International Research Journal of Natural and Applied Sciences
ISSN: (2349-4077)
Impact Factor 5.46 Volume 7, Issue 6, June 2020
Website- www.aarf.asia, **Email** : editor@aarf.asia , editoraarf@gmail.com

Micro-Nutrients: Antenatal Care For Pregnant Woman and Lactating Child

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Abstract:

Deficiencies of micronutrients are very common in pregnant woman or in new born child in Low per capita income countries (LPCIC). Inadequate intake of micronutrients can cause various health issues to prenatal mother such as anaemia, hypertension, labour complications, sometime death and adverse birth outcome too like miscarriage, premature delivery, growth retardation, reduced immune competence, and abnormal organ development. World Health Organization in 2016 published the guideline for better attention in prenatal time for expected woman and young girls. 14 out of 49 guidelines by World Health Organization under Antenatal care (ANC) scheme stressed on nutrition during pregnancy. With better micronutrients policy, growing countries should expand their ANC schemes beyond survival. In Dec 2019, Guideline Development Group (GDG) (A group of researcher, policymakers and experts), priorities two nutrition recommendation, 1. Multiple micronutrients (MMN) in pregnancy to achieve positive pregnancy and 2. Vitamin D in pregnancy. These recommendations were updated by WHO for antenatal care scheme. Deficiency management can be done by proper intake of multiple micronutrients and this supervision reflects on better pregnancy outcome.

Key words:

Micronutrients, Pregnancy, Vitamins, Minerals, Adverse Birth Outcome

Introduction:

Physiological preparation of woman before conceive or fetus development in womb, micronutrients play a major role. During this time frame human body necessitate increase demand of micronutrients and caloric requirements (Figure 1). Vitamins and minerals (micronutrients) are very essential intake during pregnancy and deficiency of nutrition can raise complication to maternal health or growth of fetal. Inadequate supply of micronutrients may push the life in danger of mother or of fetus or of both.[1,2]

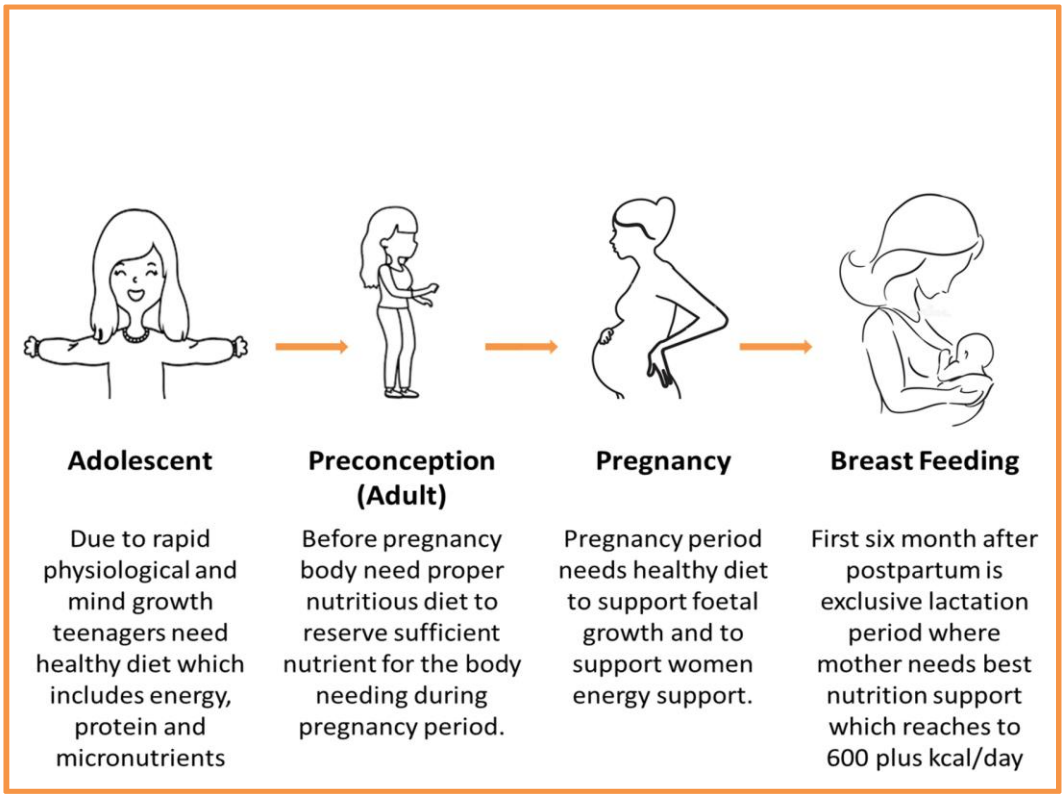

Figure 1: Woman nutrition requirement at different life stages[3,4]

Countries of lower income (developing countries) generally face adverse birth conditions due to insufficient nutrition consumption but this is not all true, developed countries also face birth complications due to poor dietary habits. During gravidity many countries have approved the iron and folic acid (IFA) as essential part of multiple micro nutrients supplements (MMS).[5,6] Vitamins, minerals and trace amount of essential element are three main part of MMS and are needed daily for better care during antenatal time. These substances take care proper hormonal balance, enzyme and physiological growth, caloric requirements thus WHO refer these as 'magic wand'.[7] 1.7 Million Mortality rate was

recorded worldwide due to malfunctioning of nutrients. Micronutrients are Vitamins are minerals that needed in very small amount but play big role in maintaining normal pregnancy condition. Essential minerals can be divided in two type's micro and macro minerals. Micro mineral are generally nutrients body needs in very small amount such as fluoride, iron, iodine, copper, manganese, selenium, zinc, chromium, molybdenum etc. whereas macro minerals are required in bit more than micro mineral. It consists of mainly sodium, potassium, chloride, phosphorus, calcium, magnesium, sulfur, etc.[8] Later year, WHO updated his guidelines that, other micro minerals are also essential for better maternal care including iron and folic acid, Common and essential micro nutrients made up of iron, zinc, iodine, magnesium, copper, selenium, calcium, Vitamins A, B1, B2, B3, B6, B12, folic acid, C, D, E and K. [9,10]

Factors responsible for adverse pregnancy condition:

Around the globe malnutrition affect severely millions of woman/child during pregnancy and lactation period.[11] Global nutrition database revels that around 170 million (9.1%) woman are underweight and 610 millions (32.5%) of woman are overweight during gravidity. Obesity and overweight have affected more than half billion woman in the world and it has been increased multiple times in last three decades (Figure 3).[12] Mean Global Body Mass Index (BMI) of woman is 24.4 kg/m^2 which show the trend of obesity in woman in general. Factor

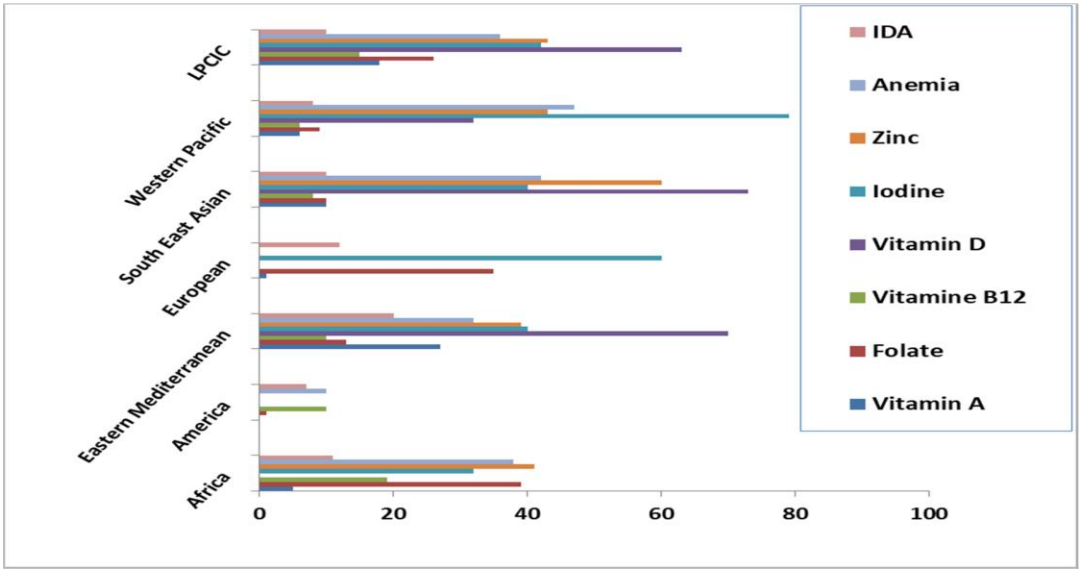

Figure 2: Regional study of deficiency of micronutrient from all over the globe during gestational period.[15]

affecting the short stature are mainly intergenerational and conical malnutrition, although there is improvement in this physiological lacking but still short stature in woman share 7% of deficient population. Deficiency of key micronutrients (Iodine, Vitamin D, B6, B12, Folate, iron and Zinc) are very common in all women weather she belong to overweight, normal or underweight category. Anaemia affects the 571 million (34%) populations of women of almost all regions of word.

Malnutrition:

In early gestation period zinc, folate, niacin, riboflavin and vitamins B6 and B12 are responsible for one carbon metabolism which is crucial for considered particularly important in early gestation as these micronutrients are involved in one-carbon metabolism, which is crucial for cell proliferation, evolution, and protein synthesis.[13,14] Throughout pregnancy period Iron, folate, Zinc, niacin, Vitamin B6 and Vitamin A support organogenesis and cares the nervous system of the fetus. Placental development can be look by Zinc and vitamin D, whereas brain development upkeeps by Iodine. Regional studies of % deficiency of various micronutrients were reported by WHO in May 2017. (Figure 2)

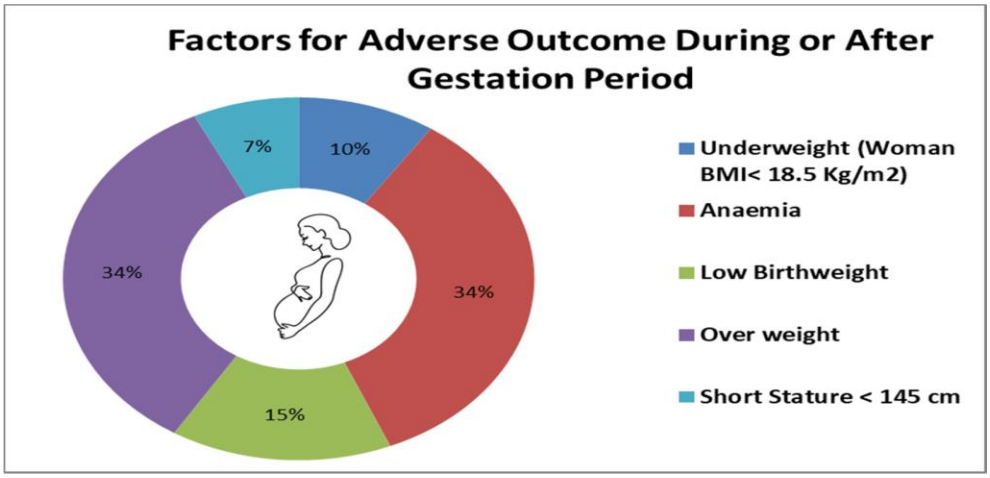

Figure 3: physiological condition affect the adverse pregnancy condition in woman

In woman of Reproductive Age (WRA) deficiency of Zinc, Vitamin D, Iron (IDA-iron deficiency anemia) and Iodine is very common and spread across the globe (Figure 2).[15] Bar diagram in Figure 2 is the data of WRA between year 2015 to 2017 and it reflects that deficiency of Vitamin D was 63.2%, Zinc was 41.1%, folate was 22.7% and iron was 31.2% (half of the anaemia case) on average.

Micronutrients and Health Benefits:

Micronutrients are generally vitamins and minerals whereas macronutrients are consist of protein, fats and carbohydrates. Macronutrients requirement is in higher amount for the body so they termed as macro. Our body is not able to produce vitamin or minerals and so we need to consume food. Vitamins are organic and come from plant or animal food source whereas minerals are inorganic and exist in soil and water. Quantities of micronutrients are different in different food source, so it is suggested to consume variety of healthy food to seal the requirement of Vitamin of minerals by human body. It becomes more vital to take proper food diet during pregnancy or preconception time.[16] (Figure 4)

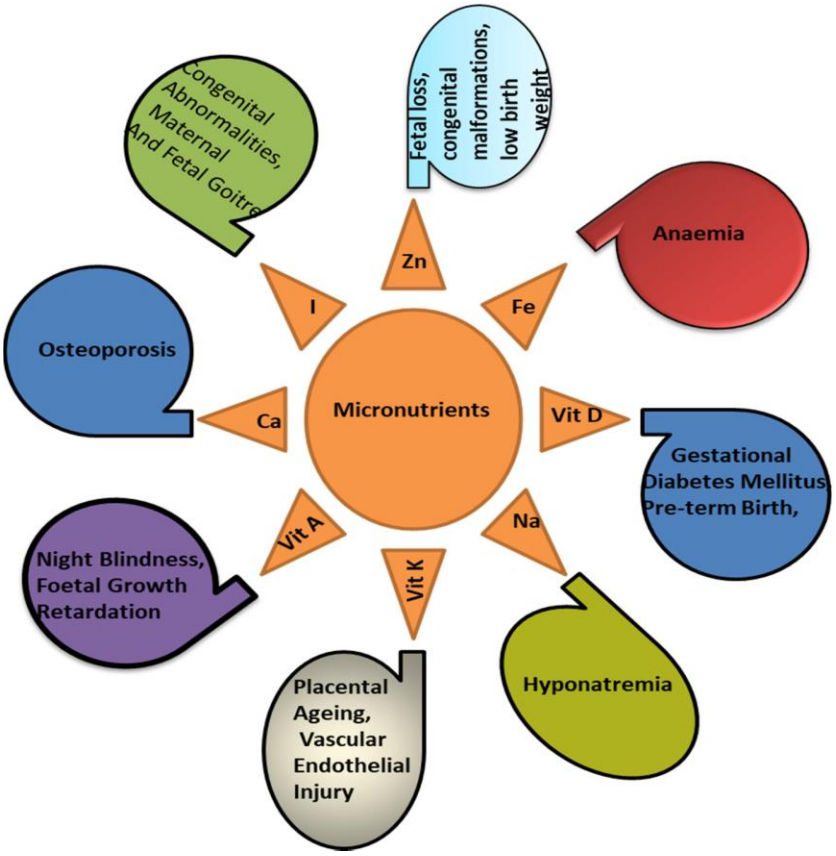

Figure 4: Cartoon representation of effect of malnutrition

Biochemical functions of micronutrients are reported by Ergin Sencer and Yusuf Orhan as given in Table 1.[17]

Table 1: Significance of Micronutrients in Biochemical Reactions

Co-Factor in metabolism	Co-enzyme in metabolism	Genetic Control	Antioxidant
Elements are often control the enzyme activities or are an essential core part of enzyme.	Vitamins are very common to play key role in biochemical reactions. These reactions are critical to provide energy, proteins and nucleic acids by breaking vitamins	Zinc "fingers" are transcription control factors that bind to DNA and regulate transcription of receptors for steroid hormones and other factors.	Many of the micronutrients have antioxidant properties. Vitamin A and E are anti-oxidant vitamins whereas Zinc and selenium are anti-oxidant minerals

Micronutrients can be divided in four parts: water soluble Vitamins, fat soluble Vitamins, Macro-minerals and Trace minerals

Water Soluble Vitamins:

Most of the Vitamins are water soluble. Human body can not store the all consumed vitamins for long and excess vitamin get flused out with urine. Each vitamin has its defined role and benefits.

Vitamin B1 (Thiamine): It helps to convert carbs nutrients into energy and support child brain development. Thiamine deficiency can cause neurological and cardiovascular complications during pregnancy.[18] (Table 2)

Vitamin B2 (riboflavin): riboflavin is necessary for energy production, cell function and fat metabolism. Riboflavin helps convert carbohydrates into adenosine triphosphate (ATP). This Vitamin supports baby's growth, vision and good skin. Around 1.4 mg Vitamin B2 each day is needed when pregnant and nearly 1.1 mg for non-pregnant women.[19] (Table 2)

Vitamin B3 (niacin): Vitamin B3 drives the production of energy from food. Vitamin B3 strengthens the mother against miscarriages and child against birth defects.[20] (Table 2)

Vitamin B5 (pantothenic acid): Vitamin B5 is Necessary for fatty acid synthesis. Beneficiary for leg cramp and generate hormones. Pregnant women need roughly 6 mg of VIT-

B5 acid daily. Scrambled egg yolks or a bowl of whole-grain cereal are good source of the same.[21,22] (Table 2)

Vitamin B6 (pyridoxine): Vitamin B6 creates energy by helping to release sugar from carbohydrate and generates red blood cells. Vitamin B6 is essential to process around 100 co-enzymatic activities in the body and helps with the development of the nervous system. Meat, poultry, fish, vegetables, and bananas are the good source of Pyridoxine.[23, 24, 25] (Table 2)

Vitamin B7 (biotin): Biotin, also known as Vitamin H. Biotin plays very vital role in fetal growth and rapid dividing of cells for DNA replication. Deficiency of biotin is responsible for preterm labour and restricted development. Babies are also vulnerable to congenital malformations, also known as teratogenesis.[26,27,28] (Table 2)

Vitamin B9 (folate): Daily 400 microgram of Folic acid intake is very important in preconception period and first trimester of the pregnancy. It is very important to reduce neural tube defects. Neural tube defect symbolises incomplete development of brain and spinal cord. Neural defect occurs during 4 weeks of pregnancy, usually before woman even knows that she is pregnant. Dark green vegetable is rich source of Vitamin B9 such as broccoli, spinach, legumes etc.[29,30,31,32] (Table 2)

The most common neural tube defects are:

- **Spina Bifida:** When the spinal cord and spinal column don't completely close
- **Anencephaly:** When the skull, scalp, and brain do not form properly.
- **Encephalocele:** When brain tissue protrudes out to the skin through an opening in the skull.

Vitamin B12 (cobalamin): Vitamin B12 is necessary to maintain healthy nervous system. It is essential by baby's brain and spinal development. Combination of cobalamin with folate helps to produce DNA synthesis and Red blood cell. By regulating the synthesis of myelin and fatty acids, cobalamin helps to maintain nervous system and neurological system. Natural sources of Vitamin B12 are soy milk or soy products, yogurt, fortified cereals, red meat, swiss cheese, milk, cottage cheese etc.[33,34] (Table 2)

Vitamin C (ascorbic acid): Collagen is one of the fibre which makes baby's body, helps to grow normal tissue, repair wound tissues and Vitamin C is needed to make collagen. Vitamin C helps to absorb Iron and store it for later use.[35] Pregnant women who are 19 and older should

aim for about 85 milligrams (mg) of vitamin C daily. Red bell pepper, Orange juice, Orange, Grapefruit juice, Kiwi, Green bell pepper, Broccoli, Strawberries, Grapefruit etc are good source of Vitamin C. (Table 2)

Table 2: Recommended Intake of Water Soluble Vitamin

Nutrients	Recommended Dietary Allowances (RDA) for		
	Non Pregnant Woman	Pregnant Woman	Lactating Woman
Vitamin B1 (thiamine) (in mg)	1.1	1.4	1.4
Vitamin B2 (riboflavin) (in mg)	1.1	1.4	1.6
Vitamin B3 (niacin) (in mg)	14	18	17
Vitamin B5 (pantothenic acid) (in mg)	5	6	6
Vitamin B6 (pyridoxine) (in mg)	1.2	1.9	2.0
Vitamin B7 (biotin) (in µg)	30	36	36
Vitamin B9 (folate) (in µg)	400	600	600
Vitamin B12 (cobalamin) (in µg)	2.4	2.6	2.8
Vitamin C (ascorbic acid) (in mg)	75	85	120

Fat Soluble Vitamin:

Fat soluble vitamins are best absorbed when we take with source of fat. Fat soluble vitamin stored in liver and fatty tissue for later use. These vitamins stay in our body so daily intake is not required.

Vitamin A: Vitamin A is crucial nutrients for antenatal period for mother and baby both. When it comes to baby development Vitamin A is play vital role in vision, breathing and immunity. Vitamin A is important for many fetal organ and skeleton development. Deficiency of Vitamin A in babies carries poor immune system and so they are prone to infection and illness. Lack or excess of Vitamin A both are not good for health. Too much

intake of Vitamin A can affect the baby growth and lead to birth defects. NHS recommended that pregnant woman should not take excess Vitamin A via supplements, natural food is enough. Recommended vitamin A per day is 700-900 µg and maximum daily limit is 3000 µg.[36,37] (Table 3)

Vitamin D: Vitamin D promotes proper immune function and assists in calcium absorption and bone growth. Vitamin D minimises the risk of morbidities during pregnancy such as maternal infections, premature delivery and weakening of bone. In 2010 Food and Nutrition Board declare the essential dose for every pregnant woman is 10-15µg. main source of vitamin D is sun light and food sources are egg yolk, liver, tuna etc.[38,39] (Table 3)

Vitamin E (alpha-Tocopherol): Vitamin E is an essential fat-soluble micronutrient for higher mammals and acts as an antioxidant that protects cells from damage. In early days Vitamin E was denoted as an 'anti-sterility factor X' which was needed for reproduction. Vitamin E intake doses are depending on the age of consumer. Normal dose for a pregnant woman and a lactating woman is 15 mg/day and 19 mg/day respectively as decided by Food and Nutrition Board of the Institute of Medicine. Natural Source of Vitamin E is Sunflower seeds, wheat germ, almonds etc.[40,41,42,43,44] (Table 3)

Table 3: Recommended Intake of Fat Soluble Vitamin[44]

Nutrients	**Recommended Dietary Allowances (RDA) for**		
	Non Pregnant Woman	**Pregnant Woman**	**Lactating Woman**
Vitamin A(in mg)	700	770	1300
Vitamin D (in µg)	15	15	15
Vitamin E (in mg)	15	15	19
Vitamin K (in µg)	60	60	60

Vitamin K: Two types of vitamin K is known.

1. K1: Phylloquinone (makes up 75-90% of all vitamin K consumed by humans)
2. K2: (Menaquinones)

Vitamin K is required for blood clotting and prevents risk of bleeding. It also helps in proper

bone development; cardio vascular health etc. babies do not get vitamin K from mother at the time of birth hence child needs an extra dose of vitamin K externally. 60 µg is adequate intake for all women either she is pregnant or normal or lactating. Food sources of vitamin K are Broccoli, Brussels Sprouts, Asparagus, Vegetable oils, Cereal grains etc.[45,46]

Macro-minerals:

As it is clear with name that macro-minerals requirement is bit more than micronutrients and they play their specific role to maintain biological fitness.

Calcium: Calcium is essential for every one either men or women, pregnant or not pregnant. Women in gestation period, proper intake of calcium becomes very vital since it strengthen your baby bone. If mother-to-be is on low diet of calcium, your body will exhaust calcium from mothers store and it will push the mother at high risk of osteoporosis in her later life. A pregnant woman should consume around 1000 mg of calcium daily. Dairy (cow, goat), fortified plant-based milks (almond, soy, rice), Cheese, Yogurt, Winter squash, Young green soybeans), Tofu, made with calcium sulphate, canned sardines are rich source of calcium.[47,48,49] (Table 4)

Phosphorus: phosphorus deficiency was observed rarely but if happens may have variety of symptoms such as anaemia, myasthenia, bone pain, rickets, Genu varum, anorexia, vertigo, confusion (). Ignorance of the symptoms may cause death too. Upper limit intake of phosphorus is prescribed, excess consumption of phosphorus intake can cause bone disorder in upcoming child and to pregnant mothers in later her life. The recommended dose for pregnant and non-pregnant woman is same.[50,51,52] (Table 4)

Magnesium: Magnesium is one of the 10th essential metals in body and among the fourth most abundant metal cation after calcium, potassium and sodium. Magnesium cation is involved in more than 300 enzymatic reactions. Magnesium is crucial for bones formation by calcium assimilation and helps in vitamin D activation in kidneys. The daily recommended dosage of magnesium varies depending on your age (310-600 mg/day).[53,54,55] (Table 4)

Sodium: Sodium balance in human body is mostly related to water since body is made up of 70% of water. Kidney is responsible to maintain the sodium balance in body. During prenatal age, woman body works for her and for life growing inside her too. Proper consumption of sodium helps the body to maintain the body fluid and stabilises the body condition. It is very

vital for the development of child brain. Preeclampsia is a hypertensive disorder and is very common in pregnancy. This complication affects roughly 5-10% of pregnancies in terms of maternal and perinatal morbidity and mortality across the globe. [56,57,58] (Table 4)

Chloride: Chloride is an electrolyte and often found in combination with sodium that helps in maintaining fluid balance between exterior and interior of cells. Vomiting, gastric suctioning, nephritis, congestive heart failure, alkalosis, adrenal insufficiency, muscle twitching and/or weakness, confusion or fatigues etc. are symptoms of deficiency of chloride.[59] (Table 4)

Potassium: Like Sodium and chloride, Potassium too helps maintaining the fluid balance nerve transmission and muscle function. Hypokalemia is the deficiency caused by low level of potassium in the body. It seems difficult to distinguished between Hypokalemia and normal pregnancy problem since potassium deficiency resembles the pregnancy symptoms. Constipation, fatigue or feeling tired, numbness of fingers and toes, swelling of feet and ankles, muscle weakness or cramping, mood swings, dry skin, low blood pressure, abnormal heart rhythms, depression, hallucination, and confusion in more severe cases are the several symptoms that may provoked by Potassium deficiency. Potassium Food sources are potatos, banana, sun-dried tomatoes etc.[60,61,62] (Table 4)

Table 4: Recommended Intake of Macro minerals

Nutrients	**Recommended Dietary Allowances (RDA) for**		
	Non Pregnant Woman	**Pregnant Woman**	**Lactating Woman**
Calcium (in mg)	1000	1000	1000-1200
Phosphorous (in mg)	700	700	700
Magnesium (in mg)	310-360	350-600	310-360
Sodium (in mg)	1500-2300	1500	1500
Chloride (mg)	-	1800-2300	-
Potassium	4000	4000	4400

Trace Minerals

Trace minerals are needed in smaller amounts than macro minerals but uniquely functional for biochemical processes for human body and especially during pregnancy. These elements have their toxicity level if consumed in excess. Iron, Zinc, manganese, selenium, copper, iodine, fluoride etc. are the trace minerals.

Iron: During pregnancy one significant change in woman body is increase volume of blood. Iron is important because it is involved in the production of haemoglobin and thus deficiency of iron is very common to pregnant woman**.** Iron deficiency develops the anaemia. Anaemia during pregnancy increases the risk of premature birth. Anaemia symptoms are fatigue, weakness, dizziness, headache, pale or yellowish skin, shortness of breath, A rapid heartbeat, Low blood pressure, Difficulty concentrating. Iron Helps to provide oxygen to muscles and backings in the creation of certain hormones.[63,64] (Table 5)

Manganese: Manganese is an essential mineral in gestation period since it play very vital role in formation of foetal bones and cartilage during pregnancy. It is also beneficial in breaking down amino acids, cholesterol and carbohydrates to assist metabolism. This mineral is also effective in protecting the new cells from any potential damage. This is commanding for the growth of the unborn baby. Recommended food source of manganese is Nuts, especially hazelnuts and pecans. Brown rice, Oatmeal, soybeans, kidney beans, chickpeas, lentils, peanuts, Black tea., Black pepper.[65,66] (Table 5)

Copper: Cu deficiency is generally rare since food contain high availability of this element. The highest concentration of copper was found in the brain and liver. Cu participates in several reactions such as co-enzyme in oxidation-reduction, regulator and transporter in Fe metabolism and collagen metabolism etc. At the time of pregnancy fetus and neonatal are susceptible to copper deficiency. Weaker fetal membrane leads to premature birth. Inadequate store of Cu in the mother's body can be life threatening as is observed in children with Menkes disease. Whole grains, beans, nuts, potatoes, and organ meats (kidneys, liver) are good sources of copper. Pregnant and lactating woman should consume 1000 µg and 1300 µg of copper from natural food sources daily.[67,68,69] (Table 5)

Zinc: Zinc plays an important role in cell division and DNA construction during pregnancy. severe zinc deficiency is although rare but data suggest that almost 82% of women having inadequate Zinc intake. Acrodermatitis enteropathica is a defect of zinc absorption causing

severe deficiencies and due to this deficiencies, pregnancy outcome is poor, foetal loss congenital malformations are common. Recommended Zinc intake for pregnant woman is 11 mg/day and for lactating woman 12 mg/day. Pimpkin seeds, sunflower seeds, pine nuts/cashew, almonds, cheddar cheese are the good food source of zinc.[70] (Table 5)

Iodine: Iodine is essential part of thyroid hormone. Thyroid play vital role in development of brain during embryonic, fetal and post natal stage. Dietary Iodine necessity during gestation and lactation period is much more than non-pregnant woman. Iodine requirement during pregnancy and lactation increases significantly from 95 µg/day to 220 µg/day. Deficiency of iodine can lead to maternal (directly affects brain development in the offspring) and fetal hypothyroidism.[71,72,73] (Table 5)

Table 5: Recommended Intake of Trace minerals

Nutrients	**Recommended Dietary Allowances (RDA) for**		
	Non Pregnant Woman	**Pregnant Woman**	**Lactating Woman**
Iron (in mg)	18	27	9
Copper (in µg)	900	1000	1300
Manganese (in mg)	1.6	2	2.6
Zinc (in mg)	8	11	12
Iodide (in µg)	95	220	290
Fluoride (in mg)	4	4	4
Selenium(in µg)	55	60	70

Fluoride: It is a vital nutrient for various organs such as teeth, bones, and the brain. Fluoride deficiency leads to defective enamel formation whereas excess of fluoride can cause fluorosis means dental, skeletal defect. It indicates the tuned intake of fluoride is very important. In India 25 million people are affected with fluorosis because many areas are fluoride rich. One should be careful taking fluoride while pregnancy.[74,75] (Table 5)

Selenium: Selenium is an important mineral works as an antioxidant to keep your immune system up and make you stress free. This is also play lead role in DNA formation and in

reproduction. Selenium protects human body against radicals and infections. Like fluoride, selenium too should consume according to recommended daily intake (RDI). Selenium is fat soluble mineral so stays for long in liver and fatty tissues so excess consumption causes toxicity. Low intake of selenium may cause low birth weight of offspring.

Conclusion:

Micronutrients includes micro vitamins, macro vitamins, macro minerals and trace minerals are very essential in antenatal age for mother and fetus, micronutrients are very vital for lactating mother and child. During pregnancy, there are many metabolic changes occurs which leads to increased and balanced need of macro- and micronutrients. Nutrients are needed in small amount but serve for life saving, caring from many diseases and abnormalities. Micronutrient deficiency during pregnancy is a matter of concern for all continents but yes, it is a big concern for country of low per capta income. It has been revealed that in lower economic zone pregnancy suffers more with micronutrients deficiency. Although adequate food diet is enough to maintain all the deficiencies of micronutrients during preconception and pregnancy nevertheless dietician suggests the micronutrient supplements precautionary. Each micronutrient is important for a pregnant woman and deficiency of each can cause several adverse effects such as anaemia, aggravate malnutrition, hypertension, pre-eclampsia, labour complications and even maternal death, miscarriage, preterm delivery, and foetal growth restriction etc. Many researchers have come up with complete diet chart and multi nutrient supplement to minimise the malnutrition. But still there is lot of scope to normalize the exact need of multivitamin region wise so the proper use of minerals during pregnancy and lactation can reduce maternal and fetal complications.

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