Original Communication

Micronutrients – a Global Perspective on Intake, Health Benefits and Economics

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Abstract: The link between a sufficient intake of vitamins and long term health, cognition, healthy development and aging is increasingly supported by experimental animal, human and epidemiology studies. In low income countries billions of people still suffer from the burden of malnutrition and micronutrient deficiencies. However, inadequate micronutrient status might also be an issue in industrialized countries. Recent results from nutritional surveys in countries like the United States, Germany, and Great Britain indicate that the recommended intake of micronutrients is not reached. This notably concerns certain vulnerable population groups, such as pregnant women, young children and the elderly, but also greatly influences the general healthcare costs. An overview is provided on the gap that exists between current vitamin intakes and requirements, even in countries where diverse foods are plentiful. Folic acid and vitamin D intake and status are evaluated in more detail, providing insight on health and potential impact on health care systems.

Key words: micronutrients, vitamin intakes, nutrition, economic burden, dietary survey, reference values, folic acid, vitamin D, deficiency

Before the discovery of vitamins, food was mainly viewed as a source of protein and energy. However, this has changed with the recognition that, given an adequate diet, it is possible to prevent diseases such as beriberi, scurvy and rickets [1]. For 100 years, after Casimir Funk introduced the term ‘vitamine’, researchers have discovered the structure, chemical and physical characteristics of the 13 vitamins and their importance for many fundamental metabolic processes [2, 3]. Consequently, dietary reference intakes (DRIs) have been established to define the intake at which health is optimal for the majority of individuals (generally 97.5 %) of a given population or group [4–9]. As the knowledge about the importance and functions of micronutrients is steadily increasing, inadequate vitamin intakes are still prevalent throughout

the globe, though by different degrees and due to different reasons.

Despite the global effort in the last decades to ameliorate micronutrient deficiencies and its consequences in the developing world, deficiencies for example from vitamin A are still affecting the lives and health of millions of people, especially the vulnerable population groups including children under five and pregnant women [10, 11].

Micronutrient deficiencies and inadequate intake compared to recommendations are also present in industrialized countries such as the United States and Europe [12]. Changed lifestyles and an increase towards the consumption of fast and convenience food with a low micronutrient density, have an impact on the quality of a persons’ daily diet and hence on their

nutritional status. Large-scale population based dietary intake surveys such as the German Nutritional Intake Study (Nationale Verzehrsstudie II) [13], the US National Health and Nutrition Examination Survey (NHANES) [14], the British National Diet and Nutrition Survey [15] and the Dutch National Food Consumption Survey [16] indicate that there is a gap between vitamin intakes and requirements for a significant proportion of the population even though diverse foods are available (Figure 1). For example more than 75 % of the population does not get enough vitamin E in the United States, Germany and Great Britain. Folic acid intake is especially low in Germany and in The Netherlands [12].

Recent reports state that non-communicable diseases (NCDs) accounted for two out of every three deaths worldwide by 2010 [17, 18]. Therefore, NCDs rank as the highest cause of human death and action is required to counteract this trend by improving lifestyles, with diets being an important component [19]. Even modest shortages of vitamins have been proposed to influence long-term survival and health. The Triage Theory provides a rationale on the suspected association of micronutrient shortages and the impact on long term health, a concept which is gaining scientific support [20–22]. The theory is well supported by a recent follow up of the Physician' Health Study (PHS). Within the PHS II, a large-scale, randomized, double-blind placebo-controlled trial in middle-aged and older men, a daily multivitamin supplement significantly reduced the risk of total cancer during a mean of 11 years of follow-up [23]. The vitamin/mineral supplement mix was given on top of a typical diet of American Health Professionals, which is assumed to be better than the diets consumed by many non-health professionals. Given that cancer is a leading cause of death worldwide, with more than 12.7 million new cancer cases diagnosed each year [24], this translates into a potential of about 1 million cancers prevented every year, and with it, all the burden of human suffering and health care costs.

Besides a combination of micronutrients, it has been suggested that even a single vitamin can have a tremendous impact on a number of body functions and health outcomes. For example, peri-conceptional folic acid supplementation has been shown to reduce the incidence of Neural Tube Defects (NTDs) by 20 % to 60 %. [25–28] However, although two thirds of pregnancies are reportedly planned, only about 4 % use an adequate prophylaxis [29]. Consequently more than 70 countries have implemented mandatory flour fortification with the result of a significant decrease in the prevalence of NTDs [30–34].

Vitamin D is another example, which has received increased attention over the past decade. The classical role of vitamin D is in bone health through its support of calcium absorption and deposition. Emerging health benefits of vitamin D include a reduced risk of falling by improving muscle strength, reducing the risk of multiple sclerosis, diabetes type I and II and infectious diseases such as tuberculosis, lowering of blood pressure and prevention of some cancers [35–37]. Although vitamin D₃, cholecalciferol, is synthesized in the skin by the action of ultraviolet light, reports from across the world indicate that hypovitaminosis D is widespread, even in sun-rich countries, and is re-emerging as a major health problem globally [38]. Older age, female sex, higher latitude, winter season, darker skin pigmentation, less sunlight exposure, dietary habits, and absence of vitamin D fortification are some factors that are significantly associated with lower levels of 25-hydroxyvitamin D (25OHD), which is an established marker of vitamin D status. Recently, the International Osteoporosis Foundation (IOF) developed a graphical illustration of global vitamin D status based on a systematic review (Figure 2). The findings show, that besides adults, widespread gaps exist especially in children and adolescents and rates of vitamin D deficiency are higher amongst women than men [39].

It has been estimated that an optimized vitamin D status in patients diagnosed with osteoporosis could reduce the number of fractures by 20 % [40]. For Germany that would be a total of 5478 hip fractures and 18420 vertebral fractures prevented every year. Taking direct and indirect costs into account this would lead to a net socio-economic benefit between 585 million – 778 million Euros. The magnitude of risk reduction for other associated diseases is assumed to be in the range of 50 % for multiple sclerosis, 25 % for diabetes, and 20 % for cardiovascular disease.

More studies are required to confirm these assumptions. However, policy makers and health insurance companies should engage to stimulate improvements in diets and adequate micronutrient intake.

Healthy nutrition is one of the global key challenges and opportunities

In 2012, an estimated 2 billion people worldwide suffered from hidden hunger, which means that people have enough calories however have inadequate vitamin intakes. In developing countries, intakes of nutritious foods are often not accessible to the poor,

Figure 1: Adapted from Troesch et al. [12]. Population with intakes below the specific recommended reference value for the country. The level of recommendation covering the needs of 97.5% of the population was used where it existed.
* Average nutrient requirement/approximation.
† No references exist, therefore, the Institute of medicine reference was used.
‡ 25–50% for men aged 19–30 years.
§ Data not available.

Figure 2: Vitamin D status in adults (>18 years) around the world when available; winter values were used to calculate the mean 25(OH) D levels [39].

whereas in industrialized countries poor diets, especially but not only, in lower socioeconomic groups affect micronutrient intake. Diet is one important factor of non-communicable diseases worldwide, and even modest inadequate micronutrient intakes can impact long-term health. Ensuring adequate micronutrient

intake and status is not only a cost effective approach to reduce health care costs but also ensures a healthy and productive life of billions.

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