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Micronutrient Malnutrition, A Tragedy To Childhood Growth And Education

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I. Introduction

Micronutrients are nutrients needed in minute specific quantities in the body. Most of them are not generated in the body but are derived from food intake. These micronutrients include vitamins A and B_{12}, iron, folic acid, iodine, and zinc. Prolonged inadequate intake of foods rich in these micronutrients result in their deficiencies. Most developing countries are battling with hunger, poverty and high rate of unemployment. This gives rise to food insecurity in most of the households.

One-third of the world's population suffers from micronutrient deficiencies, due primarily to inadequate dietary intake (Fielder and Macdonald, 2009). Vitamin A is a fat-soluble vitamin, essential for vision in dim light, cellular, bone and tooth growth, formation and maintenance of healthy skin, hair, and mucous membranes, reproduction and immunity boosting. Vitamin A is so important in embryological development that without it, the fertilized egg cannot develop into a fetus (Brody, 2007). It's deficiency results in night blindness or impaired dark adaptation, lowered immunity to infections such as measles, diarrhoea, chickenpox, respiratory infections, anemia, poor growth, slowed bone development, blindness and death. All these have disastrous effect on the healthy growth and school performance of a child. Vitamin A deficiency (VAD) can be severe in children 6 years of age while blindness is more prevalent in children below 3 years. The average preschool child requires 400 μg of vitamin A daily for healthy vision, bone growth, reproduction, cell division, and cell differentiation. This must be derived from intake of foods rich in vitamin A such as fatty meat, egg, milk, butter, margarine, palm oil, fortified foods, dark green leafy vegetables and yellow fruits. For many parents in developing countries, apart from plant sources of vitamin A, animal sources are a luxury only enjoyed by the rich. The poor only depend on plant sources and it has been established that the efficiency of the conversion of plant sources of vitamin A (Provitamin A carotenoids) to vitamin A [bioefficacy] in a mixed diet is less than was previously thought (Wardlaw and Kessel, 2002). Retinol Equivalent overestimated the contribution of carotenoids to vitamin A needs until now (Thurnham and Northrop-Clewes, 1999). Then, I RE = I μg of all-trans Retinol = 6μg of all-trans beta–carotene = 12 μg other carotenoids but the true contribution is I RAE = 12 μg of beta-carotene=24μg of other Carotenoids. Consequently, a child whose vitamin A source is solely dependent on plant sources of vitamin A will become vitamin A deficient over time. Worst still, the main component of the diet of children in developing countries is starchy foods. Another cause of vitamin A deficiency is the drifting from local foods rich in vitamins and minerals to fast foods which are highly refined as a result of the influence of urbanization and western culture. Prolonged shortage of vitamin A rich foods in the diet of the child, results in low vitamin A Recommended Dietary Allowance (RDA) and eventual depletion of any available vitamin A stored in the liver.

World Health Organization (WHO) defines vitamin A deficiency as the tissue concentration of vitamin A low enough to cause adverse consequences even without clinical evidence of xerophthalmia (Liberato and Pinheiro-sant'Ana, 2006). A child suffering from vitamin A is unable to see in the dim, a situation called night blindness or nyctalopia. If night blindness is not noticed and treated on time, it will lead to xerophthalmia (dryness of the eyes) and eventually blindness.

Vitamin A deficiency (VAD) is a widespread public health problem in developing nations where it affects more than 130 million preschool children and is the leading preventable cause of childhood blindness and major underlying cause of child mortality (WHO, 2008; FFI, 2008; West et al. 2008). Micronutrient deficiency is prevalent in Africa. In 27 African countries, every third child suffers from sub-clinical vitamin A deficiency (FORTAF, 2000). These countries are as shown in Table 1. From Table 1, the highest VAD prevalence is found in Eastern and Southern African

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countries such as Zambia, Uganda and Kenya . Only Egypt does not have Vitamin A deficiency as a public health problem. The end-of-decade goal for elimination of VAD was widely promoted in the 1990s but, although progress was made, the goal was not met (Underwood, 2006). However, many countries now have success stories e.g. Vietnam, Venezuela, Bangladesh, Indonesia, Phillippine and some parts of India. They have been able to reduce VAD and xerophthalmia to below WHO cut-off point constituting a public health problem (West, 2002; Ramakrishnan and Darnton-Hill, 2002). The International Consultative Group (IVACG) recently adopted a cut off of more than 15% of pre-school population with serum retinol below 0.70μmol (or 20 μg/dL) or displaying abnormal impression cytology as indicative of VAD (West, 2002; Wasantwisut, 2002; Ramakrishnan and Darnton-Hill, 2002). Study carried out in Venezuela showed that VAD is not a public health problem in children from 6-59 months of age (Zimmermann, 2005). Iron deficiency anaemia is one of the leading nutritional diseases worldwide, affecting an estimated 2 billion people (Li et al. 2010). World Health Organization (WHO) review of nationally representative surveys from 1993 to 2005 shows that 30% non-pregnant women of childbearing age, 42% of pregnant women, and 47% of preschool children worldwide have anaemia (Mclean et al. 2007; Black et al. 2008; Kraemer and Zimmermann, **2011).** These figures agree with that of Arcanjo et al. (2011) who also stated that the prevalence estimate of global anaemia in pre-school-age children is 293.1 million cases, or 47.4% of the total population. It is estimated that 40% of the world population, or 2 billion people, suffer from anaemia, and that iron deficiency anemia (IDA) is responsible for about half of those cases (Arcanjo et al. 2011). Vitamin and mineral deficiency is mostly prevalent in Africa. In 31 of the 38 African countries that have data on iron deficiency, every second child under the age of 5 suffers from iron deficiency (FORTAF, 2000) (Table 2).

Iron deficiency occurs when iron requirements cannot be met by absorption from the diet, such as during periods of rapid growth (infancy, adolescence), in pregnancy, and as a result of menstrual or pathological blood loss (Hurrell, et al. 2010). Developing countries' diets are predominantly dominated by plant-based foods and so limit iron absorption due to their high phytate and polyphenol contents (Hurrell, 2002; Zimmermann, et al. 2005; Hurrell, et al. 2010). Iron deficiency in infants and young children is associated with delayed mental and motor development (Lozoff, 2007). In summary, an iron-poor diet and rapid growth are primary causes of iron deficiency in infants and preschool children (Li et al. 2009). Iron deficit children may experience emotional problems and fail to meet educational goals later in life leading to a negative impact on learning capacity in adulthood (Hurrell et al. 2011).

An estimated 240,000 annual cases of folic acid-preventable spina bifida and anencephaly has been recorded (Oakley et al. 2004). Adequate consumption of folic acid before pregnancy and during the early weeks of gestation protects fetuses from developing neural tube defects (Folic Acid Working Group et al. 2010).

Interest in zinc was stimulated when zinc supplements given to short children and failure-to-thrive infants in the U.S. city of Denver improved growth (Allen, 2001). Trial studies concluded that zinc supplements are likely to improve the height gain of the most stunted children and to improve the weight gain of those with low plasma zinc concentrations (Allen, 2001). Intakes of absorbable zinc are often low in children and growth-stunting occurs nearly universally during the first two years of life in underpriviledged populations (Allen, 2001).

Because vitamin B-12 is found only in animal products, many poor populations, or those that avoid animal products for religious or other reasons, consume little or no vitamin B-12. Low serum B-12 concentration is associated with a higher risk of potentially irreversible harm to memory, cognitive function, and nerve conduction, as well as a higher risk of megaloblastic anaemia. Studies among low income people in Guatemala, Mexico, Nepal, Venezuela, and other countries show that 25 to 50 percent of individuals are deficient (Allen, 2001). Vitamin B-12 deficiency occurs in populations with low consumption of animal-source foods which are the only natural source of the vitamin. Vitamin B-12 deficiency is also prevalent in developed countries among the elderly due to their inability to release and absorb the vitamin from foods (Rosenberg, 2010).

II. Effect of Micronutrient Malnutrition on the Growth and Education of Preschool Children

Both chronic under nutrition and severe clinical malnutrition in childhood are related to scholastic backwardness (AMCOFF,1981).It has been documented that malnutrition in foetus and young children causes disturbances in the morphological and functional development of the central nervous system thus affecting the cognitive and emotional development of the child. Micronutrient Malnutrition causes birth defects, mental retardation, learning difficulties, compromised immune systems, low work capacity, blindness and death. These consequences definitely have a negative effect on the healthy growth of the child via education in terms of intelligent quotient (I.Q) and school performance. There is evidence that a poor diet associated with high fat, sugar and processed food content in early childhood may be associated with small reductions in I.Q in later childhood (Northstone et al.

2010). Iron deficiency lead to compromised ability and poor physical growth, which can impair school performance ultimately resulting to retarded cognitive, motor and academic ability. Childhood anaemia has been shown to negatively correlate with educational outcomes, such as grades, attendance and attainment (Miguel and Kremer, 2004). Agreeably, studies have recognized that there is a relationship between school performance and child health nutritional status. Early malnutrition affects brain structure and learning ability (Liu et al. 2003). Malnourished children are inactive, inattentive and lack curiosity and explorative abilities and these affect their educational performance. Malnutrition also results in language retardation. A more serious effect of malnutrition is its permanent effect on children who were less than six months when they were malnourished which is a serious handicap on schooling and has a close impact on the ability to learn, read, and write (Amcoff, 1981). The consequences of these are school failure. Iron deficiency and anemia lead to compromised ability to learn and poor physical growth, which can impair school performance ultimately resulting in retarded cognitive, motor and academic ability (REAP, 2010). Consequences of iron deficiency in children includes anaemia, poor growth, weak immune system, reduced cognition and development, poor attention span, concentration, memory, learning ability, poor muscle function and manual dexterity, behaviour, and social interaction. It has also been reported that even though VAD does not directly affect school performance, it may do so indirectly via its effect on infectious related morbidity, which in turn will affect school attendance. This was demonstrated in a study on school teachers' awareness about scholastic performance and nutritional status of Egyptian school children (van- Stuijvenberg, 2005).

Many studies have shown associations between hunger, poor dietary intakes, stunting, underweight and poor school performance stating that children who were stunted, anaemic, or iodine deficient had poorer school achievement levels and attendance than other normal children. Figs. 1 and 2 are pictures showing some malnourished children in developing countries. Some already have blotted faces.

Folate deficiency results in learning disabilities. Recent evidence suggests that poor maternal folate status is also associated with a higher risk of abnormal pregnancy outcomes, including eclampsia, premature delivery, and birth defects such as club foot and cleft palate (Allen, 2001).

III. Nutritional Intervention Strategies

The optimal growth, physical and intellectual development which will enable children to learn and reach their full potential in life must not be jeopardized. Strategies that have been identified to fight micronutrient deficiencies include exclusive breast-feeding, vitamin A supplementation (through use of capsules), nutrition education/communication, dietary diversification, food fortification, biofortification, home gardening, and disease control. Fortification of food with vitamin A, iron and folate results in smarter, stronger, healthier children. It increases the national Intelligent Quotient (I.Q.) by 5%, national GDP by 2% and prevents the 200,000 cases of severe disability in babies yearly (Moench-Pfanner, 2007).

Many local foods, fruits, and plants have been reported to be good sources of micronutrients. They are available in abundance and very cheap. Consumption of varieties of local foodstuffs will help the children have adequate nutrient stores especially during their season when the fruits, vegetables and foodstuffs are usually wasted due to poor storage facilities. Examples are palm oil, yellow maize (corn), orange-fleshed sweet potatoes, mango, banana, tomatoes etc. Red palm oil has proved effective in combating VAD in South Africa. Red palm oil has been used to fortify biscuits which provided beta-carotene at 50% of the Recommended Dietary Allowance (RDA) and red palm-oil based bread spreads for primary school feeding programs in South Africa (van Stuijvenberg, 2005). Similar fit has also been performed in Burkina Faso (Zagre, et al. 2004). The result from South Africa has a significant long-term positive implication on learning and school performance in children that are vitamin A deficient (Zimmermann, et al. 2004). This technology could be transferred. There has been an increased promotion and utilization of orange-fleshed sweet potato to combat vitamin A deficiency in Burkina Faso, Uganda, and South Africa (Vebamba, 2004; Kapinga, et al. 2004; van-Stuijvenberg, 2005). Efforts to identify Nigerian traditional edible plants that are good sources of vitamin A have yielded positive results. Recent findings reported that Baobab leaf (Adansonia Digitata L) is a rich source of beta-carotene (156.5μg/g) and iron. It's use on rural Nigerian children improved their vitamin A and iron status by decreasing the number of children with serum retinol levels below 20μg/dl significantly from 21.25% to 10.0% and their serum beta-carotene rising from 6.8μg/dl to 14.1μg/dL while serum ferritin of children with low serum ferritin (HB$<$11.0g/dl) significantly increased to 19.0μg/dL (Nnam, 2004). Nnam and Onyeka (2004) reported that Sorrel (*Hibiscus sabdariffa*) calyx is a good source of micronutrients to combat VAD. According to them,

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Sorrel Calyx is a good source of retinol (285.29RE), iron (833.00mg/100g), and ascorbate (53.00mg/100g). Rural Nigerian children fed with sorrel calyx based diet had higher hemoglobin (HB) and serum retinol (SR) levels and no VAD symptoms as against the control. Other lessons could be learnt from Malaysia where nutritious foods such as milk and multi-vitamins are distributed to families, primary school children, pregnant women and lactating mothers with twins. Milk is a good source of iron. In a study using milk fortified with 15mg iron (as iron sulphate/L) the incidence of anaemia was reduced from 36.4% (control) to 12.7% in the fortified group (Blum, 1997).

IV. Conclusion

Studies have shown that maintaining high levels of micronutrients in the diet of children is important for optimal growth, development of their normal learning and cognitive functions. Adequate vitamins and mineral diet is needed for healthy and productive children. This should be a matter of right and not charity. Agriculture should be emphasized more and research encouraged to identify more local foods rich in micronutrients in various communities in developing nations. Nutrition education/communication should encourage increased consumption of animal sources of vitamins and minerals among preschool-aged children. Nutritional policies in developing countries should be encouraged in favour of children, pregnant and lactating mothers.

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Fig. 1. Malnourished School children
Source: http://www.anec4.or.ke/s

Fig, 2. Malnourished children.
Source UNICEF, 2001

Table 1. Estimated Percentage of children with Sub-clinical vitamin A deficiency by Region

REGION :	Estimated % of children under six with a sub-clinical vitamin A deficiency in Africa, 2000
Eastern and Southern Africa	
Mozambique	26
Zimbabwe	28
Botswana	30
Eritrea	30
Ethiopia	30
South Africa	33
Tanzania	37
Swaziland	38
Rwanda	39
Madagascar	42
Burundi	44
Lesotho	54
Angola	55
Namibia	59
Malawi	59
Zambia	66
Uganda	66
Kenya	70
Western and Central Africa	
Mauritania	17
Nigeria	25
Guinea Bissau	31
Congo	32
Togo	35
Cameroun	36
Niger	41
Gabon	41
Chad	45
Burkina Faso	46
Mali	47
Sierra Leone	47
Liberia	48
Congo, Democratic Republic	59
Senegal	61
Gambia	64
Central African Republic	68
Benin	70
Horn Africa	
Egypt	7
Morocco	29

Source:http://fortaf.org/the_african_context.htm

Table 2. Estimated prevalence of iron deficiency in children under five years.

REGION	Estimated prevalence of iron deficiency (%) in children under under - five years.
Eastern and Southern Africa	
South Africa	37
Botswana	37
Namibia	42
Swaziland	47
Lesotho	51
Zimbabwe	53
Kenya	60
Zambia	63
Uganda	64
Tanzania	65
Rwanda	69
Angola	72
Madagascar	73
Eritrea	75
Mozambique	80
Malawi	80
Burundi	82
Ethiopia	85
Western and Central Africa	
Gabon	43
Congo	55
Niger	57
Cameroun	58
Congo, Democratic Republic	58
Liberia	69
Nigeria	69
Senegal	71
Togo	72
Mauritania	74
Central African Republic	74
Gambia	75
Chad	76
Mali	77
Benin	82
Burkina Faso	83
Guinea Bissau	83
Sierra Leone	86
Horn Africa	
Egypt	31
Morocco	45

Source: http://fortaf.org/the_african_context.htm