Prioritizing Nutrition Interventions: Modeling Impact on Health

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Key messages

- Understanding the potential public health impact of different nutrition program scenarios and related cost investments (cost-effectiveness) can help inform decision-making.
- Modeling tools assist in prioritizing implementation of nutrition programs by simulating their effect related to their investment costs. Effects can be modeled on population proportions with adequate intakes, reduced mortality, or overall health impact.
- Composite metrics such as the disability-adjusted life year (DALY) contain multiple dimensions of disease / health, which makes them particularly suitable for comparing risks against benefits and health impacts of alternative nutrition programs.
- The public health impact of nutrition programs can be substantial compared to the costs of these programs, and data collection and analysis to evaluate cost-effectiveness is a valuable investment.

The need for approaches that model the health impact of nutrition interventions

Significant research over the past decade has advanced our understanding of the impact and cost-effectiveness of nutrition interventions aimed at reducing maternal and child morbidity and mortality in developing countries. Substantial evidence exists to indicate that by addressing micronutrient deficiencies, countries can make significant progress towards achieving the Millennium Development Goals.[1]

Several guides for program planners exist that assist in nutrition program design by guiding the approach so as to improve the design, delivery, and effectiveness of nutrition interventions. However, few tools currently exist that can be used by policymakers to translate available scientific knowledge into concrete and strategically prioritized investment decisions. For example, supplementation, fortification, and biofortification are all approaches that can potentially reduce micronutrient deficiency. However, the choice of the appropriate cost-effective nutrition intervention strategies for national control programs is difficult. Cost-effectiveness of programs depends on distribution of micronutrient inadequacy, potential for effective coverage, and program delivery costs. There is the risk of providing insufficient or excessive amounts, missing those at risk, or else of redundant coverage, and with it, unnecessary costs. Such decisions require an understanding of the micronutrient intake distributions in the various population groups and geographic regions, the related magnitude of the nutritional problem, and the population groups and regions affected. Moreover, it requires the ability to estimate the health impact that can be achieved by different intervention portfolios designed to address the same problem but directed at targeted population segments or subgroups.

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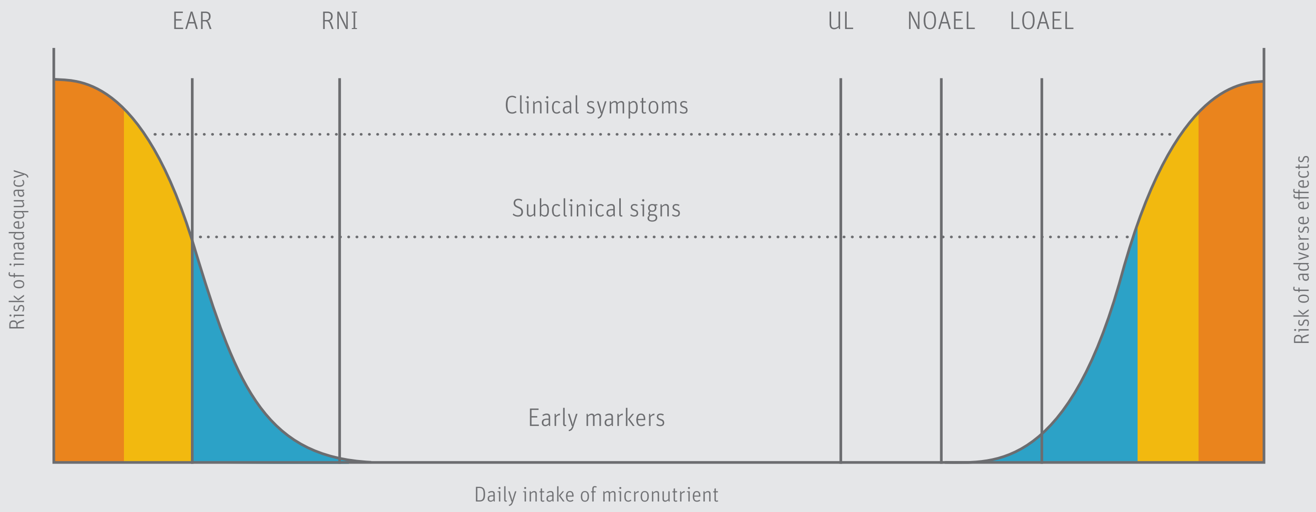
According to the definition by WHO, health impact assessment is a means of assessing the health impacts of policies, plans and projects in diverse economic sectors using quantitative, qualitative and participatory techniques.[2] A health impact

FIGURE 1: Dose-response relationship between micronutrient intake and adverse effect risk in terms of incidence and severity (based on Renwick, 2004 and 2008[6,19])



EAR: Estimated Average Requirement **RNI:** Reference Nutrient Intake **UL:** Upper Tolerable Intake Level
NOAEL: No Observed Adverse Effect Level **LOAEL:** Lowest Observed Adverse Effect Level

assessment can help decision-makers to make choices about alternatives to, and improvements to, programs to prevent disease/injury and to actively promote health. There is growing need for tools that can help decision-makers to select nutrition intervention strategies that achieve optimal health impact with the fewest risks, and the lowest costs, while targeting vulnerable but underserved populations.

A tool that estimates lives saved by health interventions

The Lives Saved Tool (LiST) is a tool recently developed with the aim of informing program managers and public health policymakers about the possible impact of different health intervention packages.[3,4] The tool helps estimate the impact of introducing or scaling up a variety of existing child health interventions (e.g., newborn resuscitation, oral rehydration therapy, hand washing, measles vaccine, antimalarials) within countries and given local conditions. The output provided by the LiST tool is the number of mortalities averted plus costing results for feasible increases in coverage. The tool was recently used to estimate mortalities averted at estimated costs of different selected high-impact maternal, newborn, and child health interventions in different Sub-Saharan African countries.[5] This computer-based tool allows users to set up and run multiple scenarios to look at the estimated impact on mortality of different health intervention packages and coverage levels for their countries, states or districts.

There is, however, still need for a tool that helps to prioritize investments in different nutrition programs based on their estimated health impact in relation to costs of their implementation. Such a tool could help decision-makers to select nutrition intervention strategies that achieve optimal health impact with the least risks, using available resources while targeting critical but underserved populations.

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A method that estimates the impact of increasing nutrient intakes on the population fraction with inadequate intakes

At intakes below the estimated average requirement (EAR), the risk of inadequacy is estimated to be 50% or more;[6,7] at intakes between the EAR and reference nutrient intake (RNI), the risk of inadequacy is still between 50% and 2–3%[6,7] (**Figure 1**). The risk of adverse effects due to excessive intake may start to increase with intakes above the no observed adverse effect level (NOAEL) or the lowest observed adverse effect level (LOAEL), although the true risk function is not known for most nutrients (**Figure 1**). To establish a maximum safe intake level that is unlikely to pose a risk of adverse health effects, an upper tolerable intake level (UL) is developed. This is set an uncertainty factor (ranging from 1 to 10) lower than the NOAEL or LOAEL in order to account for uncertainty of the data.[8]

To estimate the effect of food fortification on population numbers with adequate nutrient intakes, the EAR cut-point method can be used. As its starting-points, the EAR cut-point method assumes that the proportion of a population with intakes below the EAR and above the UL for a given nutrient corresponds to, respectively, the proportion having inadequate and the proportion having excessive intake of that nutrient.[9–11] The effect of different fortification scenarios on population intakes below the EAR and above the UL can be simulated using IMAPP, an Intake Monitoring, Assessment and Planning Program.[12] Population fractions with intakes below the EAR and above the UL provide, however, little information on the magnitude of the health risk.[6] In some cases, more in-depth understanding may be required. For example, the UL for niacin for adults is 35 mg/d, an uncertainty factor (UF) 1.5 (indicating a good level of confidence in the data) lower than the LOAEL for niacin of 50 mg/d. The adverse effect noted is a relatively benign vasodilatation causing flushing of the skin, an effect that is reversible by reducing intake. The UL for vitamin B_6 is 100 mg/d for adults, an uncertainty factor 2 lower than the NOAEL of 200 mg/d. The adverse effect observed – sensory neuropathy – is a serious and irreversible condition. Therefore, public health concern over a segment of the population routinely consuming niacin in excess of the UL would not be as great as if a segment of the population were routinely consuming vitamin B_6 in excess of the UL.

Assessing the impact of nutrient deficiency control programs on nutrient adequacy and costs

Recently, a useful model has been developed that aims to optimize the "impact" of nutrient deficiency control programs within specified budget and specified coverage, or to minimize cost at specified impact and coverage.[13] The model requires estimates of the number of individuals in a population group with inadequate intakes, reflected by intakes below the EAR. The model requires, in addition, an estimate of the program coverage, i.e., the proportion of the population at risk of inadequacy annually exposed to the program. The model simulates the "impact" of alternative interventions by modeling the number of individuals converted from inadequate to adequate intakes, represented by individuals with intakes meeting their EAR.[12] The effective coverage is estimated as the target population at risk of inadequacy exposed to the program and converted to adequacy. The costs of delivering the intervention per individual effectively covered can be used as an indicator of cost-effectiveness. In Cameroon, this prioritization model was used to predict the effects of alternative nutrition intervention strategies on the averted number of children with inadequate vitamin A intake and absorption.[13]

The different strategies that were simulated included micronutrient powders, high-dose vitamin A supplements, fortified and biofortified foods, and deworming. The effect of high-dose vitamin A supplements on the number of individuals with adequate intakes was estimated from a kinetic model of liver vitamin A stores by determining the additional dietary intake needed to maintain adequate liver stores.[14] National surveys to determine the spatial distribution of micronutrient deficiencies among population subgroups at greatest risk, regional data on food intake, and estimated costs of the different interventions served as inputs for the model. The method identified large spatial differences in micronutrient inadequacies in Cameroon. Currently efforts are ongoing to link this impact and cost optimization model with the Lives Saved output of the LiST tool.

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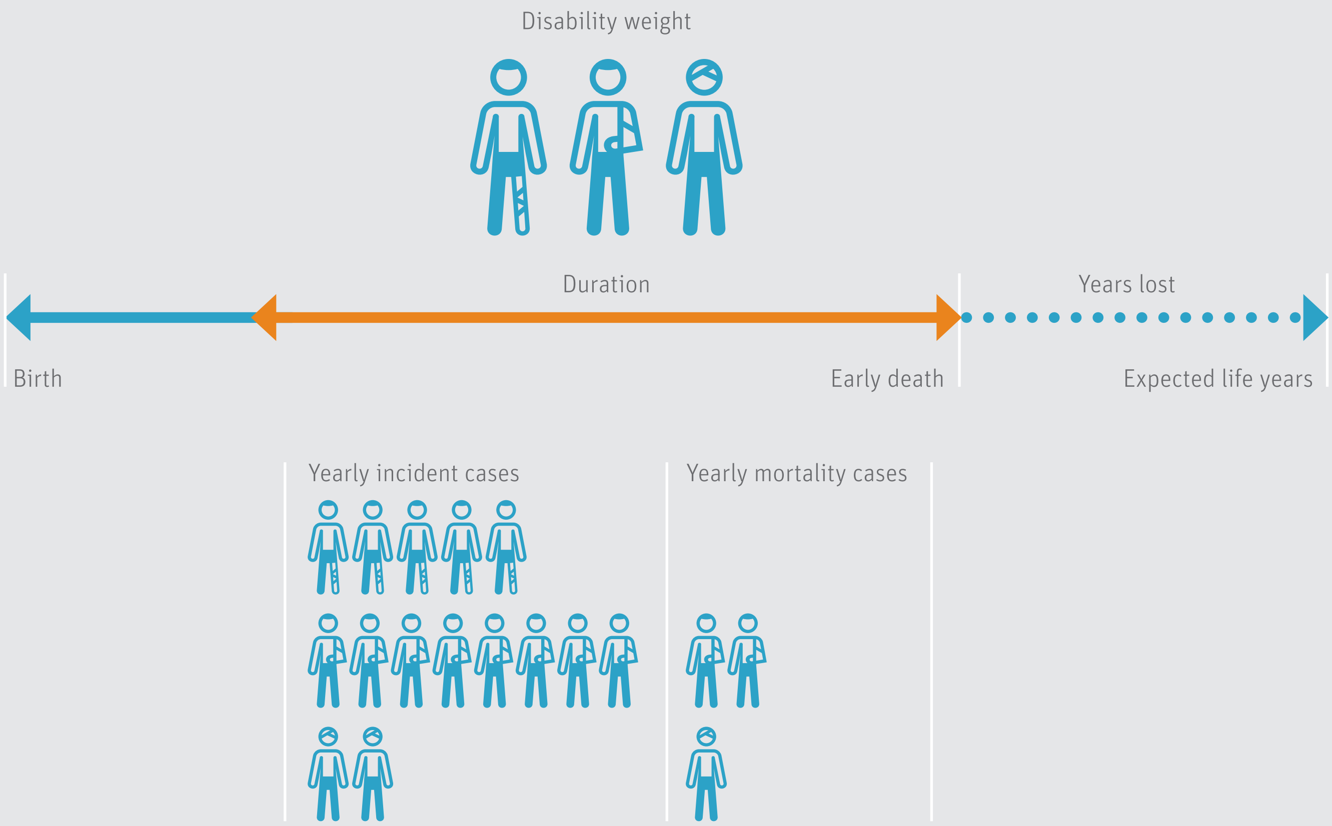
In some cases, inadequate intakes in the population may provide insufficient information for decision-making, as it does not pertain to the full range of relevant health dimensions associated with a certain public health problem. The morbidities of different nutrient inadequacies vary widely, from growth retardation through impaired immune function, blindness, skin disorders, hypogonadism and anorexia, to cognitive dysfunction. The health consequences of these morbidities not only depend on the number of people affected, but also on the severity and the time lived with the disorder, and related mortality. In these cases, incorporating various relevant health attributes in a composite health metric may improve the decision-making process.

Assessing the health impact of nutrition programs using composite metrics

Many health impact metrics present limitations for priority setting: they do not permit comparisons across different interventions or health areas. However, health metrics that capture different dimensions of disease or health are useful tools to estimate the existing disease burden or health impact of a public health intervention. Evaluation of the existing potential "health impact" of a nutrition intervention is an important basis to help decision-makers reach informed decisions in prioritizing cost-effective public health solutions.

An example of a widely accepted effectiveness indicator is the disability-adjusted life year (DALY). The DALY is a compos-

FIGURE 2: The Disability-Adjusted Life Year (DALY) is a quantitative composite measure of disease burden and comprises different aspects of disease burden, such as years of life lost due to adverse effects as well as the incidence, duration and severity of the adverse effects. The health impact of a (nutrient or health) intervention can be expressed as DALYs averted.



ite health metric and combines the incidence rates of mortality and adverse health effects due to a disease or nutrient deficiency, as well as the severity, duration, and frequency of the adverse effects (**Figure 2**). The DALYs averted can be used to assess and compare cost-effectiveness of diverse country programs by relating their cost savings and investments to their health impact. Moreover, DALYs averted can be used to compare the health impact of addressing different types of nutrient inadequacies.

For example, the magnitude of disease burden may differ substantially between different types of nutrient inadequacies: deficiencies of vitamin A and zinc were estimated to be responsible for a combined 9% of global childhood DALYs, and iron and iodine deficiencies combined for 0.2%.[15] This difference in disease burden is largely attributable to the large number of deaths resulting from vitamin A and zinc deficiency. DALYs can be used in risk-benefit modeling by comparing the public health gain from reducing nutrient inadequacy to possible health loss from excessive intakes. A tool[16] and software[17] have been made available by WHO that can assist policy-makers in estimating the public health burden in terms of DALYs. Risk-benefit software tools are also available.[18]

"DALYs can be used in risk-benefit modeling by comparing the public health gain from reducing nutrient inadequacy to possible health loss from excessive intakes"

Limitations and opportunities

Data collection is a first important step in understanding the current distribution of prevalence of food and nutrient consumption by region and population group. This can be used to provide an indication of the nutrient inadequacies that require policy attention. A next step in prioritizing possible nutrition interventions is to qualitatively or quantitatively estimate their impact. The most straightforward method merely considers a single determinant

TABLE 1: Metrics of program effectiveness due to a nutrition intervention

Metric	Impact assessment
Inadequate intakes	↓ number of people with intake < EAR
Mortality	↓ number of people dying from nutrient inadequacy
Disease burden	↓ number of people dying from nutrient inadequacy
	↓ number of disabled life years (incidence, duration, and severity of adverse effects)

of program impact in terms of increased prevalence or incidence of the population with adequate intakes. The advantage of this method is that it is relatively straightforward, requiring mostly estimates of shifts in nutrient adequacies and program coverage in the population. An advanced impact-cost prioritization tool has recently been developed that facilitates the prioritization of different programs based on their expenditures and their effect on number of the target population with adequate intakes (**Table 1**). This prioritization tool considers whether program expenditures are used efficiently to reach those in need without exposing others to possible risk of excessive intakes. LiST is another tool that prioritizes programs based on their impact on mortality (**Table 1**), which is a reasonable proxy of disease burden at young ages, since mortality at young ages contributes substantially to disease burden. However, the benefit of nutrient or health interventions may not be limited to lives saved; it may also extend to benefits for health (e.g., reduced disease severity or duration).

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When addressing a single nutrient inadequacy, the number of individuals converted to adequate intakes may provide an adequate indication of program impact that may serve as a basis for program prioritization. However, when prioritizing the impact of addressing different types of nutrient inadequacies with different health burdens, this may require a different approach that considers multiple health dimensions. Composite metrics constitute a valuable tool by incorporating different morbidity aspects and mortality in one measure (**Table 1**). They will demonstrate that the biggest impacts are achieved by investing in the mitigation of those nutrient inadequacies that involve chronic disabilities, and the highest death toll. The use of composite metrics has the advantage that the health impact of different nutrition and health interventions can be equally compared, relating them to program investments. Composite metrics also allow for equal comparison of health risks related to inadequate against excessive nutrient intakes. The method of estimating composite metrics is, however, more complicated, requires morbidity and mortality data, and can be subject to uncertainties when based on too many assumptions.

The main limitation in assessing health impact is that, in poor-resource settings, the data available are often limited. Representative quality population data on dietary intake are scarce, data on micronutrient-inadequacy-related adverse effect incidence and mortality are even scarcer, and frequently little is known about the anticipated program costs. Another limitation is the difficulty of estimating the proportion of the population at risk who will be effectively covered by the program. Meaningful modeling requires adequate data inputs. However, the savings from better planned and implemented programs can be much greater than the costs of data collection and analysis. Optimization modeling and application of quantitative metrics is promising, as it enables policy-makers to take informed decisions, and countries to choose vital, cost-effective nutrition interventions.

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