotal role in the health of expecting mothers and in foetal development along with the future health of infants (Grzeszczak ,Kwiatkowski & Kosik-Bogacka, 2020). Its deficiency can be a major reason for pregnancy induced hyper tension, anaemia in mother, low birth weight and also pre-eclampsia (Grzeszczak, Kwiatkowski & Kosik-Bogacka, 2020).

Daily consumption of Zinc should be 6.5mg/day however during pregnancy many women struggle with its deficiency that can also be a major cause of congenital abnormalities in infants (Moghimi, Ashrafzadeh, Rassi & Naseh, 2017). The daily recommended dosage for the infant is approximately 2-3 mg and can be increased when contracted with upper respiratory infections (Maggini, Wenzlaff & Hornig, 2010). Although zinc is present in meat and seafood but during pregnancy many women avoid eating sea food due to scare of lead poisoning thus, this deficiency can be a major reason for preterm birth and intrauterine growth retardation (Chaffee & King, 2012). A Cochrane review highlighted a 14 percent reduction in preterm birth due to the consumption of Zinc supplements (Ota et al., 2015). Another study was conducted on evaluating Zinc deficiency in southern Ethiopia highlighted that Zinc deficiency is a major issue experienced by pregnant women and proper maternal knowledge is much required to help these women take the right supplements and diet to avoid it (Agedew et al., 2022). Therefore, it is advisable for expecting mothers to increase their zinc consumption from 7.3mg/day to 13.3/day to avoid any pregnancy-related complications especially premature births. Also, to improve neonatal immunity and reduce infant morbidity by contracting infectious diseases (Kumari, Garg & Bhawrani, 2022). The next section highlights the importance of calcium intake for women during pregnancy for their foetal development and after birth infant bone development.

2.3 Bone Development in infants: Essential Role of Calcium in Pregnancy

Calcium is a very essential mineral required by the body and constitutes about 1 to 2 % of the body mass. The only source for this mineral is through dietary intake and is required for skeletal strength, muscle contraction, bone formation and enzyme activity. It is largely obtained through milk, cereals, and dairy products (Shkembi & Huppertz, 2022). According to the World health organization, 1000 mg of calcium is required per day for young adults and 1300 mg/day for men over 65 and for females between the age range of 9-18 years (WHO, 2001). However,

during pregnancy, women report low levels of calcium as the fetus is completely dependent on its calcium intake through the mother which disturbs the maternal calcium equilibrium. Therefore, if adequate calcium reserves are not present for the mother, calcium is taken from the maternal skeleton leading to muscle weakening during pregnancy (Korhonen et al.,2022). According to studies calcium supplement help in reducing the chances of hypertensive disorders which can be a major source of maternal deaths (Kumar & Kaur, 2017).

Its deficiency is also a cause of pre-eclampsia and increases the likelihood of preterm births. Study conducted by Hofmeyr, Lawrie, Atallah & Torloni, (2018), identified 24 studies highlighting that high dosage of calcium supplementation reduced the chances of hypertension and pre-eclampsia. Pre-eclampsia put the infant at risk of adverse health outcomes, along with increased blood pressure and increased risk of stroke and cerebral palsy in later adulthood (Mann, McDermott, Griffith, Hardin & Gregg, 2011). According to another study maternal calcium deficiency during pregnancy caused Insulin resistance in children (Takaya, 2021).

Another study conducted by Wang, Yang, Mao, Liu, Yang & Yang (2010), in Chengdu, located in China concluded that, 77 pregnant women showed prevalence of calcium deficiency even when they were consuming supplements highlighting the importance of having proper calcium nutrition. Thus, since pregnant women do not consume the required amount of calcium, proper supplementation should be carried out to restore proper maternal fetus calcium balance. Under the upcoming section, the importance of vitamin B12 and Folate will be discussed for infant brain development and maternal health.

2.4 Development Regression in Infants: Importance of Maternal Vitamin B12 and Folate

Vitamin B-12 is obtained largely through animal-based food items like milk, fish, meat and eggs. Vitamin B-12 and Folate are essential for one carbon metabolism which involves the synthesis of DNA, lipids and protein. Therefore, its deficiency can lead to disruption of DNA and have serious consequences (Finer, Saravanan, Hitman & Yajnik, 2014; Green et al., 2017). In many low-income families especially in developing countries this deficiency is very prevalent due to the non-affordability of Vitamin B-12-rich food items and also common in people who are vegetarians (Dror & Allen, 2014).

In pregnancy women suffering from Vitamin B-12 deficiency have reported an increased risk of neural tube defects, intrauterine growth reduction, increased risk for contracting chronic illnesses and insulin resistance (Nasri et al., 2015; Peker et al., 2016; Rush, Katre, Yajnik, 2014). Moreover, it increases pregnancy complications including spontaneous abortion (Finkelstein, Layden & Stover, 2015).

In terms of foetal development several studies have indicated maternal vitamin B-12 deficiency to be a strong risk factor for adverse foetal outcomes and neurological defects in infants (Dubaj, Czyż, & Furmaga-Jabłońska, 2020). Golding (2021), in their study highlighted that low intake of Vitamin B-12 was related to adverse cognitive development and reduced ability in speech and language. That's because adults have 3 mg reserve of Vitamin B-12 in their body and can remain with its deficiency without obvious symptoms for long however, infants born with this deficiency can develop symptoms within a few months of this deficiency. Infants who were born to mothers suffering from vitamin B-12 deficiency were reported to be 1.6 times more likely to have this deficiency at 6-week age compared to infants born to mothers with normal levels (Finkelstein, Kurpad, Thomas Srinivasan & Duggan, 2017). Vitamin B-12 is essential for brain development, neuronal myelination and cognitive function (Venkatramanan, Armata Strupp, Finkelstein, 2016). Vitamin B-12 deficiency is seen to cause loss of neuromotor skills in infants and also low intelligence scores reported in later life. Studies have shown cognitive deficit such as poor memory, altered sense of sensation and vibration, developmental delays, convulsions, hypotonia, memory impairment and impaired sense of vibration in infants born to mothers with Vitamin B-12 deficiency (Serin &, Arslan,2019).

It is also a major cause of developmental regression and cerebral atrophy in infants. If the deficiency is not properly treated it is seen to cause permanent issues like degeneration of neuronal cells, inflammatory bowel syndrome, loss of appetite, fatigue and lethargy, epilepsy, and delayed development growth (Stabler, 2013).

Therefore, it is advisable for all pregnant women who are vegetarians or suffering from Anaemia to be given proper supplementation to ensure their levels are stable to avoid any pregnancy-related complications such as miscarriages, gestational diabetes and pre-eclampsia. (Behere, Deshmukh, Otiv, Gupte & Yajnik, 2021). Also, to prevent neurological defects in infants such as deficits in neurocognition including speed of processing, myelination, mental focus and executive control (Doom & Georgieff, 2014; Radlowski & Johnson, 2013). These neurological defects also involve deficits in recognition memory, response inhibition and slow auditory and visual system functioning (Congdon et al., 2013).

2.5 Maternal Omega-3 fatty Acids: An essential nutrient for infant development

Omega- 3 fatty acids mostly found in items like fish, nuts and seeds play a pivotal role as an anti-inflammatory, moderating the effects of atherosclerosis by decreasing blood viscosity and thrombus development which can be a cause of heart attacks and stroke in individuals (Back, 2017).

During pregnancy, it has been observed that; Omega-3 fatty acids play a vital role in foetal development and growth and also reduce the chances of intra-uterine growth reduction and a significant reduction in preterm births (Best, Gibson, & Makrides, 2022). Studies have highlighted improved cognitive and developmental outcomes for infants whose mothers had adequate omega-3 fatty acid supplementation (Nordgren, Lyden, Anderson-Berry & Hanson, 2017) A positive effect was observed with omega -3 fatty acids levels on the child's problem-solving skills, vision, reduced chances of the child having asthma and improved neurocognitive development (Emmett, Jones & Golding, 2015; Miyata & Arita, 2015). Therefore omega-3 supplements during pregnancy is advisable as it not only improves the quality of breast milk but also improves the birth weight of the infant that is born (Warstedt, Furuhjelm, Magnusson, Fager, & Duchen, 2016).

3. Discussion

Ensuring proper maternal and foetal nutrition during pregnancy is a major challenge experienced worldwide and a major public health issue. Proper nutrition during this period is extremely important to ensure proper health for the mother and the fetus. Many women tend to ignore the importance of a proper balanced nutritious diet during pregnancy especially as the body is undergoing numerous physical and hormonal changes. Appropriate awareness and implementation of proper dietary habits can have positive outcomes for the mother but also the developing fetus (Zelalem, Endeshaw, Ayenew, Shiferaw & Yirgu, 2017). Studies have indicated that certain essential minerals and nutrients are needed more during pregnancy and during those nine months the demand in the increases of daily dosages because of the developing foetal requirements (Farias et al., 2020). Thus, if minerals and nutrients are not obtained in the right amounts and quantities then it is likely to have adverse negative outcomes for both the mother and the fetus development. Malnourished or undernourished mothers developing fetus may be at a high risk for neurological defects and are more likely to experience hypertensive disorders such as pre-eclampsia, weight gain and even miscarriages (Middleton, Lassi, Tran, Bhutta, Bubner, Flenady & Crowther, 2013). Maternal nutritional deficiencies are more likely to cause premature births and one of the prominent causes of still births. Premature births (not for all pre-term infants) may also later develop cerebral palsy, intellectual disabilities and sensory and neurological deficits (Grieger, Grzeskowiak & Clifton, 2014; Haider & Bhutta, 2017). Much of the cause for nutritional deficiency in expecting mothers is attributed to poor dietary intake due to lack of awareness but many other factors like low socio-economic status and low affordability of nutritious diet is also major attributable factors for such deficiencies.

Ignorance is another major cause of concern where mothers are seen to be ignorant in choosing the right food items that they need during the critical phase of pregnancy. This ignorant behaviour can put the mother

at a high risk of emotional, physical, environmental and psychological hazards (Nnunukwe, 2018). Therefore, it is advisable for mothers to be more aware of the proper nutrition needed during pregnancy. Therefore, we advise before the pregnancy has been planned or as soon as the mother's know about their pregnancy. An overall health and physical screening including Body Mass Index (BMI's) and nutritional advice should be mandatory from the practitioners to form the adequate levels and vitamins required during this crucial period.

Iron deficiency (Anaemia) is also of the major pregnancy complications mostly due to low Iron levels in the mother's body. According to the World Health Organization (WHO, 2008) Anaemia was found to be the most prominent deficiency in expecting mothers of Asian origin. The prevalence rate was approximately 49.7 percent compared to the global ratio of 41.8 percent (WHO, 2008). It is reported to be a leading cause of maternal death and low infant birth weight also causing infant mortality (Bone et al., 2022; Igbinosa, Berube & Lyell, 2022). Many factors like insufficient iron rich diets, iron loss during menstruation, early and frequent pregnancy, poor sanitation and low socio-economic status are all causes of Iron deficiency (Abd Rahman, Idris, Isa, Rahman, & Mahdy, 2022). During pregnancy iron supplementation is very essential to meet the increased Iron need of the mother and the fetus especially as the average iron intake needs to be 800 mg of which 300mg is consumed by the fetus (Milman, Taylor, Merkel & Brannon, 2017). Therefore, it is recommended that proper Iron supplementation should be taken by mothers to ensure there less complications related to iron deficiency and mother and infant contracting less percentage of upper respiratory infections.

Vitamin D3 deficiency is a major cause of concern especially in pregnant women. Its deficiency is seen to cause several comorbidities in infants born such as impairment in bone development and formation, Diabetes and reduced functioning of the immune system (Mulligan, Felton, Riek ,Bernal-Mizrachi, 2010; Dror & Allen, 2014). Studies have also shown a strong connection between Vitamin D3 deficiency and respiratory difficulties in infants along with poor lung development, eating disorders and neurocognitive difficulties and increased chances of the development of eating disorders (Al-Matary AlMalki, Khalil, AlHulaimi, 2021; Al-Obeidi & Al-Numan, 2019). Moreover, it is also associated with increased risk for immediate abortions and auto immune diseases in the offspring (Eremkina, Mokrysheva, Pigarova, & Mirnaya, 2018). It is also advised that mother and infant should be given adequate morning exposure to the sunlight (8am to 10am) for a good absorption of the natural source of Vitamin D3 and additionally to maintain daily recommended dosage suggested as above for infant for better immunity and overall cognitive development (Khera, Yelisetty, Spence & Alsuwaidi, 2022).

During pregnancy a women body need for calcium increases and calcium supplementation is required to meet the mother and the foetal demand. Breastfeeding mothers loose up to 289-400mg of calcium in breast milk daily and if that loss is not compensated through diet, demineralization of the skeleton is experienced (Kovacs, 2016). During the lactation period the infants tends to get its maximum calcium through the maternal breast milk and the need is more compared to the foetal time (Almaghamsi , Almalki & Buhary, 2018). There are also high chances of the calcium being extracted from the mother's bone causing maternal bone loss and impaired foetal growth (Winter et al., 2020). Studies have shown pregnant mothers being at a high risk of having Osteoporosis and low bone mineral density due to calcium deficiency (Salari & Abdollahi, 2014). Maternal calcium deficiency is very prevalent in underdeveloped and densely populated countries due to the non-affordability of milk and dairy products which are the main source of calcium (Bromage, Ahmed, Fawzi, 2016). Studies have also shown a strong association between Vitamin D deficiency and Calcium deficiency indicating that low calcium levels reduced the vitamin D levels in the body also causing more bone deterioration (Peterlik, Boonen, Cross, Lamberg-Allardt, 2009). Therefore, it is essential that adequate calcium intake should be caried out to ensure proper foetal bone development and to reduce chances of hypertension in mothers. One of the important steps for pregnant or lactating women to have a special focus on diet and include food having high concentrations of calcium. It is advised that calcium-enriched foods should be taken three times daily along with dietary supplements prescribed by the practitioners.

Zinc is an essential element needed during pregnancy to avoid any pregnancy related complications. Pregnant women are at a high risk of having Zinc deficiency especially as they enter in the third trimester effecting the overall health of the mother (Agedew at al., 2022). It is required for not only improving immunity but also for neuronal activation, information processing and proper brain functioning (Levenson & Morris,2011). Studies have highlighted zinc supplementation to help improve the immune system of the offspring that can help reduce infant mortality (Karimi, Bagheri, Nematy &Saeidi, 2012). In neonates it is seen to reduce chances of diarrhoea, slowed wound healing, hair loss and immune deficiency (Brion, Heyne & Lair,2020). According to studies high level of Zinc deficiency was recorded in expecting mothers especially in under developed countries due to non-affordability of zinc rich food items (Gupta, Brazier, Lowe, 2020). On one hand where researches have confirmed chances of congenital abnormalities in infants due to maternal zinc deficiency, its effect on brain function related disorders and behavioural abnormalities cannot be ignored (Piechal Blecharz-Klin, Pyrzanowska, Widy-Tyszkiewicz, 2012). Thus, it is very important for expecting mother to be aware of the adverse effects of Zinc deficiency as it can affect the

development of the nervous system in offspring which can have many later negative effects.

Further, Vitamin C is an essential nutrient for immunity building and acts as an antioxidant to prevent low birth weights. Studies have shown increased foetal and infant growth up to six months with Vitamin C consumption (Jang, Kim, Lee & and Chang, 2018). Vitamin C consumption helps reduce oxidative stress which could result in lung diseases. In infants Vitamin C deficiency can result in impaired cognitive development and also scurvy which causes bleeding and swollen gums (Trapani, Rubino, Indolfi, Lionetti,2022). Infants born to Vitamin C deficient mothers themselves experience this deficiency. Therefore, it is advisable for mothers to be well aware of the important value of Vitamin C and incorporate it in their daily diet so that not only their immunity is improved but also of the infant born.

Vitamin B-12 is a common nutrient deficiency experienced by pregnant women. Previously it was hypothesised that it is only prevalent more in mothers who are vegetarians but studies highlighted that even women who consumed red meat diet during pregnancy and lactation reported low levels of Vitamin B-12 in their body (Sobowale, Khan, Roy, Raqib &Ahmed, 2022). The deficiency has high prevalent in women during pregnancy and lactation period due to the increase in demand by the fetus which increases the chances of birth defects along with being a strong risk factor for pregnancy related complications (Siddiqua et al., 2016). Therefore, it is advisable to create proper awareness amongst expecting mothers to ensure that they take the proper diet to be able to maintain the right Vitamin B-12 balance. Moreover, to be knowledgeable to avoid consumption of items that could reduce the Vitamin B-12 levels in the body like acid suppressing agent (Shipton & Thachil, 2015).

Omega 3 fatty acids are also very essential in the diet but many expecting women do not recognise its importance and tend to ignore its deficiency and negative effects it has on foetal development. Many women also struggle with knowing the right amount they need to consume to ensure the adequate balance in the body. Therefore, it is advisable to create proper awareness to ensure all pregnant women consume the right amount of omega 3 in their diets (De Seymour, J.V., Simmonds, L.A., Gould, J., Makrides, M & Middleton, 2019). The important omega-3 fatty acids are (1) Alpha-linolenic acid (ALA), (2) Eicosapentaenoic acid (EPA), and (3) Docosahexaenoic acid (DHA). Studies also suggest an adequate intake of omega-3 HUFA could reduce the behavioural and learning difficulties mainly linked with attention deficit hyperactive disorder and even dyslexia during childhood.

Conclusion and scope for further research

Poor nutrition is a major cause of deaths in pregnant women and malnutrition also poses a great risk for adverse pregnancy outcomes and reproductive challenges (United Nations Children Fund [UNICEF], 2009). In many underdeveloped countries due to poverty and lack of education women struggle with having access to a proper diet and also knowledge about what to incorporate in their diet during pregnancy. Also lack of education and stigma associated with the use of such supplement's triggers fear in these mothers not to consume anything in tablet form which could be harmful for the foetal development. Therefore, considering the severe risk associated with poor nutrition for both maternal and foetal health it is extremely important and pivotal for mothers to be aware and knowledgeable about their diet to ensure healthy maternal and foetal health.

In underdeveloped countries supplementation should be provided with minimal cost and also proper awareness and educational programs should be run to reduce stigma and fear regarding using these supplementations in tablet form. Cultural norms and myths should be negated in these awareness campaigns which restrict the expecting mother access to proper nutrition. Moreover, proper knowledge about the food guide pyramid should be provided which is a conceptual framework to choose the right amount of food to be consumed on daily basis. Health workers should also be engaged and used as primary agents of creating awareness and counselling about nutrition in pregnancy to ensure proper dietary intake.

In addition, Vitamin B-12, Zinc, Folic acid, Iodine, Omega-3 fatty acid and Iron are crucial for the cognitive development of younger children and infants which required further explanation from long-term experimental observational studies.

Bibliography

1) WHO. 2016. What is malnutrition? http://www.who.int/features/qa/malnutrition/en/. Accessed 6 March, 2023
2) Lieber, M., Chin-Hong, P., Kelly, K., Dandu, M., &Weiser, S. D. (2022). A systematic review and meta-analysis assessing the impact of droughts, flooding, and climate variability on malnutrition. Glob Public Health, 17(1), 68-82. 10.1080/17441692.2020.1860247.
3) Ballestín S.S, Campos, M.I, Ballestín, J.B & Bartolome, M.J. (2021). Is Supplementation with Micronutrients Still Necessary during Pregnancy? A Review. Nutrients,8; 13(9):3134. 10.3390/nu13093134.
4) Al-Ajlan, A., Al-Musharaf, S., Fouad, M. A., Krishnaswamy, S., Wani, K., Aljohani N.J, Al-Serehi A., Sheshah,E., Alshingetti , N.M., Turkistani, I.Z., Alharbi, A.A., Alraqebah , B.A., Ali, A.M., Al-Saeed , G., Al-Daghri, N.M.

(2018). Lower vitamin D levels in Saudi pregnant women are associated with higher risk of developing GDM. BMC Pregnancy Childbirth;18(1). 10.1186/s12884-018-1723-3.

5) Shaikh, F., Fawwad,A.,Hakeem, R., Shera, A.S., Graham A. Hitman, G.A., Bhowmik, B., Moreira, N.C., Basit, A., & Hussain, A. (2018). Maternal Nutrition during Early Pregnancy and Cardiometabolic Status of Neonates at Birth, Journal of Diabetes Research. https://doi.org/10.1155/2018/7382946
6) Norain, A., Nor, S., Fazlinda, S., & Faiz, D. (2019). Understanding Myths in pregnancy and childbirth and potential adverse consequences: A systematic review, Malaysian Journal of Medical Sciences, 26(4),17-27. h10.21315%2Fmjms2019.26.4.3
7) Laitinen, J., Jaaskelainen, A., Hartikainen, A.L., Sovio, U., Vaarasmaki, M., Pouta, A.; Kaakinen, M & Jarvelin, M.R. (2012). Maternal weight gain during the first half of pregnancy and offspring obesity at 16 years: A prospective cohort study. BJOG, 119 (6), 716–723, https://doi.org/10.1111/j.1471-0528.2012.03319.x
8) Kominiarek, M.A & Peaceman, A.M. (2017). Gestational weight gain. Am. J. Obstet. Gynecol.217(6), 642–651, 10.1016/j.ajog.2017.05.040
9) Marshall, N.E, Abrams, B., Barbour, L. A, Catalano, P., Christian, P., Friedman, J.E, Jr, W, Hernandez, T.L., Krebs, N.F., Oken, E., Purnell, J.Q., Roberts, J.,Soltani, H., Wallace, J., Thornburg, K.L.(2022). The importance of nutrition in pregnancy and lactation: lifelong consequences. Am J Obstet Gynecol, 226(5):607-632. doi: 10.1016/j.ajog.2021.12.035.
10) Benedik, E. (2021). Sources of Vitamin D in humans. Vitamin and Nutrition Research, 92(2),118-125. https://doi.org/10.1024/0300-9831/a000733
11) Sizar, O., Khare, S., Goyal, A., & Giveler, A. (2023). Vitamin D Deficiency. StatPearls [Internet]. Treasure Island (FL): StatPearls Publishing, Available from: https://www.ncbi.nlm.nih.gov/books/NBK532266/
12) Xiao, J.P., Zang, J., Pei, J.J., Xu, F., Zhu, Y., Liao, X.P.(2015). Low maternal Vitamin D status during the second trimester of pregnancy: A cross-sectional study in Wuxi, China. PLoS ONE , 10.1371/journal.pone.0117748.
13) Karras, S., Paschou, S.A., Kandaraki, E., Anagnostis, P., Annweiler, C., Tarlatzis, B.C., Hollis, B.W., Grant, W.B., Goulis, D.G. (2016). Hypovitaminosis D in pregnancy in the Mediterranean region: A systematic review. Eur. J. Clin. Nutr. 70, 979–986, 10.1038/ejcn.2014.80.
14) Lundqvist, A., Sandström, H., Stenlund, H., Johansson, I & Hultdin, J. (2016). Vitamin D status during pregnancy: A longitudinal study in Swedish women from early pregnancy to seven months postpartum. PLoS ONE , 10.1371/journal.pone.0150385
15) Al-Wassia, H & Abo-ouf, N.(2016). Prevalence of Vitamin D deficiency in mother-infant pairs in a tertiary hospital in the west coast of Saud Arabia, Journal of Clinical Neonatol, 5(4), 243-246, http://dx.doi.org/10.4103/2249-4847.194164
16) Abbasian, M., Chaman, R., Amiri, M., Ajami, M.E., Jafari-Koshki T., Rohani, H., Taghavi-Shahri S.M., Sadeghi, E., Raei, M.(2016).Vitamin D Deficiency in Pregnant Women and Their Neonates. Glob J Health Sci, 8(9):54008. doi: 10.5539/gjhs.v8n9p83.
17) Lian, R.H., Qi, P.A., Yuan, T., Yan, P.J., Qiu, W.W., Wei, Y., Hu Y.G, Yang, K,H & Yi, B. (2021). Systematic review and meta-analysis of vitamin D

deficiency in different pregnancy on preterm birth: Deficiency in middle pregnancy might be at risk. Medicine (Baltimore). 18;100(24), doi: 10.1097/MD.0000000000026303.

18) Varbiro, S., Takacs, I, Tuu, L, Nas, K, Sziva, R.E, Hetthessy, J.R, Torok, M (2022).Effects of Vitamin D on Fertility, Pregnancy and Polycystic Ovary Syndrome-A Review. Nutrients.15;14(8): 10.3390/nu14081649.
19) Palacios, C., Kostiuk, L.K., Peña-Rosas, J.P. (2019). Vitamin D supplementation for women during pregnancy. Cochrane Database Syst. Rev, 7, 10.1002/14651858
20) Pet, M.A, Brouwer-Brolsma E.M.(2016). The Impact of Maternal Vitamin D Status on Offspring Brain Development and Function: a Systematic Review. Adv Nutr.15, 7(4):665-78. doi: 10.3945/an.115.010330.
21) Schwarzenberg S. J.,& Georgieff M. K.(2018). Committee on Nutrition: Advocacy for Improving Nutrition in the First 1000 Days to Support Childhood Development and Adult Health. Pediatrics.141(2). 10.1542/peds.2017-3716
22) Nielsen, N.M., Munger, K.L, Koch-Henriksen, N., Hougaard, D.M, Magyari ,M., Jørgensen K.T, Lundqvist, M., Simonsen, J., Jess, T., Cohen, A., Stenager, E., Ascherio, A. (2017). Neonatal vitamin D status and risk of multiple sclerosis: A population-based case-control study. Neurology. 88(1):44-51. doi: 10.1212/WNL.0000000000003454
23) Specht, I.O., Janbek, J., Thorsteinsdottir, F., Frederiksen, P & Heitmann B.L (2020). Neonatal vitamin D levels and cognitive ability in young adulthood. Eur J Nutr, 59(5), 1919-1928. 10.1007/s00394-019-02042-0
24) Pierrot-Deseilligny, C & Souberbielle, J.C (2017).Vitamin D and multiple sclerosis: An update. Mult. Scler. Relat. Disord.14, 35–45, 10.1016/j.msard.2017.03.014
25) Wagner, C.L.; Hollis, B.W. (2018). The implications of Vitamin D status during pregnancy on mother and her developing child. Front. Endocrinol, 9, 500, 10.3389/fendo.2018.00500.
26) Wolsk, H.M., Chawes, B.L., Litonjua, A.A., Hollis, B.W., Waage, J., Stokholm, J., Bonnelykke, K, Bisgaard, H & Weiss, S..(2017). Prenatal Vitamin D supplementation reduces risk of asthma/recurrent wheeze in early childhood: A combined analysis of two randomized controlled trials. PLoS ONE , 27, 12(10), 10.1371/journal.pone.0186657.
27) Munns C.F., Shaw, N, Kiely M, Specker,B.L., Thacher, T.D., Keiichi Ozono, K., Michigami, T., Tiosano, D., M Zulf Mughal, M.Z., Mäkitie, O., Ramos-Abad,L., Ward, L., DiMeglio,L.A., Atapattu, N., Cassinelli,H., Braegger, C., Pettifor, J.M., Seth,A., Idris, H.W., Bhatia, V., Fu, J., Goldberg, G., Sävendahl, L., Khadgawat, R., Pludowski,P., Maddock, J., Hyppönen, E., Oduwole, A., Emma Frew, E., Aguiar, M., Tulchinsky, T., Butler,G., & Högler, W. (2016). Global Consensus Recommendations on prevention and management of nutritional rickets. J Clin Endocrinol Metab.101 (2), 394-415 . 10.1210/jc.2015-2175.
28) Tan, M.L, Abrams S.A & Osborn D.A (2020). Vitamin D supplementation for term breastfed infants to prevent vitamin D deficiency and improve bone health. Cochrane Database Syst Rev, 11;12(12) 10.1002/14651858.CD013046.

29) Pérez-López F. R, Pilz & S., Chedraui, P(2020). Vitamin D supplementation during pregnancy: an overview. Curr Opin Obstet Gynecol.32(5):316-321. doi: 10.1097/GCO.0000000000000641.

30) Bacchetta, J., Edouard, T., Laverny, G., Bernardor, J., Bertholet-Thomas, A., Castanet, M., ... & Linglart, A. (2022). Vitamin D and calcium intakes in general pediatric populations: A French expert consensus paper. Archives de Pédiatrie, 29(4), 312-325.

31) Georgieff M.K, Krebs, N.F., & Cusick S.E (2019).The Benefits and Risks of Iron Supplementation in Pregnancy and Childhood. Annu Rev Nutr, 21;39:121-146. doi: 10.1146/annurev-nutr-082018-124213

32) Adetola, O.Y., Onabanjo, O.O., &Stark, A.H.(2020). The search for sustainable solutions:Producing a sweet potato based complementary food rich in Vitamin A, Zinc and Iron for infants in developing countries, Scientific African, 8. http://dx.doi.org/10.1016/j.sciaf.2020.e00363

33) Georgieff, M. K (2020). Iron deficiency in pregnancy. Am J Obstet Gynecol. 223(4):516-524. 10.1016/j.ajog.2020.03.006.

34) Milman. N., Taylor C. L, Merkel, J & Brannon P.M. (2017). Iron status in pregnant women and women of reproductive age in Europe. Am J Clin Nutr,106(6).1655-1662 . 10.3945/ajcn.117.156000.

35) Turner, J., Parsi, M., Badireddy, M. (2023). Anemia.In: StatPearls [Internet]. Treasure Island (FL): StatPearls Publishing; . Available from: https://www.ncbi.nlm.nih.gov/books/NBK499994/

36) Jouanne, M., Oddoux, S., Noël, A., Voisin-Chiret, A. S (2021). Nutrient Requirements during Pregnancy and Lactation. Nutrients , 13(2), 692. 10.3390/nu13020692

37) Karami, M., Chaleshgar M., Salari N., Akbari., H & Mohammadi, M. (2022). Global Prevalence of Anemia in Pregnant Women: A Comprehensive Systematic Review and Meta-Analysis. Matern Child Health J, 26(7):1473-1487. 10.1007/s10995-022-03450-1

38) Finkelstein J.L, Kurpad A.V, Bose B, Thomas T, Srinivasan, K & Duggan C (2020). Anaemia and iron deficiency in pregnancy and adverse perinatal outcomes in Southern India. Eur J Clin Nutr, 74(1):112-125. 10.1038/s41430-019-0464-3.

39) Thane C.W, Walmsley C.M, Bates C.J, Prentice, A & Cole, T.J (2000) Risk factors for poor iron status in British toddlers: further analysis of data from the National Diet and Nutrition Survey of children aged 1.5–4. 5 years. Public Health Nutr 3 (4), 433–440.

40) McCarthy, E.K., Ní Chaoimh, C., Hourihane J.O., Kenny L.C., Irvine A.D, Murray, D.M & Kiely, M (2017). Iron intakes and status of 2-year-old children in the Cork baseline Birth Cohort Study. Matern Child Nutr.13(3). doi: 10.1111/mcn.12320.

41) East, P., Doom, J.R, Blanco, E., Burrows, R., Lozoff B., Gahagan S. (2021). Iron deficiency in infancy and neurocognitive and educational outcomes in young adulthood. Dev Psychol. 57(6), 962-975. doi: 10.1037/dev0001030.

42) Georgieff, M.K (202). Iron deficiency in pregnancy. Am J Obstet Gynecol. 223(4):516-524. 10.1016/j.ajog.2020.03.006

43) Lynch S, Pfeiffer C.M, Georgieff M.K, Fairweather-Tait , S., Richard F Hurrell, R.F., McArdle, H.J., & Raiten, D.J (2018). Biomarkers of nutrition for development (BOND)-iron review. J Nutr 148 (1), 1001–1067. 10.1093/jn/nxx036

44) Fisher A.L & Nemeth E. (2017). Iron homeostasis during pregnancy. Am J Clin Nutr 106 (6), 1567s–1574s. 10.3945/ajcn.117.155812.
45) Man, Y., Xu, T., Adhikari, B., Zhou, C., Wang, Y., & Wang, B. (2022). Iron supplementation and iron-fortified foods: a review. Critical Reviews in Food Science and Nutrition, 62(16), 4504-4525.
46) Hansen, S.N., Tveden-Nyborg, P & Lykkesfeldt, J. (2014). Does Vitamin C Deficiency Affect Cognitive Development and Function? Nutrients 19,6(9), 3818-3846. https://doi.org/10.3390/nu6093818
47) Shahbaz, U., Fatima, N., Basharat, S., Bibi, A., Yu, X., & Hussain M.I.(2022). Nasrullah M. Role of vitamin C in preventing of COVID-19 infection, progression and severity. AIMS Microbiol, 8(1):108-124. doi: 10.3934/microbiol.2022010.
48) National Institute of Health (2021). Vitamin C fact sheet for health professionals retrieved from https://ods.od.nih.gov/factsheets/VitaminC-HealthProfessional/
49) Carr, A.C., & Rowe. S. (2020). "Factors Affecting Vitamin C Status and Prevalence of Deficiency: A Global Health Perspective" Nutrients, 12(7), 1963. 10.3390/nu12071963
50) Rumbold, A., Ota, E., Nagata, C., Shahrook, S, Crowther C.A.(2015).Vitamin C supplementation in pregnancy. Cochrane Database Syst Rev. (9) 10.1002/14651858.CD004072.pub3
51) Drug and Lactation Database(2021). National Library of Medicine. Vitamin C. Retrieved from https://ods.od.nih.gov/factsheets/VitaminC-HealthProfessional/
52) Zarban, A, Toroghi M.M, Asli, M., Jafari, M., Vejdan, M., Sharifzadeh, G. (2015). Effect of vitamin C and E supplementation on total antioxidant content of human breastmilk and infant urine. Breastfeed Med.10(4):214-7. 10.1089/bfm.2014.0143.
53) Adams, J. B., Kirby, J. K., Sorensen, J. C., Pollard, E. L., & Audhya, T. (2022). Evidence based recommendations for an optimal prenatal supplement for women in the US: Vitamins and related nutrients. Maternal Health, Neonatology and Perinatology, 8(1), 1-37.
54) Maggini, S., Wenzlaff, S., & Hornig, D. (2010). Essential role of vitamin C and zinc in child immunity and health. Journal of International Medical Research, 38(2), 386-414.
55) Sandstead H.H., & Freeland-Graves J.H.(2014). Dietary phytate, zinc and hidden zinc deficiency. J Trace Elem Med Biol. 28(4):414-7. doi: 10.1016/j.jtemb.2014.08.011.
56) Gibson R.S, Heath A.L & Szymlek-Gay, E.A. (2014). Is iron and zinc nutrition a concern for vegetarian infants and young children in industrialized countries? Am J Clin Nutr 100 (1), 459-68. doi: 10.3945/ajcn.113.071241.
57) Grzeszczak K., Kwiatkowski., S & Kosik-Bogacka, D. (2020). The Role of Fe, Zn, and Cu in Pregnancy. Biomolecules,10(8):1176. https://doi.org/10.3390/biom10081176
58) Moghimi, M., Ashrafzadeh, S., Rassi, S., Naseh A. (2017). Maternal zinc deficiency and congenital anomalies in newborns. Pediatr Int. (4):443-446. doi: 10.1111/ped.13176.
59) Chaffee, B.W., & King J. C.(2012). Effect of zinc supplementation on pregnancy and infant outcomes: a systematic review. Paediatr Perinat Epidemiol. 26, 1(1):118-37. doi: 10.1111/j.1365-3016.2012.01289.x

60) Ota E., Mori R., Middleton P., Tobe-Gai R., Mahomed K., Miyazaki C., Bhutta, Z. (2015). Zinc supplementation for improving pregnancy and infant outcome. Cochrane Database Syst. Rev. doi: 10.1002/14651858.CD000230.pub5

61) Agedew E., Tsegaye, B., Bante A., Zerihun E., Aklilu A., Girma, M., Kerebih, H., Kerebih, H., Wale, M.Z, Yirsaw, M.T (2022) Zinc deficiency and associated factors among pregnant women's attending antenatal clinics in public health facilities of Konso Zone, Southern Ethiopia, 17(7).10.1371/journal. pone.0270971

62) Korhonen, P., Tihtonen, K., Isojärvi, J., Ojala, R., Ashorn, U., Ashorn, P. and Tammela, O. (2022), Calcium supplementation during pregnancy and long-term offspring outcome: a systematic literature review and meta-analysis. Ann. N.Y. Acad. Sci., 1510: 36-51. https://doi.org/10.1111/nyas.14729

63) Kumari, D., Garg, S., & Bhawrani, P. (2022). Zinc homeostasis in immunity and its association with preterm births, 95(4),Scandinavian Journal of Immunology, 95(4). https://doi.org/10.1111/sji.13142

64) Shkembi, B., & Huppertz, T. (2022). Calcium Absorption from Food Products: Food Matrix Effects. Nutrients.14(1),180. https://doi.org/10.3390/nu14010180

65) Word Health Organization (2001). Human Vitamin and Mineral Requirements; FAO: Rome, Italy; WHO: Geneva, Switzerland

66) Kumar A, Kaur S. (2017).Calcium: A Nutrient in Pregnancy. J Obstet Gynaecol India. 67(5):313-318. doi: 10.1007/s13224-017-1007-2.

67) Hofmeyr, G.J., Lawrie, T., Atallah, Á.N., Torloni, M.R. (2018). Calcium supplementation during pregnancy for preventing hypertensive disorders and related problems. Cochrane Database Syst. 1, 10 (10). 10.1002/14651858

68) Mann, J .R., .McDermott, S., Griffith, M.I., Hardin, J., & Gregg, A.(2011). Uncovering the complex relationship between pre-eclampsia, preterm birth and cerebral palsy. Paediatr. Perinat. Epi-demiol.25:100–110. 10.1111/j.1365-3016.2010.01157.x

69) Takaya J. (2021). Calcium-Deficiency during Pregnancy Affects Insulin Resistance in Offspring. Int J Mol Sci. 29;22(13): doi: 10.3390/ijms22137008.

70) Wang J, Yang F, Mao M, Liu D.H, Yang H.M, Yang S.F.(2010). High prevalence of vitamin D and calcium deficiency among pregnant women and their newborns in Chengdu, China. World J Pediatr, 6(3):265-7. doi: 10.1007/s12519-010-0224-x.

71) Finer S, Saravanan P, Hitman G, Yajnik. C (2014).The role of the one-carbon cycle in the developmental origins of Type 2 diabetes and obesity. Diabet Med, 31(3):263-272, 10.1111/dme.12390

72) Green, R., Allen L.H, Bjørke-Monsen A.L , Brito, A., Guéant, J.L., Joshua W Miller, J.W., Molloy, A.M., Nexo, E., Stabler, S., Toh, B., Ueland, P.M & Yajnik, C (2017). Vitamin B 12 deficiency. Nat Rev Dis Primers, 3(1), 1-20, 10.1038/nrdp.2017.40.

73) Dror, D.K & Allen, L.H (2014). Dairy product intake in children and adolescents in developed countries: trends, nutritional contribution and a review of association with health outcomes, Nutr Rev, 72, 68-81, 10.1111/nure.12078

74) Nasri K, Ben Fradj, M.K., Touati, A., ,M., Jemaa, N.B., Masmoudi, A., Elmay, M.V., Omar, S., Feki ,M., Naziha Kaabechi , N., Raja Marrakchi ,R., & Soumeya Siala Gaigi, S.S .(2015). Association of maternal homocysteine and vitamins status with the risk of neural tube defects in Tunisia: a case– control study. Birth Defects Res A, 103(12): 1011-20, 10.1002/bdra.23418

75) Peker, E., Demir, N., Tuncer, O., Üstyol, L., Balahoroğlu, R., Kaba, S., & Karaman, K.(2016). The levels of vitamin B12, folate and homocysteine in mothers and their babies with neural tube defects. J Maternal-Fetal Neonatal Med.29(18):2944- 2948. 10.3109/14767058.2015

76) Rush, E.C, Katre, P& Yajnik, C. S. (2014).Vitamin B12: one carbon metabolism, fetal growth and programming for chronic disease. Eur J Clin Nutr.68(1):2-7, 10.1038/ejcn.2013.232

77) Finkelstein J.L., Layden A.J., Stover P.J.(2015). Vitamin B-12 and Perinatal Health. Adv Nutr. 15;6(5):552-63. doi: 10.3945/an.115.008201

78) Dubaj, C., Czyż, K. & Furmaga-Jabłońska, W. (2020). Vitamin B12 deficiency as a cause of severe neurological symptoms in breast fed infant – a case report. Ital J Pediatr, 46, 40. https://doi.org/10.1186/s13052-020-0804-x

79) Golding, J., Gregory,S., Clark, R., Iles-Caven, Y., Genette Ellis, Caroline M. Taylor, C.M & Hibbeln, J (2021). Maternal prenatal vitamin B12 intake is associated with speech development and mathematical abilities in childhood, Nutrition Research, 86, 68-78. 10.1016/j.nutres.2020.12.005.

80) Finkelstein J.L, Kurpad A.V, Thomas T, Srinivasan K, Duggan C (2017). Vitamin B12 status in pregnant women and their infants in South India, Eur J Clin Nutr. 71(9):1046-1053. doi: 10.1038/ejcn.2017.29

81) Venkatramanan S, Armata I.E, Strupp B.J, Finkelstein J.L (2016). Vitamin B-12 and Cognition in Children. Adv Nutr.15;7(5):879-88. doi: 10.3945/an.115.012021.

82) Serin H.M, Arslan, E.A (2019). Neurological symptoms of vitamin B12 deficiency: analysis of pediatric patients. Acta Clin Croat.;58(2):295-302. doi: 10.20471/acc.2019.58.02.13.

83) Stabler S.P (2013).Clinical practice. Vitamin B12 deficiency N Engl J Med, 368 (2),149–60. doi: 10.1056/NEJMcp1113996.

84) Behere, R., Deshmukh, A., Otiv, S., Gupte, M & Yajnik, C (2021).Maternal Vitamin B-12 status during pregnancy and health of the offspring: A systematic review and implication for policy in India, Front. Endocrinol, 12:619176. doi: 10.3389/fendo.2021.619176

85) Doom, J.R, & Georgieff M.K. (2014). Striking while the iron is hot: Understanding the biological and neurodevelopmental effects of iron deficiency to optimize intervention in early childhood. Current Pediatrics Reports, 2(4), 291–298. 10.1007/s40124-014-0058-4

86) Congdon, E.L., Westerlund, A., Algarin C.R., Peirano, P.D, Gregas, M, Lozoff, B, & Nelson, C.A.(2012). Iron deficiency in infancy is associated with altered neural correlates of recognition memory at 10 years. Journal of Pediatrics, 160, 1027–1033. 10.1016/j.jpeds.2011.12.011

87) Radlowski E.C, & Johnson R.W. (2013). Perinatal iron deficiency and neurocognitive development. Frontiers in Human Neuroscience, 7, Article 585. 1–11. 10.3389/fnhum.2013.00585

88) Back ,M. (2017). Omega-3 fatty acids in atherosclerosis and coronary artery disease. Future Sci OA. 5;3(4):FSO236. doi: 10.4155/fsoa-2017-0067.
89) Best, K.P., Gibson, R.A & Makrides,M.(2022). ISSFAL statement number 7 – Omega-3 fatty acids during pregnancy to reduce preterm birth. Prostaglandins, Leukotrienes and Essential Fatty Acids,186. 10.1016/j.plefa.2022.102495.
90) Nordgren T.M, Lyden, E., Anderson-Berry A., Hanson C (2017). Omega-3 Fatty Acid Intake of Pregnant Women and Women of Childbearing Age in the United States: Potential for Deficiency? Nutrients; 9(3):197. https://doi.org/10.3390/nu9030197
91) Emmett, P.M.; Jones, L.R., & Golding, J (2015).Pregnancy Diet and Associated Outcomes in the Avon Longitudinal Study of Parents and Children. Nutr. Rev. 73, 154–174. 10.1093/nutrit/nuv053
92) Miyata J, Arita M (2015). Role of omega-3 fatty acids and their metabolites in asthma and allergic diseases. Allergol Int. 64(1):27-34. doi: 10.1016/j.alit.2014.08.003.
93) Warstedt, K., Furuhjelm, C., Fälth-Magnusson,K., Fagerås M., & Duchén K. (2016). High levels of omega-3 fatty acids in milk from omega-3 fatty acid-supplemented mothers are related to less immunoglobulin E-associated disease in infancy. Acta Paediatr. 105(11):1337-1347. 10.1111/apa.13395.
94) Zelalem, A., Endeshaw, M., Ayenew,M., Shiferaw,S., & Yirgu, R (2017). Effect of Nutrition Education on Pregnancy Specific Nutrition Knowledge and Healthy Dietary Practice among Pregnant Women in Addis Ababa, Clinics Mother Child Health, 14(3),10.4172/2090-7214.1000265
95) Farias, P.M, Marcelino ,G., Santana, L. F, de Almeida E.B, Guimarães R.C.A, Pott A., Hiane P.A, Freitas, K.C. (2020). Minerals in Pregnancy and Their Impact on Child Growth and Development. Molecules. 30;25(23):5630. doi: 10.3390/molecules25235630.
96) Middleton, P., Lassi, Z., Tran, T. S., Bhutta, Z. A., Bubner, T., Flenady, V., & Crowther, C. A. (2013). Nutrition interventions and programs for reducing mortality and morbidity in pregnant and lactating women and women of reproductive age: A systematic review. Journal of Paediatrics and Child Health, 49,71. http://www.mendeley.com/research/nutrition-interventions-programs-reducing-mortality-morbidity-pregnant-lactating-women-women-reprodu-1
97) Grieger J.A., Grzeskowiak L.E & Clifton V.L (2014). Preconception dietary patterns in human pregnancies are associated with preterm delivery. J Nutr, 144, 1075–1080. doi: 10.3945/jn.114.190686.
98) Haider B.A & Bhutta Z.A (2017). Multiple-micronutrient supplementation for women during pregnancy. Cochrane Database Syst Rev.13;4(4), 10.1002/14651858.CD004905.pub5
99) Nnunukwe, E. N. (2018). Prevalence and socio-demographic predictors of malnutrition among primary school children in Rivers State, Nigeria.University of Nigeria,
100) World Health Organization (2008) retrieved from https://www.who.int/health-topics/anaemia#tab=tab_1
101) Bone, J. N., Bellad, M., Goudar, S., Mallapur, A., Charantimath, U., Ramadurg, U., ... & von Dadelszen, P. (2022). Anemia and adverse

outcomes in pregnancy: subgroup analysis of the CLIP cluster-randomized trial in India. BMC Pregnancy and Childbirth, 22(1), 407.

102) Igbinosa, I., Berube, C., & Lyell, D. J. (2022). Iron deficiency anemia in pregnancy. Current Opinion in Obstetrics and Gynecology, 34(2), 69-76.

103) Abd Rahman, R., Idris, I. B., Isa, Z.M, Rahman, R.A & Mahdy, Z.A (2022). The Prevalence and Risk Factors of Iron Deficiency Anemia Among Pregnant Women in Malaysia: A Systematic Review. Front Nutr. 15;9. doi: 10.3389/fnut.2022.847693.

104) Mulligan M.L., Felton S.K., Riek, A.E & Bernal-Mizrachi, C.(2010). Implications of vitamin D deficiency in pregnancy and lactation. Am J Obstet Gynecol. 202(5):429.e1-9. doi: 10.1016/j.ajog.2009.09.002.

105) Al-Matary A.,AlMalki, Y., Khalil, S., AlHulaimi, E. (2021). The potential effects of vitamin D deficiency on respiratory distress syndrome among preterm infants. Clin Nutr ESPEN. 44:243-246. doi: 10.1016/j.clnesp.2021.06.009.

106) Al-Obeidi R.A & Al-Numan, A.H. (2019).Study of low vitamin D among children with anorexia in Sulaymaniyah, Kurdistan region, Iraq during summer months. Saudi Med J. ;40(11):1129-1133. doi: 10.15537/smj.2019.11.24598.

107) Eremkina A.K, Mokrysheva N.G, Pigarova E.A, Mirnaya, S.S. (2018). Vitamin D effects on pregnancy, maternal, fetal and postnatal outcomes. Ter Arkh. 22; 90(10):115-127. doi: 10.26442/terarkh20189010115-127.

108) Khera, G., Yelisetty, R. C., Spence, G. M., & Alsuwaidi, A. M. I. (2022). Call For The Nutritional Requirements For The Cognitive Development Of The Younger Children During And After The Covid-19 Pandemic: A Review For Parents. Journal of Positive School Psychology, 6(10), 685-701.

109) Kovac, C.S (2016). Maternal mineral and bone metabolism during pregnancy, lactation and post weaning recovery, Physiol Res, 96, 449-547. 10.1152/physrev.00027.2015449

110) Almaghamsi A, Almalki M.H, Buhary B. M (2018). Hypocalcemia in Pregnancy: A Clinical Review Update. Oman Med J.33(6):453-462. doi: 10.5001/omj.2018.85.

111) Winter E.M., Ireland, A., Butterfield, N. C, Haffner-Luntzer, M., Horcajada M.N., Veldhuis-Vlug, A.G, Oei L, Colaianni G, Bonnet, N.(2020) Pregnancy and lactation, a challenge for the skeleton. Endocr Connect. 9(6):R143-R157. doi: 10.1530/EC-20-0055.

112) Salari P & Abdollahi M. (2014).The influence of pregnancy and lactation on maternal bone health: a systematic review. J Family Reprod Health.8(4):135-48. retrieved from https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4266784/

113) Bromage, S., Ahmed, T., Fawzi, W. W.(2016). Calcium Deficiency in Bangladesh: Burden and Proposed Solutions for the First 1000 Days. Food Nutr Bull. 37(4):475-493. doi: 10.1177/0379572116652748.

114) Peterlik, M. Boonen, S., Cross H.S, Lamberg-Allardt, C. (2009). Vitamin D and calcium insufficiency-related chronic diseases: an emerging world-wide public health problem. Int J Environ Res Public Health. 6(10):2585-607. doi: 10.3390/ijerph6102585.

115) Levenson C. W & Morris, D (2011). Zinc and neurogenesis: making new neurons from development to adulthood. Adv Nutr. 2(2):96-100. doi: 10.3945/an.110.000174.

116) Karimi, A., Bagheri, S., Nematy, M & Saeidi, M. (2012). Zinc Deficiency in Pregnancy and Fetal Neonatal Outcomes and Impact of the supplements on pregnancy outcomes. Iranian Journal of Neonatology, 3(2). https://doi.org/10.22038/ijn.2012.270

117) Brion L.P, Heyne, R, Lair C.S (2021). Role of zinc in neonatal growth and brain growth: review and scoping review. Pediatr Res. 2021, 89(7):1627-1640. doi: 10.1038/s41390-020-01181-z.

118) Gupta, S., Brazier, A.K.M & Lowe, N.M (2020). Zinc deficiency in low- and middle-income countries: prevalence and approaches for mitigation, Journal of Human Nutrition and Dietetics, 33(5),599-738, https://doi.org/10.1111/jhn.12791

119) Piechal A, Blecharz-Klin K, Pyrzanowska J & Widy-Tyszkiewicz E (2012). Maternal zinc supplementation improves spatial memory in rat pups. Biol Trace Elem Res. 147(1-3): 299-308. 10.1007/s12011-012-9323-y

120) Jang W, Kim H, Lee B.E & Chang N (2018). Maternal fruit and vegetable or vitamin C consumption during pregnancy is associated with fetal growth and infant growth up to 6 months: results from the Korean Mothers and Children's Environmental Health (MOCEH) cohort study. Nutr J, 12;17(1):105. 10.1186/s12937-018-0410-6.

121) Trapani, S., Rubino, C., Indolfi, G., Lionetti, P. A(2022). Narrative Review on Pediatric Scurvy: The Last Twenty Years. Nutrients.6;14(3):684. doi: 10.3390/nu14030684.

122) Sobowale O.I., Khan M.R., Roy, A. K, Raqib, R., Ahmed, F.(2022).Prevalence and Risk Factors of Vitamin B12 Deficiency among Pregnant Women in Rural Bangladesh. Nutrients.14(10):1993. doi: 10.3390/nu14101993.

123) Siddiqua T.J, Ahmad S.M, Ahsan K.B, Rashid M, Roy A, Rahman S.M, Shahab-Ferdows S, Hampel, D., Ahmed, T, Allen L.H, Raqib, R (2016). Vitamin B12 supplementation during pregnancy and postpartum improves B12 status of both mothers and infants but vaccine response in mothers only: a randomized clinical trial in Bangladesh. Eur J Nutr.;55(1):281-93. doi: 10.1007/s00394-015-0845-x

124) Shipton M.J & Thachil, J. (2015). Vitamin B12 deficiency - A 21st century perspective . Clin Med (Lond), 15(2):145-50. doi: 10.7861/clinmedicine.15-2-145.

125) De Seymour, J.V., Simmonds, L.A., Gould, J., Makrides, M &Middleton, P (2019). Omega-3 fatty acids to prevent preterm birth: Australian pregnant women's preterm birth awareness and intentions to increase omega-3 fatty acid intake. Nutr J, 18,74. https://doi.org/10.1186/s12937-019-0499-2

126) United Nations Children Fund [UNICEF], (2009).Retrieved from https://www.unicef.org/reports/state-worlds-children-2009