Building Effective Nutrition Policy Demands a Strong Scientific Base

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Abstract

Background
The global pattern of nutrition-related disease means that policy-makers need to make strategic decisions based on strong science coupled with limited available resources.

Challenge
Solid evidence of a causal relation between the intervention and the intended outcome is essential for minimizing unintended consequences.

Useful data
Data on dietary patterns (*e.g.*, who is eating what), nutrition, and health status of various subpopulations, food availability, and cultural and behavioral factors potentially impacting an intervention are essential for developing approaches that have a high likelihood of being effective. Examples of how such data have been used, including a discussion of the Social Ecological Model, are included.

Program and policy evaluation data provide critical information for program planners and policy-makers. An example of a science-based nutrition policy for health promotion in the United States, including how pilot evaluation data informed the policy development and how post-implementation data were used to support the policy, is provided.

Effective program examples
Examples of interventions addressing undernutrition are provided, including biofortification, food fortification, infant complementary foods, and food supplements. Nutrition labeling is also offered as an example of a health promotion tool that is useful in preventing non-communicable diseases as well as correcting undernutrition.

Conclusion
The targeted goal of improved nutritional status for the population being served is a common characteristic of all intervention types, including both nutrient deficiency and health promotion. The mechanisms by which this goal is achieved vary, but data-driven effectiveness should be a key consideration for policy-makers.

Key Words: nutrition policy, nutrient intakes, dietary diversity, biofortification, food fortification, complementary foods, food supplements, health promotion

Introduction

Science is critically important as the basic driver for the process of nutrition policy-making. The current global nutrition focus is on the dual burden of malnutrition, which includes hunger and malnutrition as well as obesity and non-communicable diseases (NCD). The wide prevalence of micronutrient malnutrition or "hidden hunger" attests to the fact that many diets in both developing and developed countries are energy rich but nutrient poor and some variations in the type of malnutrition may vary across communities and even among members of the same family. Nonetheless, this pattern of nutrition-related disease means that policy-makers need to make the best strategic decisions within the available resources to address both aspects of malnutrition.

The policy challenge

Effective policy making requires a clear perspective on both the problem and the best ways to address it. As always, accurate evaluation of whether policy goals were in fact achieved is indispensable. In some cases, well-intended nutritional policies can have unintended consequences. To maximize program success, there should be high probability for the effectiveness of nutrition-related interventions with low probability for unintended negative consequences. To achieve such balance, it is important to have an adequate level of scientific evidence, which can take several forms.

It is important to have evidence of a causal relation between the intervention and the intended outcome. In some cases, more evidence may be needed to establish the relationship between a dietary component and disease risk. The link between saturated fatty acid (SFA) intake and cardiovascular disease (CVD) risk is an example of such a relationship and also illustrates unintended consequences. In the last century, industrially produced trans fatty acids (TFA) were introduced as part of the process to transform vegetable oils into solid fats in order to replace animal fats, which are rich in SFA. However, TFA have been associated with CVD risk and steps were subsequently needed to avoid the unintended consequence of this type of replacement. In some countries, such action was managed by mandating the declaration of both SFA as well as TFA. Another potential consequence of policies and actions to reduce intake of SFA from animal sources is reduction in the intake of nutritious foods that contain SFA in communities with very low energy intake.

Other types of evidence that may be needed to support a policy decision include data illustrating that an intervention will result in a behavioral change in the target population that reduces risk for disease. This type of evidence is often more challenging to identify. As noted in a recent Institute of Medicine (IOM) report on obesity prevention, evidence-based data to support policy and environment approaches are largely absent from the literature and new frameworks are needed to support decision-making (Kumanyika *et al*., 2010).

Although prevention is typically justified as important for reducing health care costs, prevention initiatives require an investment of financial and human resources. Investing in approaches that are not supported by scientific evidence compromises the ability to invest in potentially effective strategies. Without understanding which aspects are most important for a target population, the strategies developed may be ineffective or may have unintended consequences on health (Hall *et al*., 2012).

The role of advisory scientific bodies also needs to be considered. Although decision-makers are not necessarily experts in nutrition and food science, they should have access to the best impartial advice from both public and private sectors. Such advice will help them determine what information will be most important to make the best decision and most effective use of limited resources.

Types of data useful for understanding various policy options

Public and private data sources

Before developing interventions, it is important to consider what types of data can be useful in developing strategies that have the highest probability of being effective. Below is a selected listing of sources, public and private, that can be used to inform public policy.

The World Health Organization (WHO) established the e-Library of Evidence for Nutrition Actions (eLENA), which contains "evidence-informed guidelines" that provide "available scientific evidence supporting the guidelines; biological, behavioral and contextual rational statements, and commentaries from invited experts" (WHO, 2013). The interventions available through the website are ranked based on the strength of evidence supporting the intervention. Such information can be useful to decision-makers. However, to make effective use of this information, decision-makers will need certain types of data that are relevant for the target population to determine whether a particular strategy is likely to be relevant and effective in that population.

A report on "Preparation and Use of Food-Based Dietary Guidelines" illustrates some of the important factors to understand about a target population in order to effectively fit interventions related to food and nutrition (FAO/WHO, 1998). A first step is to clearly define the public health issues to be addressed and to determine the contribution of diet-related issues and non-diet-related factors. Certain non-nutritional factors in the target population, such as infection, safe food and water, physical activity, or smoking, may need to be simultaneously addressed for nutrition strategies to be effective. Data on dietary patterns and food availability are essential to developing approaches that have a high likelihood of being effective because the ecological, agricultural, social, and economic factors that determine food supply and utilization and cultural contexts can determine viability of an intervention.

The importance of scientific evidence for decision-making that makes effective use of available resources points to the importance of implementing evaluations of interventions. Understanding human behavior related to dietary patterns is critical because many interventions are predicated on a specific behavior change. Evaluation provides feedback that is needed to detect the effects of programs and to make the necessary modifications and improvements to guide changes in public health strategies. The Centers for Disease Control and Prevention published the "Framework for Program Evaluation in Public Health," which is widely used by public health scientists (CDC, 1999).

In 2012, the IOM published "An Integrated Framework for Assessing the Value of Community-Based Prevention," which considers various frameworks for evaluating interventions at the community level and outlines a new framework to address the charge to the expert committee "to develop a framework for assessing the value of community-based, non-clinical prevention policies and wellness strategies, especially those targeting the prevention of long-term, chronic diseases." In developing a framework, the expert committee defined four key elements of a framework for assessing value: 1) a decision-making context, 2) a list of valued outcomes, 3) a list of admissible sources of evidence, and 4) a method of weighing and summarizing (IOM, 2012).

One particularly valuable resource is INFOODS, the International Network of Food Data Systems. INFOODS is a worldwide network of food composition experts who work to improve the quality, availability, reliability, and use of food composition data in different parts of the world. The FAO INFOODS program provides a platform for international harmonization and support for the development of food composition databases for use by diverse stakeholders including government agencies, health and agriculture professionals, policy-makers and planners, the agro-food industries, and the consumer. INFOODS is organized into several regional data centers with a global coordinator. One goal is to facilitate access to and promote the use of reliable nutrient composition data on foods and beverages in different regions. Having nutrient composition data is of critical importance in assessing diet quality of populations and in estimating diet-disease risks.

Nongovernmental organizations are another important source of data. For example, the International Life Sciences Institute (ILSI) developed and evaluated programs designed to reduce iron deficiency anemia (Chen et al., 2005) and to encourage physical activity in primary school-aged children (Kibbe et al., 2011). ILSI Focal Point in China initiated and continues to follow nutrition policy formulation activities in that country.

China offers a good example of a logically designed nutritional program based on nutritional status evaluation of specific subpopulations. Surveillance data on subpopulations and analysis of cause and risk factors are in place and reveal the following:

- A 20-year surveillance on nutrition status of children aged <5 years during 1990–2010 demonstrated the trend of nutrition status of children aged <5 years. The current high stunting prevalence of rural China was identified. The data showed that the complementary feeding problem is the major contributing factor. This finding justified a national program on nutrition improvement of children under 2 years in poor areas. A pilot project in 100 poor counties was initiated in 2012 (Chen et al., 2010).
- The National Survey on Student Constitution and Health, conducted every 5 years during 1985–2010, provided data on undernutrition, overnutrition, and health outcomes and fitness of urban and rural students aged 7–22 years. Studies on the nutrition status of students in rural boarding schools showed the emerging issue of nutrition deficiencies. Thus, the nutrition subsidy for the boarding school children was the focus for nutrition improvement at this time, which covers 30 million school children across China.
- A joint analysis was performed on data from the 2002 National Survey on Nutrition and Health and previous relevant epidemiology surveys on hypertension and coronary heart disease. The sharp increase of NCD and the rapid changes in related risk factors in the past 20 years justify

interventions for prevention and control of NCD in terms of the level of risk. In this case, the urban population was emphasized in the program for NCD prevention.

Factors in determining effective nutrition strategies

Several types of data are essential for developing and implementing effective nutrition strategies, which include the following: 1) knowledge of what the population is eating (who is eating what), 2) knowledge of nutritional and health status of the population and key subpopulations, 3) behavioral changes important to successful implementation, and 4) program evaluation of outcomes.

Knowledge of what the population is eating—Nutrient density of the diet along the human life course, anti-nutritional factors, and main food ingredients

Essential nutrients for humans are provided across a diverse pattern of foods; consequently, dietary diversity is essential for good nutrition. Overdependence on cereals may limit the ability to meet the needs for essential nutrients.

Important nutrients and their main sources that humans need to receive pre-formed in the diet are shown in **Table 1**. Niacin and vitamin D are the only vitamins that can be synthesized partially by human metabolism from the amino acid tryptophan (Holman and De Lange, 1950), and cholesterol (specifically 7-dehydrocholesterol) and irradiation of the skin by ultraviolet light (Norman, 2012), respectively. This dependence on many exogenous nutrients provided by different food groups explains why dietary diversity is essential for good nutrition.

Although vegetable foods may contain iron, zinc, and calcium, the simultaneous presence of fiber and mineral-absorption inhibitors (phytates, oxalic acid, and polyphenols) limits their bioavailability (Miller *et al.*, 2007; Petry *et al*., 2010, 2012). Similarly, pro-vitamin A carotenoids in green leafy vegetables are poorly absorbed (de Pee *et al.*, 1998). By contrast, animal products, including meat, milk, and eggs, contain high-quality protein and readily bioavailable vitamins and minerals, notably pre-formed retinol (vitamin A), calcium, and iron. Even in developed countries, vegetable foods cannot supply all of the nutrients needed. For example, vitamins B-12 and D are exclusively provided by animal foods or by intentional addition through food fortification or supplementation. Another example is the supply of iodine through salt in most countries worldwide (Andersson *et al*., 2005).

Human inventiveness during the 20th century extended the availability and accessibility of food energy sources, mostly fats and carbohydrates. However, over-reliance of low-cost added sugars and vegetable oils has created new nutritional problems, such as the reduction of the nutrient density of the diet, as well as the increase of TFA and salt. For some groups, this situation has also been combined with keeping intake of SFA and cholesterol in high amounts. Low-cost diets that are energy dense, but nutrient poor, have been associated with obesity, metabolic syndrome, and NCD (Bremer *et al*., 2012; Drewnowski and Specter, 2004).

In summary, promotion of good nutrition is not a simple matter of emphasizing the content of plant foods in the diet or promoting specific practices, following approaches that “one size fits all.”

Knowledge of nutritional status and health status of target population

An important point is to examine local data as well as that found in worldwide databases. It is well known that undernutrition remains a global challenge (FAO/WFP/IFAD, 2012; UNICEF/WHO/World Bank, 2012; World Bank, 2013), as shown in the following examples.

- In 2011, an estimated 165 million children aged <5 years worldwide were stunted (*i.e.*, low height-for-age), a decrease from an estimated 253 million similar children in 1990.
- High prevalence of stunting among children aged <5 years in Africa (36% in 2011) and Asia (27% in 2011) remains a public health problem, one that often goes unrecognized.
- In 2011, an estimated 101 million children aged <5 years worldwide were underweight (*i.e.*, low weight-for-age), a decrease from an estimated 159 million similar children in 1990.
- Although the prevalence of stunting and underweight among children aged <5 years worldwide has decreased since 1990, overall progress is insufficient and millions of children remain at risk.

Annex 1 contains recent data from Uganda showing the temporal cycle for children being admitted to a large hospital with complicated, acute malnutrition.

On the whole, an undernourished population is often characterized by cyclical food insecurity, poor infant and young child feeding, social and cultural factors, diseases (*e.g.*, malaria, diarrhea, HIV), and limited access to water and sanitation as well as health and social services. Dietary patterns for lower income consumers are often different from those with higher income. For example, in population-based studies, diets high in TFA are often cheaper and more likely to be selected by the lower income consumer. Even though the impact of economic factors on health has been proven beyond any doubt, some current epidemiologic studies on diet and chronic disease do not fully take consumers' socioeconomic status into account.

Framework for behavior change

We propose a framework for behavior change for consideration by the FAO. The goal is to complement the Social Ecological Model (SEM) with economic and additional environmental variables. Even though the SEM incorporates different levels from the individual to the community, it fails to come to terms with social, economic, and health disparities across diverse population groups. New epidemiologic and social indicators are required to determine how proposed dietary changes will apply to population groups of widely disparate educations and incomes.

The FAO framework for adoption by local governments would include analyses of the cost of the food supply. The FAO framework ought to include some considerations of the quality of the food supply in relation to the purchasing power of different population groups. The effect would be to complement traditional nutrition education with consideration for the social and economic environments in which this sub-population lives.

For example, the existing SEM, as applied outside the United States, could take into account the socioeconomic determinants of health and examine how they factor into the design of nutrition intervention programs. The impact of such programs can be compromised by poverty, unemployment, low incomes and low educational status, or by the cumulative and life-long effects of age, gender, disability, race, or ethnicity. Models of dietary change ought to shift from emphasis on individual behavior change, albeit supported by structures at the family, organizational, and community levels, to broader policy-based interventions that are multi-sectorial, involving not only nutrition, but also economics and public health.

The traditional SEM model, focusing on individual behavior change to drive health promotion, is a multi-level approach to the promotion of health (McLeroy *et al*., 1988; Sallis *et al*., 2008). SEM uses a systems approach with multiple bands of influence acting on each desired health change. At the core of SEM is the individual person, surrounded by four bands of influence representing the interpersonal, organizational, community, and public policy levels[CW1] (**Figures 1 and 2**).

Individual level. Strategies are designed to increase the person's knowledge, and change his or her attitudes and beliefs about this desired health change or target behavior. This might include discussions of risks and benefits of the target behavior, including the potential health outcome of adopting this new desired behavior.

Interpersonal level. Strategies might include influences on changing social and cultural norms and overcoming individual-level barriers. Friends, family, health care providers, and promotoras represent potential carriers of health messages at this level. For example, promotoras are Hispanic community members who are trained to provide basic health education (Office of Minority Health, 2013), and they may encourage breast cancer screenings by discussing benefits to the participant's children to early detection of the parent's cancer.

The SEM: McLeroy 1988

Level of influence	Description
Intrapersonal	Individual characteristics that influence behavior: Knowledge, skills, self-efficacy
Interpersonal Family, friends, peers	Interpersonal processes and groups providing identity and support
Organizational Churches, stores, community orgs.	Rules, regulation, policies, structures constraining or promote behaviors
Community Social networks	Community norms (community regulations)
Public policy Local, state, federal	Policies and laws that regulate or support healthy practices/actions

Organizational level. These strategies are intended to facilitate individual and family behavior change by influencing organizational systems and policies. Health care systems and providers, workplace employers, local health departments, and professional organizations are potential extenders of organizational messages and support. An example might be the adoption of a worksite policy in support of breast-feeding by providing the employee with time to express/pump milk in a clean, private, relaxing environment without disturbances.

Community level. These strategies are intended to promote behavior change by leveraging resources and participation of community-level institutions such as coalitions, tribal health departments, media, and community-based advocacy groups. An example might be a community-wide anti-smoking educational campaign.

Public policy level. This is the fifth and final, but equally important, level of influence in SEM. These strategies involve targeting existing policy or laws. National, state, or local governments might support specific policies to promote the targeted health behavior. Another example being used by many countries is mandating declaration of nutrition information on foods.

There are variations on the SEM. Some researchers have added a strong emphasis on the environments. For example, water sanitation would be affected by the presence of handwashing stations, and separate latrine facilities—along with water treatment capabilities, water table properties, and population density—would be important additions to the model for improving water sanitation. Other researchers report that habit formation is not adequately addressed by the individual level of influence.

For SEM-based interventions to be effective, they need to be well targeted to the specific population in a specified environment. These interventions are informed by formative research of the target population and an understanding of the theoretical underpinnings of SEM and involve complex interactions among levels in the model. The intervention is of sufficient intensity and reinforced at these multiple levels in the SEM. It is very important to note that the application of SEM cannot be done in a broad sweep. Each context, circumstance, and target population requires its own specific adaptation of the socioecological model.

Importance of program evaluation—Example of science-based school nutrition policy in California

Ideally, theory and science, reflected in policy and practice, influence each other, with scientific data providing the theoretical underpinnings for policy, and data collection informed by theory-based policy initiatives. There are times, however, when policy and science are out of synch, as illustrated in the following example. The prevailing ideology in the United States, and hence the basis for many public policies, has long been one of individualism, with the political and social systems based upon a belief in the efficacy of individual choice, individual freedom to act, and individual responsibility for one's choices and actions. To a great extent, approaches to the treatment of obesity have accepted this paradigm of individual responsibility, holding parents and children solely responsible for behavior change to prevent or undo weight gain. However, if major causes of the current obesity epidemic are environmental rather than individual in nature, then it follows that a policy focus on broad-based environmental rather than individualistic responses is needed to effectively halt the epidemic. Hence, growing science on the (in)effectiveness of individually based methods suggests that new policy approaches must be crafted.

Implementing an environmental approach to obesity prevention involves acceptance by policy-makers of the need to take steps to influence the environmental or community/institutional context in ways that are conducive to, and supportive of, individual change. Schools, where children spend a high proportion of their waking hours and children participating in the school breakfast and school lunch programs receive up to 50 percent of their daily caloric intake, can be seen as a prime setting for environmental modification (Dwyer, 1995). Schools can influence students' eating patterns by setting criteria, including nutritional guidelines, for what can be sold and promoted on campus (CDC, 1996). According to the US General Accounting Office (2003), 43 percent of elementary schools, 74 percent of middle schools, and 98 percent of high schools had vending machines, school snack bars, and/or other food services outside of the school lunch and breakfast programs. These venues usually offered foods of minimal nutritional value, known as "competitive" foods; students were individually responsible for deciding whether to purchase these items, and most did.

In 2001, in response to data that demonstrated increasing rates of pediatric obesity, increasing consumption of sugar-sweetened beverages, the link between sweetened beverage intake and weight gain, and the apparent failure of individual efforts to reverse these trends, California policy-makers at the state level enacted legislation to change the school environment in ways that would influence and actually limit individual behavior. The *Pupil Nutrition, Health, and Achievement Act of 2001* established nutrition standards for competitive foods and beverages sold on school campuses. Policies that had governed school food provision for decades were changed in response to scientific data that demonstrated the need for a new approach.

The California legislation was passed, but was unfunded and therefore not widely implemented; its failure was widely predicted based on the lack of funding to replace schools' anticipated loss of income from sale of competitive foods. Many school food service departments in the United States have relied on sales of unregulated foods to supplement federal and state meal reimbursements to support additional school-based groups and programs (Fox *et al*., 2001; Vargas *et al*., 2005; Woodward-Lopez *et al.*, 2005). However, money was provided for implementation and evaluation of the new legislation in 16 middle and high schools in 9 California school districts. The *Linking Education, Activity and Food* (LEAF) evaluation was conducted by the University of California Berkeley's Atkins Center for Weight and Health (CWH) in 2003–2004 to determine whether nutrition standards would change student behaviors and whether they could be implemented in a fiscally sustainable fashion (Woodward-Lopez *et al*., 2010). The LEAF study showed that students' dietary intakes improved: consumption of fruits and vegetables increased and consumption of sugar-sweetened beverages decreased, confirming the results of other studies showing that when snack foods and highly sweetened beverages are limited on school campuses, students choose healthier options if they are available (LaFee, 2003). Furthermore, and perhaps more surprisingly, as availability of alternative foods decreased, student participation in the school lunch program increased, suggesting that fears of financial loss were overstated and that school districts could successfully adopt state legislation regulating competitive foods (Woodward-Lopez *et al*., 2010). In fact, revenue increases were greatest at school sites that eliminated *a la carte* food sales entirely.

An understanding of the impact of environmental policy is urgently needed to provide policy-makers with information on successful strategies that improve feasibility, acceptability, and effectiveness of programs and enhance the sustainability of these efforts. The LEAF evaluation illustrates the value of using scientific data to inform policy design and implementation. The study's results demonstrated to both policy-makers and schools that it would be fiscally possible to implement school-based environmental changes designed to prevent weight gain and to model desirable dietary behaviors for all children in the community. The evidence provided by the LEAF evaluation confirmed the prediction that children's nutrition would benefit from the legislation, and also disproved the assumption that schools would necessarily suffer serious financial losses in implementing the new standards. The LEAF evaluation revealed the potential for the environmental approach and provided guidance for health professionals, policy advocates, and community groups as well as policy-makers themselves. LEAF findings were substantiated by results from studies conducted in California over a similar time period (Crawford, 2006; McCarthy, 2006; Samuels *et al*., 2006; Vargas *et al*., 2005; Woodward-Lopez, 2004; Woodward-Lopez *et al*., 2005).

In 2007, California's Senate Bill 12 established nutrition standards for competitive foods sold in all of the state's K–12 schools, limiting total calories as well as calories from fat, saturated fat, and sugar. A second law, Senate Bill 965, limited the competitive beverages that could be offered during the school day. The Robert Wood Johnson Foundation Healthy Eating Research Study of 56 high schools, conducted by the CWH before and after legislation (in Spring 2007 and Spring 2008, respectively), assessed aspects of the implementation and impact of these school nutrition standards in diverse settings, finding that regulation of competitive foods improved school food environments and student nutritional intakes. Improvements, however, were modest, partly because many compliant items were simply modified versions of products of low nutritional value. Similarly to the LEAF study, this later evaluation showed that although food and beverage sales decreased at most competitive food venues, revenue losses were usually offset by increased meal program participation. Nonetheless, increased food service expenditures outpaced revenue increases.

The data demonstrate the need to monitor implementation of policy mandates. Just as data support the theoretical basis for policy initiatives, they also indicate the need for monitoring compliance with policy dictates. Furthermore, data highlight the gaps in policy design and implementation standards. The study findings indicated that legislation to regulate competitive foods in schools is an effective first step in improving the nutritional environment of California students and in shifting the focus of obesity prevention from individual accountability and responsibility to environmental support. Future efforts would likely be most effective if complemented by high-quality nutrition education and promotion (Gordon *et al*., 2009; Johner, 2009; Story *et al*., 2009).

Examples of effective public health nutrition policies and the data on which they were based

In principle, human nutrition should first be based on a good combination of different food groups and assuring dietary diversity. However, due to ecological, economic, cultural, or special physiological needs (infants, pregnant and lactating women, elderly persons, etc.), human diets should be reinforced with specific interventions that complement the nutrient gaps that may occur. Four sequential types of nutrition interventions are available: biofortification, food fortification, complementary foods and other targeted-designed foods[1], and food supplements. Each type of intervention is described below, and the use of nutrition labeling as a tool to support NCD prevention is also discussed.

Biofortification

Biofortification is currently defined as the increment in the nutrient density of vegetable foods (seeds, roots, or tubers) using traditional techniques of plant-genetic improvement (Hotz and McClafferty, 2007). Although tools of molecular biology might be used, such as the synthesis of β-carotene–enriched rice (“golden rice”), thus far HarvestPlus (the most important global project promoting biofortification) has used only standard breeding practices. Focus has been placed on increasing the amounts of β-carotene (the most important pro-vitamin A carotenoid) in orange-fleshed sweet potato, “orange” maize, and “yellow” cassava, as well was iron in beans and pearl millet and zinc in wheat flour (atta = whole) and rice. **Table 2** summarizes biofortification achievements thus far.

Biofortification has been shown to provide important amounts of pro-vitamin A to the point that country programs are already introducing orange-fleshed sweet potato. The situation with orange maize and yellow cassava is still under experimentation, but it seems that useful amounts of nutrient could be delivered. It is important to point out that the estimations of additional intake of pro-vitamin A were done assuming very large intakes of maize and cassava, to the point that it would represent 1,048 kcal/d (assuming 365 kcal/100 g) for maize and 1,573 kcal/d (assuming 160 kcal/100 g) for cassava, which means 42% and 63% of the energy contribution in a 2,500 kcal/d diet. These amounts of energy from only one food are not consistent with the principle of dietary diversity, and may place intake of other

[1] Targeted-designed foods are products formulated to satisfy nutritional requirements of specific groups of the population, and with the aim of supplying a large proportion of almost all the daily nutrient requirements.

micronutrients at risk. If one accepts that approximately 30% of the energy supply could come from these sources, then the additional provision of vitamin A through these biofortified crops would be 22% and 51%, respectively. Thus, orange maize would be a good source and yellow cassava an excellent source of vitamin A. These data show that biofortified crops with β-carotene are becoming important sources of vitamin A. In this sense, they are being integrated into the group of good vegetable sources of vitamin A, together with carrot and orange-fleshed fruits (mango, papaya, etc.).

The situation of biofortification with iron is less positive. Thus far, only biofortified pearl millet appears to provide good amounts of this mineral, whereas the supply through biofortified beans is relatively low. For iron, the reduction of iron-absorption inhibitors (mainly phytates) seems to be essential for improving the iron status. The situation with zinc, although better, is similar to that of iron. Additional provision of zinc through biofortified rice and wheat flour (atta) seems adequate in the data presented in **Table 2**.

In summary, biofortification can significantly improve the supply of pro-vitamin A and can raise intakes of iron and zinc. However, for the two minerals, it is important to reduce the content of phytic acid in the diet or to introduce other complementary measures that will fill the remaining nutrient gaps. Thus far, biofortification has not been designed to supply calcium and iodine, vitamins B-12 and D (nutrients supplied through animal foods), and vitamins folate and B-2 that may be needed in certain populations.

Food fortification

Food fortification is defined as the intentional addition of nutrients—including vitamins, minerals, certain fatty acids, and amino acids—based on a public health need to industry-manufactured foods, which become vehicles or carriers of those nutrients. The potential benefit of food fortification is due to the quality and amount of the added nutrients (**magnitude of the solution**) and the portion of the population that moves from nutrient inadequacy to adequacy (**size and extent of the need**) after the introduction of the fortified food, and is not due to the simple intake of the fortified food (Dary, 2007; Hurrell *et al*., 2010).

Nutrient contents used in food fortification are limited because of concerns regarding safety (avoiding excessive intakes by individuals eating the food vehicle in large amounts), technological incompatibility (undesirable changes in the sensorial properties of the food vehicle), or economic effects (avoiding increasing the price of the food vehicle beyond what is reasonable to compete with unfortified products in the market or avoiding illegitimate profit if the product is not fortified but claimed as such). Consequently, although the benefit of fortification is linked to the amounts and quality of the nutrients and not the fortified vehicle, individuals with low or infrequent intake of the food vehicle will be excluded from the potential benefit of food fortification (Imhoff-Kunsch *et al.,* 2007). Targeted fortification is more efficacious than mass-driven (staples) or market-driven fortification (Allen *et al*., 2006) because of the higher content of nutrients that can be incorporated due to the less restrictive situation of individuals with high intakes of the fortified food. However, the coverage (proportion of the population consuming the product) is much larger in the other two types of fortification, especially in mass fortification, which is thus their main advantage.

Infant complementary foods

Foods targeting infants after the period of exclusive breast-feeding (6 months) until 23 months of age[2] are known generically as *complementary foods*. These foods, either made at home or produced by the food industry, intend to supply all or almost all nutrients that are required for child growth and health; therefore, their formulas include macronutrients (energy from fats and carbohydrates, and protein), essential fatty acids and amino acids, and micronutrients (vitamins and minerals). Micronutrient amounts are half or more of the recommended nutrient intake values because these products may be the only food consumed by this age-group of children in addition to breast-milk. In this case, limitations due to sensory incompatibility and cost are much less restrictive because the complementary foods are final processed products, whose flavors, odors, and colors can be controlled to be acceptable to consumers. Furthermore, the higher costs are associated with the macronutrients and processing, rather than the micronutrients. Indeed, infant complementary foods are a classical example of targeted fortification.

Table 3 presents examples of nutrient composition of complementary foods and compares their nutrient density with the theoretical nutrient density that would satisfy the nutrient requirements of children aged 12–23 months with and without breast-feeding. It is interesting to note that the breast-fed children are at risk of suffering inadequacy of iron, zinc, and calcium if the accompanying complementary food does not provide a good supply of these nutrients. Here, it is assumed that the mother has a good nutritional status, otherwise her milk, depending on the insufficient nutrients, could also be poor in vitamins A, D, B-1, B-2, B-6, choline, B-12, iodine, and selenium (Allen, 2012). Breast-milk also transfers essential n-3 and n-6 fatty acids from the mother's diet to the child, which are important for child brain development (Fleith and Clandinin, 2005). Obviously, if the children are not breast-fed, intakes of all of these micronutrients could be low. Many efforts and studies have been dedicated to formulate complementary foods that satisfy the nutrient requirements of this vulnerable period of human life (Dewey and Adu-Afarwuah, 2008; Dewey and Brown, 2003; Dewey and Lutter, 2001).

During the last 10 years, *ready-to-use therapeutic foods* (RUTF), a special type of complementary food mostly using ingredients rich in fat, were introduced to treat cases of severe acute malnutrition. The recovery of the affected children has been remarkable and was explained through the supply of the correct amounts and qualities of macronutrients and micronutrients that are required under that condition; this achievement is the practical application of accumulated knowledge in nutritional biochemistry and physiology, food science, and food technology (Briend *et al*., 1999). RUTF are mixes of vegetable oil or fat (frequently peanut paste), powder milk, whey protein, sugar, and micronutrients. Their main advantages are that they are ready to be consumed and they lack water and utilize packaging that makes them highly resistant to bacterial contamination (Briend, 2001). Their environment stability, nutritional composition, and lack of need for special preparation have motivated the replacement of milk formula F-100, which was previously used for the recovery of severely malnourished children (Diop *et al*., 2003). Despite these positive results, RUTF have limitations because of difficulty in ensuring that

[2] Part of the most critical period of human life for adequate growth and mental and cognitive development that, along with the period of fetal life, is considered the "1000-days window of opportunity".

the ingredient supply is free of mycotoxin (Manary, 2006; Mutegi *et al*., 2009) or *Salmonella* and other pathogenic bacteria (Latham *et al*., 2011) in developing countries. Nevertheless, use of RUTF for the treatment of severe cases of acute malnutrition is now widely recognized despite the higher cost than traditional products.

It is important to note that RUTF work because of the nutrients that they deliver or the anti-nutritional factors that RUTF do not contain (*e.g.*, aflatoxins, phytates, and tannins). Therefore, those characteristics might be replicated by using natural food ingredients or by modifying the formula of traditional and less expensive complementary foods. The formulations of these products could be adjusted to dosage size and the nutrient requirements of the targeted population groups. The Codex Committee on Nutrition and Foods for Special Dietary Uses completed work in 2012 on "Draft Guidelines on Formulated Supplementary Foods of Older Infants and Young Children" (CAC/GL 8-1991) (Codex, 1991, 2012). The description in this guideline indicates that these foods include porridges including cereals, ready-to-use products, and food-based home fortificants and that they are specifically formulated to provide additional energy and nutrients to complement the family foods derived from the local diet by providing those nutrients that are either lacking or are present in insufficient quantities.

Micronutrient supplements

The nutritional impact for the recovery of children with severe acute malnutrition prompted the initiative of promoting RUTF as products to complement children's diets in nutritionally vulnerable populations (*i.e.*, for prevention of moderate malnutrition) (Briend *et al*., 1999). For this application, smaller serving sizes were suggested (20–75 g/d instead of 200 g/d), and their name was changed to *ready-to-use foods* (RUF) and *ready-to-use supplementary foods* (RUSF)[3]. As food supplements, these types of products are referred to as *lipid-based nutrient supplements* (LNS) (Chaparro and Dewey, 2009). As their name implies, these products are based on vegetable fats and are used as vehicles to deliver nutrients in concentrated amounts in small-size dosages. Their lipid nature favors the increment in the energy density of the diet of small children, and also permits the addition of correct proportions of essential fatty acids of types n-6 and, principally, n-3 as docosahexanoic acid (DHA), which are important for brain and other metabolic functions (Makrides *et al.*, 2009). Although these products are already used by UNICEF, the World Food Programme, and other international groups, they have triggered the opposition of strong voices in public health nutrition. Latham *et al*. (2011) argued that the use of these products may have negative influence over the usual diet by encouraging use of costly ultra-processed foods, undermining breast-feeding, shifting attention to other causes that halt physical and mental development, and increasing the risk of changing dietary habits in favor of very sweet flavors. Therefore, they suggested that RUTF should be used under medical supervision and only for treating severe cases of acute malnutrition. These are legitimate concerns. Nevertheless, as micronutrient supplements, these products deserve additional research.

Several studies have collected evidence that LNS not only improved motor development—as only-micronutrient supplements did—but also favored growth in moderate malnourished children in Ghana

[3] As an example, see the list of presentations for different applications by Nutriset: http://www.nutriset.fr/fr/nos-produits/presentation-gamme.html.

(Adu-Afarwuah *et al*., 2007). This extra benefit of LNS is attributable to the presence of essential fatty acids (n-3 and n-6; see **Table 4**) and likely to the additional amount of energy. Again, it is important to emphasize that the beneficial effects are due to the correction of a deficiency through the provision of the appropriate nutrient through LNS; other vehicles may be equally effective, if they contain the necessary nutrients. For example, Chile fortifies powdered milk with DHA that is distributed to women during pregnancy and lactation with the purpose of assuring appropriate transference to the newborn children. The program has resulted in increased DHA composition of red blood cells of the mothers, thereby raising the DHA content in breast-milk by 50% (Atalah *et al*., 2009).

Despite the fact that micronutrient-only supplements did not affect growth in Ghanaian children (Adu-Afarwuah *et al*., 2007), Rah *et al.* (2012) summarized that stunting decreased in Nepal and Kenya associated with the use of micronutrient powders (MNP)[4]. These results were not unexpected, because the impact depends not only on the magnitude of the solution (the additional intake of micronutrients) but also on the size of the need in the vulnerable populations. Rah *et al.* (2012) also described that MNP were efficacious for reducing moderate anemia in children aged 6–24 months, both in efficacy trials as well as programs. This finding is not surprising because if the anemia is due to micronutrient inadequacies and sufficient amounts (and qualities) of the insufficient micronutrients are provided, then the organism will react as expected. If no impact is found, then it would be interesting to investigate whether the causes of the problem are other factors or the micronutrients are neither bioavailable nor bioconverted, or whether there are negative interactions among them or with the other substances present in the diet or in the organism.

Although both LNS and MNP are supplements, the practice in which they are promoted for consumption in combination with foods in the meal is commonly known as “fortification at the point-of-use” or “home-fortification.”

Nutrition labeling and claims

Nutrition labeling on prepackaged foods illustrates the need for various types of evidence for effective decision-making. The first phase of decision-making requires scientific data to determine the most appropriate nutrients to declare in food labels. This type of data might address both the adequacy of intake as well as overconsumption of nutrients by a population and the linkage between patterns of nutrient intake and prevalence of diet-related disease within the population. Organizations responsible for policy-making on food labeling need to have a reliable systematic review process in place to evaluate available scientific information in order to establish the validity of the causal relationship between the intake (or lack thereof) of a nutrient and a public health issue. This would ensure the validity of the causal relationship. Codex recently reviewed and revised the list of nutrients that are always declared on food labels based on evidence linking nutrients with risk of NCD. In addition to declaration of energy, protein, available carbohydrate, and fat, Codex agreed to add saturated fats, sodium, and total sugars to the list of nutrients that are always declared (CAC/GL 2-1985) (FAO/WHO, 1985). The decision to add these nutrients was based on the association between SFA and CVD risk, the association between

[4] MNP are blends of vitamins and minerals in powder form and are usually distributed in sachets of <1 g.

sodium intake and hypertension, and the link between sugars and dental caries. In addition, Codex recognized that TFA intake is associated with CVD risk and should be declared if justified by dietary patterns in a country.

In addition to considering the scientific evidence to justify declaration of certain nutrients, scientific evidence is needed to determine how best to communicate the information to consumers and how to educate consumers on the use of this information. Consumer studies can be used to determine how consumers use the information on the food label and whether they will be able to use the information to make more informed decisions for food choices and how they fit into a total daily diet. For example, when mandatory nutrition labeling was implemented in the United States, studies indicated that consumers were better able to understand the nutrient content of foods when expressed as the percentage of a daily reference value. This research resulted in the use of this format in the Nutrition Facts label. Consumer studies are also useful for making decisions about presentation of information as well as graphics and design elements to facilitate consumer understanding (Levy *et al*., 1991, 1992, 1996).

Another aspect of nutrition labeling is the voluntary declaration of claims related to nutrition content or the link between a food or food component and a health benefit or reduction of disease risk. For such claims to be useful to consumers, they should reflect current scientific evidence. Claims that characterize the nutrient content of a food (*i.e.*, nutrient content claims) are for nutrients known to be essential and for which a reference value for intake has been established. Because of the reference value, such claims can characterize the nutrient content as a good or excellent source of the nutrient relative to the recommended intake. Otherwise, only information about the absolute amount can be provided. The other scientific data needed for nutrient content claims are reliable, agreed-upon analytical methods to determine nutrient content. The other types of claims made in food labeling are claims about nutrient function related to health and well-being or claims about a food or food component reducing the risk of chronic disease. Such claims require clinical evidence from human populations in order to substantiate such claims. Codex has provided guidelines for substantiation of such health claims and several countries have developed detailed guidance for evidence-based review of such scientific data (Codex, 1997; US Food and Drug Administration, 2009).

An economic analysis is an additional dimension of scientific analysis to determine the potential value of an intervention. Such an approach allows economists to estimate the cost of an intervention in relation to the potential benefits of taking action. Those interventions that have been validated scientifically will be most suitable for an economic analysis of costs and benefits (Wong *et al*., 2011). Such an analysis may need to consider various scenarios, including the impact of taking no action, and, if done accurately, provides the decision-maker with additional information to determine a course of action.

Discussion

As discussed effective policy development relies on a variety of data which may or may not be easily collected. The data needed to help countries identify effective policies include the following:

- Relevant population data in order to design nutrition policy that is culture specific and dietary habit based.

- Identification of the nutrition problem and its specific cause (including any relevant non-dietary/nutritional factors), assessing its magnitude and the proportion of the affected population.

- Research, including field application, on food standards that are suitable for nutritional improvement and that facilitate the implementation of nutrition policy.

- Effectiveness of innovative mechanisms to bring foods that have been nutritionally improved into the market and to ensure that delivery of nutrients is effective throughout the whole process.

- Formative research (i.e., individual interviews, focus group discussions with community members) to guide the development of the intervention in the community.

- Monitoring and evaluating data as policy is implemented of the impact on foods, dietary patterns, and behavior, available at each step during the process. Such data should facilitate the stages of scaling up an intervention.

- Reliability and effectiveness of partnerships among government agencies as well as public-private partnerships so that there is coordination across sectors for achieving nutrition objectives.

- Market data to determine whether the nutrition product is available (in the market), accessible (to the needed population), affordable (to the specific households/population), and acceptable (to the consumers).

- Knowledge of sectors of the food industry, food product development strategy, and food technology that are capable of encouraging health based on adherence to national policies as well as innovation. The strategies of food industry and the retail system on nutrition and food safety, quality control, food marketing, distribution, and retail policy should be nutrition specific.

- Information on rural market development, including what incentives are needed to facilitate distribution. Determine the channel for free-supplementation distribution (integrated with health care reform system, government, or marketplace) and incentives needed for distribution in the purchase market.

The goal is to create demand/education and facilitate supply for nutrition products by understanding how to manage the above-mentioned market drivers. Analyses of such data are essential for upgrading the efficiency of nutrition policies. The above-mentioned problem-solving process calls for sound and real public-private partnerships, with the governmental leadership covering both nutrition-specific and nutrition-sensitive policy-making, which is the nucleus of the whole issue and is a systematic undertaking.

Concluding remarks

The last 10 years have witnessed advances in yield production and food processing (e.g., extending shelf-life, improving hygiene, introducing friendly nutritional messages) as well as the introduction of several nutritional interventions, which include both overcoming nutrient deficiencies as well as reducing NCD risk. These strategies include dietary diversification, biofortification, mass-driven and market-driven fortification, complementary foods, and other target-fortification programs, food supplements, and nutrition labeling. Each of these interventions is generally implemented independently of the others, rather than assessing the nutrient inadequacies and the combined effect of all of these interventions. Consequently, the risk of inefficient use of resources and even potential excessive intakes of certain nutrients is increased.

To solve this undesirable situation, it is important to take decisions supported on technical evidence, both for diagnosing problems and their causes as well as monitoring and evaluating the impact of the interventions. The common feature of all the nutrient interventions aimed to correct deficiencies is provision of additional nutrient intakes and prevention of excesses associated with NCD at the same time. Baseline intakes as well as changes due to the implementation of the interventions should be a mandatory part of the programs. If there is a reasonable amount of information that there is a nutrient gap and it is corrected, then the determination of biomarkers associated with that nutrient is justified. If the biomarker does not improve from the control group or the original situation despite the provision of sufficient additional intake of nutrients that are considered insufficient, then research is warranted to find the reasons.

Positive changes should be explained through incremental change in nutrient intakes, and not by the simple use of the delivery mechanism. This approach will allow integration of the different interventions as well as estimate their proportional contribution to the solution, in terms of nutrient intakes and population coverage. The healthfulness of a particular food needs to be evaluated in the context of the total diet and lifestyle factors. The ability of interventions to be effective in improving nutrition status will depend on the circumstances and an appropriate combination of intervention and related factors.

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Table 1

Dietary sources of nutrients

Nutrients	Milk[1]	Fish	Meat, poultry	Eggs	Legume grains[2]	Whole cereals	Vegetables	Fruits and roots	Refined cereals, polished rice, oil, sugar
Vitamin A	+++	++	+	+++	-	-	(++)[3]	++	-
Vitamin D	+++	+++	+	+	-	-	-	-	-
Vitamin E	-	-	-	-	+	++	+	+	+[4]
Vitamin C	+	-	-	-	-	-	+++[5]	+++	-
Vitamin B-1	+	++	+	+	+++	++	+	+	-
Vitamin B-2	+++	++	++	++	+	+	++	+	-
Vitamin B-6	+	++	++	++	++	++	++	++	-
Niacin	+	+++	+++	+	++	+	++	+	-
Folate	-	+	+	++	++++	+	++	+	-
Vitamin B-12	++	++	+	++	-	-	-	-	-
Iron	-	+++	++++	(+)	(+++)	(++)	(++)	(+)	-
Zinc	-	++++	++++	-	(+++)	(++)	(+)	(+)	-
Calcium	+++	++	+	+	(++)	(+)	(++)	-	-
Iodine[6]	++	+	-	-	-	-	-	-	-

Notes

[1] Vitamins A and D are eliminated if the milk is defatted.

[2] Examples: beans, lentils, chickpeas, groundnuts.

[3] Parentheses mean that although present in the food, absorption and bioavailability for humans are low.

[4] Only in vegetable oil.

[5] If eaten fresh and raw.

[6] If animals have a good nutritional status of iodine.

Table 2

Current conditions of the biofortified projects of HarvestPlus and estimated nutrient provision to women¶

Crop	Nutrient	Food intake (g/d)	Additional micronutrient amount (mg/kg)	Additional nutrient intake (mg/d)	Retention (%)[1]	Bioavailability (%)	Daily requirement (%)
Orange-fleshed sweet potato[2]	β-carotene	143	72.2	10.3	84	8.3	144.0
Orange maize	β-carotene	287	9.0	2.6	37.5	16.0	30.9
Yellow cassava	β-carotene	983	7.5	7.4	32.5	22.5	107.8
Beans	Iron	147	22	3.2	97	5	10.7
Pearl millet	Iron	189	49	9.3	80	6	30.4
Rice (parboiled, and polished)	Zinc	420	8	3.4	86	25	36.1
Wheat flour (atta)	Zinc	420	15	6.3	99	15	46.8

¶ Information about conditions of biofortified crops, except orange-fleshed sweet potato, by Erik Boy (HarvestPlus) (personal communication, 2012). Amounts consumed by women were taken from the true situation in the countries where the biofortified crops have been studied. Estimated average requirements of vitamin A, iron, and zinc for women of reproductive age were as follows: 500 µg/d as equivalent of retinol, 1.46 mg/d if 100% bioavailability, and 2.0 mg/d if 100% bioavailability, respectively.

Notes

[1] Retention refers to the permanence of the added micronutrient until it reaches the consumer's table.

[2] Source: Hotz *et al*. (2012).

Table 3

Nutrient composition of complementary foods

Nutrient	RNI		Theoretical composition			Example of a complementary food		USDA corn soy blend plus	
	WHO/FAO for 12–23 mo[1]	Considering supply through average breast-feeding[2]	Daily from complementary foods for breast-fed children[3]	Foods for non-breast-fed child (amount/100 g)	Foods for average breast-fed child (amount/100 g)	Food (amount/100 g)[4]	After diluting with water, (amount/100 g)	Food (amount/100 g)[5]	After diluting with water, (amount/100 g)
Food portion (g/d)	-	-	378–515	654–890	378–515	130	458	80	580
Serving size (g)	-	-	94–129	163–223	94–129	65	229	40	290
Energy (kcal)[6]	950	582	550	107–146	107–146	423	120	≥380	52
Energy from fat (%)	-	-	17–42	17–42	17–42	21	21	≥14	≥14
Fat (g)	-	-	10.4–25.7	2.0–4.2	2.7–5.0	10	2.8	≥6	≥0.8
Protein (g)[7]	10.9	5.0	-	1.41	1.12	16.00	4.5	≥14	≥1.93
Vitamin A (µg ER)	400	126	-	51.8	28.2	127	36.1	1039	143
Vitamin D (µg)	5	5	-	0.65	1.12	0.00	0.00	11	1.51
Vitamin E (mg)	5	-	-	0.65	-	3.6	1.0	8.3	1.14
Vitamin C (mg)	30	8	-	3.9	1.8	24	6.8	90	12.4[8]
Vitamin B-1 (mg)	0.5	0.4	-	0.06	0.09	0.42	0.12	0.20	0.03
Vitamin B-2 (mg)	0.5	0.3	-	0.06	0.07	0.48	0.14	1.40	0.19
Vitamin B-6 (mg)	0.5	0.0	-	0.06	0.00	0.42	0.12	1.00	0.14
Niacin (mg)	6	5	-	0.78	1.12	5.40	1.53	8.00	1.10
Folate (µg DFE)[9]	150	9	-	19.5	2.0	50	14.2	110	15.2
Vitamin B-12 (µg)	0.9	0.0	-	0.12	0.00	0.70	0..20	2.00	0.28
Iron (mg)[10]	11.6	11.1	-	1.50	2.48	10.00	2.84	6.5[11]	0.90
Zinc (mg)[10]	8.2	3.1	-	1.06	1.84	10.00	2.84	5.00	0.68
Calcium (mg)	500	280	-	65	63	240	68	350	48
Iodine (µg)	90	13	-	11.7	2.9	0.0	0.0	40	5.5
Crude fiber (g)			-	-		?	?	<5	<0.7

Notes

[1] Source: WHO/FAO (2004).

[2] Extrapolated from values presented by Lutter *et al.* (2007).

[3] For children aged 12–23 months, and assuming 4 serving sizes per day. Source: Dewey and Lutter (2001).

[4] "Mi Papilla" from Ecuador, a combination of cereals, powder milk, soy flour, and fat. Recommended 2 serving sizes per day for a total daily portion of dry product of 130 g. This product is diluted with water for preparing a porridge that is 3.52 more diluted. Source: Lutter *et al.* (2007).

[5] Corn soy blend plus is a combination of corn (78%), whole soybean (20%), and micronutrients. Forty grams of corn soy blend should be mixed with 250 g of water; *i.e.* a dilution 1:7.25. Source: US Department of Agriculture (2012).

[6] Value for moderate physical activity; boys have a slightly larger requirement than girls. Source: FAO/WHO/UNU (2011).

[7] Source: WHO/UNICEF/Orstrom/University of California at Davis (1998).

[8] The content of vitamin C could be much lower after cooking this food.

[9] Folic acid is 70% more bioavailable than dietary folate, hence the folate content should be divided by 1.7 when folic acid is used.
[10] For low bioavailability (5% for iron and 15% for zinc). If food does not contain phytate and other mineral-absorption inhibitors, the RNI values are half of these amounts.
[11] Iron is from ferrous fumarate (4 mg/100 g) and NaFeEDTA (2.5 mg/100 g), which has approximately double bioavailability than intrinsic iron and other sources of iron in food matrixes rich in phytic acid.

Table 4

Nutrient formulation of different supplements

Nutrients	WHO/FAO RNI for 12–23 mo[1]	RNI considering supply through average breast-feeding[2]	Lipid nutrient supplement[3]	Micronutrient supplements during emergencies WHO (6–59 mo)[4]	MNP-Home Fortification Technical Advisory Group (6–59 mo)[5]	MNP–WHO (6–23 mo)[6]
Dosage (g/d)	-	-	20	-	1 sachet[7]	1 sachet[8]
Energy (kcal)[9]	950	582	108	-	-	-
Fat (g)	-	-	12	-	-	-
Protein (g)[10]	10.9	5.0	-	-	-	-
Vitamin A (µg ER)	400	126	400[11]	400	400	300
Vitamin D (µg)	5	5	-	5	5	-
Vitamin E (mg)	5	-	-	5	5	-
Vitamin C (mg)	30	8	30	30	30	-
Vitamin B-1 (mg)	0.5	0.4	0.3	0.5	0.5	-
Vitamin B-2 (mg)	0.5	0.3	0.4	0.5	0.5	-
Vitamin B-6 (mg)	0.5	0.0	1.8	0.5	0.5	-
Niacin (mg)	6	5	4	6	6	-
Folate (µg DFE)[12]	150	9	136[13]	150	150	-
Vitamin B-12 (µg)	0.9	0.0	0.5	0.9	0.9	-
Iron (mg)	11.6[14]	11.1	9.0[15]	5.8	10.0	12.5[16]
Zinc (mg)	8.2[14]	3.1	4.0	4.1	4.1	5.0[16]
Copper (mg)	-	-	0.2	0.56	0.56	-
Calcium (mg)	500	280	100	-	-	-
Iodine (µg)	90	13	90	90	90	-
Selenium (µg)	17	-	10	1	17	-

Notes

[1] Source: WHO/FAO (2004).

[2] Extrapolated from values presented by Lutter *et al.* (2007).

[3] As used in a research study in Ghana. It also contained phosphorus, magnesium, manganese, linoleic acid (n-6), linolenic acid (n-3), and phytate (82 mg). Source: Adu-Afarwuah *et al*. (2007).

[4] Source: WHO/WFP/UNICEF (2006).

[5] Source: Home Fortification: Technical Advisory Group (2012).

[6] Other micronutrients could be added as required for the epidemiological conditions of the country. Source: WHO (2011).

[7] Between 60 and 180 sachets in 180 days, with an ideal aim of 90 sachets; *i.e.* to supply 50% RNI in average.

[8] One sachet daily for a period of 2 months, followed by a period of 3–4 months off supplementation. Locations: where anemia is 20% or higher.

[9] Value for moderate physical activity; boys have a slightly larger requirement than girls. Source: FAO/WHO/UNU, (2001).

[10] Source: WHO/UNICEF/Orstrom/University of California at Davis. 1998.

[11] As β-carotene.

[12] Folic acid is 70% more bioavailable than dietary folate, hence the folate content should be divided by 1.7 when folic acid is used.

[13] As folic acid (80 µg), and for this reason the table shows 1.7 larger than the value reported in the paper.

[14] For low bioavailability (5% for iron and 15% for zinc). If food does not contain phytate and other mineral-absorption inhibitors, the RNI values are half smaller.

[15] As ferrous sulfate.

[16] Iron preferable as encapsulated ferrous fumarate; and zinc as zinc gluconate.

Annex 1

Malnutrition in Uganda

Surprisingly, the decreasing global trends may not necessarily reflect specific service point trends. For instance, at Mwanamugimu Nutrition Unit, a care point in the national referral hospital in Uganda, there are annual increasing numbers of newly admitted children diagnosed with complicated acute malnutrition (**Figure A1**).

On the whole, an undernourished population is often characterized by cyclical food insecurity, poor infant and young child feed practices, limited access to water and sanitation, social and cultural factors, diseases such as malaria, diarrhea, and HIV, and limited access to health and social services. Effective nutrition practices should be supported by many sectors such as health, trade, education, gender, agriculture, and the environment. Careful regulation of taxation and subsidies may be instrumental in reducing challenges of poor health and food and nutrition insecurity that directly impact nutritional status.

Changing nutritional priorities along the life course

The pandemic nature of overweight and obesity has triggered initiatives to raise awareness and consumption of vegetable foods as suppliers of antioxidants, dietary fiber, and some micronutrients, which in extreme cases has led to total rejection of industry-manufactured foods, promotion of absolute vegetarianism, or adoption of the Paleolithic diet, which is highly dependent on animal foods and small amounts of cereals (Eaton and Eaton, 2000), without realizing the impracticability of these approaches for feeding the world's growing population. Encouraging consumption of a healthy diet is not an easy task. Nutritional requirements vary among members of the same family. Within the same community, some may suffer from micronutrient malnutrition, whereas others are affected by NCD.

For example, high amounts of fiber are appropriate for healthy intestinal motility and reduced reabsorption of cholesterol in older children and adults. However, these amounts are not appropriate for complementary foods for young children (aged 6–24 months). High mineral absorption is needed during this part of the lifecycle, as are adequate calories for growth. More attention should be given to reducing fiber and the associated phytic acid in producing complementary foods. Combinations of soya-wheat and soya-maize flour blends are still considered suitable foods for infants and small children in many countries (Pérez-Expósite and Klein, 2009), even though soya flour contains large amounts of phytate. Unlike cereals, phytate in legume seeds is found in the cotyledon and not the seed cover (Reddy *et al*., 1982). Such blended flours are important for food emergency situations, but they may not be appropriate as complementary foods when food is generally available.

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