Review of Literature

II REVIEW OF LITERATURE

The literature pertaining to the present study entitled **"Prevalence of Micronutrient Deficiency in Ramanathapuram District and Impact of Interventions"** have been presented under the following headings.

A. Prevalence of Micronutrient Deficiency
B. Aetiology of Micronutrient Deficiency
C. Significance of Micronutrients in Child Growth and Development
D. Role of Diet in Improving Micronutrient Status
E. Strategies to Combat Micronutrient Deficiency

A. PREVALENCE OF MICRONUTRIENT DEFICIENCY

Over the past generation, widespread concerns have arisen about micronutrient deficiencies associated with inadequate intake of essential vitamins and minerals. Iron deficiency anaemia, vitamin A deficiency, and iodine deficiency disorders are the "big three" deficiencies affecting the world today (Horton *et al.*, 2008).

1. Global prevalence

The Micronutrient Initiative (2009) has estimated that vitamin and mineral deficiencies affect more than two billion people worldwide. Two thirds of the world's undernourished live in just seven countries of Bangladesh, China, the Democratic Republic of Congo, Ethiopia, India, Indonesia and Pakistan (Lee *et al.*, 2012).

Iron deficiency is the most common single-nutrient deficiency in the world. Iron deficiency, which affects over half the world's population, is the most common preventable nutritional deficiency and, together with vitamin A and zinc deficiencies, has the largest documented disease burden among micronutrients (WHO 2009). In many low and middle income countries, the prevalence of iron deficiency anaemia among children under five years of age is at least 25 per cent, and is often higher (Black *et al.*, 2011). It is a major underlying cause of death among children and pregnant women in the

developing world, and because it is most prevalent in the poorest communities, it represents a useful marker of social and economic marginalization (Noor, 2011). According to Pettit *et al* (2011) iron deficiency remains one of the world's greatest public health problems and the greatest contributor to anaemia, globally affecting 47 per cent of preschool children and 25 per cent of school age children. Balarajan (2011) has reported that anaemia affects one quarter of the global population, including 293 million children younger than five years and 468 million non-pregnant women.

As stated by Black *et al* (2008), iron deficiency anaemia during pregnancy is associated with 115,000 women's deaths each year, which account for one fifth of total maternal deaths. It is further estimated by UNICEF (2008) to cause almost 600,000 stillbirths or deaths of babies within their first week of life.

Vitamin A deficiency is the leading cause of childhood blindness with an estimated 190 million, about one-third of children under the age of five and 19 million, about 15 per cent of pregnant women deficient in vitamin A with a vast majority in sub-Saharan Africa and South Asia (WHO, 2009). The deficiency impaired immune response to many infectious diseases contributing to the premature death of an estimated one million young children annually (Edem, 2009).

While vitamin A deficiency annually claims the lives of almost 670,000 children under five years, zinc deficiency claims more than 450,000 (Black *et al.*, 2008). The WHO (2009) has warned that approximately one third of the world's children under the age of five have inadequate dietary intake of vitamin A and are ill equipped for survival.

Iodine deficiency occurs when iodine intake falls below recommended levels (WHO, 2007) resulting in low level of thyroid hormones in the blood (hypothyroidism) which is the principal factor responsible for damage to the developing brain and other harmful effects known collectively as "iodine deficiency disorders" (WHO, 2007).

About 31 per cent (1900.9 million) of the world's population is estimated to have insufficient iodine intakes, with the most affected regions being South-East Asia and Europe (WHO, 2007). The UNICEF (2008) has recognised maternal iodine deficiency as the greatest cause of preventable mental impairment in the world with 38 million newborns each year are at risk of iodine deficiency in developing countries.

2. National prevalence

South East Asia still faces problems of inadequate nutrition in sections of the population and most attention has been directed to preventing deficiency diseases, with an emphasis on the provision of adequate energy and protein, as well as specific nutrients such as iodine, iron and vitamin A (Benton *et al.*, 2012). The scourge of childhood malnutrition, especially in Asia and Africa, often amounting to hunger and starvation still remain a public health scandal. The fulfilment of children's rights to good nutrition, including adequate food, health and care, deserves much more attention and resources than it currently receives (Latham *et al.*, 2011).

Anaemia has been identified as one of the most common and intractable nutritional deficiency. In India, the prevalence of anaemia is among the highest in the world, with more than 50 per cent of pregnant and non-pregnant women being anaemic (Berger *et al.*, 2011) and anaemia is estimated to be responsible for 40 per cent of maternal deaths (Kalaivani, 2009). Southeast Asia is one of the most affected areas where over half of all women are estimated to have anaemia (WHO, 2008).

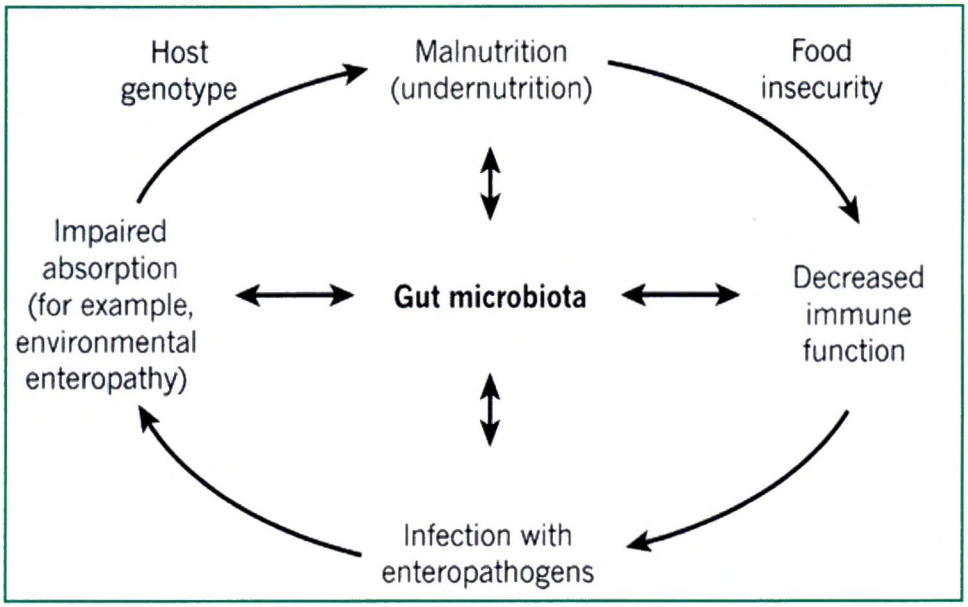
Estimates from the International Institute for Population Sciences (2007) has documented an anaemia prevalence of approximately 80 per cent in children aged between six and 36 months. The Micronutrient Initiative (2006) has estimated percentage of Indian children under five years of age with subclinical vitamin A deficiency to be 57 per cent and the number of child deaths precipitated annually attributable to vitamin A deficiency to be 3,30,000. Sood (2010) has revealed the sad picture that India has the largest

percentage as well as the largest absolute numbers of vitamin A deficient children in the world.

On a worldwide basis, iodine deficiency is the single most important preventable cause of brain damage (WHO, 2007). The Micronutrient Initiative (2006) has declared that the general perception that the prevalence of iodine deficiency disorders is confined to the sub-Himalayan region is not true and a high prevalence of iodine deficiency disorders has been evident in as many as 254 districts.

B. AETIOLOGY OF MICRONUTRIENT DEFICIENCY

The causes of vitamin and mineral deficiencies are multiple and interconnected. At the most basic level, the problem is related to diet (Micronutrient Forum, 2009) (Figure I).

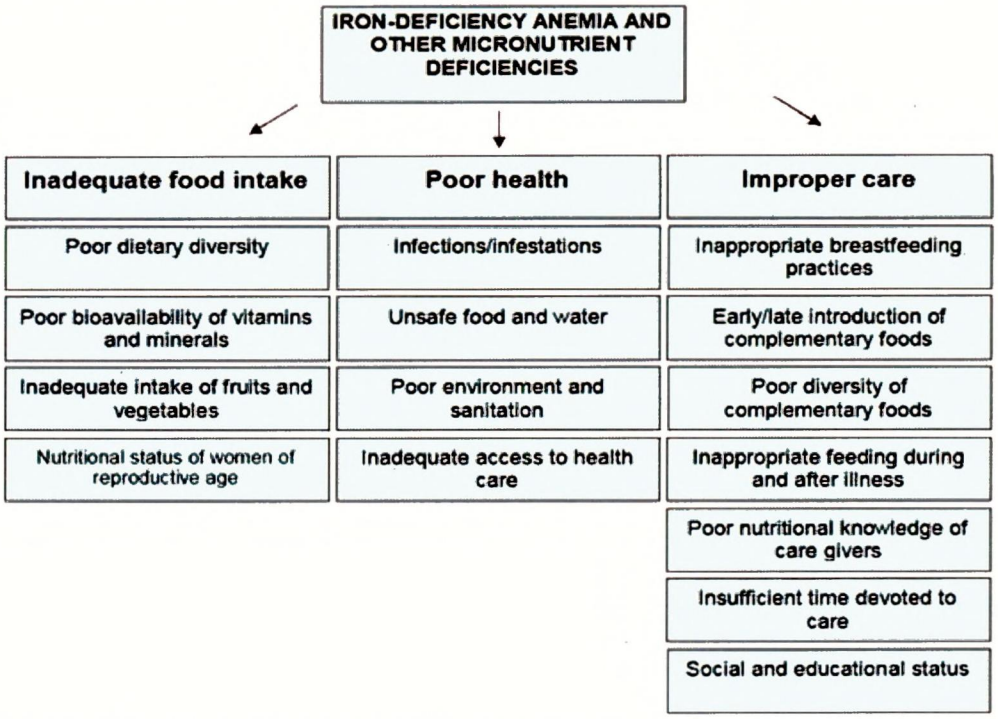


DEVELOPMENT OF MALNUTRITION (Kau *et al.*, 2011)

FIGURE I

The term 'nutritional anaemia' encompasses all pathological conditions in which the blood hemoglobin concentration drops to an abnormally low level. In public health terms, iron deficiency is by far the first cause of nutritional anaemia worldwide (Kotecha, 2011). The main nutrients involved in the synthesis of hemoglobin are iron, folic acid, and vitamin B_{12}. Physiologically,

iron deficiency occurs when the body's requirements for iron exceeds the amount of iron absorbed from the diet (Berger *et al.*, 2011). Anaemia is the result of a wide variety of causes that can be isolated, but more often coexist. It is generally assumed that 50 per cent of the cases of anaemia are due to iron deficiency, but the proportion may vary among population groups and in different areas according to the local conditions. The main risk factors for iron deficiency anaemia include a low intake of iron, poor absorption of iron from diets rich in phytate or phenolic compounds, and stage of life when iron requirements are high. Among the other causes of anaemia, heavy blood loss as a result of menstruation, or parasite infections can lower blood haemoglobin concentrations. Acute and chronic infections, including malaria, cancer, tuberculosis, and HIV can also lower blood haemoglobin concentrations. The presence of other micronutrient deficiencies, including vitamins A and B12, folate, riboflavin, and copper can increase the risk of anaemia. Furthermore, the impact of haemoglobinopathies on anaemia prevalence needs to be considered within some populations (WHO, 2008). The problem tree of micronutrient deficiency is presented in Figure 2.



PROBLEM TREE FOR MICRONUTRIENT DEFICIENCIES (FAO, 2006)

FIGURE 2

Anaemia is defined as a decrease in the concentration of circulating red blood cells or haemoglobin concentration and a concomitant impaired capacity to transport oxygen. McLean (2008) has proposed that anaemia has multiple precipitating factors that can occur in isolation but more frequently co-occur. These factors may also be genetic, such as haemoglobinopathies. Many of these risk factors for anaemia co-exist in communities and affect individuals in composite ways not adequately understood (De Benoist *et al.*, 2008) and this complexity presents a challenge to effectively address the population determinants of anaemia (Balarajan, 2011).

The main cause of iron deficiency among young children in developing countries is a lack of bioavailable iron in a diet that is largely plant based and low in animal foods. Although evidence is accumulating that improvement of iron status will confer large health benefits, progress has been extremely slow in the prevention of iron deficiency through public health interventions (Lutter, 2008). The most frequent causes of insufficient thyroid hormone availability during development are iodine insufficiency, maternal hypothyroxinemia and congenital hypothyroidism (Visser, 2010).

The two major factors responsible for iodine deficiency disorders are inadequate iodine intake and inadequate iodine utilization. The presence of goitrogens in certain foods may lead to inadequate iodine utilization (Ahad and Ganie, 2010). In the state of deficiency when iodide uptake of thyroid is seriously hampered, thyroid stimulating hormone fails to promote the release of T4 and only ends up with the hyperplasia of follicular cells (Mihai, 2011). Insufficient dietary supply of iodine, which is a principal component of thyroid hormone, during critical periods of development, may result in severe and permanent growth impairments, deafness, motor and mental retardation.

Illness is another cause which impedes the body's ability to absorb and retain vitamins and minerals. Vitamin and mineral nutrition is severely compromised by parasitic infections such as hookworm. A vicious cycle ensues when the deficiencies caused by disease leave the individual more vulnerable to further illness, and less able to combat it when affected.

C. SIGNIFICANCE OF MICRONUTRIENTS IN CHILD GROWTH AND DEVELOPMENT

As research progresses and micronutrient interventions expand, evidence continues to emerge of their impressive impact on survival and development. Remarkably powerful for the tiny levels required, micronutrients support an array of critical biological functions including development of the brain, nervous system, skeletal system, growth, immune function, and eye function (Sanghvi *et al.*, 2007).

Micronutrients needed in small quantities are essential to a good start in life and robust growth and development. In particular, vitamin A, iodine, iron, zinc and folate play pivotal roles in maintaining healthy and productive populations. At the subclinical level, micronutrient deficiency impedes mental performance during the critical school years, impairs work performance and earning capacity, reduces disease resistance, and increases risk of severe morbidity and premature death. Even marginally low intakes of micronutrients have been shown to contribute to increased morbidity and mortality rates, diminished livelihoods, and adverse effects on learning ability, development and growth in infants and children (World Health Organization, 1999). This can have impinging effects on the overall quality of life and subsequently slows national development.

One of the major constrains to the development of human capital and capacities is the impact of loss of human potential at the levels of physical, mental and performance due to poor childhood nutrition (Richter *et al.*, 2010). Pre pubertal children are an important population, in which one must encourage healthy diet practices which will reduce the risk of various nutritional disorders during their adulthood (Batra and Grover, 2011).

Studies have shown that infants with anaemia caused by iron deficiency have lower mental and motor scores than infants without anaemia (Walker *et al.*, 2007). Ensuring sufficient iron levels in the first months and years of life is, therefore, critical.

Anaemia has also been conclusively documented to affect intellectual ability. The effects of iron-deficiency anaemia during infancy and the first years of life on cognitive performance are long lasting. Globally, it is estimated that 47 per cent of children under the age of five suffer from anaemia. It is generally assumed that half of all anaemia cases are due to iron deficiency (De Benoist *et al.*, 2008).

Iron is essential to red blood cells and is involved in several metabolic reactions; there is compelling evidence that infants aged six months to 23 months with iron-deficiency anaemia are at risk of poor cognitive, motor, social-emotional, and neurophysiologic development (Lozoff, 2007). Anaemia is a major contributor to both physical and neuro-developmental morbidity (Pettit *et al.*, 2011).

1. Association of micronutrients to physical health

Iron is an essential mineral for human development and function. It helps to synthesize haemoglobin, the oxygen-carrying component of red blood cells. As these cells carry oxygen to the muscles and brain, iron is critical for motor and cognitive development in childhood, and for physical activity in all humans (Micronutrient Forum, 2009).

Vitamin A is a critical micronutrient for the survival and physical health of children exposed to disease (Micronutrient Forum, 2009). Vitamin A also promotes healthy eye surface membranes and prevents scarring of the cornea. This makes adequate vitamin A vital for the prevention of a widespread condition called xerophthalmia, a serious eye disorder that is the primary cause of sight loss among the five million visually disabled children in the world. Studies have shown reductions of up to 70 per cent in the prevalence of xerophthalmia in children after sustained vitamin A supplementation (Micronutrient Forum, 2009).

Vitamin A deficiency results in an increased risk of severe morbidity and mortality due to anaemia and depressed resistance to infectious disease and is responsible for more than a million child deaths annually. The most apparent result of vitamin A deficiency is clinical eye symptoms due to

xerophthalmia which is a destructive dryness of the conjunctival epithelium, manifested in early stages by deposits in the conjunctiva known as Bitot's spot, making it the leading cause of preventable childhood blindness in developing countries. Vitamin A deficiency also affects many women in poor countries, specifically causing night blindness, anaemia, and increased maternal morbidity and mortality during pregnancy and lactation (Chow *et al.*, 2010).

Deficiencies in vitamin A and zinc are particularly dangerous for children who are fighting measles, diarrhoea and malaria. About 20 to 24 per cent of deaths from these three diseases is attributable to inadequate vitamin A or zinc (Black *et al.*, 2008). The high morbidity among this population is due to parasitic infections, malnutrition, micronutrient deficiencies and other diseases (Rai *et al.*, 2009).

Iodine is present in the body in minute amounts, mainly in the thyroid gland, its main role being synthesis of thyroid hormones. When iodine requirements are not met, thyroid hormone synthesis is impaired, resulting in hypothyroidism and a series of functional and developmental abnormalities grouped under the heading of Iodine Deficiency Disorders and goitre is the most visible manifestation of these (WHO, 2004).

Iodine deficiency has emerged as a socio-medical problem of vast dimensions associated with physical and mental retardation, neurological disorders, feeble mindedness, low educability, poor performance, social handicaps, dependability and disfigurement (Bunevicius and Robertas, 2010). The deficiency of iodine not only leads to goitre formation but also to severe retardation of growth, development and maturation of nearly all the tissues of the body, especially those that are fast developing.

2. Association of micronutrients to cognition

Micronutrient malnutrition impairs children's cognitive performance and developmental potential (McGregor *et al.*, 2007). The brain requires adequate nutrition for optimum growth, development and maturation. Protein, fatty

acids and many micronutrients are essential for the proper structure of brain tissue, healthy neurochemistry, and the overall growth and maturation of the brain (Benton *et al.*, 2012).

Although the causal link between iron deficiency and adverse child development is unclear, evidence from animal studies suggested that iron deficiency may affect neurological development through brain functions, specifically myelination, dopamine and norepinephrine metabolism, and neuronal energy metabolism (Beard, 2008).

Iron deficiency *in utero* appears to have direct effects on indicators of brain maturation in premature infants. Within the first day following delivery, neonates exposed to low iron *in utero* have exhibited reduced brain maturation (Amin *et al.*, 2010). Children with umbilical cord serum ferritin concentrations <76 µg/L had significantly lower scores on tests of auditory language comprehension and ability to follow instructions compared to children with higher levels of cord iron (Black *et al.*, 2011).

In many studies, iron deficiency anaemia has been linked to socio-emotional difficulties among young children, and to poor fine and gross motor development. In a series of studies using brain-based measures conducted among urban African American infants in the United States, iron deficiency anaemia was associated with poorer socio-emotional functioning, worse motor functioning (Carter *et al.*, 2010). Among infants under 12 months of age, differences were apparent between iron deficient and iron sufficient infants on brain-based measures and lower scores in object permanence and short-term memory (Lozoff *et al.*, 2010).

Normal levels of thyroid hormones are required for neuronal migration and myelination of the foetal brain, and lack of iodine irreversibly impairs brain development (Wang *et al.*, 2009). Adequate thyroid hormone is critical for cerebellar development. Developmental hypothyroidism induced by iodine deficiency during gestation and postnatal period results in permanent impairments of cerebellar development with an unclear mechanism (Wang *et al.*, 2011).

Developmental iodine deficiency leads to inadequate thyroid hormone, which damages the hippocampus, the major component of human brain which plays important roles in the consolidation of information from short-term memory to long-term memory and spatial navigation (Gong *et al.*, 2010).

Patients with neurological cretinism, caused by iodine deficiency and subsequent maternal hypothyroxinemia, are characterized by severe mental retardation. Although iodine deficiency is easily corrected by iodine supplementation, it remains the most frequent cause of preventable mental retardation (Bunevicius and Robertas, 2010).

People living in areas affected by severe iodine deficiency may have an intelligence quotient of up to 13.5 points below that of those from comparable communities in areas where there is no iodine deficiency (Micronutrient Forum, 2009) This mental deficiency has an immediate effect on child learning capacity, women's health, the quality of life in communities, and economic productivity (WHO, 2007).

3. Association of micronutrients to performance

Multiple vitamin and mineral deficiencies frequently occur simultaneously, and their joint effects can be associated with irreversible physical and cognitive consequences leading to increased perinatal mortality, and reduced physical work capacity and productivity, leading to lifelong detrimental consequences (De-Regil *et al.*, 2011). There is mounting evidence to indicate that malnutrition and poor health in early childhood create a predisposition among children which negatively influences their capacity to effectively participate in schooling and benefit from the teaching-learning process.

Sood (2010) opines that deficiency of micronutrients such as iron, iodine, vitamin A and zinc has also been found to have a negative influence on school participation. However, the National Food Consumption Survey Fortification Baseline (2008) has reported an increase in vitamin A deficiency

as well as an increase in iron deficiency in children inspite of mandatory fortification of staple foods since 2003.

McClung *et al* (2009) reported that increased intake of iron proved to be beneficial for physical performance during the training period reflected by the increase in vigour scores and running time among female soldiers.

D. ROLE OF DIET IN IMPROVING MICRONUTRIENT STATUS

The most immediate cause for micronutrient deficiency is poor nutrient intake through inadequate diets. Vitamins and minerals occur naturally in food. A varied diet of meat, eggs, fish, milk, legumes, fruits and vegetables is the best basis for obtaining adequate vitamin and mineral nutrition.

While of fundamental importance, improving the diets of the world's poor is a complex and long-term undertaking that depends largely on rising incomes. In the short term, lives can be saved and improved through a range of cost effective interventions, including supplementation and fortification.

Diets of infants and young children that are predominantly plant-based generally provide insufficient amounts of key micronutrients to meet the recommended nutrient intakes and the inclusion of animal-source foods that could meet the nutrient gap increases the cost and may be not practical for the lowest income groups (Vist *et al.*, 2011).

Food based solutions for dealing with micronutrient deficiencies, although extremely challenging, are potentially sustainable, affordable, effective and feasible approaches to addressing macro and micronutrient malnutrition. Food based approaches are more feasible and sustainable in rural areas of poor countries, especially with the use of locally available and familiar foods and traditional preparation and preservation methods (Neumann *et al.*, 2011).

The amount of iron that can be absorbed from diet alone is sufficient to cover women's increased iron requirements during pregnancy except when women can draw enough iron from pre-pregnancy iron reserves (Noor *et al.*,

2011). Suboptimal infant feeding practices and poor quality of complementary foods are among the major determinants that contribute to the high mortality among infants and young children (Ayoya, 2010).

In 2008, another WHO/UNICEF Expert Consultation recognized that the evidence for effective interventions to improve feeding in children 6 to 23 months of age has been strengthened considerably in recent years. However, the experts also concluded that the evidence for what works to improve the utilization and intake of adequate complementary foods remains limited. They recommended, among other things, increasing dietary diversity by using locally available nutritious foods as an effective approach to improve the quality of young children's diet, especially for the poorest groups of the population who have no access to appropriately fortified food products and/or cannot afford point-of-use fortification or enrichment of the local diet.

Plant foods such as cereals, pulses and legumes, green leafy and other vegetables, roots and tubers form bulk of the Indian diets and are an important part of diet in the rural areas, as they play a very significant role in food security, health and nutritional status of the rural population of India (Arlappa *et al.*, 2010). Studies indicate that the bran fraction of wheat contains the majority of the phytonutrients betaine and choline (Graham *et al.*, 2009). Groundnut contains more protein than meat, two and half times more than eggs and more than any other vegetable food. The protein content of groundnut is well balanced and its selenium content is the highest compared to the other exotic fruits (Sousa *et al.*, 2011).

Lotus stem further finds a special place in Chinese culinary and is believed to stop diarrhoea, clear heat, improves appetite and stimulates peristalsis thereby relieving constipation. Additional research into complementary foods and feeding practices is necessary to strengthen programs to prevent micronutrient deficiency in young children (Stoltzfus, 2008).

Studies conducted by Chiplonkar and Kawade (2011) on providing a food supplement prepared using zinc and micronutrient rich foods revealed a

significant increase in plasma levels of zinc, β-carotene, and decreased the prevalence of zinc deficiency by 19.9 per cent, β-carotene deficiency by 13.7 per cent and mild anaemia by 8.5 per cent. Punia and Gupta (2009) developed value added products by incorporating soybean, green leafy vegetables, peanuts, and sesame seeds could meet up to one-third requirement of protein and iron and can be a good supplement to meet the nutritional requirements of growing Indian children.

Rosendo *et al* (2010) supplemented two types of biscuits fortified with iron sulfate or heme-iron concentrate to adolescent girls for seven weeks and found that the haemoglobin levels in both supplemented groups increased significantly during the study period. Further, studies by Vitali *et al* (2009) reported that improved bioaccessibility and uptake of iron could be achieved by using soy flour and amaranth in biscuit preparation.

Ibrahium and Hegazy (2009) reported that biscuits produced from wheat flour replaced by different levels of soaked or germinated fenugreek seed flours revealed that an incorporation of 10 per cent germinated fenugreek seed flours considerably improved iron bioavailability with highest values of blood hemoglobin, hematocrit, serum iron, liver weights and liver minerals content. Studies by Rai *et al.*, (2008) by the incorporation of sorghum flour at the 15 per cent level has been shown to produce acceptable breads without affecting loaf volume, crust colour and crumb texture.

E. STRATEGIES TO COMBAT MICRONUTRIENT DEFICIENCY

Underlying poor nutrient intake and disease are issues of insufficient access to food, inadequate health care, and poor caring practices that inhibit growth and health. The provision of nutrition and child-care education, particularly to women, is also essential to improve practices that would pay great dividends for children's nutritional health like early and exclusive breastfeeding for first six months, providing nutrient-rich foods, stimulating children to encourage physical and cognitive development and timely visits to health service providers.

Reduction of knowledge gaps in research and policy and improvement of the implementation of effective population-level strategies will help to alleviate the burden of deficiencies in low-resource settings (Balarajan, 2011). Strategies for addressing VAD have traditionally fallen into three main categories: supplementation, food fortification, and diet and behaviour modification.

Many micronutrient programmes have yielded well documented returns in improved physical and intellectual capacity. With increased long-term investment by national governments and their partners in development, they could yield much more. Emerging new programmes, which are affordable, feasible and well-grounded in science, are now also available to help expand still further the potential benefits offered by micronutrients (Micronutrient Forum, 2009).

1. Diet supplementation

Supplementation is the term used to describe the provision of relatively large doses of micronutrients, usually in the form of pills, capsules or syrups. It has the advantage of being capable of supplying an optimal amount of a specific nutrient or nutrients, in a highly absorbable form, and is often the fastest way to control deficiency in individuals or population groups that have been identified as being deficient (WHO/FAO, 2006).

According to the HEMO Study Group (Leung *et al.*, 2011), micronutrient interventions, particularly vitamin A and zinc supplementation of children, have been shown to be among the most cost-effective global development efforts. Despite the well-recognized benefits of micronutrient interventions, implementation has been hindered by poor adherence to supplementation dosing regimens, inadequate supply, low coverage, and potential dose-related side effects and safety concerns.

Randomised controlled intervention trials in iodine and iron deficient populations have shown that providing iron along with iodine results in greater improvements in thyroid function and volume than providing iodine

alone(Zimmerman *et al.*, 2008). Vitamin A supplementation given alone or in combination with iodised salt can have a beneficial impact on thyroid function and thyroid size (Hess, 2010).

Vitamin A supplementation is considered among the most important tools to reduce child mortality in low-income countries (Benn, 2012). Recent series of papers on maternal and child under nutrition published in The Lancet concluded that "Of available interventions, counselling about breastfeeding and fortification or supplementation with vitamin A and zinc have the greatest potential to reduce the burden of child morbidity and mortality" (Bhutta *et al.*, 2008).

Research has shown that, where a population is at risk of vitamin A deficiency, vitamin A supplementation reduces mortality in children between six months and five years of age by an average of 23 per cent (Micronutrient Forum, 2009). Vitamin A supplementation is a simple, cost-effective way to boost children's immune systems so that their bodies can fight off deadly infections, such as measles, and get the best start in life (Micronutrient Initiative, 2010).

It has been reported that vitamin A supplementation of children between six months and five years of age significantly reduces total mortality by about 23 to 30 per cent and reduces childhood blindness by 70 per cent (Imdad *et al.*, 2010). The reduction in mortality is believed to be mediated through improved vitamin A status, which may affect susceptibility to infection by an effect on the immune system (Vist *et al.*, 2011).

Iron supplementation during pregnancy lowers the risk of maternal mortality due to haemorrhage, the cause of more than 130,000 maternal deaths each year (UNICEF, 2009). Supplementation also helps to lower the risks of premature birth and low birth weight.

Reviews of double-blind, placebo-controlled preventive and therapeutic iron treatment trials found evidence for poorer functioning on cognitive and behavioral tasks among infants with iron deficiency anaemia, compared to

children without anaemia (Szajewska *et al.*, 2010). Data from a study by Bhutta *et al* (2009) suggested that multiple micronutrient supplements were well tolerated during pregnancy with modest effect on birth weight.

2. Food fortification

WHO/FAO (2006) defines food fortification as the practice of deliberately increasing the content of an essential micronutrient, such as vitamins and minerals including trace elements in a food, in order to improve the nutritional quality of the food supply and provide a public health benefit with minimal health risk.

Food fortification was proven an effective tool for tackling nutritional deficiencies among population (Vaesken *et al.*, 2012). Food fortification has the dual advantage of being able to deliver nutrients to large segments of the population without requiring radical changes in food consumption patterns.

Fortification has a nearly century long record of success and safety, proven effective for prevention of specific diseases, including birth defects (Tulchinsky, 2010).

A community based double-masked, randomized trial carried out by Sazawal *et al* (2010) evaluating the effects of micronutrients delivered through fortified milk on growth, anaemia and iron status markers of children between one to four years of age revealed significant increments in height, weight, serum haemoglobin and ferritin levels and a lower risk of iron deficiency anaemia.

A large-scale iron-fortified subsidized-milk program was effective at reducing the rates of anaemia and iron deficiency in Mexican children during 12 mo of implementation (Rivera, 2010). Studies by Cabalda *et al* (2009) showed that bakery products prepared from iron fortified flour significantly reduced the prevalence of iron deficiency among anaemic school children, and double fortification with iron and vitamin A significantly improved haemoglobin status.

Andersson *et al* (2010) reported that margarine fortified with micronized ground ferric pyrophosphate or sodium iron edentate improved iron status in women of reproductive age with low iron stores. There have been instances of fortification of sugar with vitamin A effectively applied on a national scale through private-public arrangements as in four Central American countries in which mandatory fortification has contributed significantly to the reduction of vitamin A deficiency (Boy *et al.*, 2009).

Interestingly, the UNICEF (2007) has highlighted that globally, there has been a threefold increase in effective coverage with vitamin A supplementation since 1999. Securing funding and solving strategic bottlenecks constitute the key challenges in achieving sustainable universal coverage of vitamin A supplementation. The Global Alliance for Vitamin A (GAVA, 2009) has calculated that of the estimated 800 million vitamin A doses required annually to achieve universal coverage of children under the age of five years who are at risk of vitamin A deficiency.

A school based intervention by Nga *et al* (2009) using multi micronutrient fortified biscuits resulted in significantly improved concentrations of haemoglobin, plasma ferritin, body iron, plasma zinc, plasma retinol, and urinary iodine levels in Vietnam. A 20 week randomized placebo-controlled trial on non anaemic 12 to 20 months old children with iron fortified milk resulted in significantly increased iron stores (Gay *et al.*, 2009).

3. Nutrition education

One of the most important reasons of nutritional problem is lack of nutritional knowledge and consequently improper practice in this issue which can cause complications such as malnutrition and non contagious diseases (Heshmant *et al.*, 2009). Culturally appropriate nutrition education empowers caregivers with the information and skills needed to optimise the utilisation of available food resources and is especially important in less resourced communities where diets often centre on bulky, plant-source foods, that do not contribute significant amounts of micronutrients in bioavailable forms (Kabahenda, 2011).

The Ministry of Health Priority Program Intervention for 2010-2014 Ministry of Health Malaysia, 2006) also focused on nutrition education and the strengthening of inter-program and inter-sectoral coordination as one of the key strategies imperative to the reduction of child mortality.

A quasi-experimental design consisting of four weeks of nutrition education resulted in significantly increased mean hemoglobin and serum ferritin values and decreased prevalence of anaemia (Alaofe *et al.*, 2009). Further, Joshi and Vijayalaxmi (2009) suggested that nutrition education provided to farming women in urban areas of Bangalore was effective in significantly improving knowledge levels confirming and emphasizing the need for effective nutrition education to eradicate existing malnutrition.

Studies by Alaofe *et al* (2009) proved that four weeks nutrition education carried out among adolescent girls suffering from mild iron deficiency anemia improved hemoglobin and serum ferritin levels with a decrease in anaemia along with improved nutrition knowledge scores. Olney *et al* (2012) also agreed that identifying critical knowledge gaps and highlight on diet is needed to increase effectiveness for delivering multiple micronutrient interventions which can be done effectively with nutrition education.