Identifying Nutritional Need for Multiple Micronutrient Interventions¹,²

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Abstract

Micronutrient deficiency remains a major public health problem in many countries worldwide with important consequences for the health of the population and child growth and development. The objective of this article is to review information that should be taken into consideration in identifying the need for and in designing micronutrient programs. We review information that could be used to identify nutritional need, including the prevalence of deficiency and evidence of inadequate dietary intake as well as potential data sources and some strengths and weaknesses of such data for program decision-making. We also review factors that might modify the potential impact of programs and that should therefore be taken into consideration in their design. For example, such factors may include access to formal and informal health systems, quality of health provider training, and behavior change communication and complementary or overlapping interventions. Nationally representative data on micronutrient deficiencies and dietary intake are most useful for identifying unmet needs. Although the burden of micronutrient deficiencies lies in low-income countries, few have detailed information on specific deficiencies beyond anemia, and nationally representative dietary intake data are scarce. Nationally representative data may still mask considerable within-country variability by geographic, economic, or ethnic group. Some efforts designed to promote coordination in nutrition programming within countries utilizing information on prevalence, intake, and program coverage and utilization are also reviewed. Improving the quality of such data and ensuring continual updates are vital to guide decision making and to ensure that programs can appropriately respond to needs. J. Nutr. 142: 166S–172S, 2012.

Introduction

Micronutrient deficiency remains a major public health concern in many developed and developing countries around the world.

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It is estimated that up to 2 billion people worldwide are anemic (1). Similarly, millions are affected by iodine deficiency and deficiency of other nutrients such as vitamin A and zinc and likely others (2). Infants and young children are particularly vulnerable to micronutrient malnutrition due to rapid growth in the first 2 y of life and the use of complementary foods with low micronutrient content and/or poor bioavailability.

The impact of a number of interventions to ensure adequate intake and improve micronutrient status on pregnancy outcome (3,4), child growth and development (5–7), and morbidity and survival (8,9) has been documented. Based on this evidence, recommendations exist for many interventions, including dietary diversification and food fortification to increase regular consumption of a number of nutrients in populations, vitamin A supplementation to reduce child mortality, iron folic acid supplementation during pregnancy to improve maternal outcomes and fetal growth, and zinc as adjunct to oral rehydration solution for the treatment of diarrhea. Deficiency data and programs currently tend to focus on iron, iodine, and vitamin A and, to a slightly lesser extent, zinc and folic acid (2,10). This was motivated by evidence that deficiency of these nutrients is high and associated with important functional outcomes. Current evidence suggests, however, that intake of other nutrients may also be inadequate among many populations and interventions to ameliorate negative health impacts may be needed, including, e.g., vitamin D (11,12) and vitamin B-12...
(13). At this time, few countries have considered interventions for micronutrients beyond vitamin A, iron, zinc, iodine, and folic acid; as additional interventions are developed, indicators that permit monitoring these should be included.

Despite the documented efficacy of many micronutrient interventions (impact under controlled conditions), evidence of their impact under programmatic conditions (effectiveness) remains undocumented for most interventions (14). Likewise, evidence is lacking to explain what factors might modify the effect of an intervention, whether implemented as a controlled research study or program. The potential of a micronutrient intervention to improve micronutrient status and functional outcomes is likely dependent on the severity of the micronutrient deficit and the extent to which the intervention addresses the specific causes of deficiency in the population. When implemented under programmatic settings, a number of additional factors could also modify the effect, including the quality and accessibility of health services, training and behavior change communication strategies, and the existence of complementary or overlapping interventions (15).

The objective of this paper is to review information that should be taken into consideration in identifying the need for and in designing micronutrient programs. We will review information that could be used to identify nutritional need for micronutrient interventions, including the prevalence of deficiency and evidence of inadequate dietary intake and potential data sources for such information. We will also review factors that might modify the potential impact of programs and should thus be taken into consideration in their design.

**Identifying Nutritional Need for Micronutrient Interventions**

**Micronutrient deficiency.** The prevalence of deficiency can be identified using clinical signs and/or biomarkers. Relying solely on prevalence of deficiency identifies only those who have reached a state of insufficiency so as to alter biochemical or biological processes. Most biomarkers identify deficiency and cannot be used to assess whether intakes are optimized or whether there is a risk of excess intake. For some (e.g., serum zinc), this is due to tight homeostatic control (16). For others, biomarkers are not specific to the nutrient of interest and we require additional information to adequately interpret values. For example, serum ferritin is elevated as a response to infection or inflammation (16); without markers of inflammation, ferritin values cannot be adequately interpreted. Biomarkers of optimal micronutrient status and not just reduced risk of deficiency would be ideal, but much research would be required to develop them.

Anemia is diagnosed as hemoglobin concentration below a cutoff point and reflects insufficiency in the mass of circulating RBC (1). It is commonly estimated that 50% of cases of anemia are due to iron deficiency (17,18). Given the variability in the prevalence of causes of anemia such as deficiency of other micronutrients, malaria and other parasitic infection, hemoglobinopathies, state of chronic disease or pregnancy, and possibly obesity among and within countries, it is likely that the figure of 50% of anemia due to iron deficiency is not accurate in all contexts (19–21). Thus, without complementary information it is difficult to determine what type of intervention is most appropriate to reduce anemia in any specific context.

Urinary iodine is one of the few commonly used biomarkers that can indicate low, adequate, and excessive dietary intake of iodine. Risk of high intake of iodine using urinary iodine as a biomarker has been identified in some populations (22). Current surveillance systems require strengthening before this indicator can routinely be used to assess risk of excess intake as part of routine monitoring (27).

**Dietary intake.** Micronutrient deficiency occurs when needs and losses exceed dietary intake. A number of factors contribute to needs, including normal metabolism, growth and development, pregnancy and lactation, and disease state (16). Loss of nutrients can also be part of normal physiological processes (e.g., menstruation) and can be highly accelerated during disease and with parasitic infections (16). Nutrient intake can be quantified from consumption of foods with naturally occurring or fortified micronutrients and supplemental sources, but actual uptake of nutrients will depend on multiple factors, including the bioavailability of nutrients in foods and supplements and presence of facilitators and inhibitors of absorption in the diet, among others. For example, the bioavailability of iron from nutritional supplements and fortified foods may depend on the type of iron used (23); for iron and zinc, absorption will depend on the phytate content of the diet (24).

In populations, nutrient intake can be quantified from various types of dietary data, ideally from representative population groups. Most countries recommend a range of age- and sex-specific nutrient intake values associated with minimum risk of insufficient intake and without risk of adverse effects for the majority of the population. To avoid confusion related to differences in terminology across countries, three values have been identified (25). The Average Nutrient Requirement is the average or mean nutrient requirement for a specific age and sex group. The Individual Nutrient Intake Level represents the recommended intake for all healthy individuals in an age- and sex-specific population group, and the Upper Nutrient Level represents the highest intake that is likely to pose no risk of adverse effects for the given group (25). These reference values provide a framework to estimate the range of safe intakes, focusing on minimizing risk of insufficient and excess intakes.

**Data Sources for Identifying Deficiency, Inadequate Nutrient Intake, and Other Causes of Deficiency**

**Data sources on the prevalence of deficiency.** The WHO maintains a repository of information on micronutrient status from its member countries (2). Previously, the VMNIS included only iodine status, vitamin A deficiency, and anemia and relied mainly on multi-nation surveys such as the DHS, UNICEF MICS, and other national surveys. The VMNIS system recently received a considerable upgrade with the objective of improving its functionality for decision making in countries (2). Information sources on micronutrient status will be systematically and regularly updated, including a number of sources not previously considered. The new system will also include additional indicators of micronutrient status, including hemoglobin, serum ferritin, serum transferrin receptor, serum or plasma retinol, serum or plasma retinol binding protein, urinary iodine excretion, serum or plasma zinc, serum or plasma folate, RBC folate, as well as clinical indicators of vitamin A and iodine deficiencies (i.e., night blindness and goiter, respectively) (2).

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2 Abbreviations used: DHS, Demographic and Health Survey; MICS, Multiple Indicator Cluster Survey; REACH, Regional East African Community Health Initiative; VMNIS, Vitamin and Mineral Nutrition Information System.
Although the systematization of this information will be extremely useful, the extent to which it improves accessibility to information on micronutrient status for decision making in countries depends on the availability and quality of information included. At this time, national and within-country representative data for micronutrients beyond vitamin A and iodine and anemia remain scarce for most countries. Nationally representative data will mask considerable variability by geographic region, economic status, and ethnic group within countries. For zinc deficiency, we continue to rely on the prevalence of stunting, an indicator not specific to zinc deficiency (26). Furthermore, the limitations of the existing data for vitamin A, iodine, and anemia to represent the true risk of micronutrient deficiency in populations are clearly recognized. For example, pregnant women and their fetuses are the most vulnerable to the effects of iodine deficiency, yet information on their status is scarce and insufficient to estimate the global burden of deficiency in this group (27).

At this time, logistic concerns related to transportation of biological samples and the cost of analyzing micronutrient biomarkers remain an important barrier to their inclusion in large surveys. The development of noninvasive methods for assessing micronutrient status and laboratory methods that can be used on very small biological samples could do much to improve this. For example, the use of dried serum spots for ferritin obtained from capillary samples holds much promise for assessing iron status in population surveys, though standardization is required and many laboratories in lower resource settings lack the equipment and expertise to analyze this less invasive method (28). There have also been efforts to develop noninvasive tests for quantifying hemoglobin concentration (29), but methods still require validation.

**Dietary intake data.** National level data on food availability such as food balance sheets have been used to assess the adequacy of energy available to meet population needs and have recently also been used to assess adequacy of the supply of vitamin A (30) and zinc (31) at a national level. Although the above-mentioned strategies are useful for planning some national untargeted strategies such as agricultural policies and food fortification, targeted programs such as supplementation require information on nutritional needs of specific age groups or other vulnerable groups. This requires nationally and preferably regionally representative survey data for those groups (16). Few countries have nationally representative dietary intake data from individuals from the past 10 years (Fig. 1) (32–49). Data are particularly scarce for regions of the world with the highest vulnerability to micronutrient deficiency; notably, published data were found for only five countries in Africa, four in South and Central America, and four in South East Asia.

Most countries collect information with some regularity on household income and expenditure (50). Such information distinguishes consumers from nonconsumers (at the household level) and those foods that are purchased from those that are home produced or gifted, a strength distinguishing this data source from food balance sheets. The method permits a proxy estimation of individual consumption based on assumptions of intra-household distribution (adult-equivalent method) (50). The extent to which this is appropriate for consumption among specific vulnerable groups (e.g., pregnant women or children) is currently being evaluated using data from a number of countries in Africa and Asia (Jack Fiedler, personal communication).

**Additional Factors That Should Be Taken into Consideration in Program Design**

Beyond the prevalence of deficiency and quantification of dietary intake, additional information about population characteristics may support the design of context-appropriate interventions to improve micronutrient status. For older children and adults, we may assume that access is a key limiting factor for micronutrient intake. For infants and young children and possibly for pregnant women, traditions related to breast-feeding and complementary feeding and food taboos may also be important causes of inadequate micronutrient intake. Such factors should be taken into consideration in the design of interventions to address deficiency. Some of the same data sets used to document deficiency prevalence, such as the DHS and MICS surveys, usually contain some information related to feeding practices.

Strengths and weaknesses of some data sources can be found in Table 1 (2, 51). For many, particularly the multi-nation surveys such as DHS, attempts have been made to standardize methodologies across sites. Although appropriate to ensure comparability, this may limit flexibility to adapt the surveys to country-specific potential causes of micronutrient deficiency, e.g., traditions related to dietary intake during pregnancy. Some countries such as Mexico have invested in large, national surveys with regional, state-wide, and urban-rural level representative samples, including dietary data and biological indicators of micronutrient status (52). This information, coupled with the wealth of information from program evaluations that exist in Mexico, allows for detailed assessments of need among different groups in the population (53). This has permitted the implementation of specific targeted strategies and the refinement of program targeting criteria to the

![Figure 1](https://example.com/figure1.jpg) Countries in the world with nationally representative dietary intake surveys (food frequency, 24 h recall or both) since 1999. Some countries may have been excluded if at least a summary was not publicly available online in English, French or Spanish (32–49).
<table>
<thead>
<tr>
<th>Source of data</th>
<th>Examples of types of information available</th>
<th>Type of intervention data are useful for</th>
<th>Strengths</th>
<th>Weaknesses</th>
</tr>
</thead>
<tbody>
<tr>
<td>WHO/normative agency reports (e.g. MICS1, VMNIS)</td>
<td>Micronutrient status; anemia</td>
<td>Priority setting for micronutrient deficiency burden</td>
<td>Incorporates multiple data sources and nationally representative where available</td>
<td>VMNIS focuses only on vitamin A, anemia, and iodine</td>
</tr>
<tr>
<td></td>
<td>Stunting, wasting</td>
<td></td>
<td>Most often free</td>
<td>Lack state/local-level specificity</td>
</tr>
<tr>
<td></td>
<td>Information of some determinants of malnutrition, e.g. socioeconomic status, education</td>
<td></td>
<td>Easily accessible</td>
<td>Already out of date at time of publishing</td>
</tr>
<tr>
<td>DHS (CDC)</td>
<td>Micronutrient status; anemia</td>
<td>Valuable for public health policy needs assessment at national/state level</td>
<td>Often nationally representative with data collected and reported by state, urban vs. rural dwelling, socioeconomic status, gender, and smaller age group</td>
<td>Exhaustive in other health measures, not biochemical micronutrient status</td>
</tr>
<tr>
<td></td>
<td>Stunting, wasting</td>
<td></td>
<td>Free access</td>
<td>Possible language barriers</td>
</tr>
<tr>
<td></td>
<td>Information of some determinants of malnutrition, e.g. socioeconomic status, education</td>
<td></td>
<td>Includes anemia prevalence and night blindness during pregnancy</td>
<td>No dietary intake data (FFQ/24 h)</td>
</tr>
<tr>
<td>Ministry reports</td>
<td>Routine monitoring of nutritional status (e.g. stunting, wasting, anemia)</td>
<td>In-country design of targeted micronutrient interventions</td>
<td>May provide details at local level (e.g. inter-state variability)</td>
<td>Often unpublished</td>
</tr>
<tr>
<td></td>
<td>Coverage and utilization of routine health services, vaccinations</td>
<td></td>
<td>Recently, many include biomarkers of vitamin A, iron, others</td>
<td>Language barriers common inconsistent methodology</td>
</tr>
<tr>
<td>Peer-reviewed literature</td>
<td>Detailed information of micronutrient status and determinants</td>
<td>Any program for supportive literature reviews</td>
<td>Scientific rigor</td>
<td>Often not nationally representative</td>
</tr>
<tr>
<td></td>
<td>Effect of interventions in specific context</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>NGO reports</td>
<td>Descriptions of programs implemented/supported</td>
<td>Context-specific regional/national intervention design</td>
<td>Boutique expertise</td>
<td>Often not nationally representative</td>
</tr>
<tr>
<td></td>
<td>Coverage and utilization of services</td>
<td></td>
<td>Experience in a specific setting</td>
<td>Inconsistent methodology and presentation</td>
</tr>
<tr>
<td></td>
<td>Needs assessment (e.g. prevalence of nutritional problems and their determinants)</td>
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</table>

1 DHS, Demographic and Health Survey; MICS, Multiple Indicator Cluster Survey; NGO, nongovernmental organization; VMNIS, Vitamin and Mineral Nutrition Information System.
most vulnerable. Many countries would not be in a position to make such a large investment. At a minimum, information should be available for the administrative level at which programs will likely be implemented. For example, if a country considers targeting a program to the most vulnerable provinces, then information should be available by province to prioritize their inclusion in the program.

One aspect of need that is often inadequately documented is the availability and utilization of existing programs and strategies to improve micronutrient status. Coordinated program delivery may or may not be effective among governmental and nongovernmental organizations operating within a single region and even across different government sectors within a country. A number of initiatives exist to support this process, including the REACH and WHO Core health indicators (54,55). The REACH Initiative serves as a knowledge broker for east African health programs, and the Core health indicators report world health statistics from the WHO database. Although promising, the REACH Initiative is still in its infancy and the Core health indicators, though exhaustive, lack information about specific indicators of micronutrient status. In addition to nutrition-specific interventions, programs that may complement strategies should be considered in the design of micronutrient interventions. For example, social protection programs may be complementary to efforts to reduce micronutrient deficiency by facilitating access to the population in which micronutrient deficiency is high. An excellent example of such complementarity is conditional cash transfer programs that have been shown to increase the use of health services among the poor in a number of countries (56). At this time, only the program in Mexico has been used as a delivery platform for a micronutrient intervention, specifically the free distribution of a micronutrient-fortified food for pregnant and lactating women and complementary food for children 6–24 mo of age (57).

A number of factors might limit or facilitate the successful implementation of interventions, including utilization of formal and informal health services in the population, quality and regularity of training of health personnel, and coverage of other vital health services such as immunization and growth monitoring. Such factors have been shown to be important modifying factors in the success of implementation of the Integrated Management of Childhood Illness program, including the success of vitamin A supplementation (58).

The WHO’s Nutrition Landscape Information System (59) provides access to country profile information on the nutrition situation in the country, existing programs, infrastructure, and a number of measures of country commitment, capacity, and other factors vital for understanding the need for further interventions. Like the VMNIS and other compiled data sets, the utility of this information system will depend on the quality of the information included and the frequency with which it is updated to ensure that it reflects the current situation.

Summary and Conclusions

Micronutrient interventions should be implemented in response to a demonstrated need, whether that is the prevalence of deficiency or evidence of insufficient dietary intake to meet the needs of the majority of the population and a lack of existing programs to address that need. Up-to-date information on the prevalence of deficiency beyond vitamin A and iodine is scarce for most countries in the world and particularly for many of those with the highest risk of deficiency. Even when available, national-level data may be insufficient to identify vulnerable groups due to variation in dietary intake and deficiency prevalence by region, economic status, or other factors. The need for information to guide policy and program development in nutrition has been recognized (59) and some advances to the systematization of data collection and dissemination have been made.

Most recommendations and guidelines are intervention specific and do not provide clear indications or contra-indications on the simultaneous implementation of multiple interventions. This limits our ability to predict risk of excess consumption in contexts where multiple interventions exist or where changes to dietary patterns have improved usual intake of micronutrients. For example, guidelines for the management of severe acute malnutrition should clearly specify whether other interventions likely to be implemented in the country, such as vitamin A supplementation, zinc with oral rehydration solution for treatment of diarrhea, and home fortification (micronutrient powders and/or lipid-based nutrient supplements) should be suspended during treatment and when these should resume. Although this may not yet be a problem in most countries with a high burden of micronutrient deficiency, monitoring and evaluation systems should be in place that would permit such reflections over time.

In addition to clear guidance, programs should assure accurate monitoring and evaluation and include indicators beyond simple measures of program coverage to ensure that trends on coverage and utilization of programs can be tracked over time. For some interventions such as vitamin A supplementation, coverage might be an acceptable proxy for utilization as the intervention is delivered directly by trained personnel. For such interventions, data from large surveys have been used to identify characteristics of those not receiving the program (60) and provide contextual factors that might help improve program implementation and estimate potential impact. Adding a module to such surveys on receipt and utilization of other programs that might affect vitamin A intake and status would be useful for assessing overlap and complementarities. For other programs, e.g., iron-folic acid for pregnant women and micronutrient powders or lipid-based supplements for children, coverage estimates do not reflect the extent to which the supplements were consumed or the regularity, duration, or mode of use. Consistent collection, analysis, and reporting of such information would complement deficiency and dietary intake data and allow for the accurate mapping of nutritional shortfalls and help determine whether existing interventions are likely to meet that need.

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