FOOD FORTIFICATION AND SUPPLEMENTATION (BTG 306)

Global prevalence of micronutrient malnutrition

Micronutrient malnutrition (MNM) is widespread in the industrialized nations, but even more so in the developing regions of the world. It can affect all age groups, but young children and women of reproductive age tend to be among those most at risk of developing micronutrient deficiencies. Micronutrient malnutrition has many adverse effects on human health, not all of which are clinically evident. Even moderate levels of deficiency (which can be detected by biochemical or clinical measurements) can have serious detrimental effects on human function. Thus, in addition to the obvious and direct health effects, the existence of MNM has profound implications for economic development and productivity, particularly in terms of the potentially huge public health costs and the loss of human capital formation. Worldwide, the three most common forms of MNM are iron, vitamin A and iodine deficiency. Together, these affect at least one third of the world's population, the majority of whom are in developing countries. Of the three, iron deficiency is the most prevalent. It is estimated that just over 2 billion people are anaemic, just under 2 billion have inadequate iodine nutrition and 254 million preschool-aged children are vitamin A deficient (Table 1.1). From a public health viewpoint, MNM is a concern not just because such large numbers of people are affected, but also because MNM, being a risk factor for many diseases, can contribute to high rates of morbidity and even mortality. It has been estimated that micronutrient deficiencies account for about 7.3% of the global burden of disease, with iron and vitamin A deficiency ranking among the 15 leading causes of the global disease burden (4). According to WHO mortality data, around 0.8 million deaths (1.5% of the total) can be attributed to iron deficiency each year, and a similar number to vitamin A deficiency. In terms of the loss of healthy life, expressed in disability-adjusted life years (DALYs), iron-deficiency anaemia results in 25 million DALYs lost (or 2.4% of the global total), vitamin A deficiency in 18 million DALYs lost (or 1.8% of the global total) and iodine deficiency in 2.5 million DALYs lost (or 0.2% of the global total) (4). The scale and impact of deficiencies in other micronutrients is much more difficult to quantify, although it is likely that some forms of MNM, including zinc, folate and vitamin D deficiency, make a substantial contribution to the global burden of disease. However, there are few data on the prevalence of deficiencies in these micronutrients, and as their adverse effects on health are sometimes non-specific, the public health implications are less well understood. In the poorer regions of the world, MNM is certain to exist wherever there is undernutrition due to food shortages and is likely to be common where diets lack diversity. Generally speaking, whereas wealthier population groups are able to augment dietary staples with micronutrient-rich foods (such as meat, fish, poultry, eggs, milk and dairy products) and have greater access to a variety of fruits and vegetables, poorer people tend to consume only small amounts of such foods, relying instead on more monotonous diets based on cereals, roots and tubers. The micronutrient content of cereals (especially after milling), roots and tubers is low, so these foods typically provide only a small proportion of the daily requirements for most vitamins and minerals. Fat intake among such groups is also often very low and given the role of fat in facilitating the absorption of a range of micronutrients across the gut wall, the low level of dietary fat puts such populations at further risk of MNM. Consequently, populations that consume few animal source foods may suffer from a high prevalence of several micronutrient deficiencies simultaneously. In the wealthier countries, higher incomes, greater access to a wider variety of micronutrient-rich and fortified foods, and better health services, are all factors that contribute to the lowering of the risk and prevalence of MNM. However, consumption of a diet that contains a high proportion of energy-dense but micronutrient-poor processed foods can put some population groups at risk of MNM. Although at present this practice is more common in industrialized countries, it is rapidly becoming more prevalent among countries undergoing social and economic transition. Table 1.2 provides an overview of the prevalence, risk factors, and health consequences of deficiencies in each of the 15 micronutrients covered in these guidelines.

TABLE 1.2

Micronutrient deficiencies: prevalence, risk factors and health consequences

Micronutrient[a]	Prevalence of deficiency	Risk factors	Health consequences
Iron	There are an estimated 2 billion cases of anaemia worldwide In developing countries, anaemia prevalence rates are estimated to be about 50% in pregnant women and infants under 2 years, 40% in school-aged children and 25–55% in other women and children Iron deficiency is estimated to be responsible for around 50% of all anaemia cases There are approximately 1 billion cases of iron-deficiency anaemia and a further 1 billion cases of iron deficiency without anaemia worldwide	Low intakes of meat/fish/poultry and high intakes of cereals and legumes Preterm delivery or low birth weight Pregnancy and adolescence (periods during which requirements for iron are especially high) Heavy menstrual losses Parasite infections (i.e. hookworm, schistosomiasis, ascaris) which cause heavy blood losses Malaria (causes anaemia not iron deficiency) Low intakes of vitamin C (ascorbic acid) Allergy to cow's milk	Reduced cognitive performance Lower work performance and endurance Impaired iodine and vitamin A metabolism Anaemia Increased risk of maternal mortality and child mortality (with more severe anaemia)
Vitamin A	An estimated 254 million preschool children are vitamin A deficient	Low intakes of dairy products, eggs and β-carotene from fruits and vegetables Presence of helminth infection, ascaris	Increased risk of mortality in children and pregnant women Night blindness, xerophthalmia

Iodine	An estimated 2 billion people have inadequate iodine nutrition and therefore are at risk of iodine deficiency disorders	Residence in areas with low levels of iodine in soil and water Living in high altitude regions, river plains or far from the sea Consumption of non-detoxified cassava	Birth defects Increased risk of stillbirth and infant mortality Cognitive and neurological impairment including cretinism Impaired cognitive function Hypothyroidism Goitre
Zinc	Insufficient data, but prevalence of deficiency is likely to be moderate to high in developing countries, especially those in Africa, South-East Asia and the Western Pacific	Low intakes of animal products High phytate intakes Malabsorption and infection with intestinal parasites Diarrhoea, especially persistent Genetic disorders	Non-specific if marginal deficiency Possibly poor pregnancy outcomes Impaired growth (stunting) Decreased resistance to infectious diseases Severe deficiency results in dermatitis, retarded growth, diarrhoea, mental disturbance, delayed sexual maturation and/or recurrent infections
Folate (vitamin B_9)	Insufficient data	Low intakes of fruits and vegetables, legumes and dairy products Malabsorption and intestinal parasites infections (e.g. *Giardia Lamblia*) Genetic disorder of folic acid metabolism	Megaloblastic anaemia Risk factor for: — neural tube defects and other birth defects (oro-facial clefts, heart defects) and adverse pregnancy outcomes; — elevated plasma homocysteine; — heart disease and stroke — impaired cognitive function — depression

Food fortification

Food fortification refers to the addition of micronutrients to processed foods. In many situations, this strategy can lead to relatively rapid improvements in the micronutrient status of a population, and at a very reasonable cost, especially if advantage can be taken of existing technology and local distribution networks. Since the benefits are potentially large, food fortification can be a very cost-effective public health intervention. However, an obvious requirement is that the fortified food(s) needs to be consumed in adequate amounts by a large proportion of the target individuals in a population. It is also necessary to have access to, and to use, fortificants that are well absorbed yet do not affect the sensory properties of foods. In most cases, it is preferable to use food vehicles that are centrally processed, and to have the support of the food industry. Fortification of food with micronutrients is a valid technology for reducing micronutrient malnutrition as part of a food-based approach when and where existing food supplies and limited access fail to provide adequate levels of the respective nutrients in the diet. In such cases, food fortification reinforces and supports ongoing nutrition improvement programmes and should be regarded as part of a broader, integrated approach to prevent MNM, thereby complementing other approaches to improve micronutrient status.

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. In developing countries, supplementation programmes have been widely used to provide iron and folic acid to pregnant women, and vitamin A to infants, children under 5 years of age and postpartum women. Because a single high-dose vitamin A supplement improves vitamin A stores for about 4–6 months, supplementation two or three times a year is usually adequate. However, in the case of the more water-soluble vitamins and minerals, supplements need to be consumed more frequently. Supplementation usually requires the procurement and purchase of micronutrients in a relatively expensive pre-packaged form, an effective distribution system and a high degree of consumer compliance (especially if supplements need to be consumed on a long-term basis). A lack of supplies and poor compliance are consistently reported by many supplementation programme managers as being the main barriers to success.