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Vitamin and mineral deficiencies technical situation analysis: a report for the Ten Year Strategy for the Reduction of Vitamin and Mineral Deficiencies

*Tina Sanghvi, Marc Van Ameringen, Jean Baker, and John Fiedler, guest editors**

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Acronyms and abbreviations

A2Z	USAID Micronutrient and Blindness Project	INACG	International Nutritional Anemia Consultative Group
ADB	Asian Development Bank	INCAP	Institute of Nutrition of Central America and Panama (Guatemala)
AED	Academy for Educational Development	INTA	Institute of Nutrition and Food Technology (Chile)
BAFF	Business Alliance for Food Fortification	IUNS	International Union of Nutritional Sciences
BASICS II	USAID Basic Support for Institutionalizing Child Survival	IQ	intelligence quotient
CDC	Centers for Disease Control and Prevention	IVACG	International Vitamin A Consultative Group
CDD	control of diarrheal diseases	IVB	WHO Immunization, Vaccines and Biologicals
CFNI	Caribbean Food and Nutrition Institute	IZiNCG	International Zinc Nutrition Consultative Group
CFTRI	Central Food Technological Research Institute (India)	JHU	Johns Hopkins University
CHW	child health week	LHV	Lady Health Visitor (Pakistan)
CI	confidence interval	MCH	maternal and child health
CIDA	Canadian International Development Agency	MDG	Millennium Development Goal
DALY	disability-adjusted life year	MI	Micronutrient Initiative
DFID	Department for International Development (UK)	MOH	Ministry of Health
DHS	Demographic and Health Surveys	MOST	USAID Micronutrient Project
ECSA	Eastern, Central, and Southern Africa	MT	metric ton
EPI	Expanded Program of Immunization	MTSP	medium-term strategic plan
FCHV	Female Community Health Volunteer (Nepal)	NCP	Nutrition Center of the Philippines
FDA	Food and Drug Administration	NFNC	National Food and Nutrition Commission (Zambia)
FFI	Flour Fortification Initiative	NGO	nongovernmental organization
FNRI	Food and Nutrition Research Institute (Philippines)	NID	national immunization day
FTE	full-time equivalent	NIN	National Institute of Nutrition (India)
GAIN	Global Alliance for Improved Nutrition	NTD	neural tube defect
GDP	gross domestic product	OMNI	USAID Micronutrient Project
GH	USAID Global Health Office	ORS	oral rehydration solution
GI	gastrointestinal	PEM	protein-energy malnutrition
GNP	gross national product	PROFILES	Process for nutrition analysis and policy advocacy
GTZ	Deutsche Gesellschaft für Technische Zusammenarbeit (German Technical Cooperation Agency for International Development)	RCT	randomized controlled trial
HH	household	REC	Regional Economic Community
HIV/AIDS	Human Immunodeficiency Virus/Acquired Immunodeficiency Syndrome	SCN	Standing Committee on Nutrition (UN)
HKI	Helen Keller International	SD	standard deviation
ICCIDD	International Council for Control of Iodine Deficiency Disorders	SSDS	Social Sectors Development Strategies
ICDS	Integrated Child Development Services (India)	TB	tuberculosis
IDA	iron deficiency anemia	TFNC	Tanzania Food and Nutrition Center
IDD	iodine deficiency disorders	UI	urinary iodine
IDPAS	Iron Deficiency Project Advisory Service	UNC	University of North Carolina
IDRC	International Development Research Centre (Canada)	UNICEF	United Nations Children's Fund
IEC	information, education, and communication	USAID	US Agency for International Development
IFA	iron and folic acid	USI	universal salt iodization
IIH	iodine-induced hyperthyroidism	VAD	vitamin A deficiency
ILSI	International Life Sciences Institute	VITAL	USAID Global Vitamin A Project
IMCI	integrated management of childhood illness	VMD	vitamin and mineral deficiency
		WFP	World Food Programme
		WHO	World Health Organization

Foreword

Adequate amounts of vitamins and minerals are essential to human health and development. Despite this reality there is a high prevalence of micronutrient malnutrition in many parts of the world. In an effort to better coordinate work to improve the micronutrient health and well-being of those most in need, key individuals representing government, intergovernmental and nongovernmental organizations (NGOs), and the private sector have decided to participate in a global strategy.

As a result, the Global Alliance for Improved Nutrition (GAIN) was asked to coordinate the Ten Year Strategy for the Reduction of Vitamin and Mineral Deficiencies. During the first phase of this collaboration, the Academy for Educational Development (AED) conducted the *Vitamin and Mineral Deficiencies Technical Situation Analysis*. This report summarizes technical information about vitamin and mineral deficiencies (VMDs), identifies gaps in data and programs, and is also a call to action. More specifically, it explores key issues related to VMDs: (i) their magnitude; (ii) the ways in which deficiencies in vitamin A, iron, iodine, zinc, and folate can be reduced; (iii) the costs and benefits of reductions in VMDs; and (iv) the role of international organizations in the drive to reduce VMDs.

The report argues that despite progress in certain countries, serious gaps remain, and there are “few safeguards to ensure that the gains already made are sustained.” This raises a point of concern given that malnutrition has long lasting effects on individuals

and can undermine the socioeconomic development of a country. Noting that strategies aimed at reducing VMDs must necessarily be multisectoral in approach, several critical elements are identified for an effective strategy moving forward. These include forging substantive links between policies, action plans, and institutional arrangements at the global, regional, and national levels; developing appropriate capacities for planning and implementing programs to reduce VMDs at the national level; facilitating partnerships between the public and private sectors with the aim of developing and delivering affordable and effective solutions; providing adequate financial resources; and increasing awareness of the dangers of malnutrition.

Recognition must go to the Ten Year Strategy Reference Group, whose contributions are reflected in the following pages, and to the Bill and Melinda Gates Foundation for their financial support to this project. This publication is a challenge to all of us, in the public, private, and nonprofit sectors, to collaborate in the development, production, and promotion of foods that will prevent and control VMDs and improve the health and well-being of over 2 billion of the world’s population.

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*Ten Year Strategy for the Reduction of Vitamin
and Mineral Deficiencies*

Summary

Micronutrients are among the best buys in development, according to economists and public health leaders. At the United Nations General Assembly Special Session on Children in May 2002, UN Secretary-General Kofi Annan, 70 heads of state, and high-ranking government delegations from 187 countries committed to reducing VMDs among children. This level of global commitment was based partly on the substantial evidence of the negative impacts of VMDs and on the availability of proven, cost-effective interventions. Unfortunately, currently available data on the magnitude of deficiencies and program coverage levels indicate that only a small part of the vulnerable populations has been reached with effective interventions. A notable exception is iodized salt, the use of which has successfully prevented a high incidence of iodine deficiency worldwide.

This report summarizes the current technical information about VMDs and identifies gaps in data and intervention programs. It is intended to inform the development of a future comprehensive multidonor strategy for accelerating the reduction of VMDs in the next decade.

Why reducing VMDs is critical for development

Micronutrients have proven to be essential for chemical processes that ensure the survival, growth, and functioning of vital human systems. Large field trials and observational studies have documented reductions in maternal and child mortality and morbidity. This includes the prevention of disabilities such as neural tube defects (NTDs) and child blindness, protection of learning abilities and progress in school, and improved adult capacity for physical labor.

At current prevalence levels, vitamin A deficiency (VAD) accounts for 9% of child deaths and 13% of maternal deaths. Iron deficiency causes about half of all anemia, and anemia in pregnancy contributes to 18%

of maternal deaths and 24% of perinatal deaths. Intellectual impairment occurs in babies born to iodine-deficient mothers. Zinc deficiency is a contributing cause of 5.5% of child deaths. Folic acid-preventable NTDs are estimated to number 240,000.

Studies measuring productivity impacts have found that countries stand to lose about 1% of their gross domestic product (GDP) if iron, iodine, and zinc deficiencies persist. The cost of reversing these deficiencies is a small fraction of that loss of GDP. According to the available evidence, inaction could delay the achievement of the Millennium Development Goals (MDGs) in countries with a high burden of VMDs.

How widespread are the deficiencies and what are their causes?

Deficiencies of vitamin A, iron, iodine, zinc, and folate affect over 2 billion people. Countries in sub-Saharan Africa and South Asia have both the largest prevalence rates and the largest absolute numbers of micronutrient-deficient people. The global prevalence of vitamin A and iodine deficiencies, particularly in their severe forms, has declined significantly in the last three decades as a result of large-scale programs but prevalence remains high in some countries. Data on iron deficiency are virtually nonexistent; the available information on a related indicator—anemia—suggests little improvement in that area in the past thirty years.

VMDs are caused by diets that are poor in vitamins and minerals, and the deficiencies are made worse by losses or poor absorption related to illness. These conditions are found in every region of the world. Transitions in food consumption patterns with rising incomes have not taken care of all deficiencies. Moreover, the rise of new infections and the resurgence of old ones, such as malaria, have prevented reductions in deficiency diseases in some regions.

Available global databases report that an estimated

25% of preschool-aged children and 18% of women worldwide are vitamin A-deficient; 37% of the total population has anemia; 35% of the population is at risk for iodine deficiency; and 20% is estimated to be at risk for zinc deficiency. The figures for vitamin A and iodine deficiencies are likely to be overestimates, as programs have expanded since the last estimates were developed.

There are significant gaps in the data that are currently available. This reflects inadequate resources to update prevalence figures and track coverage trends. For example, household (HH) coverage with iodized salt is estimated to be substantially greater than currently reported in global databases, and the prevalence of iodine deficiency lower. Some indicators of VMDs need to be better defined, and field methods streamlined for broader use. The deficiencies are often overlapping and the same person can experience more than one deficiency. But the magnitude and patterns of multiple micronutrient deficiencies are not well defined. Disaggregated food intake data are particularly lacking for critical age groups and income segments, and the precision of projected consumer trends associated with demographic transitions needs to be improved.

How well have programs performed in reducing VMDs?

Dramatic reductions in national indicators of mortality and clinical signs of deficiency diseases associated with a rise in program coverage have proved the effectiveness of two intervention approaches: fortification and supplementation. Both are highly cost-effective compared with other health interventions, especially fortification as shown by a reduction in NTDs following folic acid fortification of flour and the elimination of ocular signs of VAD after vitamin A fortification of dairy products. But fortification alone cannot solve the problem of VMDs in any country. Supplementation is an essential component of successful strategies to address the needs of critical target groups. The intake of foods naturally rich in micronutrients can reinforce the benefits of fortification and supplementation; breastfeeding for infants is particularly critical, as are the use of animal foods and fruits and vegetables in diets of women and children.

The evidence of program effectiveness includes sharp reductions in childhood mortality following vitamin A supplementation in countries as diverse as Nepal, Nicaragua, and Tanzania; lower incidence of severe disabilities among newborns following prenatal folic acid fortification; and the virtual elimination of severe clinical deficiencies of iodine and vitamin A in several countries.

Despite progress in some countries, serious gaps

remain. And there are few safeguards to ensure that the gains already made are sustained. In emergencies, when food and health systems are disrupted, intervention strategies tailored to reach the most vulnerable need to be put into place rapidly. Most importantly, even in stable situations large populations in South Asia and sub-Saharan Africa do not have access to adequately fortified foods or supplements. For example,

» According to UNICEF's 2004 database (containing data from 1998–2003) for iodized salt, among 116 countries with HH data, only 62% had coverage of 50% or more.

» In 2004, of 196 countries with data, 73 countries provided vitamin A supplements linked with routine immunizations or immunization campaigns, or both; over 60 countries did not link vitamin A with immunization; and 56 countries were not classified as deficient. Few countries provide vitamin A without linking with immunizations but immunization programs do not reach a large proportion of children in the 1 to 5 year age group.

» On paper, prenatal iron supplementation is universally included in antenatal care policies, but only about 40 countries report data on coverage with prenatal iron supplements. The quality of these data is also questionable. Those countries with data show very low coverage, probably due to poor supplies, and compliance is a significant problem. More than 22 countries have adopted public health policies for iron supplementation for infants and preschool-aged children, but few countries actually implement such programs.

» The value of zinc in reducing morbidity from diarrheal diseases was demonstrated several years ago, but few countries have established policies to introduce zinc within diarrheal disease control programs.

» Programs to improve folate nutrition have been introduced in about 40 countries; these countries account for less than 10% of NTDs that can be prevented with folic acid.

This slow progress could change rapidly. The roadblocks to achieving high coverage—such as policies, supplies, quality assurance, training, monitoring and supervision, and public education and communications—are well known and can be addressed with available tools and methods, adequate resources, leadership, and political commitment. The interventions are affordable and highly cost-effective.

Program approaches and delivery strategies have undergone important transformations over the past two decades. New products, market channels, and health delivery approaches have opened up more options to meet country-specific needs. For example, a broader array of fortified staple foods and specially formulated foods and supplements are now available

through a larger number of producers. Processes and frameworks for successful industry-led and government-mandated strategies for delivering micronutrients are being worked out. Better coverage has recently been documented among high-risk groups, even in remote areas, using intensified outreach from health facilities to deliver micronutrients. Several large countries in South Asia offer government-supported program platforms—such as Integrated Child Development Services (ICDS) in India, Lady Health Visitors (LHVs) in Pakistan, and Female Community Health Volunteers (FCHVs) in Nepal—that are capable of reaching a substantial segment of the vulnerable population. In all regions, employer health schemes can support micronutrient interventions with direct payoffs in worker productivity, especially among women of reproductive age; schools can deliver vitamins and minerals with substantial payoffs in attendance and learning. These programs have produced promising results in some countries.

While activities to increase the provision of micronutrients expanded, consumer demand for micronutrient-rich foods has also accelerated. The livestock and dairy industries have grown rapidly in response to burgeoning demand from consumers in developed and developing countries. There is some evidence that fruit and vegetable consumption will rise with incomes in sub-Saharan Africa. It appears unlikely that this increase is a result of attempts to improve dietary diversity through traditional nutrition education efforts, as there is little evidence that these programs have achieved sufficient scale. Analysts believe that favorable costs for production and marketing, affordable prices, and the image of these foods as prestige foods may have fueled the increase in demand. The recent trend in developing countries toward centrally managed food retailing for all foods through large supermarket chains offers a new opportunity for consumer education and greater product choices with the goal of further raising micronutrient intakes.

There are additional options for improving micronutrient status beyond fortification, supplementation, and changing food choices. Research and field trials currently under way suggest that plant breeding to develop new varieties of foods high in vitamin and mineral content could substantially contribute to improved micronutrient status. Among health interventions that have proved effective in supporting the reduction of VMDs are malaria control and deworming for anemia, and measles immunization for VAD. Other important adjunct interventions include appropriate breastfeeding and complementary feeding practices, and strategies to reduce low birth weight.

What do micronutrient interventions cost?

Micronutrient fortification and supplementation are among the most cost-effective public health interventions, but there is enormous variation in the documented costs of programs. The costs vary dramatically by specific cost measure, program, type of intervention and delivery system, country, and a host of other factors.

Given these tremendous differences among program costs, it is not useful to generalize cost estimates across different countries and different types of programs. For example, in the most studied intervention, vitamin A supplementation, the reported unit cost per beneficiary ranges from 14 cents to US\$5.56. The estimated cost per death averted for vitamin A supplementation programs varied by a factor of 35, ranging from US\$90 to US\$3,383. The single most important cost in vitamin A supplementation programs is personnel, which constitutes roughly 65% of total costs. The imputed value of the time of volunteers who participate in biannual vitamin A supplementation programs is about one quarter of total costs. Combining the delivery of other health services with vitamin A supplementation reduces the costs attributable to vitamin A alone and increases health benefits, thereby improving cost-effectiveness. Thus, the increasing trend of countries implementing integrated child health packages that include micronutrients is encouraging, and should be promoted.

The single most important cost for food processors in fortification programs is the cost of the added vitamins and minerals (fortificants) themselves, accounting for approximately 90% of total costs. The composition of the premix, therefore, largely determines total and unit costs. For example, wheat flour fortification costs vary from 40 cents per metric ton (MT) for iron and folic acid (IFA) to \$3.52 for iron, folic acid, riboflavin, thiamin, and vitamin A. Targeted fortification with products formulated to meet the needs of high-risk groups may cost more but could deliver larger impacts. The use of costing and cost-effectiveness analysis could measurably improve the efficiency of micronutrient programs and thereby contribute to accelerating reductions in VMDs.

Data on food intakes by young children and women of reproductive age and their use of health services suggest that additional resources will be required for achieving the full payoffs from micronutrient programs. This is because the cost per person reached with a combined supplementation and fortification strategy is likely to increase once the first 50–60% of the population has been covered. Existing food vehicles and health services may not be able to deliver the required nutrients to the groups who are most in need, making it necessary to find additional delivery channels.

What type of external assistance is available to countries?

International agencies fulfill a broad range of technical and financial gaps in country programs. They support activities to develop new approaches and build capacity, provide data and tools for advocacy and planning, supply materials and equipment, and document results. Some institutions place technical experts in country and regional offices to provide technical support and facilitate information exchange. At the global level, they support coordination activities, gather and disseminate information, and support basic and applied research.

Gaps in resources and coordination remain, however. Certain areas of technical support and operations overlap among donors, and there are a number of missing pieces. Few agencies provide flexible multiyear funding for comprehensive strategies, and details of how best to access and put together packages of donor support to meet country goals are not well understood.

The financial contribution to micronutrient programs in 2004 of the organizations successfully contacted for this review is conservatively estimated at US\$124 million. Vitamin A received the bulk of these resources; folic acid and zinc received far less. The Africa region benefits from roughly half the resources available for micronutrient programs, with substantial investments also being made in Asia. This assessment suggests that country programs are underfunded and receive relatively low levels of external assistance compared with the calculated payoffs from the impacts, and compared with donor investments in other health areas.

Implications for a coordinated global strategy

This review of the available information related to the impacts, prevalence and causes of, and interventions, costs, and external assistance for, reducing VMDs suggests that there is a need to develop a global approach. The following principles may be useful for developing such an approach:

- » Focus first on specific regions and countries that have the greatest number and highest prevalence of persons with VMDs, starting with the countries in which the potential is high for rapid impact.
- » Build intervention packages around the two proven core intervention approaches—supplementation and fortification—recognizing that people obtain micronutrients through multiple channels. Provide for adequate monitoring of safety issues.
- » Aim to fulfill the needs of women of reproductive age, the very young, and the very poor first. Include health interventions that affect VMDs in the package of services for these groups; and link with food

security and other food interventions as needed.

- » Expand coverage using district-wide approaches for supplementation and strategies such as intensified outreach and social mobilization to assure coverage of marginalized communities. Identify special delivery channels for the urban poor, possibly through the commercial private sector.
 - » Build country capacity for the long-term institutionalization of effective strategies, for example, within decentralized district health plans and as part of public–private partnerships.
 - » Support government entities in harnessing private sector expertise, market channels, and interest in contributing to social objectives.
 - » Strengthen the country databases and diagnostics for developing best intervention mixes to guide policy and program choices. Invest in mechanisms to maintain up-to-date prevalence and coverage figures across countries using consistent definitions, methods, and age groups. Track trends in consumer demand for micronutrient-rich foods and potential food vehicles for fortification; support the evolving structure of industries related to processing, production, and marketing of relevant products; monitor transitions in food purchasing and consumption patterns; determine HH food allocation and child feeding practices; and identify patterns in the use of health services and indicators of infections that predispose people to poor micronutrient status.
 - » Explore in more detail the *modus operandi* of key institutions involved in international support for micronutrient programs. Specifically, clarify and define the regulatory and policy frameworks within which these institutions operate; their mandates and the parameters that limit or encourage what they can and cannot do; the source of their resources; and the guidelines or regulations to which they are subject. Determine the opportunities and challenges for accessing resources from each agency and the mechanisms through which they communicate with and provide support to recipient countries.
 - » Expand the scope of current donor coordination to cover the main micronutrients and intervention approaches in order to support comprehensive country strategies for reducing the five most damaging VMDs. The basic elements of a global coordination framework for micronutrients are listed in the last section of this report.
- In conclusion, there is a basic foundation of evidence for public health and development impacts arising from micronutrient programs. The know-how appears to exist for successfully reaching high-risk populations in a range of country settings. There is growing documentation of the strengths and limitations of different delivery channels. Food fortification and supplementation have proved successful in diverse

settings, and promising new approaches such as bio-fortification are emerging. There are several success stories, but huge gaps remain. A global strategy could help address several of the more prominent gaps with: (i) more timely and complete tracking of prevalence

and program indicators; (ii) coordinating donor support; (iii) bringing a critical mass of resources to focus on high burden countries; and (iv) helping to secure sustained benefits.

Introduction

When asked how \$50 billion should be invested for development, the world's top economists ranked "providing micronutrients" second only to combating Human Immunodeficiency Virus/Acquired Immuno-deficiency Syndrome (HIV/AIDS). Micronutrients offer a better cost/benefit ratio than trade liberalization, reducing migration barriers, new agricultural technologies, climate change, water and sanitation and other topics (Copenhagen Consensus 2004).*

The analysis and conclusions of the Copenhagen Consensus [1] reaffirmed why micronutrients receive attention as one of the most cost-effective public health interventions available. The returns on investing in nutrition overall and in micronutrients, in particular, are very high [2]. Individuals, entire communities, and nations pay a significant price for allowing VMDs to persist. Leading economists estimate that the benefit-cost ratios are in the range of 1: 176–200 for fortification and 1: 4–43 for supplementation [3].

A wide range of development impacts are possible with effective programs. Investing in micronutrients is likely to contribute towards achieving the MDGs.

Building on a decade of accelerated program achievements and a strengthened base of evidence, many experts believe that it is time to scale-up engagement and investments in reducing VMDs. At the United Nations General Assembly Special Session on Children (2002), Secretary-General Kofi Annan, 70 heads of state, and high-ranking government delegations from 187 countries committed themselves to reducing these deficiencies.

Transitions taking place on a large scale across the globe provide new opportunities to improve the micronutrient status of populations. For example, there

are rapid shifts in lifestyles and food choices, better and faster ways to raise public awareness and most prominently, there is increasing capacity in business to become part of the solution for global challenges. Technically, experts have the knowledge and tools to address VMDs in diverse settings. There is sufficient evidence that the fortification of staple foods and supplementation programs, in particular when built into existing public health programs, can effectively reduce deficiencies. Child survival, mental and physical health, rates of blindness, and labor productivity have all shown improvements following the expansion of micronutrient programs in different regions.

By providing access to currently available technical knowledge and relevant data, this report aims to help lay the foundation for a new global strategy to significantly reduce micronutrient malnutrition by 2015. The global strategy is expected to be implemented through a global alliance of governments, international and national organizations, and businesses. With increasing demands on limited resources this strategy will be challenged to focus on the most critical and high-payoff actions. Choices will need to be made. To inform these choices, national and regional information related to the five most widely recognized deficiencies—vitamin A, iron, iodine, folic acid, and zinc—is summarized in this report. The information corresponds to the following questions:

- » What is the importance of micronutrients in the current development context?
- » Where are the deficiencies most widespread? Who is most affected and why?
- » How can we prevent/reduce/eliminate VMDs or mitigate their impact?
- » How well are we reaching scale, what would it cost, and what are the unmet needs?
- » What is the role of international agencies currently engaged in micronutrient programs?

* A panel of economists that included three Nobel Laureates was convened in Copenhagen to identify global development priorities, primarily using economic costs and benefits.

Contribution of improved micronutrient status to Millennium Development Goals (MDGs)

Goal 1: Eradicate extreme poverty and hunger	Iron and iodine deficiencies are related to mental and physical incapacity and this has implications for learning and productivity; zinc deficiency is associated with stunting that is related to low earnings; vitamin and mineral deficiencies (VMDs) are interrelated with poverty and hunger.
Goal 2: Achieve universal primary education	Iron and iodine nutrition are closely related to cognitive function; anemia is related to low school attendance independent of cognition.
Goal 3: Promote gender equity and empower women	The demands of childbearing, menstruation, pregnancy, and lactation create high demands on micronutrient stores in women, which results in a higher level of deficiencies for them; reducing VMDs improves maternal health and productivity and reduces disabilities such as night blindness.
Goal 4: Reduce child mortality	Iodine supplements, vitamin A, and zinc are proven to reduce childhood deaths and/or severe illness; improving folate status around the time of conception reduces the risk of mortality related to neural tube defects (NTDs).
Goal 5: Improve maternal health	Anemia is an important cause of maternal deaths; several VMDs (vitamin A, iron, iodine, folate, and calcium) are associated with complications of pregnancy.
Goal 6: Combat HIV/AIDS, malaria, and other diseases	Adequate micronutrient status may reduce progression of HIV/AIDS and improve the quality of life of survivors; the evidence that micronutrient deficiencies may interfere with HIV progression needs to be better researched and documented; VMDs (e.g., zinc and vitamin A) increase morbidity and mortality from diarrhea, pneumonia, measles, and malaria.
Goal 7: Ensure environmental sustainability	Fortification and supplementation support environmental sustainability compared with consumption of animal foods; micronutrient status in turn is dependent upon a safe environment, e.g., soils and iodine-deficiency disorders (IDDs).
Goal 8: Develop a global partnership for development	The micronutrient sector has facilitated a broad range of partnerships that raise the awareness and functioning of public and private sector development initiatives.

HIV/AIDS, Human Immunodeficiency Virus/Acquired Immunodeficiency Syndrome

Source: UN Standing Committee on Nutrition (SCN). Fifth report on the world nutrition situation: nutrition for improved development outcomes. Geneva: SCN, 2004.

Why is reducing vitamin and mineral deficiencies critical for development?

The links between VMDs and survival, health, education, and productivity

Tina Sanghvi, Jay Ross, and Helen Heymann

“Called micronutrients because they are needed only in minuscule amounts, these substances are the ‘magic wands’ that enable the body to produce enzymes, hormones and other substances essential for proper growth and development. As tiny as the amounts are, however, the consequences of their absence are severe” (WHO 2006).

Summary of findings

- » There is consistent evidence that micronutrients are essential for chemical processes that assure survival, growth, and functioning of vital human systems. Research and surveys have shown their health and economic impacts on individuals, communities, and at the national level.
- » Reducing VMDs strengthens the innate immune capacity of individuals, helping ward off a broad range of existing and emerging infectious diseases. Also, recovery from illnesses is faster, with fewer adverse outcomes.
- » All age groups benefit from micronutrients but the deficiencies are particularly damaging and difficult to reverse when they occur during fetal development and in early childhood.
- » Education and learning abilities are affected by micronutrients. Among school-aged children, VMDs have been shown to reduce their ability to pay attention and result in lower school attendance. Increased performance and attendance in school are likely to translate into greater productivity as adults.
- » Reducing VMDs have also been shown to directly increase adult physical aerobic capacity and productivity.
- » The seriousness and broad range of impacts attributable to VMDs suggest that their continuation will delay the achievement of MDGs in high prevalence countries.

Review of the evidence

How strong is the evidence and what types of impacts can be expected from reducing VMDs?

There is good clinical and epidemiological evidence of the benefits of micronutrients*

Clinical research, intervention trials, and biochemical studies have confirmed the wide-ranging impact of VMDs on the following: immune function, brain and nervous system development, psychomotor development and cognition, skeletal development and growth, integrity and functioning of the epithelial and endothelial (e.g., gastrointestinal [GI] tract) systems, health and functioning of the eyes, and muscular performance.

Population-wide impacts of micronutrients on outcomes related to these systems have been documented in intervention trials and observational studies. The evidence is particularly strong for vitamin A,

* The following are the primary references for this section; (a) Stoltzfus RJ, Mullany L, and Black RE. Chapter 3. Iron deficiency anemia, in *Comparative Quantification of Health Risks, Global and Regional Burden of Disease Attributable to Selected Major Risk Factors 2004, Volume 1*; Rice AL, West KP Jr, and Black RE. Chapter 4. Vitamin A deficiency in *Comparative Quantification of Health Risks, Global and Regional Burden of Disease Attributable to Selected Major Risk Factors 2004, Volume 1*; Caulfield LE and Black RE. Chapter 5. Zinc deficiency in *Comparative Quantification of Health Risks, Global and Regional Burden of Disease Attributable to Selected Major Risk Factors 2004, Volume 1*; K Bell and G Oakley, personal communication summarizing the literature on folic acid deficiency, 2006; Stoltzfus RJ. Iron-deficiency anemia: reexamining the nature and magnitude of the public health problem. *J Nutr* 2001; 131:697S–700S; R Semba, personal communication on micronutrients and immune function, 2005; Black R. Micronutrient deficiency—an underlying cause of morbidity and mortality. *Bull World Health Organ* 2003; 81(2):79; Sommer A. 2005. Innocenti Micronutrient Research Report # 1. Draft paper, UNICEF; WHO 2004, Iodine Status Worldwide, who.int/whosis; Demographic and Health Surveys (DHS) ORC/MACRO; Behrman JR, Alderman H, and Hodinott J. 2004. Hunger and malnutrition. In: *Copenhagen Consensus*. 19 February 2004.

iodine, zinc, folate, and iron.

The impact of VMDs varies according to the magnitude of the deficiency, other accompanying nutritional problems and health conditions, the age of the subject, and the duration of the deficiency. All stages in the lifecycle are vulnerable to the ill effects of deficiencies. However, pregnant women and children at stages of rapid growth and development are particularly vulnerable. When accompanied by infections, the VMDs are more severe, and the ensuing damage is substantially greater.*

VMDs contribute to death, illness and disability

Deficiencies of vitamin A, iron, iodine, zinc, and folate are important contributing factors to maternal, newborn, infant, and child mortality. They affect a range of immune factors, increase disability and mortality resulting from illnesses, and can delay recovery from illnesses. See **box 1.1**.

The results of mortality trials indicated that preventive vitamin A supplements could produce a 23% reduction in childhood mortality in vitamin A-deficient populations [5]. Treatment of measles with vitamin A could reduce hospitalizations, blindness, and deaths [6]. A major pathway for these and similar effects of other micronutrients is through strengthening the immune response. The total burden of deaths and disability makes micronutrients one of the highest priorities for public health. See **figures 1.1** and **1.2**. **Table 1.1**

BOX 1.1. Micronutrients protect health and survival in several ways

- » Strengthened innate immune capacity (e.g., vitamin A and zinc in reducing morbidity due to diarrhea, pneumonia, and malaria)
- » More effective immunization—potentiating effect of micronutrients on vaccine efficacy (e.g., zinc and oral cholera vaccine)
- » Improved care-seeking and increased use of disease control services (e.g., sustained high coverage of polio national immunization days (NIDs) when linked with vitamin A distribution)
- » Increased efficacy of treatment for illnesses (e.g., zinc in severe diarrhea, vitamin A in measles, multiple micronutrients in Human Immunodeficiency Virus/Acquired Immunodeficiency Syndrome [HIV/AIDS])
- » Improved recovery and disease outcomes—e.g., zinc supplements reduce the severity of diarrhea and vitamin A reduces the adverse effects of measles, diarrhea, and malaria.

*The methodology for calculating these effects involves using estimates of the prevalence of deficiencies (available at www.gainhealth.org) and a rapid PROFILES model (available at www.gainhealth.org).

lists the type of impacts by nutrient.

The effects on mortality of vitamin A supplementation were confirmed through national surveys. The rapid decline in mortality in children under 5 years of age in Nepal is credited in large part to the vitamin A program. According to the 2001 Nepal Demographic and Health Surveys (DHS), under-five mortality fell from 158 to 91 per 1,000 over a 10-year period (1987–1991 to 1997–2001), a decline of 42%. A similar decline in under-five mortality over a 10-year period was also documented in Bangladesh (at 38%) and recently in Tanzania [7]. A common feature across these countries is that biannual vitamin A supplementation was launched and reached high nationwide coverage during the years of most rapid decline in mortality. Iodine supplementation has been shown to be associated with child survival in China and Indonesia. **Box 1.2** summarizes the estimated levels of health impacts from VMDs.

Iron and iodine deficiencies affect brain development and cognition

Adequate iron intake is necessary for brain development, and its deficiency is implicated in impaired cognitive development (see **table 1.2**). Anemia in school-aged children may also affect learning abilities whether or not they experienced earlier impaired brain development.

Iodine deficiency concerns the irreversible impairment of mental capacities with resulting lower learning capacity. Although iodine is a required nutrient throughout life, most documented consequences of deficiencies are from prenatal and early childhood deficiencies [8]. This evidence comes from epidemiological studies, including maternal supplementation studies and an analysis showing a 13.5 point difference in intelligence quotient (IQ) between deficient and normal individuals [9, 10]. The earlier the iodine deficiency

FIG. 1.1. Several micronutrients strengthen the immune system and increase resistance to infections

Nutrient	Antioxidant capacity	Immune system	Resistance to infections
A	↑	↑↑↑	↑↑↑ / ↓
B group	↑	↑	
C	↑↑↑	↑	
E	↑↑↑	↑↑	
Iron	↓	↑	↑ / ↓
Zinc	↑↑↑	↑↑↑	↑↑↑
Selenium	↑↑↑	↑	↑

↑ Increase ↓ Decrease

Number of arrows indicate relative importance; arrows in both directions indicate conflicting findings

Source: Friis H, WHO, 2005

can be corrected, the greater the impact.

The impact of VAD on childhood blindness and of folate deficiency on NTDs severely limits the quality of

human resources in communities where the prevalence of these deficiencies is high.

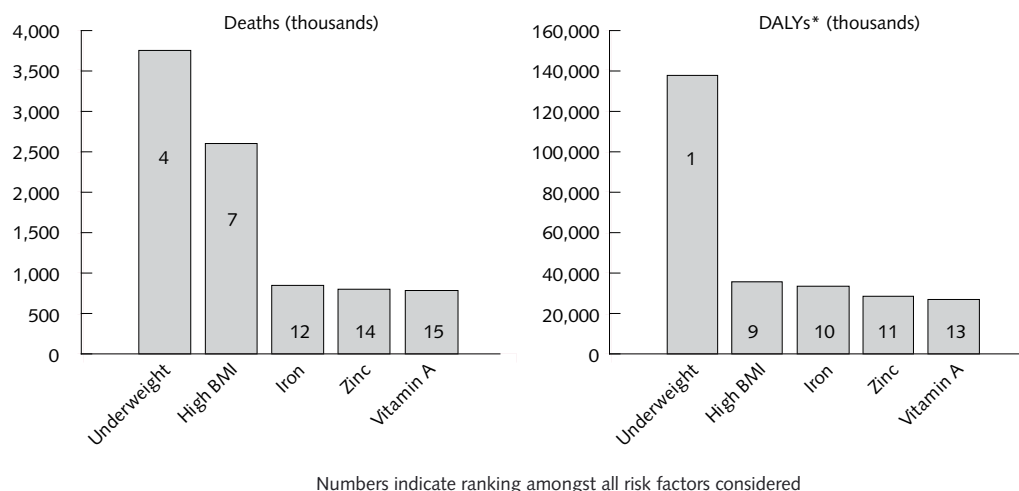


FIG. 1.2. Global burdens of death and disability for nutrition risk factors
*Disability-adjusted life years

TABLE 1.1. Health impacts of vitamin and mineral deficiencies (VMDs)

Deficiency	Impacts
Vitamin A deficiency (VAD)	<p>Mortality Meta-analyses demonstrate a link between vitamin A and cause-specific mortality for measles, and there is some evidence for a link with diarrhea and other infectious diseases. Single studies have shown a link between malaria mortality among children and all-cause maternal mortality [11]. Children 6–59 mos old living in vitamin A–deficient areas who received vitamin A supplements were on average 20–30% less likely to die from any cause than children not receiving supplements, according to meta-analysis of supplementation and fortification studies [5, 12–14].^a Pregnant women receiving a weekly supplement of 10,000 IU of vitamin A were 40% less likely to die than those receiving a placebo in one study in Nepal [15]. Based on the current estimates of prevalence, VAD contributes to an estimated 9% of the childhood deaths and possibly more than 13% of maternal deaths worldwide.</p> <p>Morbidity Vitamin A supplements reduce complications from measles such as blindness and the need for hospitalization [6].</p> <p>Disability Night-blindness in pregnant women is a reversible consequence of VAD [16]. VAD is a significant preventable cause of childhood blindness in developing countries [17].</p>
Iron and anemia	<p>Mortality Anemia as a risk factor for mortality is estimated to contribute 591,000 perinatal deaths and 115,000 maternal deaths globally. [18]. When combined with the direct impacts of iron deficiency anemia (IDA), the deaths total 841,000 annually [18]. Using current data on prevalence, 18.4% of maternal deaths and 23.5% of perinatal deaths are attributable to anemia.^b A substantial body of observational data relates pregnancy anemia to preterm birth and low birth weight both of which predispose to childhood mortality and morbidity [18]. Two recent studies, one from Tanzania [19] and one from Nepal [20], suggest that iron supplementation in areas with high malaria prevalence may increase adverse outcomes but no adverse impact was found in non-malarious areas.^c</p>

continued

VMDs in children and adults translate into substantial productivity losses

There is good evidence that nutritional deficiencies severely erode productivity. VAD causes blindness and the economic losses from childhood blindness accumulate throughout life. Night-blindness caused by VAD in women of reproductive age severely limits their number of working hours. Similarly, the deficiencies of folate and iodine result in mental and physical impairments and lifetime losses in productivity. Zinc deficiency contributes to child stunting, which is directly linked to productivity losses in adulthood [1].

Additionally, adult productivity unrelated to child-

hood morbidity, stunting, or cognition is independently affected by micronutrient status. In both cross-sectional studies and randomized interventions, anemia in adults is associated with reduced productivity and ability to perform critical HH tasks, such as caregiving by mothers. The magnitude of the impacts appears to depend on the nature of the task. An overview of the effects of VMDs on productivity is given in **table 1.3**.

Data sources, limitations, and issues

Randomized controlled trials (RCTs) provide evidence of the health impact of several micronutrients, for

TABLE 1.1. Health impacts of vitamin and mineral deficiencies (*continued*)

Deficiency	Impacts
Iron and anemia (cont.)	<p>Morbidity and disability</p> <p>Iron deficiency predisposes people to diseases through reduced immune function (e.g., humoral, cell-mediated, and nonspecific immunity and the activity of cytokines, which have an important role in various steps of immunogenic mechanisms, are influenced by IDA).</p> <p>Iron deficiency directly causes decreased oxygen delivery to muscles and the brain resulting in impaired aerobic capacity and altered child development (or intelligence) [21].</p>
Iodine deficiency	<p>Mortality</p> <p>Maternal iodine deficiency is associated with increases in the risk of perinatal mortality, childhood mortality, stillbirths, miscarriages, thyroid disorders, and brain damage, based on epidemiological data [22].</p> <p>Morbidity and disability</p> <p>The effects of iodine-deficiency disorders (IDDs) include cretinism, deaf mutism, and mental retardation [4].</p>
Zinc deficiency	<p>Mortality</p> <p>Infants born small for gestational age who received zinc supplements six days per week were 0.32 times as likely to die during infancy as compared with infants who received a placebo supplement [23]. In another study, children who received zinc supplements of 20 mg/d as adjunct to oral rehydration solution (ORS) during diarrhea were half as likely to die as those receiving ORS alone [24].</p> <p>Based on current estimates of zinc deficiency, it is a contributing cause of 5.5% of child deaths in developing countries.</p> <p>Morbidity</p> <p>In placebo-controlled trials, children supplemented with zinc had fewer episodes of diarrhea and pneumonia and lower clinic attendance for malaria [25]. The duration of diarrhea and fluid losses were also lower.</p>
Folate deficiency	<p>Mortality</p> <p>Folate deficiency is associated with an increased risk of preterm delivery and low birth weight [26]; these conditions predispose to mortality.</p> <p>Morbidity</p> <p>Folate deficiency is thought to contribute to anemia, especially in pregnant and lactating women in communities with a low intake of folate [27].</p> <p>Disability</p> <p>Folic acid plays an important role in preventing congenital malformations [7].</p>

a. Studies that provided vitamin A supplements to newborn infants immediately after birth have not demonstrated consistent effects on newborn mortality according to Rice et al. [11]; the evidence for postpartum vitamin A supplementation remains weak. A recent study by Humphrey et al. [28] in HIV-positive pregnant women in Zimbabwe suggests that increased adverse outcomes may occur in some infants if they or their mothers are given high doses of vitamin A at birth or post partum.

b. Data on anemia prevalence and methods for estimating mortality are available at www.gainhealth.org.

c. World Health Organization (WHO) Statement on Iron Supplementation and Child Mortality [29].

example, zinc supplementation and the prevention and treatment of vitamin A deficiencies. Documented improvements in national or area health indicators following the introduction of large-scale programs provide further evidence of impact. However, the research and evaluations are not representative of all country settings, and study designs are limited by cost constraints, measurement difficulties, and ethical considerations. For example, there are no experimental trials of iron deficiency and maternal mortality, and researchers have estimated the risk relationship from observational data.

- » The literature on efficacy and effectiveness of micro-nutrient interventions can be difficult to interpret and compare due to differences in definitions, age groups, and methods. Despite these limitations, however, the collective evidence is strong. The results are in the same direction, the ranges of impact similar, and there is growing understanding of the likely mechanisms of action.
- » The extrapolation of efficacy and effectiveness results obtained in one setting to other contexts assumes that the local conditions and interventions are similar, but this may not be universally accurate. In this report, estimates of mortality and productivity impacts are based on the rapid PROFILES model. While the exact level of impact of each deficiency may be under- or overestimated, it provides a good

BOX 1.2. Health impacts of vitamin and mineral deficiencies (VMDs)

Current levels of VMDs are estimated to have the following impacts.

- » Vitamin A deficiency (VAD): A contributing cause of an estimated 9.0% of child deaths and possibly of 13.2% of maternal deaths.
- » Iron deficiency: Anemia in pregnancy contributes to an estimated 18.4% of maternal deaths and 23.5% of perinatal deaths; about half of anemia is associated with iron deficiency.
- » Iodine deficiency: An estimated 19.7% of babies who are born to iodine-deficient mothers are likely to suffer from some form of intellectual impairment. The World Health Organization (WHO) estimates (2004, based on data from 1998–2003) [30] that nearly 50 million people were at risk of some degree of iodine deficiency disorder (IDD)-related brain damage.
- » Zinc deficiency: A contributing cause of an estimated 5.5% of child deaths.
- » Folate deficiency: An estimated 240,000 neural tube defects (NTDs) could be prevented through supplementation with folic acid.

approximation of the order of magnitude of the effects.

TABLE 1.2. Impacts of vitamin and mineral deficiencies (VMDs) on cognition and education

Deficiency	Impacts
Vitamin A deficiency (VAD)	Childhood blindness caused by VAD is a deterrent to education.
Iron deficiency and anemia	Observational studies show infants with moderate iron deficiency anemia (IDA) have test scores that are 0.5 to 1.5 SD lower than those of infants with sufficient iron stores [31, 32]. Iron supplementation corrects IQ deficits in anemic children [33–35]. A quantitative estimate of the size of this effect suggests a reversible IQ deficit in anemic 5- to 6-yr-old Indian boys of 8 points or half an SD. Two published placebo-controlled, randomized trials found significant benefits from longer-term (> 2 mos) iron supplementation on cognitive development of young anemic children in Indonesia and Zanzibar [36–38]. There appears to be a causal relationship between IDA in early childhood and intelligence in mid-childhood. Impairments may only be partially reversible later in life [39, 40].
Iodine deficiency	Iodine deficiency during pregnancy affects the development of the fetus, results in cretinism, deaf mutism, and other forms and degrees of mental and physical impairment. A review of reports from seven countries indicates that approximately 3.4% of births to iodine-deficient women result in cretinism and another 10.2% of their offspring are mentally impaired [41]. A meta-analysis shows the average IQ to be 13.5 points lower in iodine-deficient communities when compared with iodine-sufficient communities [42].
Folate deficiency	The development of the newborn central nervous system is severely damaged in utero when mothers are folate-deficient around the time of conception; survival among infants born with spina bifida and encephalocele has improved since folic acid fortification [43].

Next steps for strategic action and research

Research is needed on the impacts of multiple micronutrient deficiencies during early childhood and among women of reproductive age and the role of diet in controlling them.

- » Research is needed on addressing co-morbidities of micronutrients and infectious diseases (e.g., malaria, HIV/AIDS, tuberculosis [TB]) safely and efficaciously.
- » Research on the long- and short-term impacts of improved iron intake among women and children will be useful, including impacts on fetal development, birth weight and neonatal mortality, as well as later growth and development.
- » Evidence needs to be documented linking country micronutrient strategies and changes in intake with indicators related to functional outcome (e.g., mortality, morbidity, blindness, NTDs, productivity, schooling, and education). While there is already evidence of the impacts of micronutrients, documenting additional examples from diverse country settings will help build momentum through advocacy, highlight ways in which the benefits can be enhanced, and help maintain a focus on reducing the deficiencies. This does not mean more mortality studies but rather opportunistic data collection where programs are being scaled up and where ongoing routine health data can be used.
- » Analysts and policy makers should have a common understanding of the estimated magnitude of potential impacts based on recent evidence. An updated standardized approach is needed for characterizing and documenting the public health and productivity

outcomes from investments to be made over the next decade. This information is necessary for advocacy and continuing analysis of the cost-effectiveness of programs using tools such as PROFILES.

Conclusions and recommendations

VMDs erode the fundamental capacities of individuals, HHs, communities, and nations; they are likely to impede the achievement of the MDGs.

- » Strategies to reduce poverty and narrow the equity gap should include targeted approaches for delivering adequate micronutrients. Low-income households are several times more likely to suffer from deficiencies than are better off households; this affects their children's education, adult productivity, and earnings and widens the income gap.
- » Health investments will have enhanced payoffs if micronutrient interventions are an integral component of health sector strategies—examples include preventive vitamin A supplementation of preschool-aged children; zinc supplements given to children with diarrhea; promotion and testing for use of adequately iodized salt; iron supplements for pregnant women; and folic acid for women of reproductive age.
- » Investments in school education will also benefit from investing in micronutrient and related programs, especially through increased coverage with iodized salt, reduction of iron deficiency and anemia in infants and young children, IFA fortification, and treatment of measles with vitamin A to prevent blindness.

TABLE 1.3. Productivity impacts of vitamin and mineral deficiencies (VMDs)

Deficiency	Impacts
Iron deficiency and anemia	Anemia is associated with reduced productivity both in cross-sectional data and in randomized interventions [44–46]. About half of anemia is associated with iron deficiency. The magnitude of productivity impacts may depend on the nature of the task. Iron supplementation in anemic adults is estimated to result in a 5% increase in “blue collar” labor productivity and an additional 12% increase in heavy manual labor productivity [47]. Workers with iron-deficiency anemia (IDA) were found to be less productive in physical tasks than non-anemic workers in Indonesia, producing 1.5% less output for every 1.0% that hemoglobin is below standard [38, 46].
Iodine deficiency	Brain function is impaired by iodine deficiency during fetal development. The future productivity losses due to iodine deficiency are equal to about 0.23% of GDP. See www.gainhealth.org .
Zinc deficiency	Stunting during childhood translates into equal height deficiencies in adulthood, and the elasticity of height on productivity—as measured by wage—is estimated to be up to 1.38. This implies that a difference of 1% in the height of adult workers is associated with a 1.38 difference in their wages [48].
Folate deficiency	Folate deficiency has been shown to be a factor in anemia—a debilitating condition in women in communities where diets are folate poor.

- » The following areas need further research: the role of diet; interactions among micronutrients and between micronutrients and the environment (especially infection); range of safe levels of intake between minimum requirements and upper tolerance levels (especially in young children); the public health significance of marginal deficiencies for iodine, iron, and vitamin A; and channels to increase intakes of multiple micronutrients.

What is the extent of vitamin and mineral deficiencies?

Magnitude of the problem

Reena Borwankar, Tina Sanghvi, and Robin Houston

“One out of three people in developing countries are affected by vitamin and mineral deficiencies and therefore more subject to infection, birth defects and impaired physical and psycho-intellectual development” (WHO 2006).

Summary of findings

VMDs—particularly of vitamin A, iron, iodine, zinc, and folate—pose a public health problem that affects over 2 billion people. An estimated 25% of preschool-aged children and 18% of women are vitamin A-deficient; 37% of the total population has anemia; 35% of the world’s population is at risk for iodine deficiency (data from 1998–2003 [49]); and 20% is estimated to be at risk for zinc deficiency. These prevalence figures may not reflect the current situation, as limited resources have prevented the gathering and maintenance of up-to-date information.

- » Apart from iodine, vitamin A, and anemia, we do not have data on the prevalence of other micronutrient deficiencies. Surveys are needed to fill these gaps. We need to develop, field test, and apply field methods for other micronutrients.
- » More evidence is needed on the relationship between interventions and different measures of micronutrient status. The present indicators have considerable limitations, e.g., biological indicators are more invasive and cumbersome but more likely to be specific, whereas functional indicators are less specific.
- » The deficiencies are caused by diets poor in vitamins and minerals and by losses or poor absorption related to illness—conditions found in every region of the world.
- » Countries of sub-Saharan Africa and South Asia have the largest deficiency prevalence rates and the largest absolute numbers of micronutrient-deficient people; many countries in East Asia, Latin America, Central Asia, and eastern Europe also

have sizable populations with a high prevalence of specific VMDs, notably of iron, iodine, and folate.

- » Economic prosperity per se does not protect communities or countries against deficiencies. However, the poorest segments of the population—both urban and rural—and women and young children suffer the most severe forms of deficiencies.
- » Deficiencies tend to cluster in individuals, households, and communities. The same populations tend to suffer from more than one micronutrient deficiency at a time, which provides an opportunity to address multiple deficiencies together.
- » The global prevalences of VAD and iodine deficiencies, particularly their severe forms, have declined significantly as a result of large-scale programs. However, these deficiencies remain high in several regions and ongoing large-scale programs need to be sustained.
- » The prevalence of iron deficiency and anemia have remained high over the past several decades despite prenatal iron supplementation programs; this is due to the multiple causes of anemia and partly to inadequate implementation of the iron supplementation programs. Our understanding of various causes of anemia such as malaria, intestinal parasites, other infections, and micronutrient deficiencies and hemoglobinopathies has increased, and more effective programs are expected to be developed.
- » The magnitude of zinc and folate deficiencies has not been directly measured in more than a few areas; however, indirect indications suggest that the factors that cause these deficiencies are widely prevalent. With little progress on interventions for reducing zinc and folate deficiencies, global prevalence figures have probably not changed recently. See **box 2.1**.

Review of the evidence

What are the global patterns of VMDs?

Extensive evidence from surveys and extrapolations

BOX 2.1. Five questions raised by current prevalence data

- » Why do VMDs remain at such high levels if many national programs have been successful?
- » Do prevalence data reflect the actual situation, since large-scale programs were introduced in the past five years and many data are from older surveys?
- » If biochemical indicators of prevalence are too invasive and costly for regular tracking, can intermediate steps (e.g., intakes) be monitored or can proxies be used?
- » Who are the deficient populations, and do current approaches effectively reach them?
- » Are the indicators that are used to measure prevalence the right ones?

from the best available data indicate that vitamin A, iron, and iodine deficiencies remain widespread public health problems.* Other micronutrient deficiencies may also be widespread but few prevalence studies have been done. Only limited precise, up-to-date, global figures exist for the current prevalence of the major VMDs; steps should be taken to fill these data gaps. In general, less is known about zinc and folate deficiencies. For zinc deficiency, prevalence figures are estimated from predictions of national risks of inadequate zinc intake based on national food supplies. For folate deficiency, experts differ in their assessment of adequate intake and few large-scale population-based surveys have been done to measure the deficiency. Despite the data limitations, regional estimates for the major micronutrients have been developed (often through extrapolations based on measured levels and their predictors), and regional trends have been documented.

Current estimates are that, throughout the world, 25% of preschool-aged children and 18% of women are vitamin A-deficient; 37% of the total population has anemia, of which about half is due to iron deficiency;

* The following are the primary references for this part: Standing Committee on Nutrition (SCN). 2004. 5th report on the world nutrition situation: nutrition for improved development outcomes. WHO: Geneva; WHO 2004, Iodine Status Worldwide, who.int/whosis; Mason J et al. 2005. Recent trends in malnutrition in developing regions: vitamin A deficiency, anemia, iodine deficiency and child underweight. *J Nutr* 26(1); West KP, 2002. Extent of vitamin A deficiency among preschool children and women of reproductive age. *J Nutrition* 132 (9S); WHO MDIS 2005. Global Database for Anemia; International Zinc Nutrition Consultative Group (IZiNCG), 2004. Assessment of the Risk of Zinc Deficiency in Populations and Options for Its Control. Hotz C and Brown KH, guest editors. *Food Nutr Bull* 2004;25(1); K Bell and G Oakley for folate deficiency, personal communication, 2006; Stoltzfus RJ, Mullany L, and Black RE. Chapter 3. Iron deficiency anemia. In: Comparative Quantification of Health Risks, Global and Regional Burden of Disease Attributable to Selected Major Risk Factors 2004, Volume 1. WHO, 2006.

35% do not consume adequate iodine (data from 1998–2003 [49]); and 20% is estimated to be at risk for zinc deficiency.

VAD is a public health problem in 118 countries, especially in Africa and Asia

Extrapolations from the available data suggest that about 125 million preschool-aged children and 20 million pregnant women suffer from VAD, and 4.4 million children and 6.2 million women suffer from xerophthalmia [50]. See **table 2.1**. Nearly half of all VAD and xerophthalmia occurs in South and Southeast Asia. India, Indonesia, China, Ethiopia, Afghanistan, and Nigeria account for the largest concentrations of vitamin A-deficient and xerophthalmic children. The World Health Organization [51] estimates that 250,000 to 500,000 children become blind every year as a result of VAD and half of them die within 12 months of losing their sight. **Map 2.1** shows the global distribution of VAD.

Iron deficiency is the world's most prevalent form of undernutrition

Iron deficiency is one of the most common causes of anemia. In developing countries, anemia is frequently exacerbated by malaria and worm infections. Most of the disease burden from anemia occurs in pregnancy and early childhood and is borne by women and children in Asia and Africa. Substantial numbers of women and children in other regions also are affected. **Map 2.2** shows the global distribution of anemia. **Table 2.2** contains the best estimates of anemia in the population; however, these are not based on representative national samples from countries of the regions.

No current global figures exist for iron deficiency, but using anemia as an indirect indicator, WHO estimates that most preschool-aged children and pregnant women in nonindustrialized countries and at least 30 to 40% in industrialized countries are iron deficient [29]. Nearly half the pregnant women in the world are estimated to be anemic: 52% in nonindustrialized countries and 23% in industrialized countries.

More young children and pregnant women suffer from moderate and severe forms of anemia than any other group, according to DHS. See **figure 2.1**. This is related to the very high requirements for iron during periods of rapid growth and pregnancy (see **fig. 2.2**). Prevalence of anemia in children ages 6 to 35 months can exceed 50% in countries as diverse as India, Madagascar, and Peru (DHS, ORC/MACRO 1996–2000). This is particularly troubling because iron deficiency and anemia can have lasting deleterious effects on mental and physical development.

The prevalence of anemia in children and non-pregnant women has declined in some countries; however,

TABLE 2.1. Global prevalence of vitamin A deficiency (VAD) in young children [50]

WHO region	% Vitamin A-deficient* (number)	Eye changes due to VAD (xerophthalmia)	
		%	Number
Africa	32.1 (33,406,000)	1.53	1,593,000
Eastern Mediterranean	21.2 (12,664,000)	0.85	510,000
South/Southeast Asia	33.0 (55,812,000)	1.20	2,026,000
Western Pacific	14.0 (17,128,000)	0.18	220,000
The Americas	17.3 (8,212,000)	0.16	75,000
Global	25.3 (127,273,000)	0.88	4,424,000

* Serum retinol < 0.70 $\mu\text{mol/L}$ or abnormal conjunctival cytology



MAP 2.1. Global distribution of vitamin A deficiency (VAD)

Source: Adapted from Black RE [52]



MAP 2.2. Global distribution of anemia

Source: Adapted from Black RE [52]

overall, prevalence levels have remained steady over the past 20 years. From 1977 to 1987, anemia levels increased in South Asia and sub-Saharan Africa. In 1990, the World Summit for Children set goals for reducing malnutrition that included a goal to reduce

IDA by one-third by the year 2000. Anemia has long been recognized as a problem, but the high prevalence levels globally have not improved [55].

Substantial efforts have been made in the past several decades to implement programs to reduce iron defi-

TABLE 2.2 Geographic distribution of anemia in the population

WHO region	Total affected population (%)	Children 0–59 months (millions)	Women 15–59 years (millions)
Africa	46	45	58
The Americas	19	14	54
South/Southeast Asia	57	111	215
Europe	10	12	27
Eastern Mediterranean	45	33	60
Western Mediterranean	38	30	159
Global	37	245	573

Source: Adapted from WHO/UNICEF/UNU [53]

ciency. Yet, compared with other micronutrients such as vitamin A and iodine, overall progress in reducing iron deficiency has been limited. Such limited progress is not attributed to a lack of scientific knowledge about the prevalence, causes, or consequences of iron deficiency, but to limited implementation of effective interventions [56].

An analysis conducted by Mason et al. [57] suggests that if current trends continue, anemia in non-

pregnant women will decline only marginally from the current 40% to 38.5% by 2010; in pregnant women, it will decline from the current 45% only to 44.5% by 2010. The situation is even worse for young children, half of whom suffer from anemia across developing countries.

Reporting on iodine deficiency has greatly improved and program coverage has expanded in the past few years

The prevalence of iodine deficiency declined in the past two decades because of high coverage with iodized salt. Clinical signs declined sharply, and the available data on urinary iodine (UI; although not up to date for many countries) show improving trends in iodine intake.

A total of 117 countries now report coverage and/or deficiency of iodine through the Universal Salt Iodization (USI) initiative, according to UNICEF. USI has progressed from 20% coverage in the 1990s to 68% in 2005. In 1993, 110 countries reported average UI levels of < 100 µg/L; in 2003 the number of countries with these levels was down to 54. According to WHO (data reported from 1990s to 2003 in the report of 2004 [49]), IDD affects over 740 million people, or 13% of

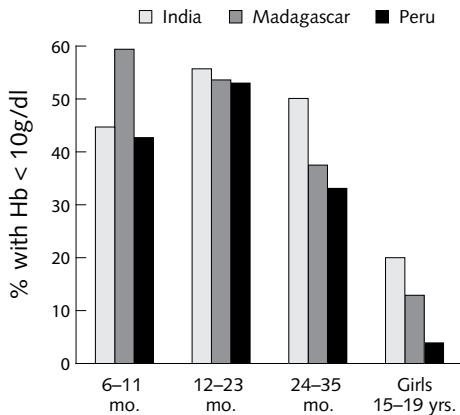


FIG. 2.1. Moderate/severe anemia by age groups [54]

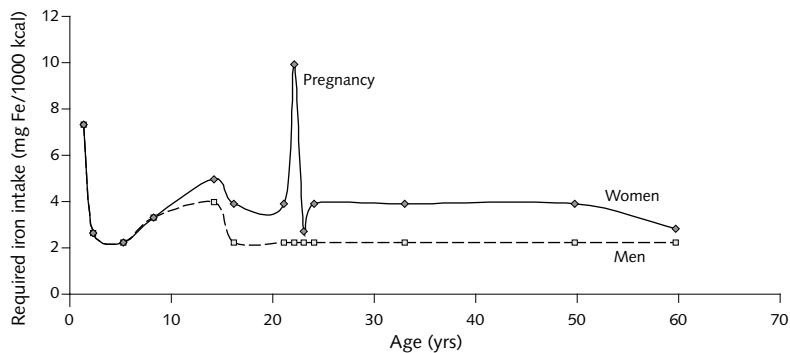


FIG. 2.2. Requirements for iron are high during periods of rapid growth
 Source: Based on FAO/WHO. Requirements of vitamin A, iron, folate and vitamin B12. Report of a Joint FAO/WHO Expert Consultation. Food and Nutrition Series No. 23. Rome: FAO, 1988.

the world's population. An additional 30% are at risk of IDD.

The Americas have the lowest prevalence of iodine deficiency, consistent with the high household coverage of iodized salt. See **table 2.3**. Europe has the reverse situation, with a high prevalence of iodine deficiency and low coverage of iodized salt. More than half of the two billion people at risk of iodine deficiency live in Asia.

Approximately 20% of the world's population is estimated to be at risk for inadequate zinc intake

Zinc deficiency has not been measured in nationally representative surveys, and its prevalence is not known. IZiNCG used indirect indicators to predict national risks of inadequate zinc intake based on such factors as national food supplies and stunting [25]. In this analysis, the estimated percentage of individuals at risk for inadequate zinc intake ranged from 9.3% to 9.5% in North Africa, the eastern Mediterranean, the

TABLE 2.3. Proportion of population with insufficient iodine intake

UN region	% General population UI <100 µg/L	Total number (millions)
Africa	43.0	324.2
Asia	35.6	1,239.3
Europe	52.7	330.8
Latin America and Caribbean	10.0	47.4
North America	9.5	27.6
Oceania	64.5	19.2
Global	35.2	1988.7

UI, urinary iodine

Source: WHO Global Database on Iodine Deficiency (2004). Note that much of these UI data are from 1999 or before and do not fully reflect progress of universal salt iodization (USI).

United States, and Canada to 33.1% in Southeast Asia. See **table 2.4** and **map 2.3**.

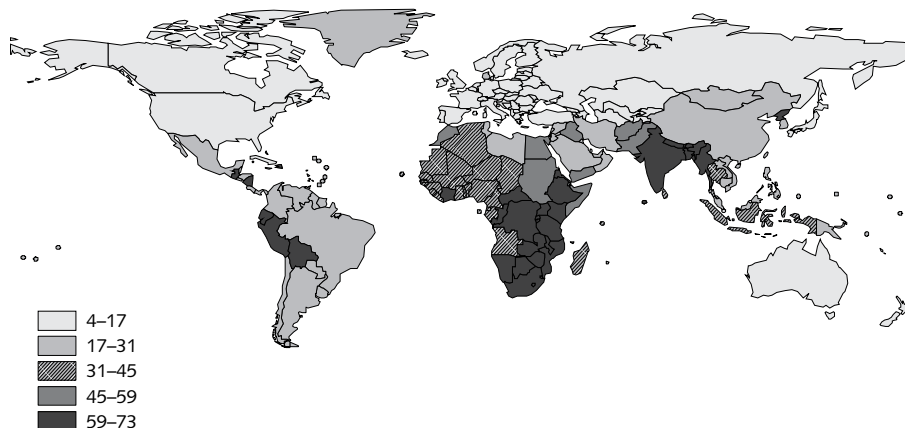
In industrialized countries folate deficiency may be one of the most prevalent micronutrient deficiencies

WHO recently completed a comprehensive review of data available on folate deficiency throughout the world and it appears the prevalence of folate deficiency is comparable in developed and developing countries (Bruno de Benoist, personal communication, 2006). Large-scale population-based surveys of folate deficiency are rare. Food fortification and supplementation trials in the United Kingdom, Australia, China, and other countries indicate that folate deficiency may be fairly widespread among all age groups. In a recent survey in Vargas state in Venezuela, the prevalence of folate deficiency was 81.8% in adolescents and 61.3% in pregnant women [58]. Pathak and others [59] found

TABLE 2.4. Estimated population at risk for inadequate zinc intake by region [25]

Region	% of population with inadequate intake
Western Europe	10.9
USA and Canada	9.5
Eastern Europe	16.2
North Africa and eastern Mediterranean	9.3
China (and Hong Kong)	14.1
Western Pacific	22.1
Latin America and Caribbean	24.8
South Asia	26.7
Southeast Asia	33.1
Sub-Saharan Africa	28.2
Global	20.5

Source: International Zinc Nutrition Consultative Group (IZiNCG), 2004



MAP 2.3. Global distribution of zinc deficiency
Source: Adapted from Black RE [52]

a prevalence of 26.4% in pregnant women in a survey of rural villages in Haryana state, India. Earlier studies from India reported folate deficiency in the range of 21% to 63.5%. In Anqing, China, 23% of women textile workers of reproductive age were deficient in folate [60]. These studies recorded multiple VMDs—particularly B vitamin deficiency, iron deficiency, and anemia—in the same women. Folate deficiency may be the most prevalent micronutrient deficiency in industrialized countries, primarily because of a decline in consumption of folate rich foods such as leafy green vegetables and whole grains.

What is the evidence that VMDs have declined?

WHO and other international authorities estimate that the global prevalences of VAD and iodine deficiencies have declined significantly as a result of large-scale nutrition and health programs in most countries of the world. **Figure 2.3** illustrates the decline in the prevalence of clinical VAD since 1990.

Trend data also show that the mean prevalence of goiter declined from 26.7% before 1990 to 21% after 1990. The analysis by Mason and others [57] suggests that in countries with high endemic goiter levels, these rates are halved when iodized salt reaches a coverage of 50%. Several countries have exceeded these minimum effective coverage levels. By 2000, USI appears to have spared 800,000 people from iodine deficiencies [57].

From the few repeated surveys conducted during 1990–2000, it appears that xerophthalmia, as indicated by night-blindness and Bitot's spots, declined (**fig. 2.3**). Mason and others [57] developed comprehensive country and regional estimates that show that the declines took place in the Americas, in some countries in South Asia (e.g., Bangladesh and Nepal), and in the Middle East and northern Africa.

West [50] developed national estimates of clinical and subclinical forms of VAD. The available data show that the decline in clinical VAD is attributable

to increasing measles immunization coverage as well as effective large-scale vitamin A supplementation programs.

The prevalence of iron deficiency and anemia has remained high in the past decade, even in countries where it declined. The magnitudes of zinc deficiency and folate deficiency have not been empirically determined in nationally representative household surveys [25], and there have been few interventions to address these deficiencies. National flour fortification has led to reductions in folate deficiency in Chile, the United States, Canada, and Costa Rica [61].

What are the trends in VMDs for specific geographic regions?

Among regions, sub-Saharan Africa shows an unchanging or worsening trend in subclinical vitamin A and mineral deficiencies, except for intake of iodine, which improved with expanded coverage of iodized salt. This favorable trend in IDD can be sustained if sufficient resources are provided to maintain and enforce supportive policies. Anemia levels in Africa are particularly troublesome; they are among the highest in the world among women and especially children.

South Asia, particularly India, continues to register VAD and anemia. Xerophthalmia is above 1% and there is recent evidence of a high prevalence of VAD in children. The prevalence of anemia is also very high, at levels that have not changed for several decades. Even among people in the highest income percentiles, the prevalence rate for anemia in women is over 60%.

Documented success stories for reducing national levels of VMDs through large-scale programs are found in Latin America, China, Thailand, and Vietnam for all major deficiencies, and in Nepal and Bangladesh for vitamin A.

What causes VMDs, and how are they identified?

The principal VMDs known to cause widespread public health problems are deficiencies of vitamin A, iron, and iodine. Recently, deficiencies in zinc and folate have also been identified as major problems. A micronutrient inadequacy is reflected in lower than recommended circulating levels of the nutrient in blood (for vitamin A, folate, zinc, and iron); low levels in urine (for iodine); low liver stores (for vitamin A and iron); or the presence of physical symptoms related to the deficiency (e.g., pallor due to lack of iron, night-blindness and other signs of xerophthalmia due to lack of vitamin A, and NTDs due to lack of folic acid).

Globally recommended intake levels have been established for each nutrient based on the amounts needed to maintain adequate stores and circulating levels for each nutrient in a healthy population. Sometimes dietary intake of nutrients below these recommended

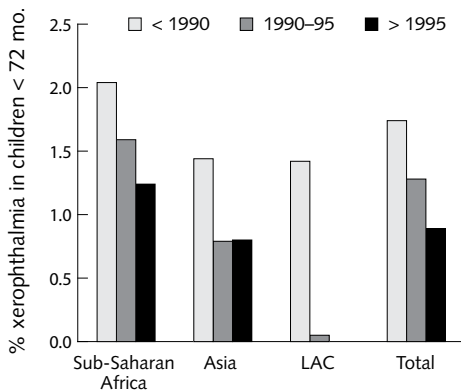


FIG. 2.3. Decline in prevalence of vitamin A deficiency (VAD; 1990–1995)

Source: Based on actual surveys, cited in Mason et al., 2005.

levels is used to establish that a deficiency is present, as in the case of folate and zinc. **Box 2.2** summarizes the factors that cause VMDs.

Data sources, limitations, and issues

There are important gaps in data on the changing trends in VMDs. However, sufficient information is available to develop strategies and target programs, even while efforts are under way to obtain more complete, up-to-date, and precise data. The analyses of Mason and others [57] and West [50], as well as a collection of survey results from DHS and WHO MDIS (www.gainhealth.org), provide useful information on the prevalence of VMDs for more than 150 countries, even though many of the figures are approximations and are now somewhat out of date. The authors have demonstrated the validity of their models, which allows us to examine regional trends.

The data at www.gainhealth.org contain some of the available information on the prevalence of VAD, anemia, and iodine intake (as measured by UI). They were prepared to guide the development of country priorities for the global strategy. The figures on deficiencies are drawn from the following sources:

- » Direct measurements of the prevalence of VAD and xerophthalmia, anemia, and iodine deficiency. These include DHS and other national or subnational surveys carried out using more or less comparable indicators, cut-offs, and age groups.
- » Country or national estimates derived from equations that incorporate predisposing or other factors found to be closely related to the deficiency (e.g., infant mortality, female literacy, stunting, meat in the diet, phytate in the diet, measles immunization, and regional tendencies). This is the approach used to estimate zinc deficiency levels [25] and vitamin A and anemia levels [57]. In Mason's estimates [57], the equations were developed from countries with measured prevalence.
- » Figures extrapolated from countries with measured prevalence having a similar demographic profile and anticipated risk [50].
- » Country estimates developed for iodine deficiency using information on soil mapping, characteristics of land, extent of household use of iodized salt, and iodine deficiency levels measured in other countries in the same region [57].

The difficulty of maintaining current estimates of deficiencies requires the development of new streamlined methods for data collection and/or agreement on appropriate modeling methods to simulate trends and patterns of deficiencies in a consistent and comparable manner. There needs to be consensus on the appropriate uses of biochemical and dietary measures, data on outcomes, and the role of modeling in defin-

BOX 2.2. Diet and diseases work together to cause VMDs during various stages of the lifecycle and during emergencies [62]

- » The vitamin and mineral content of the diet is the main determinant of the micronutrient status of a person or a group. Deficiencies can be caused by insufficient micronutrient intake compared with the physiological need for each nutrient or excessive losses of the nutrients due to illness, poor absorption, or bleeding. Often both factors—low intake and loss—are responsible. Failure to fully address these direct causes has led to the failure of some intervention programs.
- » Some foods (e.g., animal foods) have a higher content of micronutrients than others. Breastfeeding is a good source of micronutrients in infants and protects against infections. A deficiency in the soil (e.g., an iodine-deficient soil) can cause foods to have low nutrient content. Inhibitory factors may be present in the diet that prevent absorption of the micronutrients in food, e.g., phytates prevent iron and zinc absorption. Processing can remove these inhibitors.
- » An increased need for micronutrients in pregnancy and during periods of rapid growth in infancy and childhood makes people in these physiological states highly vulnerable to VMDs. A mother's nutritional status before conception and her micronutrient status during pregnancy determine the adequacy of micronutrient stores at birth for the newborn. The mother's status continues to influence the infant's status through the levels of micronutrients in breastmilk. Aging populations in developed and developing countries are also experiencing significant VMDs because of poor dietary intake and low absorption.
- » Rapid urbanization is one of the driving forces for transitions in dietary practices, resulting in greater access to a diversity of foods, particularly livestock and dairy products, among some segments of the population and thereby potentially improving micronutrient intake. But among the urban poor, the problems of affordability and access to foods have increased the risk of poor nutrition and poor health. According to WHO/FAO [62], "[U]rbanization will distance more people from primary food production, and in turn have a negative impact on both the availability of a varied and nutritious diet...and the access of the urban poor to a varied diet."
- » Natural and man-made emergencies can create situations that lead to VMDs. In some settings, seasonal or cyclical peaks in VMDs are manifestations of seasonal/cyclical food access, dietary changes, and/or disease incidence.

ing the prevalence of deficiencies. For example, there is concern that UI in school children does not accurately reflect population-wide coverage of iodized salt. Measurement of serum retinol is confounded by the presence of infections. Also, the use of a single blood spot to assess several deficiencies was being considered some years ago but there has been little follow up.

A major gap is the absence of dietary intake data. Very little representative information is available on food consumption among high-risk groups; this is a limitation in planning food-fortification programs and complementary or hybrid strategies (e.g., combining fortified staple foods with home-based powders containing vitamins and minerals such as Sprinkles or supplements for young children).

It is also worth noting that relatively few data are currently available for quantifying either the joint distribution of multiple deficiencies or the impact that multiple VMDs have on specific health outcomes. In this report, each deficiency is treated independently, although some of these nutrients affect closely related biological systems.*

Next steps for strategic action and research

- » A monitoring and surveillance component for the proposed global strategy will be essential to track global progress and identify bottlenecks. Designing this component will involve addressing issues related to indicators, methods, and definitions. There is need for consensus on indicators to be used and standardized data collection and reporting for countries.
- » Technical reviews are needed to interpret the VAD trends in existing data, especially trends following large-scale supplementation programs in which mortality declines but serum retinol distribution does not change.
- » Mechanisms should be established for gathering and reporting data from routine surveys and surveillance for iron, zinc, and folate deficiencies, anemia, and intestinal parasites. More detailed dietary data should be routinely collected, disaggregated by household income, and should focus on young children and women of reproductive age.
- » Current prevalence data based on nationally representative surveys are urgently needed, especially for the high-burden countries of Asia and Africa, where a reduction in deficiencies is likely to take place as part of the global strategy. Funds should be set aside

* For example, vitamin A and zinc play important roles in maintaining different aspects of immune function, and vitamin A, iron, B12, and folate affect hemoglobin metabolism. Epidemiological studies have demonstrated that the prevalences of these deficiencies are high in the same populations, indicating that many people suffer from multiple micronutrient deficiencies at the same time.

for baseline studies. Ideally, program process indicators and information to guide capacity building and donor support should be tracked. Low-cost methods should be developed, for measuring more than one deficiency at a time.

- » Support should be provided to document improved functional outcomes linked to improved micronutrient indicators in key countries (e.g., reduced mortality and improved productivity, test scores, and school attendance). Opportunistic strategies based on routine rather than controlled trials would be cost-effective.
- » Country and regional capacity must be built to track VMDs and the related variables, especially individual quantitative food intakes in key age groups, and to make optimum use of the data to guide country programs.

Conclusions and recommendations

- » VMDs remain at high prevalence levels, but important progress has been made in reducing IDD and VAD, even in remote areas. Rapid improvements resulting from programs indicate the potential to make a major contribution to global public health by reducing VMDs. A large number of countries with sizable populations have not yet scaled up programs, except for iodized salt.
- » Countries of sub-Saharan Africa and South Asia have the largest prevalence rates and the largest absolute numbers of people with VMDs. The success of a global strategy will be determined by the ability to scale up proven interventions in these two regions.
- » Considering the distribution of VMDs among various segments of the population and various age groups, a combination of universal and targeted intervention approaches is needed. Specific approaches are needed to reach women of reproductive age, the very young, and the very poor.
- » It is important to continue tracking the prevalence of deficiency diseases even after substantial reductions are achieved in order to determine whether the improvements are being sustained.
- » Resources are needed for adequate baseline studies in key countries to establish current levels of VMDs for the global strategy.
- » New noninvasive, low-cost, and rapid techniques need to be developed for assessing the prevalence of deficiency diseases.

How can vitamin and mineral deficiencies be reduced?

Implementing proven interventions at scale

Tina Sanghvi, Omar Dary, and Robin Houston

Summary of findings

- » The main options for addressing VMDs are food fortification and supplementation. Support of optimal breastfeeding and appropriate complementary feeding are key food-based approaches that support good micronutrient status during the high-risk period of infancy. Broader dietary diversification has not produced significant results at scale, and plant breeding is relatively new. Public health interventions—especially malaria control, control of intestinal parasites, and measles immunization—have helped reduce deficiency diseases.
- » Databases on national coverage of programs are inadequate to assess the relative success of interventions in reaching coverage and reducing deficiencies. The notable exceptions are iodized salt and vitamin A supplementation for which evidence of coverage and impact is available. There is some evidence of the success of folic acid supplementation and fortification but no global databases so far. In countries with a high burden of VMDs, there is strong evidence that fortification and supplementation have been effective. Dramatic reductions in national indicators of childhood mortality and the virtual elimination of clinical deficiencies of iodine and vitamin A have proved the effectiveness of these interventions on a large scale in countries as diverse as Nepal, Nicaragua, and Tanzania.
- » The number of countries with iodine deficiency as a public health problem declined substantially from 1993 to 2003, although these countries may still have pockets of iodine deficiency requiring targeted attention. Most countries with scaled-up, high-coverage vitamin A supplementation have linked supplementation with routine immunization or immunization campaigns, or both, at least initially. However, several large, high-burden countries have reached coverage of only 50% or less, a level that will probably not produce the expected declines in mortality.
- » In high-burden countries, prenatal IFA supplementation is being attempted, but there is little evidence of impacts. Problems include irregular supplies and noncompliance. Folic acid fortification is likely to have been more cost-effective than supplementation in the few countries where it has been implemented and this needs to be evaluated. Iron and the B vitamins fortification of cereal flours and condiments has been implemented in several countries, but the coverage of fortified products is not well documented. Vitamin A–fortified sugar has been successful in Central America; fortified vegetable oil is widely used in food distribution programs and is expanding commercially in Asia, Africa, and Latin America. Zinc supplementation is being launched as part of the control of diarrheal disease (CDD) efforts; in several countries, the supplement is added to premixes for cereal fortification. Supplements and fortified foods have successfully prevented the emergence of VMDs common in emergencies according to the World Food Programme (WFP).
- » The available data on the progress of programs do not provide a complete picture. Many more countries than reflected in current databases have achieved good vitamin A supplementation and iodized salt coverage. It is necessary to define the various kinds of programs currently being implemented and to track their progress systematically, beginning with the high-burden regions of South Asia and sub-Saharan Africa.
- » Mandatory public-sector-led food fortification and voluntary industry-led fortification have both demonstrated results. The success factors for fortification programs are availability of suitable food vehicles (i.e., centralized processing and widespread regular consumption); adequate food regulations and labeling; public awareness and demand; quality assurance and monitoring to ensure shelf life and adequate levels of micronutrients; compliance; and advocacy based on evidence of positive impact. Building strong public–private partnerships is a critical first step.
- » The majority of supplementation efforts targeting high-risk groups are public health programs linked to antenatal care or immunizations. Success factors for supplementation programs are assured supplies,

trained frontline providers, proactive outreach combined with social mobilization, consumer/target group awareness and compliance, listing/registration of eligible women and children, and regular monitoring of coverage.

- » Iodized salt and vitamin A supplementation have both achieved scale. The common factors that appear to have helped in scaling up were strong evidence of impact; low-cost, affordable, and streamlined interventions that could be easily adapted to existing delivery channels; advocacy; documented progress in coverage; leadership in support of the intervention programs at the global and country levels; social mobilization and public awareness; and well-coordinated donor support sustained over several years.

Review of evidence

The principal options for delivering micronutrients are food fortification and supplementation*

The feasibility and effectiveness of the available options vary in different settings, even within countries. Countries are combining and adapting various approaches to suit their local contexts. A growing proportion of the population in many countries fulfills its vitamin and mineral needs through diet, including various kinds of fortified foods complemented with supplements. Strategy development to accelerate progress should be based on a good understanding of age and income disaggregated data on deficiencies and dietary deficits as well as patterns of food consumption and supplement use.

Fortification of foods can provide a substantial proportion of the required nutrients without changing food habits

Table 3.1 provides an example of the range of products being fortified in countries of the Africa region.

* The following are the primary references for this section: Proceedings of the 20th International Vitamin A Consultative Group (IVACG) Meeting, 2002; (b) Pinstrup-Andersen P, Pandya-Lorch R. 2001. *The Unfinished Agenda*; UNICEF/UNU/WHO/Micronutrient Initiative (MI), Preventing Iron Deficiency in Women and Children, 1998; Aguayo et al., 2005; Dary O et al., 2005; Lutter C., 2006; Sanghvi T, Harvey P. 2006. USAID Micronutrient and Blindness Project (A2Z) reports; Mannar MG, Sankar R. 2004. Micronutrient fortification of foods—rationale, application and impact. *Indian J Pediatr.* 2004 Nov;71(11):997–1002; MI/UNICEF 21 Country Assessment, 2005 Draft Report; Houston/USAID Micronutrient Project (MOST), 2004; World Bank, 2006; Thapa S et al. 2005; Mora JO, Bonilla J. 2002; Zlotkin SH et al. 2005; Gallo-way R. 2003. Anemia Prevention and Control: What Works?; Deitchler M et al. 2004; Darnton-Hill I and Nalubola R. 2002; Fortification strategies to meet micronutrient needs: successes and failures. *Proc Nutr Soc.* 2002 May;61(2):231–41; Gibson R. 2004.

Proper choices of fortificant and processing methods are necessary to ensure the stability and bioavailability of nutrients. The level of fortification should take into account variations in food consumption to ensure safety for those at the higher end of the scale and impact for those at the lower end. Fortification must be supported by adequate food regulations and labeling, quality assurance and monitoring to ensure shelf life and adequate levels of micronutrients, public education, compliance, and desired impact. In industrialized countries, food fortification has played a major role in the substantial reduction and elimination of a number of micronutrient deficiencies.

Starting in the early part of the 20th century, fortification was used to target specific health conditions: goiter with iodized salt; rickets with vitamin D-fortified milk; beriberi, pellagra, and anemia with B vitamins and iron-enriched cereals; and NTDs with folic acid-fortified flour [64]. It has taken more than five decades to expand fortification within developing countries. Constraints have included the lack of appropriate centrally processed food vehicles, less-developed commercial markets and technology, and relatively low consumer awareness and demand. The long-term sustainability of fortification programs is ensured when consumers are willing and able to bear the additional cost of fortified foods.

Lutter identified the importance of specially formulated fortified foods for infants and young children [65]. She suggests that macro- and micronutrient composition and the cost of products marketed to urban populations will determine the success of this approach. In the high-burden countries of South Asia and sub-Saharan Africa, changes in complementary feeding practices will need to be encouraged, where delayed introduction of complementary feeding and the use of liquids/low-density products are common barriers.

Vitamin and mineral mixes in powder form or “sprinkles” provide a well-tested vehicle to improve micronutrient status in children ages 6 to 24 months [66] that could be expanded quickly. Pastes containing micronutrients in combination with protein and fats are likely to improve growth and micronutrient status, but they are more expensive and thus may not reach those in need through commercial channels [67].**

According to Mannar and Sankar, “[A]lthough a growing number of large-scale fortification programs in different parts of the world are beginning to demon-

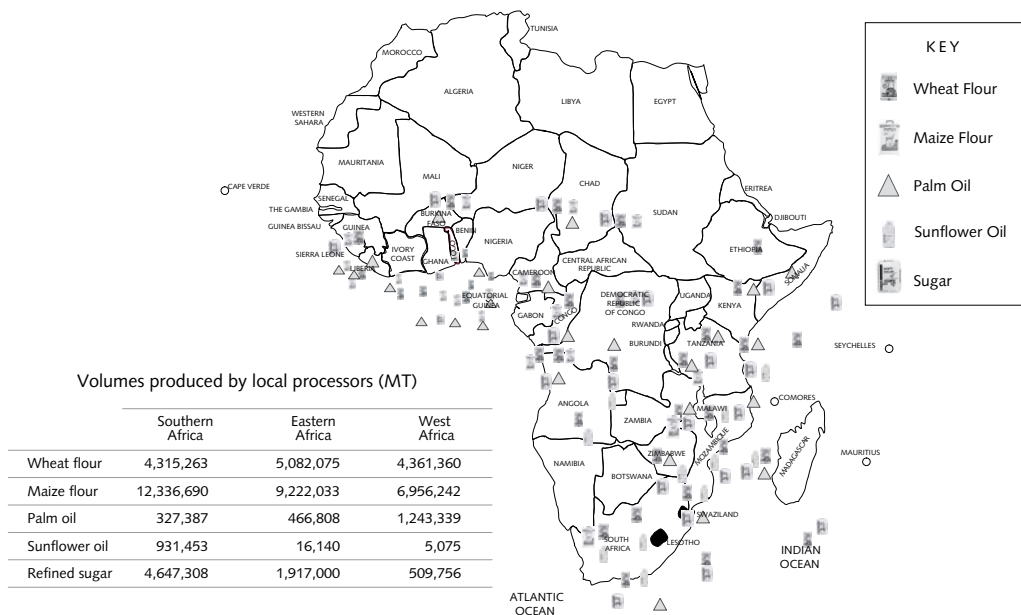
** There are also other presentation options, such as dispersible tablets (see IRIS study, UNICEF). These new approaches are promising and are being documented for effectiveness. Spreads are currently used for the treatment of malnutrition. On-going studies are looking at their preventive uses. However the cost may be a limitation. Research is still needed to explore all possibilities of increasing micronutrient intake, especially during the complementary feeding period (personal communication, B. de Benoist, 2006).

TABLE 3.1. Overview of fortified products in the Africa region, 2005 [63]

Country/region	Wheat flour	Maize flour	Vegetable oil	Sugar	Palm oil
Eastern, Central and Southern Africa (ECSA)	++	+	+	+	
Burkina Faso					+
Eritrea	+				
Ghana	+		+		
Kenya	+	+	+		
Malawi		(maize porridge)	(margarine)		
Morocco	+		+		
Namibia		+			
Nigeria	+	+	+	+	
South Africa	+	+	+		
Uganda		+	+	+	
Zambia	+	+		+	
Zimbabwe		+	+		
			(margarine)		

strate impact at the biochemical level and are leading to the elimination of several nutrient deficiencies, food fortification remains an underutilized opportunity in many developing countries” [68]. But this is changing. The Micronutrient Initiative (MI) has systematically mapped the producer and importer countries and trade flows of key food vehicles in the Africa region [69]. See **map 3.1**.

There is growing support in Asia for public-private partnerships (e.g., the Philippines, India, and others through the Global Alliance for Improved Nutrition (GAIN), MI, International Life Sciences Institute (ILSI), and USAID Micronutrient Project (MOST), and regional organizations such as NEPAD and Eastern, Central, and Southern Africa (ECSA). MI and others have supported the expansion of new products for



MAP 3.1. Potential food vehicles for fortification in Africa
Source: Micronutrient Initiative (MI) Africa, 2006

TABLE 3.2. Examples of key issues in fortification in Africa [70]

Issues	Recommended actions
Need for advocacy for resources and supportive policies for food fortification	Develop food-fortification policy and action plans at the African and Regional Economic Community (REC) levels. Document impact and cost-effectiveness of food fortification in the elimination of VMDs.
Engagement of the private sector to play a significant role in food fortification	Support harmonization of food-fortification standards and develop enforcement capacity at REC level through strategic relationships with RECs. Develop region-wide markets for fortified-food products by creating an investment climate. Actions would include supplying loans, removing tariff and non-tariff barriers, and building consumer demand, including regional logos and certification systems.
Need for building human resource capacity to advance the food-fortification agenda	Identify key capacity areas and competencies required for specific operations and positions. Develop an Africa-wide training program that includes both short-term and long-term training as well as mentoring. Lobby and support governments, development agencies, and the private sector in providing incentives for retention of specialized personnel.

large, public-sector social programs, such as ICDS in India, as well as commercial marketing of staples and targeted foods at a reasonable cost. Specific issues are beginning to be identified at the regional and country levels, and a number of workshops and meetings have been held in Latin America, Asia, and Africa. **Table 3.2** describes key fortification issues identified for Africa.

The recent developments bode well for the achievement of scale and impact, especially if adequate monitoring and evaluation guide the expansion and targeting of the operational elements of strategies. Joint monitoring and evaluation plans should be developed and baselines established during the initial phases of launching a coordinated global strategy.

Oral supplements can be provided through health services to prevent or treat specific deficiencies. Biannual vitamin A supplementation has been successfully scaled-up through outreach activities of peripheral health centers, in combination with catch-up rounds for immunization with intensified community mobilization. **Map 3.2** shows the global coverage of vitamin A supplementation linked to immunization.

According to the WHO database, of 196 countries with data, about 40% provided vitamin A supplements linked to routine immunization or immunization campaigns, or both [49] (and personal communication, T Goodman, WHO, 2006). More than 60 countries did not link vitamin A to immunization. Prenatal iron supplementation is a universal part of antenatal care policies, but only about 40 countries report data on consumption of prenatal iron supplements (see: www.gainhealth.org) using DHS and other surveys, and most have very low coverage. More than 22 countries have adopted public health policies for iron supplementation for infants and preschool-aged children, but few implement such programs [71]. Programs for improving folate nutrition have been introduced in about 40

countries; these are estimated to account for less than 10% of NTDs caused by folate deficiency [72].

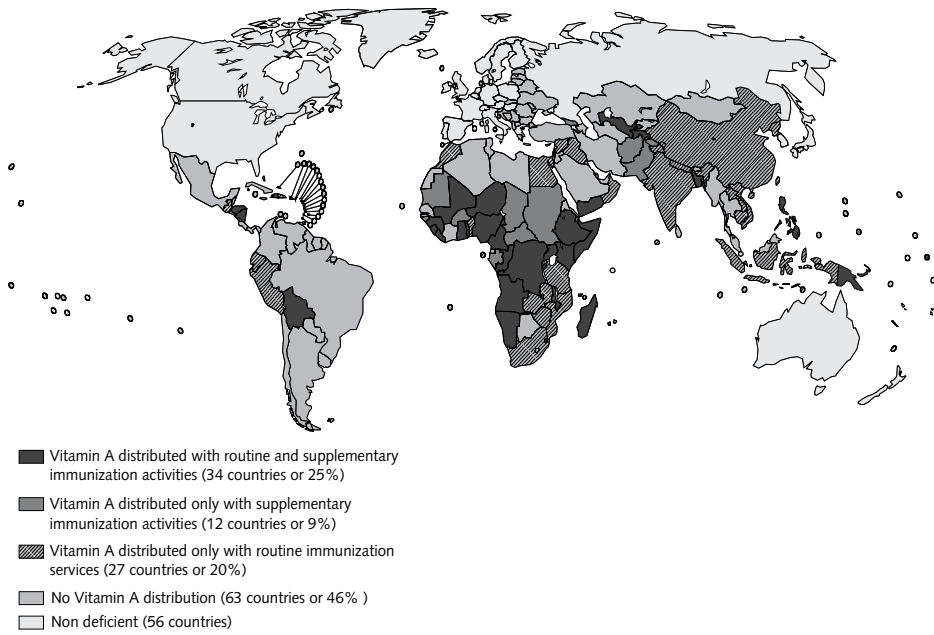
Immunization campaigns are a major delivery channel for vitamin A. As seen in **table 3.3** and **map 3.2**, immunization campaigns are likely to be phased out or redirected to new disease control initiatives. They are not a stable platform on which to build an ongoing strategy.

In theory, activities to enhance dietary diversification are an attractive option for improving micronutrient status, but these have proved difficult to evaluate. Data on the extent and forms of micronutrients in plant-based diets show that it is virtually impossible to correct VMDs through dietary changes. Young children in particular, who have enhanced physiological needs and limited capacity, find it difficult to consume the required amounts of plant foods [70, 74]. However, improving diets to raise micronutrient intake and increasing the use of foods that enhance absorption for the purpose of improving the efficacy of fortified

TABLE 3.3. Proportion of vitamin A doses delivered via national and subnational immunization days

Region	2004 (%)	2005 (%)	2006 (%)
Africa: Eastern, Central, and Southern	14	18	14
Africa: West	86	88	91
Asia: East and South-east	0	0	0
Asia: South	47	33	33
Latin America and Caribbean	0	0	0
Total	39	38	37
Exclusive of India	49	48	47

Source: UNICEF 2005, as presented by the Micronutrient Initiative, (MI) 2005 [73]



MAP 3.2. Regional patterns of vitamin A supplementation linked to immunization
 Source: WHO/IVB database, 2005 192 WHO Member States. Data as of September 2005

products and supplements are valid objectives of public education and dietary counseling programs. People will be able to obtain sufficient micronutrients from a combination of food sources, fortified products, and supplements.

Recently, consumer demand for micronutrient-rich foods of animal origin has accelerated. The livestock and dairy industries have expanded in response to burgeoning demand from consumers in developed and developing countries. Annual production of fruits, vegetables, meat, and fish has accelerated in developing countries (fig. 3.1) There is some evidence that fruit and vegetable consumption is higher in upper-income households in sub-Saharan Africa (fig. 3.2), and the gap in micronutrient intakes between rich and poor households may have increased. It appears unlikely

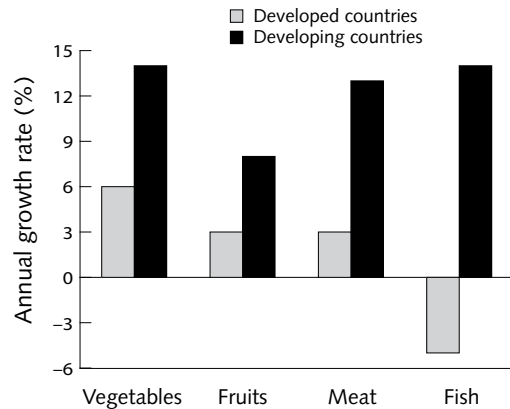


FIG. 3.1. Increased production of micronutrient rich foods
 Source: FAO Statistical Databases (FAOSTAT) 2005 [75]

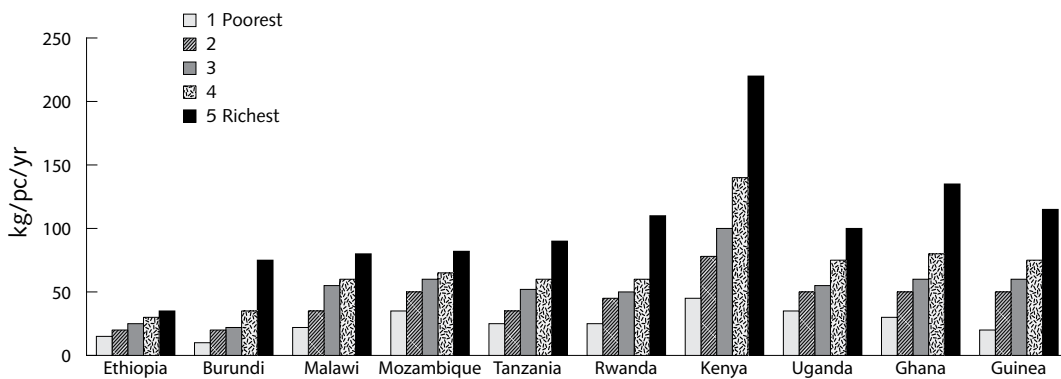


FIG. 3.2. Differential intakes of fruits and vegetables by household income in Africa
 Source: Ruel et al. [76]

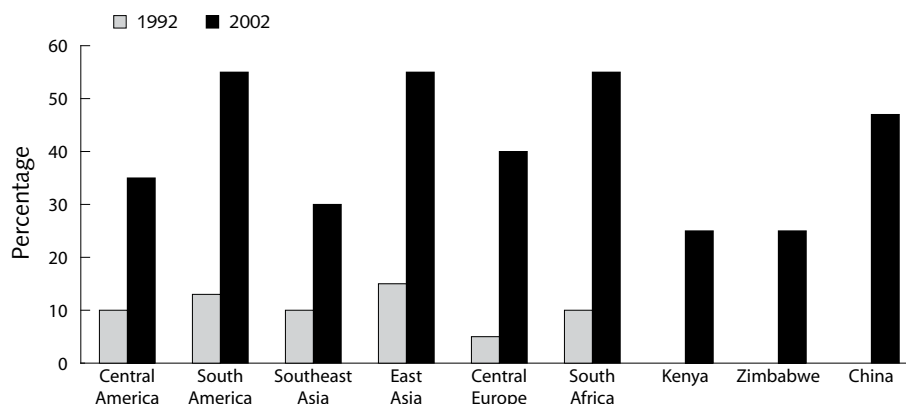


FIG. 3.3. Growth of retail food sales through supermarkets in developing countries and regions
Source: Reardon and Timmer et al [77]

that increased consumption is a result of attempts to improve dietary diversity through traditional nutrition education efforts, as there is little evidence that these programs have achieved sufficient scale. Analysts believe that the increased consumption is the result of low costs of production and marketing, affordable prices, and the image of these foods as prestige foods. The recent trend toward centrally managed purchasing in the food retailing sector (namely, through large supermarket chains in developing countries) offers a new opportunity for market-based improvements in micronutrient intake (see **fig. 3.3**).

The composition of foods can be modified through selective plant breeding and genetic modifications, or biofortification (the development of food crops rich in bioavailable micronutrients, through either conventional breeding and selection or transgenic techniques).^{*} While traditional staples tend to be low in micronutrients, biofortification is showing promise. Although the levels of micronutrients are unlikely to reach those that can be achieved through commercial fortification, once they are developed and integrated into agricultural systems, biofortified cultivars can be incorporated rapidly into the diets of vulnerable groups with important health benefits.

Some health interventions have been important adjuncts for reducing VMDs. Health interventions—such as measles immunization for VAD, deworming for anemia and VAD and malaria treatment for severe anemia—have documented impacts on deficiency diseases such as anemia and VAD. In addition, there is strong evidence that infant feeding practices, especially optimal breastfeeding and appropriate complementary feeding, are closely related to micronutrient status. Epidemiological evidence of causality and program

results suggest that country strategies for reducing VMDs should explicitly link with these maternal and child health (MCH) and nutrition services, or vitamin and mineral deficiencies are likely to persist.

Strategies for delivering vitamins and minerals have adapted to new opportunities and evidence. Delivery strategies for interventions that address VMDs have evolved considerably over the past 30 years (see **table 3.4**). Research in the 1970s and 1980s suggested that even where clinical forms of VMDs were not widespread, they could cause functional damage in humans. This finding changed the perception of the problem. It suggested that a much larger proportion of the population needed to be reached, and transformed the way intervention programs were designed and implemented. The emphasis shifted from simply detecting xerophthalmia and treating it with vitamin A, for example, to providing universal biannual doses of vitamin A. A similar shift occurred with goiter and anemia, as intervention strategies sought to provide universal coverage of iodine and iron to prevent the deficiencies.

Food fortification emerged as one of the most cost-effective interventions and one that could achieve scale rapidly if foods commonly consumed by a large proportion of the population were fortified. This led to a new appreciation for the role of the private sector in reducing VMDs. There is growing emphasis on community mobilization and raising public awareness, not only to promote fortified products and motivate uptake and compliance with supplementation protocols, but also to generate ownership and commitment at the community, district, and national levels.

New products, market channels, and health delivery approaches have opened up more options to meet country-specific needs. For example, a broader array of fortified staple foods and specially formulated foods and supplements is now available through a larger number of producers. Processes and frameworks for successful industry-led and government-supported

^{*} The obvious advantages and recognized potential of this approach to address VMDs (Welch and Graham, 2004) have recently attracted many advocates, donors, and commercial interests; it is considered a promising approach for the long term.

strategies are delivering micronutrients in various country settings. Better coverage has recently been documented among high-risk groups, even in remote areas, using intensified outreach from health facilities to deliver micronutrients. Several large countries in South Asia offer government-supported program platforms—such as ICDS in India, Lady Health Visitors (LHVs) in Pakistan, and FCHVs in Nepal—that are capable of reaching a substantial segment of the vulnerable population.

Safety concerns for micronutrients have surfaced periodically, and WHO has addressed them appropriately. Two recent studies have highlighted the importance of supporting the responsible use of supplements where infection rates are high [28, 79]. WHO has been at the forefront of interpreting safety concerns arising from research findings. However, there is currently no central authority or mechanism to help countries manage these issues programmatically. Recognized safety issues are summarized in **table 3.5**.

What is the evidence of effectiveness in large-scale programs?

Fortification has reduced vitamin and VMDs in all geographic regions. Developed countries have benefited from fortification for more than 80 years, and food fortification has been in place in selected countries of Latin America for more than 30 years. In the early 20th century in Switzerland, school children had a high prevalence of goiter, and 0.5% of the population had cretinism. When salt iodization was introduced in 1922, the prevalence of goiter and deaf mutism in children dropped dramatically. Since then, salt iodization has been sustained and the population of Switzerland has achieved adequate iodine status. Recently, several countries have documented a reduction in NTDs following folic acid fortification of cereal flour (**fig. 3.4**).

The addition of vitamin D to milk in Canada and the United States started in the 1930s and virtually elimi-

nated childhood rickets, although rickets is re-emerging as a public health problem. In the 1930s, beriberi, riboflavin deficiency, pellagra, and anemia were public health problems in the United States, leading to the decision to add thiamin, riboflavin, niacin, and iron to wheat flour. In the United States and Europe, a diverse diet containing animal foods plays a role in ensuring healthy micronutrient status, but fortified cereal products still make an important contribution.

Supplementation programs for vitamin A have been followed by mortality declines. The predicted reductions in under-five mortality from vitamin A supplementation [5] have been validated through recent DHS surveys that document shifts in child mortality trends paralleling the scaling up of vitamin A supplementation in several countries. **Figure 3.5** provides data from Nicaragua. Thapa and others [83] showed a stepwise relationship between vitamin A coverage and mortality levels in Nepal based on data from DHS surveys.

A substantial proportion of all vitamin A supplementation is carried out with immunization activities twice a year. Since 1987, WHO has advocated the routine administration of vitamin A with measles vaccine in

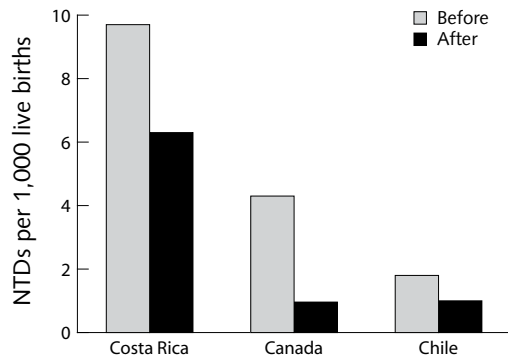


FIG. 3.4. Annual rates of neural tube defects (NTDs) before and after folic acid fortification
Source: PAHO, CDC, MOD, UNICEF, INTA, 2003 [81]

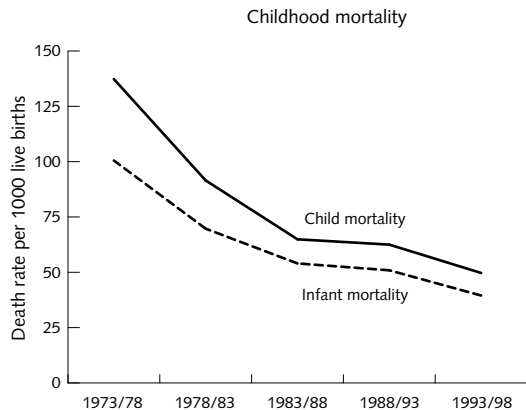
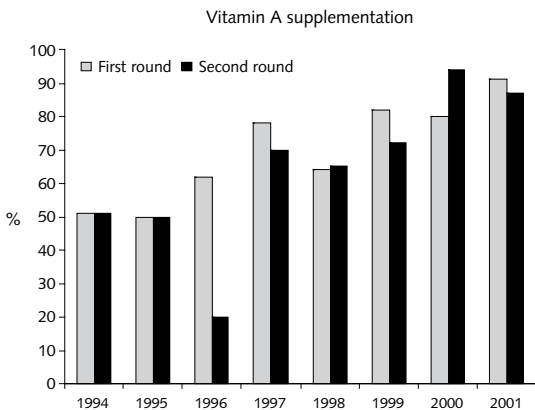


FIG. 3.5. Rising vitamin A coverage and childhood mortality decline in Nicaragua
Source: Ministry of Health (MOH), Nicaragua [82]

TABLE 3.4. Milestones in evolving micronutrient strategies

<p>I. Micronutrients gain a discrete place on national public health agendas</p> <p>Supplementation Recognition of life-saving and functional importance of micronutrients. Vitamins and minerals provided to individuals diagnosed with deficiency diseases.</p>	<p>Establishment of mortality impacts of vitamin A even where clinical signs in the population are not highly significant. Need established for mass supplementation as preventive measure for mortality reduction. Low measles immunization coverage and analysis on vitamin A supplementation during measles puts disease-linked vitamin A supplementation high on priorities for pediatric care. Connection of iodine deficiency to brain development receives attention.</p>	<p>III. Alternative delivery strategies tailored for local contexts; USI; vitamin A and iron integrated within IMCI</p> <p>Policies in many countries call for expanded vitamin A supplementation and universal iron/folic acid supplementation in prenatal care. Iodized oil supplements used where iodized salt is not produced or used. Clinical detection and treatment of severe anemia integrated within the IMCI; also, vitamin A for measles and the severely underweight.</p>	<p>IV. Successful mass distribution of vitamin A; sustainability issues arise; no breakthroughs yet in iron interventions</p> <p>Nepal demonstrates the use of community-based volunteers to administer vitamin A at almost national scale. Vitamin A supplements are linked to national immunization days (NIDs) for polio and reach unprecedented numbers of children in large numbers of countries. Iron coverage still lagging behind. Iodine supplements found to be not cost-effective and use severely limited.</p>	<p>V. Lancet series reestablishes importance of new “super-nutrients,” zinc and folic acid; need for coordinated global strategy for acceleration [78]</p> <p>Phasing out of NIDs, although a number of countries in Africa still depend on NIDs for vitamin A delivery. Donor-dependent vitamin A supplies raise concerns. Alternatives such as child health weeks (CHW) are found to be feasible and cost-effective when services are combined. The six-month outreach strategy becomes accepted as a public health tool for delivery of basic services. Malaria and deworming are recognized as key adjuncts for anemia reduction. Supplies, formulations for young children, and compliance are identified as key constraints for iron supplementation. Zinc to lead the revitalization of control of diarrheal disease (CDD) and oral rehydration therapy programs.</p>
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TABLE 3.4. Milestones in evolving micronutrient strategies (continued)

<p>Food fortification Enrichment to replace nutrients lost during processing. Fortified margarine and dairy products.</p>	<p>Need for universal strategies is emphasized as subclinical indicators are found to be associated with important outcomes (e.g., vitamin A, iron, and iodine deficiencies). Potential of fortification gains momentum.</p>	<p>Salt iodization universalized. Sugar fortification in Guatemala and other Central American countries demonstrates feasibility for reaching scale; introduced in Africa (Zambia). Emergence of previously eliminated deficiency diseases in refugee camps raises concerns for providing fortified products and supplements. Fortified foods come under scrutiny in food aid programs.</p>	<p>Intensified efforts in USI, but issues of sustainability, quality, and surveillance arise. Fortification of cereal flours with iron and B vitamins begins to take off, but public health impact is yet to be established at scale. A wide array of products emerge as fortification vehicles, including powders for home fortification for children. Lack of government capacity in enabling industry and enforcement are identified as key barriers.</p>	<p>Capacity building in fortification intensified; recognition of regional nature of production and trade flows in Africa; greater efforts to build public-private partnerships as a bridge. Growing understanding of regulatory frameworks, laboratory needs, creation of public demand, and other hitherto underemphasized elements. Need for more realistic cost projections and time lags. Need to define how to target for better public health impacts (e.g., trends in consumption patterns of high-risk groups).</p>
<p>Dietary diversification Food composition studies help identify good food sources, and these are promoted through nutrition education.</p>	<p>Studies on iron inhibitors, vitamin A absorption, and conversion of beta carotene define the limitations of dietary approaches. Studies on food behavior modification find positive results, but intensity of interventions raises concerns about feasibility.</p>	<p>Cost-effectiveness studies put fortification at the top of intervention priorities. Severe lack of "problem nutrients" in complementary foods identified, reemphasizing the need for fortified special foods and supplements.</p>	<p>Lack of evidence that large-scale reductions in deficiencies can be accomplished through dietary diversification strategies minimizes the role of this approach. Rise of biofortification through plant breeding. Orange sweet potato successfully introduced in East Africa. Biofortification gains momentum with other crops.</p>	<p>Reemergence of dietary diversification as a key component of micronutrient strategies, especially with regard to time lags in take-off of programs at scale, and interactions among micronutrients and between micronutrients and infectious agents (e.g., malaria and HIV/AIDS). Role of phytochemicals (quasi-micronutrients) in disease prevention highlights need for continued work to expand public education and investment in the horticulture/nutrition crops sector.</p>

USI, universal salt iodization; IMCI, integrated management of childhood illnesses

TABLE 3.5. Safety issues

Micronutrient	Issue	Evidence
Vitamin A	Toxicity from excessive intake from high-dose capsules that can cause fetal abnormalities or bone fragility. Acceleration of HIV/AIDS infection in neonates of supplemented mothers.	No confirmed evidence of toxicity in currently implemented programs. New US survey data [80] show dietary excess in young children above recommended levels. The ZVITAMBO study [28] in Zimbabwe indicates adverse events in a small proportion of infants of HIV-positive mothers.
Iron	Iron toxicity in young children from accidental excessive intake of tablets or syrup. Increased morbidity in iron-replete young children where malaria is endemic.	The United States has few cases of overdosing; emergency medical services use simple methods to remove the excess iron to prevent serious effects. The Pemba study [19] in Tanzania shows deleterious effects on malaria progression in children.
Iodine	Excessive iodine that causes hyperthyroidism, tremors, and nodules, especially in the elderly and where low iodine intake has been endemic for a long time.	Iodine-induced hyperthyroidism (IIH) is the most common complication of iodine prophylaxis; it has been reported in some iodine supplementation programs in their early phases. Excess iodine in salt can result from not adjusting added levels to account for greater stability of iodine in processed, refined salt.
Folic acid	Excess can interfere with vitamin B ₁₂ metabolism and neurologic functions. The US Food and Drug Administration (FDA) has set a safe upper limit of consumption at 1 mg/d of folic acid.	Cases of pernicious anemia incorrectly treated with folic acid instead of B ₁₂ demonstrated adverse effects; needs further study.
Zinc	Interactions with iron. Effects of excess zinc intakes on the immune system as indicated in the literature.	None; there are no large-scale programs in operation.

Source: WHO website and published documents

countries where VAD is a problem. The first dose of vitamin A is given with measles vaccination at about 9 months of age; children 1 to 5 years old receive vitamin A doses through intensified outreach every 6 months [84].

Lessons learned about scaling up

Public education and social mobilization are critical but often neglected components of supplementation and fortification activities. Mobilizing the community for vitamin A supplementation and creating demand for fortified products are key components of effective strategies. National and district budgets seldom provide adequate resources for these activities (**box 3.1**).

Monitoring and evaluation are important program components that can facilitate scaling up but require ongoing attention. Emphasis on surveillance in USI programs helped maintain a focus on problem-solving as large-scale programs for iodized salt were rolled out. Where salt iodization has been in place for more than five years, improvement in iodine status has been clear cut. Over the past decade, the number of countries with salt iodization programs has doubled, rising from 46 to 93. As a result, 68% of the five billion people living in

countries with IDD have access to iodized salt, and the global rates of goiter, mental retardation, and cretinism have fallen.

Vitamin A supplementation was scaled up at the global level following the meta-analysis of Beaton and others [5]. In early implementation countries, evaluation data were used to initiate action. For example, nationwide vitamin A supplementation was initiated as a result of two key studies on child mortality in Nepal. A unique characteristic of this program was the use of monitoring data for program advocacy; use of data in this way helped obtain resources and motivated staff to maintain high levels of coverage [85].

Progress has been substantial in identifying and improving the use of common indicators among stakeholders. However, technical issues related to methods, interpretation, and comparability must be addressed on an ongoing basis. For example, the complex etiology of anemia requires the use of locally appropriate indicators and methods, and these may not be comparable across programs and countries. The precision of iodized salt testing kits and standard approaches to using different-colored vitamin A capsules to help recall vitamin A supplementation in DHS and similar surveys have created problems of consistency in the field. Greater

BOX 3.1. Mobilizing communities: the vitamin A project in Nepal

- » The ongoing success of vitamin A supplementation at the national level over several years is partly due to an innovative communication approach.
- » The management body developed a unique and respectful relationship with the primary outreach workers, the Female Community Health Volunteers (FCHVs). The program staff were treated as they were expected to treat mothers.
- » Training for field workers was highly participatory, involving extensive role-plays designed to build confidence, support, and a sense of ownership of the program. The approach was entertaining and empowering. These attitudes and approaches led to high levels of motivation among the FCHVs, who then motivated and organized others.
- » The program featured creative media and communication approaches combined with carefully field-tested materials and messages to popularize desired behaviors.
- » At the community level, special outreach efforts were held in hard-to-reach communities often neglected by local programs. The program achieved and maintained high levels of coverage and produced epidemiologically significant outcomes.
- » The periodic reporting of evidence-based results formed the underpinnings of advocacy at the district and national levels.

Source: USAID Basic Support for Institutionalizing Child Survival (BASICS II)/USAID Micronutrient Project (MOST), 2004 [85]

BOX 3.2. Evaluating Vitamin A supplementation programs in the Philippines

The prevalence of vitamin A deficiency (VAD) as measured by serum retinol in children ages one to five years in the Philippines rose from 35.8% to 38% between 1993 and 1998, despite a twice-yearly universal vitamin A capsule distribution program. In-depth analysis showed that there was a detectable impact in groups with the highest prevalence of VAD and that it lasted up to four months after the dose was given. In highly urban cities in Visayas, where very high prevalences were found, the prevalence was reduced from 27% to 9% 1 to 2 months after distribution of vitamin A capsules, and to 16% at 3 to 4 months. Two concerns have been raised following this analysis: (1) the uneven level of magnitude of the effect of high-dose vitamin A capsules; and (2) the fact that the effect did not persist for 6 months, which is the interval between doses. The authors note that with more frequent dosing, especially for those most deficient, a progressive reduction in VAD may occur. The policy implication arising from these results is that a shift in resources is warranted. In areas of low prevalence of VAD, distribution of vitamin A capsules should be targeted to deficient children only. In areas of high prevalence, vitamin A capsules should be distributed to children ages 1 to 5 years at least three times a year.

Source: Pedro et al., 2004 [86]

attention needs to be given to the quality of data.

An issue that has concerned public health leaders in countries such as the Philippines and Zambia is related to the evaluation of vitamin A supplementation using serum retinol as the indicator of VAD. Technical discussion at the global level is needed to clarify how best to capture the success of vitamin A supplementation in reducing VAD at a time when clinical signs are no longer common. **Box 3.2** summarizes an example from the Philippines that reflects current thinking.

Vitamin A supplementation was accelerated with the help of free or subsidized capsules. Global expansion took off when donors pledged free supplies of vitamin A if countries linked polio national immunization days (NIDs) and routine immunization with vitamin A supplementation. Within a 2- to 3-year period, a large number of countries reached millions of children through polio campaigns. However, the trends documented by WHO* reflect instability and frequent transitions between any supplementation, routine immunization-linked supplementation, and

supplementation with biannual events or immunization campaigns. Immunization campaigns have been unpredictable and the addition of vitamin A to these campaigns is idiosyncratic.

Partnerships have been crucial to success. In both salt iodization and vitamin A supplementation, progress has been dramatic since global partnerships were formed. To control IDD, USI was adopted in 1993. Alliances among UN agencies (WHO, UNICEF) and the World Bank, the Network for Sustained Elimination of IDD, the International Council for Control of Iodine Deficiency Disorders (ICCIDD), international institutions, bilateral agencies (e.g., United States Agency for International Development [USAID] and the US Congress), and the salt industry have helped countries put permanent national salt iodization programs firmly in place. Global standards, guidelines, tools, and resources have been provided by international agencies. These agencies have helped public health authorities in various countries successfully partner with the salt industry and have provided critical technology and technical inputs.

Clear evidence of the mental and physical damage done by IDDs, along with mandatory fortification, fueled the momentum for scaling up iodized salt programs worldwide. Salt iodization has proved to be highly cost-effective and feasible for producers, consumers, and governments. Led by a strong global partnership (USI)

*Vitamin A and immunization tables (personal communication, T. Goodman, 2006).

and with the support of WHO, UNICEF, bilaterals, and private donors (e.g., Kiwanis International and the Bill and Melinda Gates Foundation), countries began to mandate iodization of salt. Coverage with iodized salt increased substantially after 1990. Forty-three of 126 countries with national data documented adequate levels of intake [49]. Iodized salt coverage exceeded 75% in 26 countries in 2004. The number of countries with iodine as a public health problem decreased from 110 to 54 during 1993 to 2003, although these countries may still have pockets of iodine deficiency that require targeted support. Constraints to reaching all target groups with iodized salt include the difficulty of equipping, staffing, and monitoring small-scale production; the lack of consumer awareness and demand; weak or no legislation or legislation that is not implemented; and inadequate technical support and accountability.

Sustainable programs are important; micronutrient interventions must be maintained in perpetuity or the deficiencies will reappear. These interventions are unlike disease eradication strategies, such as the eradication of smallpox and polio. The human body cannot manufacture these vitamins and minerals to meet critical life functions; they must be consumed through food or by supplementation. Because of the need to build permanence in this sector and the vulnerabilities of public-sector delivery systems, interest is increasing in strengthening both public- and private-sector delivery systems.

Once fortification programs are put in place, continued advocacy on behalf of fortification is important. In India, salt iodization was once mandatory; later, the ban on un-iodized salt was lifted and this led to increases in iodine deficiency.

To facilitate sustainability, policies must be continuously monitored. Public education and the awareness, motivation, and capacity of healthcare providers play important roles. Data and results from monitoring systems can be effectively used in advocacy for ongoing support.

In programs of iron supplementation for women, ensuring supplies, providing appropriate counseling on compliance, and mobilizing communities are key to impact. Iron supplementation programs for pregnant women are among the oldest micronutrient interventions still being implemented worldwide. In recent years, countries have embarked on iron supplementation programs for adolescents and young children as well, and there is evidence of impact. Experience has provided useful lessons. For decades, prenatal iron supplementation was a neglected program; it was embedded in routine antenatal care but was poorly implemented. Supplies of iron supplements were unreliable and of poor quality, and the program was not considered a high priority. This may be changing now.

For example, in Nicaragua during 2000–2003, several indicators related to IDA improved nationwide. Cov-

erage with prenatal iron rose from 70 to 88%, and the prevalence of anemia in pregnant women fell by one-third [82]. Coverage of children ages 6 to 59 months with iron supplements improved from 37% to 62%, and anemia fell from 29% to 23%. During this period, breastfeeding duration and vitamin A coverage through fortified sugar and supplements also increased, which may explain some of the reduction in anemia.

In India, UNICEF assisted national efforts to intensify programs for adolescent girls ages 10 to 19 years in seven states. All programs provided weekly IFA supplements, and one state provided daily IFA tablets, as well as albendazole to treat worm infestation [87]. All assessments showed a decrease in the prevalence of anemia. The decrease varied from 5% in Jharkhand state to 40% in Andhra Pradesh state after one year. Andhra Pradesh also conducted an assessment 2 years later and reported a total reduction of about 70% in anemia. Programs conducted through schools showed greater impact than non-school-based programs, achieving a more than 20% decrease in the prevalence of anemia. Moderate and severe anemia decreased in all but one program.

Thailand has addressed nutrition in national development policies and plans since the mid-1970s. Anemia is still widespread and observed in almost all vulnerable groups, but there is an improving trend in all regions of the country. Data from national nutrition surveys and routine Ministry of Health (MOH) data show a consistent decline in anemia prevalence among pregnant Thai women during 1986–1996 [88]. The program initially consisted of surveillance and iron supplementation; fortification has been added.

The effectiveness of weekly iron supplementation in women of reproductive age in three Asian countries has recently been documented by Cavalli-Sforza and others [89]. Social marketing and community mobilization were strong elements of the programs.

For preventive vitamin A supplements for children, community mobilization and well-planned outreach sessions at least twice yearly are important. Once polio campaigns began to be phased out, countries developed plans to continue high coverage strategies for vitamin A supplementation. Child health days/weeks/months were seen as a twice-yearly outreach session during which immunization, vitamin A, deworming, and other services and information could be provided, especially to hard-to-reach communities.

The Nepal vitamin A supplementation program was introduced in the poorest districts in 1993 (even before polio NIDs) and was phased in to reach almost national coverage by 2001. Coverage has remained high, attributed to a system of resident FCHVs trained to administer vitamin A with supervision from health authorities on two fixed days each year. The volunteers know the eligible children in their communities and monitor their need for supplementation. Analysis of child mor-

tality trends based on consecutive DHS surveys shows a reduction in child mortality of 50% among children who receive two doses each year of vitamin A in the period from ages 6 to 59 months [83].

In Vietnam, biannual vitamin A supplementation rounds were implemented through NIDs and micronutrient distribution days from 1993 to 1997 [90]. National protein-energy malnutrition (PEM) and VAD surveys carried out in 1985, 1988, and after vitamin A supplementation in 1993–94, found that night blindness, Bitot spots, and corneal scars had declined by 87% to 90% following supplementation.

In Nicaragua, strong partnerships helped achieve and maintain high coverage of the vitamin A supplementation program.

Lessons learned from a large number of countries that followed this model of twice-yearly supplementation have found the following components to be key aspects of success: bringing services closer to communities through a variety of extended outreach mechanisms at fixed times during the year; monitoring and frequent review of coverage; communication and community mobilization; logistics and financing; and training and supervision [91]. Leadership and partnerships across sectors have helped several countries sustain these programs over several years.

How have micronutrients been delivered during emergencies?

Fortification of donated food resources is key to preventing deficiencies. For many years, donated commodities did not contain vitamin and mineral premix. As evidence was reported of deficiencies in vitamins A, B, and C, international donors and NGOs took steps to ensure fortification or supplementation as integral elements of relief efforts. The WFP has implemented local processing and fortification in Angola, Bangladesh, India, Nepal, and Zambia, and in the southern Africa regional drought emergency.* The experience shows that local fortification is possible but challenging. Specifically, the challenges involve technical and managerial capacity constraints, lack of compliance with procurement specifications and quality control, unclear policies on micronutrient content labeling, and inadequate cash resources to support many aspects of local processing and fortification activities. Blended and fortified foods typically given during an emergency now contain added vitamin A, thiamine, riboflavin, niacin, vitamin C, folic acid, iron, iodine and zinc.

Blended foods may not fully meet the needs of pregnant

and lactating women or young children in emergencies. This is primarily because the micronutrients may not be absorbed very well and because other critical micronutrients, such as vitamin B₆, vitamin B₁₂, and zinc, are lacking in emergency situations where food and health systems are dysfunctional. UNICEF, WHO, and WFP recommend daily multiple micronutrient supplements that can meet the recommended nutrient intake for these vulnerable groups during a humanitarian crisis. Helen Keller International (HKI), UNICEF, and WFP are also providing “sprinkles” (a mix of vitamins and minerals that can be added to individual portions or a group feeding) for use in tsunami rehabilitation and through the commercial markets in Asia (Saskia de Pee, personal communication, 2006).

Data sources, limitations, and issues

A lack of objective reviews and evaluations of program implementation and coverage seriously limited this stock-taking exercise. The data used in this review, from web searches and available global datasets, have significant gaps. Taking IDD as an example, among 185 countries, only 123 report UI. Of the 123 countries that report a UI value, only 20% have data more recent than 1999. Among the 24 countries that have more recent UI data, only 54% of the data are from a national survey and only 6 countries report low UI. The WHO database does not include household iodized salt coverage, but salt coverage is reported in the 2004 UNICEF database. Of the 188 countries in that dataset, 117 reported salt coverage. Among the 116 countries with a date associated with the salt coverage data, only 86 (74%) had data more recent than 1999. Among the countries with recent data, 62% had coverage of 50% or more.

Household iodized salt coverage is presented in global datasets as using “adequately” iodized salt. Adequacy is almost always based on the subjective interpretation of the salt test kit, which may underestimate the use of salt with some iodine—perhaps enough to reduce deficiency. Thus, the assumptions made using these global data may be outdated or limited by the accuracy of the data and may not reflect the true situation in the country.

The situation is similar for vitamin A. For many countries, there is a lag between prevalence data and supplement coverage data, so the prevalence data may be misleading if supplement coverage has increased dramatically. Data on prevalence should be used with caution, as improved coverage is likely to have changed the prevalence.

Improved data is essential to building a more comprehensive planning and monitoring framework for a global strategy. Various groups maintain valuable databases that can be further built upon: WHO MDIS, Iron Deficiency Project Advisory Service (IDPAS), and MI/

* Partly adapted from WFP WFP/EB.A/2004/5-A/2 Micronutrient fortification: WFP experiences and ways forward. April 2004. Also see WHO/UNICEF/WFP Joint statement on multiple vitamin and mineral supplements for pregnant and lactating women, and for children aged 6 to 59 months, 2005.

UNICEF/Canadian International Development Agency (CIDA) (vitamin A documents); WHO/Expanded Program of Immunization (EPI) (vitamin A and immunization spreadsheets and maps); Flour Fortification Initiative (FFI); Iodine Network; and others.

Data on food intake and the use of supplements by high-risk age and income groups would be valuable for comprehensive planning. Key information is also missing on types of programs, community platforms, and innovative ways of generating ongoing community demand for micronutrient products and services.

Next steps for strategic action and research

- » There is an overriding need to develop different types of intervention mixes and program strategies to meet the diverse and changing needs of countries as demographics and disease patterns change; no single intervention, such as food fortification, can address the needs of all target groups (e.g., even iodine supplements are essential in some situations).
- » Support for optimal breastfeeding should be a part of micronutrient programs. Operational models for improving micronutrient intake for children ages 6 to 24 months are needed to complement strategies intended for the general population; in South Asia and sub-Saharan Africa, the problem of macronutrients in young children should be addressed at the same time. Solutions for low birth weight are urgently needed in South Asia.
- » Programs should aim to reach at least 80% of the target population with adequate levels of each micronutrient. Coverage data on programs for the five main micronutrients should be updated frequently using surveys, tally sheets, or routine health services data.
- » Ongoing global monitoring of country progress is critical. Systematic program reviews such as the analytic review conducted under the Integrated Management of Childhood Illness (IMCI) are useful every 2 to 3 years to respond to changing needs and adapt new research findings. More frequent (e.g., annual) reviews of country operations and policy issues should be conducted in each region to maintain momentum and target technical assistance as needs arise. An example of such a mechanism is the regional EPI managers meetings organized by WHO.
- » Agreement on program coverage and process indicators and ongoing support for data collection, analysis, and use would help countries target hard-to-reach groups and refocus program efforts.
- » Operational programs are needed to expand the use of zinc in diarrheal disease control programs in different contexts; food-based options are needed to enhance coverage with preventive zinc and folic acid.
- » A summary of evaluations and studies of programs to reduce adolescent anemia reduction would help spearhead this approach to successful anemia reduction in this target group.
- » A review is needed of evidence of effectiveness from large-scale programs of iron fortification of cereal flours.
- » Fortification and supplementation approaches must be developed for addressing multiple VMDs while promoting consumption of micronutrient-rich foods.

Conclusions and recommendations

- » Food fortification and supplementation are effective strategies for reducing VMDs on a large scale in many different settings, but coverage and scale remain limited. Both are highly cost-effective, especially fortification, as compared with other health interventions. But fortification alone cannot solve the problem of VMDs in any country. Supplementation is an essential component of successful strategies to address the needs to critical targets groups. The intake of foods naturally rich in micronutrients can reinforce the benefits of fortification and supplementation; breastfeeding for infants is particularly critical, as are the use of animal foods and fruits and vegetables.
- » Current data limitations and planning mechanisms need to be improved to encourage the development of combined strategies and best intervention mixes for different populations and contexts.
- » A global effort should focus on a group of jointly selected high-need and “potential for high-impact” countries. It is important not to overlook small countries where progress has been made and countries that have good programs that could achieve high universal coverage with limited additional input. Focusing only on high-population countries with large micronutrient problems may result in a loss of momentum in countries that are moving quickly in the right direction.
- » Public–private partnerships are key for effective national strategies; fortification efforts led by private industry have worked well in several countries. Public education and consumer groups are key. The track record on mandatory fortification is impressive where enforcement capacity exists. Both mandatory and voluntary food fortification are greatly helped by adequate monitoring and quality control by industry and government.
- » Micronutrient supplementation can be effectively integrated with routine services and special outreach efforts; supplementation has been successfully combined with other primary health care interventions

- such as antenatal care and immunizations. These efforts should be institutionalized through routine monitoring, planning, training, and supervision within district health services.
- » Both food and health systems should be strengthened to deliver micronutrients to critical target groups in a sustainable manner; lack of leadership is a major constraint and ongoing advocacy is key. Substantially more must be done to clarify, develop, and implement follow-up, monitoring, and evaluation efforts and the use of data.
 - » Much more can be accomplished even with current levels of external support. Global and regional coordination mechanisms have served other health initiatives well and should be adapted. Additional resources are needed for implementation and global coordination.

What are the costs of interventions?

Program costs vary by type of intervention, country setting, and methodology

John Fiedler, Margaret Saunders, and Tina Sanghvi

Summary of findings

Micronutrient interventions are among the most cost-effective public health interventions; combining delivery approaches such as fortification and supplementation to assure coverage of over 60% to 70% of key target groups will increase costs but also assure high impacts.

- » There is enormous variation in the estimated costs of micronutrient interventions. The costs vary dramatically by specific cost measure, program, type of intervention, delivery system, country, and a host of other factors.
- » In the most studied intervention, vitamin A supplementation, the unit cost per beneficiary reported in 27 studies ranges from 14 cents to US\$5.56, varying by a factor of 40.
- » The cost per death averted for vitamin A supplementation programs averaged US\$711 and varied by a factor of 35, ranging from US\$90 to US\$3,383.
- » The estimated costs of vitamin A supplementation interventions vary more than those of any other supplementation or fortification intervention.
- » The single most important cost in vitamin A supplementation programs is personnel, which constitutes roughly 65% of total costs.
- » The single most important cost in fortification programs, accounting for approximately 90% of total costs, is the cost of the vitamins and minerals (fortificant) mixed into the product. Vitamin A is the most costly nutrient in fortification programs. The higher the price of the food vehicle, the easier it is to pass along the cost of fortification to consumers because the natural rise in prices due to inflation can hide the small incremental costs of fortification.
- » The imputed value of the time spent by volunteers who participate in campaign-style vitamin A supplementation programs accounts for about 25% of total costs.*

* Valuing their time at the country-specific minimum legal wage.

- » Tremendous differences in program costs show that it is not useful to generalize cost estimates across different types of programs or different countries.
- » More needs to be learned about government regulatory and enforcement costs and public education costs of food fortification and of large-scale, sustainable biofortification programs.
- » Lack of data on food and supplement consumption among critical target groups makes it difficult to project the coverage and cost-effectiveness of food fortification and supplementation activities. Consumer perceptions of costs and factors influencing consumer choices are important factors determining cost-effectiveness but little information is available.

Review of evidence

Why do cost analysis?

In addition to its use in macro health policy and resource allocation discussions, cost analysis of micronutrient programs has proved useful for understanding and assessing the performance of the programs and for planning and budgeting. Specifically, cost studies have provided information that has been used in the following ways:

- » To provide information for developing budgets or monitoring budget execution.
- » In the analyses of existing programs in Guatemala and hypothetical programs in South Africa, the Philippines, and Peru to inform policy discussions about the cost-effectiveness of alternative program interventions.
- » In an analysis of Nepal and the Philippines, to determine the types and quantities of specific inputs used to produce a service or output.
- » In Nepal, to identify the quantities and types of inputs and the financing required to complete the scaling up of a subnational program.
- » In Zambia and Ghana, to explore the costs and coverage differences of alternative program implementa-

tion schemes.

- » In Jamaica, to identify supply constraints as bottlenecks to improving coverage.
- » In studies of Tanzania, Ghana, Zambia, Nepal, and the Philippines, to assess the relative degree of vulnerability or dependency on foreign funding.
- » In Nepal, to provide information to assess progress toward sustainability.
- » In Jamaica, to demonstrate that the cost to households of participating in the program is substantial and constitutes an impediment to high coverage rates.

In five Asian country studies, public–private teams conducted cost analyses; this cooperation provided a process for cultivating partnerships and breaking down walls of isolation between the private and public sectors and facilitated the development of fortification programs.

What do interventions cost?

Micronutrient interventions are among the most cost-effective public health interventions. There have been no new studies since the 1990s that suggest that this fact has changed. The most common cost measure reported in the literature is the average (or unit) cost per beneficiary. Several other measures are also frequently used, including average cost per deficient person (sometimes referred to as the average cost per “useful” coverage); average cost per disability-adjusted life year (DALY)*; and average cost per death averted. Additional cost measures are reported for specific types of program interventions: vitamin A supplementation studies, for example, frequently report the cost per dose (e.g., vitamin A capsule). In the case of fortification programs, three cost measures are commonly reported: (1) incremental fortification cost per MT of the food vehicle, (2) proportion of increase in the retail price of a food due to fortification, and (3) cost per person per year.

In the most studied intervention, vitamin A supplementation, various studies have used different measures to determine costs.

- » *Unit cost per beneficiary.* Reported in 27 studies, the unit cost per beneficiary ranges from 14 cents in the Philippines in 1993 [92] and Bangladesh in 1997–98 [93] to US\$5.56 in Uganda in 1998 [93]. The Bangladesh and Uganda estimates are based on subnational programs. The large variation in the cost estimates (they vary by a factor of 40), the different years in which they were determined, and the differences in country setting are contraindications for combining them to develop a general measure.

* DALY is a composite index of health that takes into account loss of life, morbidity, and disability, and their combined effect on productivity.

- » *Unit cost per vitamin A-deficient beneficiary.* Eighteen studies estimated the unit cost per vitamin A-deficient beneficiary (i.e., person-year of useful coverage) of a vitamin A supplementation program. Here the range of estimates is even larger than in the unit cost per beneficiary method, ranging from 42 cents to US\$23.76 (varying by a factor of 56). The mean and median (US\$6.95 and US\$2.71, respectively) vary by a factor of more than 2.
- » *Cost per death averted.* Nineteen studies estimated the cost per death averted for vitamin A supplementation programs. The cost averaged US\$711 and varied by a factor of 50, ranging from US\$90 to US\$3,383.

Programs implemented exclusively by NGOs appear to be one-quarter to one-third more expensive per beneficiary than programs implemented primarily or predominantly by a public-sector entity. There is even greater variability between NGO and public-dominated systems when the cost per person-year of useful coverage is analyzed.

How different are program structures and their related costs?

Interventions to address VMDs have different program structures and different cost structures. Supplementation programs have a greater diversity of costs than fortification programs. Personnel costs constitute the most important input expense of supplementation programs. In contrast, fortification programs have cost structures that are dominated by the cost of the micronutrients themselves. Personnel costs are one of the least important costs of fortification interventions. Still, studies of fortification interventions have used different methodological approaches, and the estimates of costs vary substantially across programs. The component of fortification programs that was most precisely and uniformly estimated was private industry costs; within that subset, the most precisely estimated costs were the costs of fortificants.

Cost structures of supplementation programs

Programs have different implementation mechanisms and vary in other important ways that contribute to large variations in cost, but their cost structures have some commonalities. Cost structures of the seven vitamin A supplementation programs for which data are available were analyzed in three categories: (1) personnel, (2) program-specific costs (i.e., additional direct costs, which include outlays essential to the program), and (3) capital costs.

1. Personnel costs are the single most important cost in four of the programs. The one exception is the Nepal analysis, which did not estimate all personnel

costs.* All programs rely significantly on volunteers, and those that estimated the personnel costs valued the time of volunteers. The volunteers' share of costs averaged 20% of total program costs (range, 10–30%) and roughly one-third of total personnel costs.

2. Program-specific costs generally accounted for about 30% of total costs.
3. Capital costs were estimated in only three of the seven studies. They were uniformly the least important category of costs, although their importance varied substantially across the three countries covered by these studies.

For iron supplementation programs, few empirical data exist on the cost of interventions. They are likely to have cost structures that are quite similar to those of vitamin A programs; however, iron programs are likely to be somewhat more expensive because more frequent doses are necessary for useful coverage. **Figure 4.1** shows the cost of vitamin A capsules as a percentage of annual operating costs in eight supplementation programs. Note that the capsules constitute a small proportion of total program costs—ranging from 2% to 14% in the eight country studies. The major cost is not the vitamin A supplement itself but rather the cost of the system to deliver it. In the delivery system, by far the most important cost is for personnel.

Cost structures of fortification programs

Data on the structure of costs of 15 fortification interventions were reviewed for this report. The data for 10 of the 15 studies are drawn from the Asian Development Bank (ADB)/Keystone RETA 2 studies [94], which were proposed projects or hypothetical programs. *Recurrent costs* constitute the single most important of the four cost components, accounting for roughly 80% of total public and private fortification program costs. *One-time start-up costs and capital* generally represent 5% to 10% of total costs, as do *marketing and education*. The smallest of the four cost components, *government regulatory responsibilities*, is estimated to account for roughly 5% of total program costs.

Costs for the fortificant constitute the vast majority of annual operating costs and average total annual costs. They account for a mean of 77% and a median of 83% of total costs, and a mean of 93% and a median of 96% of operating costs.

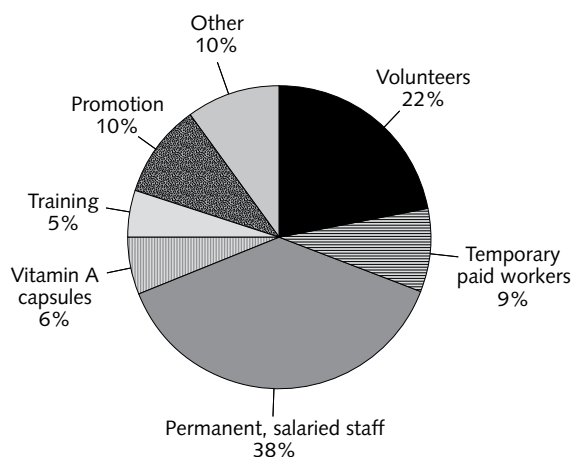


FIG. 4.1. Common cost structure of vitamin A supplementation programs

Source: Analysis by Fiedler J, Saunders M, and Sanghvi T, 2005.

Why do cost estimates vary?

There is enormous variation in the estimated costs of micronutrient interventions. The types of delivery systems used, country characteristics, program characteristics, and costing methodologies all contribute to the variability among cost estimates found in the literature. These differences show that it is not useful to generalize cost estimates across countries or across different types of programs; in fact, this common practice is misleading and disturbing. To provide greater comparability and understanding, and to enhance the usefulness of cost studies, estimation techniques must be more transparent and the discussion of results more specific.

The estimated costs of vitamin A supplementation interventions vary more than the costs of any other supplementation or fortification intervention. Estimated costs of vitamin A supplementation programs vary five-fold; for vitamin A fortification programs, estimates of cost per person per year and cost per death averted vary 15- and 24-fold, respectively. **Table 4.1** outlines variations in the costs of supplementation and fortification interventions in terms of cost structures, country and program characteristics, implementation mechanisms, and costing methodology. Details about these variations are provided in the following sections.

How are cost estimates affected by country characteristics?

Supplementation programs

The cost of a given type of micronutrient supplementation program is likely to reflect a number of country-specific factors:

» *The specific nature of the micronutrient deficiency*

* The Nepal analysis considered the personnel costs of the nongovernmental organization (NGO) in charge of implementing the program but included the time of Ministry of Health (MOH) personnel only when they were in initial or annual refresher training or on the campaign distribution day.

problem in a particular country—the prevalence, composition, rural–urban distribution, and degree of geographic clustering of the deficiency.

- » *Other important factors*—key population characteristics and how difficult or easy it is to reach target groups; geographic and climatic conditions that impose certain requirements (and, thus, affect costs) for logistics systems, packaging, and storage; and the MOH's treatment protocols, including its definition and target populations.
- » *The healthcare delivery system*—including the composition, size, and distribution of its infrastructure; demand-related factors that determine the rate of health care utilization; and the general level of wages in the healthcare sector.

In their econometric study of 50 countries, Ching et al. [90] found that differences in cost per death averted in vitamin A supplementation programs depended on several country-specific variables, including program coverage, whether one or two doses of vitamin A were delivered, and the underlying level of mortality. Obviously, estimates of cost per death averted and cost per DALY averted are sensitive to assumptions about the estimated mortality impact of programs. The magnitude of that impact is subject to debate.

Knowledge about VMDs, along with cultural factors, affects the demand for programs. Since they affect the denominator of the cost measure (the cost per beneficiary), country-specific, demand-side factors are also likely to play an important role in cost variations across countries. Relevant country-specific, demand-side factors include knowledge about micronutrient deficiency, awareness of the existence of the micronutrient program, and travel distances and transportation requirements that would-be participants face. Cultural differences might affect a person's predisposition to use healthcare and participate in a program.

Only three studies of supplementation program have investigated any of these demand-side factors [95–97]. Two of the three studies found that household costs accounted for a high proportion of total program costs, 79% and 65% of an iron and vitamin A program, respectively. The third study, which analyzed household costs incurred in a program designed to prevent both malaria and anemia, found that these costs constituted 18% of a health-facility-based intervention strategy. These findings suggest that demand is constrained by household costs. This consideration has been largely ignored in the literature, which is overwhelmingly dominated by supply-side considerations.

Fortification programs

The primary country-specific factors influencing fortification costs are food consumption patterns and the industrial structure of the food fortification vehicle (amount of product produced, where and how it is marketed, and concentration in the industry).

- » *The size, distribution, and extent of industrial concentration of potential food fortification vehicles* must be analyzed early on to assess the feasibility of a fortification intervention. If the number of companies is judged to be “unmanageable” (in terms of the costs of monitoring and enforcement), or plants are not located in a relatively concentrated area or are not accessible, fortification is generally deemed too expensive.
- » *Other aspects of the economic environment, including taxation and tariff levels, interest rates, and levels of price competition*, constitute potential sources of variation in the costs of a fortification program by country and may have a significant impact on costs. For example, the import duties on fortificants in some Asian countries vary from 1% in Thailand [94] to 47% in Bangladesh [98].
- » *The costs that a government incurs in monitoring fortification efforts* are another factor that adds to the costs of fortification. In many studies, these costs are ignored. The magnitude of these costs can vary substantially, depending on whether the government already has this type of capability (e.g., monitoring food safety, as was the case in the Philippines and South Africa) or must develop this capability (as in Zambia).

How do costs vary by program characteristics?

The heterogeneous nature of micronutrient interventions is an important reason for variation in costs. It is necessary to distinguish the cost of supplementation from the cost of fortification and the cost of dietary change or some combination of these very different types of interventions.*

Supplementation programs

There is inadequate discussion of and appreciation for the many distinguishing characteristics of interventions that have important cost implications. The major cost reviews, for instance, refer to the cost of “supplementation programs” without distinguishing between supplementation programs that are routine service-based programs and campaign-based interventions, and those that are in-facility or outreach-based. Supplementation programs are not standardized; personnel play an important role in implementing these programs, and many country-specific variables affect costs.**

* This is the case, for example, with some of the most visible discussions in the literature of the cost of micronutrient interventions (World Bank, 1993 and 1994; and Horton 1999).

** The difference between how a program is designed and how it is implemented is a complex issue. It is at the heart of the important impact evaluation concept of “intention to treat.” For further discussion, see Habicht JP, Victora CG, Vaughan JP. Evaluation designs for adequacy, plausibility and probability of public health programme performance and impact. *Int J Epidemiol* 1999 Feb;28(1):10–8.

TABLE 4.1. Supplementation interventions—sources of variation in estimated cost

Cost structures	Country characteristics	Program characteristics and implementation	Costing methodology
<p>Vitamin A program costs</p> <ul style="list-style-type: none"> » Major cost is the delivery system. » Personnel costs are the single most important cost in 4 out of 5 programs. » Programs rely heavily on volunteers, whose time is valued; volunteers' share of costs ranges from 10% to 30% of total program costs, averaging 20%. Volunteers constitute about 1/3 of total personnel costs. » Program-specific costs account for 30% of total costs in 4 out of 5 programs. » Vitamin A capsules constitute a small proportion of total program costs, ranging from 2% to 14% in 8 country studies. » Capital costs estimated in 3 of 7 studies were the least important category, although this varies. <p>Iron program costs</p> <ul style="list-style-type: none"> » Little data on costs, but likely similar to vitamin A cost structures. » Costs may be higher than those for vitamin A because of more frequent doses, implementation mechanisms, need for consistently maintained supplies, and greater compliance-promotion efforts. 	<p>Costs vary with country factors</p> <ul style="list-style-type: none"> » Nature of micronutrient deficiency. » Size, composition, rural-urban distribution of population. » Variations in geography and climate. » Ministry of Health (MOH) treatment protocols. <p>Costs vary with health care delivery system characteristics</p> <ul style="list-style-type: none"> » Composition, size, distribution of infrastructure. <p>Costs vary with knowledge and culture</p> <ul style="list-style-type: none"> » Knowledge about micronutrient deficiency. » Knowledge about specific program. » Distance and transportation to participate. » Cultural differences toward health care and the specific program. <p>Study of vitamin A supplementation costs in 50 countries [90]</p> <ul style="list-style-type: none"> » Differences in cost per death averted depended on country-specific variables, including program coverage, whether 1 or 2 doses were delivered, and underlying level of mortality. » Estimates of cost per death averted and cost per disability-adjusted life year (DALY) averted are sensitive to assumptions about the estimated mortality impact of programs. 	<p>Costs vary by program approach</p> <ul style="list-style-type: none"> » Less standardized than fortification programs. » Personnel costs are important. » Many more country-specific program variables that may affect costs. <p>Costs vary by delivery channels</p> <ul style="list-style-type: none"> » Important to specify costs of program delivery channels. » Distinguish among routine service-based programs, campaign-based interventions, in-facility, outreach-based. 	<p>Optimal costing is comprehensive</p> <ul style="list-style-type: none"> » Look at the sum of private, government, donor, and consumer costs. » Most supplementation programs focus on government costs. » Donors often play an important role in financing supplementation programs. » Look at household costs to determine ease of participation, effect on rate of participation, coverage, and average cost per beneficiary. <p>Adjust comparators</p> <ul style="list-style-type: none"> » It is realistic to assume that some portion of those who receive the first vitamin A supplement receive the second dose. <p>Allow for price adjustments and price indices</p> <ul style="list-style-type: none"> » Comparability is difficult, as data are not always adjusted for changes in the value of currency.

- » *Cost per person reached varied substantially* in countries where cost-effectiveness analyses of alternative intervention configurations were investigated.
- » *Integrated approaches may be considerably cheaper than stand-alone approaches.* When vitamin A supplementation was integrated with routine immunization services in Peru, it cost US\$1.62 per person (1998 dollars), 55% of the US\$2.97 per-person cost

of a stand-alone, campaign-based approach [99]. In the Philippines, a vitamin A capsule distributed through a stand-alone micronutrient campaign was estimated to cost nearly twice as much as a capsule distributed as part of a NID program [100]. A Zambian study that estimated the cost per child of two mechanisms onto which vitamin A capsule distribution was piggybacked found that the average cost per

child in an NID round was more than six times the distribution cost during a child health week (CHW) [101].*

Fortification programs

Inadequate specificity is another problem that plagues discussions of fortification program costs.

- » *Fortification intervention costs are commonly grouped together* with little regard for whether the fortification vehicle is sugar, wheat flour, maize flour, cooking oil, soy sauce, or fish sauce, and with little or no discussion about the nature of the food industry and how that affects the cost of the fortification intervention, or the composition or level of the fortificant.
- » *Changing the fortificant mix affects the rate at which the fortificant is mixed, which also affects costs.* For example, depending on the composition of the fortificant, wheat flour fortification costs can vary by a factor of nearly nine.
- » *Variation in the fortificant mix is a potential source of significant variation in the cost of fortification,* given that fortificant costs are commonly 85% of the total cost to industry of fortification.
- » *The structure of the food industry has a bearing on costs, both costs to industry and the cost of government monitoring and enforcement.* More needs to be learned about government regulatory and enforcement costs.
- » *More information is needed on the costs of public education in strategies that have major food fortification components.* The same will apply to large-scale, sustainable biofortification programs once they are implemented.
- » *Marketing, distribution, and customer use patterns can influence costs.* Lack of data on food and supplement consumption patterns among critical target groups makes it difficult to project the coverage and cost-effectiveness of food fortification and supplementation activities. Consumer perceptions of costs and factors influencing consumer choices are important factors determining cost-effectiveness but little information is available.

Table 4.2 shows four different mixes of fortificants, whose costs vary by a factor of four. Changing the fortificant mix and the rate at which it is mixed with the wheat can cause fortification costs to vary by a factor of nearly nine.

Variations due to differences in costing methodologies

There are a number of ways in which variations in

costing methodology might result in variations in the estimated cost of a micronutrient program. Often, studies consider only government costs if it is a supplementation program or, in the case of a fortification program, only private-sector costs. Studies rarely take the comprehensive approach of including private, government, donor, and household costs. Other factors that make it difficult to compare studies are different assumptions about variables and prices and the use and types of price indices.

Data sources, limitations, and issues

The literature is highly disparate in its definitions, perspectives, scope, and methodologies and in what is included in “costs.” Limited documentation is available, which in turn limits the ability to draw conclusions about costs and to determine how to improve the efficiency and cost-effectiveness of programs.

Next steps for strategic action and research

To construct a costing benchmark or gold standard, more thorough discussion is needed of the methodological issues involved in designing and implementing a cost study, as well as decision points concerning potential “shortcuts” and the implications of those shortcuts. Such a benchmark could serve as the reference point to facilitate better understanding of the generalizability of the results of studies, encourage greater transparency, and promote discussion of the specific cost-impacting characteristics of programs.

Conclusions and recommendations

Supplementation and fortification programs have markedly different cost structures.

- » In supplementation and fortification interventions, country characteristics are important factors in cost variations and must be clearly identified for costing.
- » Supplementation programs are less standardized than fortification programs, making cross-country comparisons relatively more difficult for supplementation programs. Greater specificity about program characteristics is needed to better understand how the costs of supplementation programs vary by implementation methods.
- » The study of household costs is a relatively neglected topic that holds promise as a tool for identifying and reducing one set of obstacles to improving coverage rates.
- » Optimal costing methodology should be more comprehensive than the narrowly defined approach that has characterized many studies to date. In particular,

* The national immunization day (NID) covered only 35 of Zambia's districts, whereas the CHW covered all 72 and, in addition to vitamin A and immunizations, provided deworming, health education, family planning, prenatal care, and growth monitoring.

TABLE 4.2. Variations in wheat flour fortificant and fortification costs^a

Fortificant level (ppm)	Fortificant cost ^b		Feed rate (g/MT)	Fortification cost	
	Cost/kg (US\$)	Relative cost/kg (%)		Cost/MT (US\$)	Relative cost/MT (%)
Iron 60, folic acid 2	4	100	100	.4	100
Iron 60, folic acid 2, riboflavin 4, thiamin 2.5	10	250	160	1.6	400
Iron 60, folic acid 2, riboflavin 4, thiamin 2.5, zinc 30	12	300	200	2.4	600
Iron 60, folic acid 2, riboflavin 4, thiamin 2.5, vitamin A 25 IU	16	400	220	3.52	880

a. Personal communication, O. Dary, 2005

b. Iron costs are for electrolytic iron

MT, metric ton

government regulatory system and enforcement costs associated with fortification should be incorporated into cost studies of these programs.

- » More needs to be learned about government regulatory and enforcement costs and public education costs of food fortification and of large-scale, sustainable biofortification programs.
- » Lack of data on food and supplement consumption

among critical target groups makes it difficult to project the coverage and cost-effectiveness of food fortification and supplementation activities. Consumer perceptions of costs and factors influencing consumer choices are important considerations in determining cost-effectiveness, but little information is available.

What is the role of international agencies in the micronutrient sector?

A broad range of agencies provides technical and financial support in all regions but there are major funding and programmatic gaps and lack of coordination

Margaret Phillips and Annette De Mattos

This section provides a preliminary look at the global financial picture for international support of VMD programs. We directly approached organizations known to be involved, asking for information on the resources they expended in 2004 on micronutrient activities and whatever information they could provide on the nature of those activities, such as geographic location, type of micronutrient involved, and whether the project involved research or service provision. See www.gainhealth.org for more information on the sources of data and the methodological issues encountered. We also obtained background information on the principal organizations from a survey of organization websites and reviews. Two examples of these reviews [102, 103] are available at www.gainhealth.org.

Summary of findings

Information on more than 40 institutions—including bilateral donors, multilateral agencies, NGOs, foundations, and universities—was collected for this review. Hundreds of additional organizations at the regional, national, and subnational levels play an important part.

- » International agencies fulfill a broad range of technical and operational needs to build capacity, improve and document micronutrient program results, and develop new approaches at the country level; globally, they support coordination activities, gather and disseminate information, and support basic and applied research.
- » Certain areas of technical support and operations overlap among donors, and there are a number of gaps in the countries that receive assistance, types of interventions, range of micronutrients, and types of assistance provided.
- » The financial contribution to VMD activities in 2004 of the organizations successfully contacted for this review is estimated conservatively to be on the order of US\$124 million.

- » Funding for reducing vitamin and mineral disorders amounts to only a small fraction of the funding for infectious diseases and immunization, although vitamin and mineral disorders contribute substantially more to the global burden of death, disease, and disability.
- » Vitamin A receives the bulk of resources, while folic acid and zinc are low priorities.
- » Research on plant breeding appears likely to receive more emphasis in the future.
- » The African region benefits from roughly half the resources available for micronutrient programs, and substantial investments are being made in Asia.
- » Important gaps exist in the available financial data, and most organizations have difficulty readily accessing disaggregated financial data. The complex flow of resources among various organizations adds to the difficulty of getting an accurate picture of overall support for reducing VMDs.
- » Developing a more transparent, accessible, and consistent way of tracking micronutrient funding, at least for major supporters, would help with future efforts to document the nature of global support for reducing VMDs.
- » For the development of any global strategy, it is essential to explore in more detail the current *modus operandi* of key institutions involved in international support of VMD reduction, including the regulatory and policy frameworks within which they operate, the mechanisms through which they communicate with and support developing countries, and through which they coordinate their micronutrient efforts with others.

Review of the evidence

Micronutrient programs in the developing world receive support from many different sources. Governments of developing countries and the private sector are the main sources of financing for country-level activities

in the micronutrient sector. A third broad category is external international support through bilateral and multilateral donors, private foundations, universities, and NGOs.

More than 40 institutions are significantly involved in international support for the micronutrient sector. Some are multilateral bodies or official bilateral donor agencies, others are foundations or universities. Some are implementing agencies with health programs in the field, while others focus on research or are active in providing technical advice, disseminating information, teaching, or coordination.

Donors and implementing agencies have complex interrelationships. **Figure 5.1** illustrates some of the principal financial interactions among organizations providing international support for reducing VMDs and shows the complexity of these relationships. This complex situation argues for the formation of a coordination mechanism among donors at the global, regional, and country levels.

As the programs have gathered momentum, so has the urgency of the need for coordination and more systematic information sharing. While the evidence in favor of increased support for micronutrient programs has grown stronger and more complex, pressures on resources have increased. A number of attempts

have been made to form coordinating mechanisms and working groups; examples include IVACG, International Nutritional Anemia Consultative Group (INACG), IZiNCG, ICCIDD, FFI, Iodine Network, Business Alliance for Food Fortification (BAFF), Global Vitamin A Alliance, Wakefield Coalition, and others at various levels.

Two bilateral donors are the dominant external financiers of worldwide micronutrient activities. For many years, the CIDA and the USAID have been the major donors in this sector. Both are active in food fortification and are key supporters of national vitamin A supplementation programs. CIDA leads a global effort to coordinate procurement of vitamin A supplements and itself finances a large proportion of the supplements. Both USAID and CIDA have established large field-based micronutrient projects or initiatives for which they are the sole or primary donor. These include A2Z (previously USAID Global Vitamin A Project [VITAL], USAID Micronutrient Project (OMNI), and MOST), which are projects of USAID, and the MI, which is largely financed by CIDA.

Other primary sources of funding include foundations such as the Bill and Melinda Gates Foundation and charitable fundraising organizations such as Kiwanis, which has been a significant source of support

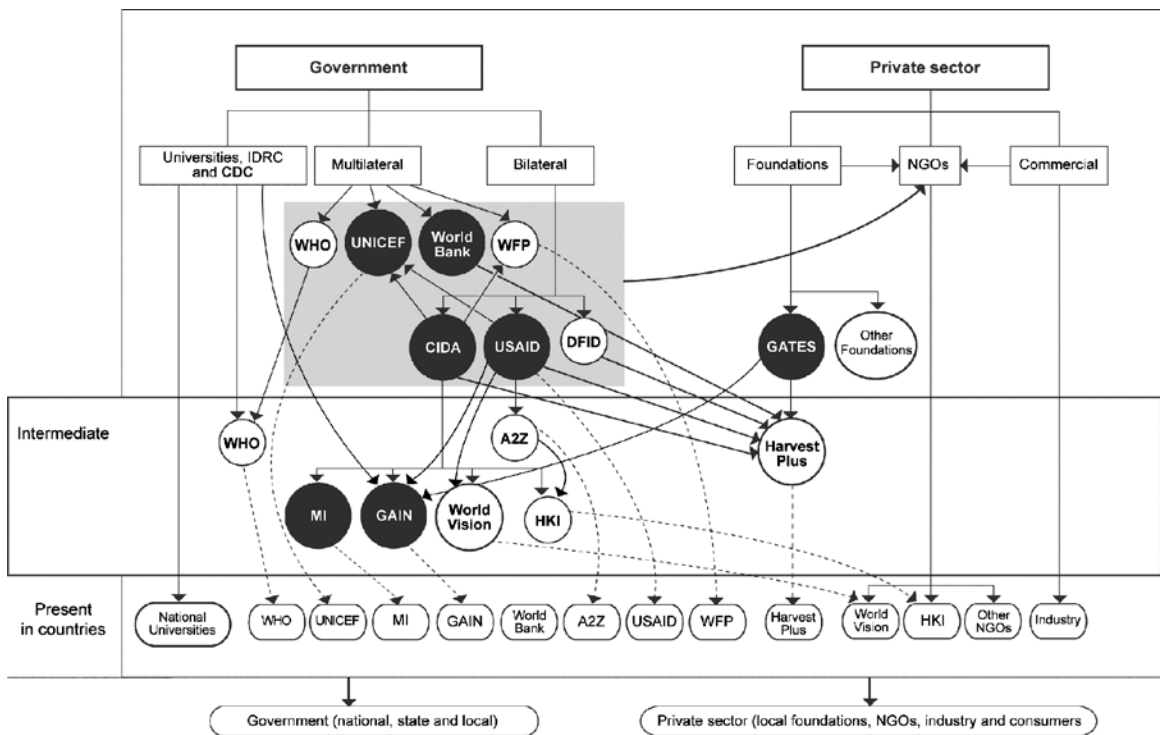


FIG. 5.1. Illustrative relationships among donors and intermediaries supporting micronutrient programs
 Note: Though not represented here, regional organizations also play an important role.

for iodine initiatives. The international banks—the World Bank and the ADB—are both active in funding micronutrient activities as components in their often large-scale health and nutrition projects. Nonprofit voluntary organizations such as HKI and World Vision (WV) are key players that raise private funds from the commercial sector and individual donors.

The primary funding sources channel their funds and in-kind resources through a variety of other institutions, including multilateral agencies. UNICEF and WHO—two key organizations involved in supporting micronutrient activities worldwide—receive funds from bilateral agencies and a range of other sources. UNICEF primarily supports national programs and, in its global leadership capacity, gathers and disseminates critical data for planning and monitoring. WHO provides technical guidance at the global, regional, and country levels; helps translate research findings into policy guidelines; funds applied research; and maintains global databases on VMDs.

UNICEF plays a crucial role in the provision of vitamin A supplements and salt iodization. Especially significant in financial terms is UNICEF, whose micronutrient activities attract funds from many bilateral organizations, particularly USAID and CIDA (through MI and independently), as well as the Gates Foundation. Their focus in supporting large-scale implementation has been salt iodization and vitamin A. Sixty-five percent of MI project funds are “managed” by UNICEF, and 11% of Gates Foundation support for micronutrients in 2004 was directed through UNICEF. The World Bank has also purchased vitamin A capsules through UNICEF (e.g., for the Bangladesh National Nutrition project). In fact, UNICEF appears to be responsible for providing or managing the procurement of 95% of vitamin A supplements for developing countries.

The private sector contributes to the development of technologies, new products, and formulations and provides micronutrient supplies as gifts in kind. Private firms carry out advocacy and support newsletters and other information dissemination activities. Some, such as World Vision and ILSI, provide funds and facilities for NGOs to support communication and advocacy activities at the global and country levels. The food processing and pharmaceutical sectors are deeply engaged in policies and programs at the country level. Programs such as Harvest Plus work with the agricultural sector.

The private sector contributes through its core business operations, through public–private partnerships, and on a philanthropic basis. Currently, the private sector supports the micronutrient effort primarily by developing and producing the products (namely, fortified foods and supplements) and contributing to specific programs mostly through donated commodities.

Some of the agencies covered in this section oper-

ate public–private partnerships in an effort to engage companies in micronutrient projects. The projects range from R&D on new formulas and applications to joint advocacy, technical capacity building along the value chain (e.g., premix companies for staple food producers), and program delivery (e.g., school feeding projects). In addition, some organizations—such as GAIN and BAFF—have standing platforms aimed at catalyzing project activities.

Companies also engage on a purely philanthropic basis, through product donations and in-kind support, as was seen with the tsunami and other emergencies. The emerging area of corporate social responsibility often unites philanthropic and commercial goals, such as volunteer opportunities or the preferential pricing that appears in the pharmaceutical sector (although not necessarily in the context of VMDs).

The potential of business to contribute to reducing VMDs is enormous and largely untapped so far. This potential includes all relevant sectors but especially the pharmaceutical sector with regard to supplements and the food sector with regard to fortification and retail. In principle, populations of high need also represent a huge number of potential customers with a demand for vitamin and mineral products; in practice, the challenge is to develop a business model that can deliver to customers with limited and fragmented purchasing power at scale and on a sustainable basis. A global strategy geared toward significantly reducing micronutrient deficiencies will need to explore this opportunity in depth.

An urgent need for better coordination and information sharing has led to the formation of formal and informal alliances and groups. Some of these groups address issues of research and applications to policy development; others are more programmatic in their orientation. The following are some examples:

- » IVACG provides guidance to international activities aimed at controlling VAD worldwide; it is funded by USAID.
- » IDPAS is supported principally by MI but also by UNICEF, WHO, and the Centers for Disease Control and Prevention (CDC).
- » The ICCIDD is an international nonprofit NGO promoting the elimination of IDD through technical assistance and training; it is supported by UNICEF and WHO.
- » GAIN was established in 2002 as an alliance of potential donors, UN agencies, industry, NGOs, civil society, and academia to implement national food fortification programs; it receives funding mainly from entities such as the Gates Foundation and USAID.
- » Harvest Plus is an alliance of international research organizations tackling the micronutrient problem (with a focus on iron, vitamin A, and zinc) by breed-

ing nutrient-dense staple foods such as cassava, wheat, maize, beans, and sweet potatoes; it is funded by the World Bank, the ADB, the Gates Foundation, USAID, and CIDA.

- » The Standing Committee on Nutrition (SCN) and the International Union of Nutritional Sciences (IUNS) have played key roles in synthesizing program and policy relevant information and coordination.
- » The Iodine Network engages the private sector, implementing agencies, and civil society in coordination and advocacy activities.

Universities and sometimes nutrition institutes play a key role in building capacity and in establishing the importance of vitamins and minerals through training, education, research, and analysis. Universities have also helped clarify safety and efficacy of vitamins and minerals, and they maintain information exchanges. The best-known examples of these universities are Mahidol University (Thailand), Wageningen University (the Netherlands), Auckland University (New Zealand), University of Toronto (Canada), Emory University, Johns Hopkins University (JHU), University of California at Davis, and Cornell University (United States). More assistance to field-based institutions is needed to build leadership and broaden the base of stakeholders for micronutrient programs and policies. Examples of field-based nutrition institutes include Institute of Nutrition of Central America and Panama (INCAP, Guatemala), Food and Nutrition Research Institute (FNRI, the Philippines), Nutrition Center of the Philippines (NCP), Tanzania Food and Nutrition Center (TFNC), National Institute of Nutrition (NIN, India), Central Food Technological Research Institute (CFTRI, India), Institute of Nutrition and Food Technology (INTA, Chile), Caribbean Food and Nutrition Institute (CFNI), and National Food and Nutrition Commission (NFNC, Zambia).

An initial analysis of the financing picture shows that about US\$124 million is allocated annually by the main external donors for reducing VMDs. **Table 5.1** summarizes the data obtained on expenditures for micronutrient programs in 2004.* The figures may not accurately reflect the global level of international financial support for micronutrient activities for two reasons: (1) they fail to capture important contributions from some donors, and (2) they include some double-counting, a problem described in detail below. After

making some adjustments,** we conservatively estimate the total international contribution to vitamin and micronutrient deficiency activities in 2004 at US\$124 million. The World Bank notes that “initial estimates suggest that the costs of addressing the micronutrient agenda in Africa are approximately US\$235 million per year.” Clearly, resource needs for micronutrient programs must be assessed and ways found to raise new funds and link with other resources. Countries need the support of a cohesive donor community to accelerate their programs.

Funding relationships, combined with existing approaches to budgeting and financial accounting, do not allow the calculation of fully accurate figures. The Harvest Plus program provides an example of the kind of problem faced in teasing out figures to include in the estimate of total financial support. In the period 2003–2007, Harvest Plus received funding from two of the primary donors for which we have data: Gates (43% of Harvest Plus funding) and USAID (17%). It is not clear whether the USAID data include the agency’s contribution to Harvest Plus***; we have assumed they do not. For the Gates funding, we decided that it was more appropriate to use the Harvest Plus figures (which represent actual expenditures on research in the period) rather than the amount of the grant Gates made to Harvest Plus. The contributions of other Harvest Plus supporters—World Bank (20%), Department for International Development (DFID, UK; 5%), and CIDA (12%)—are not included elsewhere, so the entire sum for Harvest Plus is used in the estimate. UNICEF attributions are also complex; the agency separately records its allocations for micronutrient programs from regular program funds and specific donor resources that are earmarked for micronutrients. The latter comprise four-fifths of the total amount allocated to

** Including the Gates Foundation (minus its allocation to Harvest Plus of US\$6.25 million) (US\$21.87 million), USAID (US\$32.44 million), DFID (US\$2.39 million), MI (US\$23.40 million), Harvest Plus (US\$5.45 million), CDC (US\$4.99 million), World Vision (US\$4.17 million), the regular resources of UNICEF (US\$3.74 million), CIDA (excluding its contribution to MI (US\$9.18 million), DANIDA, Spain, SIDA and AusAID (US\$.97 million collectively), and assuming that the World Bank contribution is very roughly of the order of US\$15 million. See www.gainhealth.org for explanations. The Flour Fortification Initiative (FFI) is primarily funded by CDC and is therefore excluded from our final estimate. GAIN’s contribution is not included, as we assume that it is largely captured through the data we have from Gates, USAID, and CIDA.

*** USAID data relate to “expenditures occurring via two channels: centrally managed activities procured and managed in Washington DC, by GH (USAID’s Global Health Office) and bilateral activities managed by USAID Missions.” It does not include “field support” expenditures or agreements managed by USAID’s regional bureaus, nor some multilateral contributions.

* See www.gainhealth.org for notes on the sources and methods used to derive the information in this table.

TABLE 5.1. Levels of financial support

Donor	Total Contribution to VMD activities in 2004 (US\$1,000s)	Regional allocations (%)			Breakdown by type of micronutrient (% / yes)					
		Africa	Asia	Other	Vitamin A	Iron	Folic acid	Iodine	Zinc	Multi-MN or unk
MI	23,400	45	40	15	63	19	9	7	1	
USAID	32,442	41	54	5	50	15		10	10	15
UNICEF	19,401	63	21	16	yes	yes	yes	yes	no?	
World Bank	No data	14	61	25	62	66	7	34	0	21
Harvest Plus	5,448	NR	NR	NR	yes	yes			yes	
DFID	2,389				yes					
FFI	100	yes	yes	yes						
CDC	4,986	10	30	60	yes	yes	yes	yes	no	yes
GAIN	17,270	40	17	43	yes	yes	yes	no	no	yes
CIDA	27,637				yes	yes		yes		
Gates	28,122	50	14	36	14	1		11	8	65
WV/ Canada	4,166	yes	yes	yes	yes	yes	yes	yes	no	yes
HKI	No data	yes	yes		yes	yes			yes	yes
DANIDA	296									
SIDA	177									
Spain	17									
AusAID	480									
Preliminary total	166,331									
Adjustment	-42,000									
Adjusted total	124,000 approximate									

VMD: vitamin and mineral deficiency, MN: micronutrient, unk: unknown, NR: no response, MI: Micronutrient Initiative, USAID: United States Agency for International Development, DFID: Department for International Development (UK), FFI: Flour Fortification Initiative, CDC: Centers for Disease Control and Prevention, GAIN: Global Alliance for Improved Nutrition, CIDA: Canadian International Development Agency, Gates: Bill and Melinda Gates Foundation, WV: World Vision, HKI: Helen Keller International, DANIDA: Danish International Development Authority, SIDA: Swedish International Development Authority, AusAID: Australian Agency for International Development Sources: See www.gainhealth.org for a detailed description of sources and methods

micronutrient programs.*

An important undercounted input supporting global micronutrient activities is the manpower involved in managing international efforts by these organizations.

* UNICEF separately records its “regular” and “other” resources. The latter comprise 81% of the total amount allocated to micronutrient programs and are “often earmarked effectively by the donor (e.g., vitamin A and CIDA)” (personal communication, I. Darnton-Hill, 2005). As this is a potential source of double-counting, we have included only UNICEF’s regular resources (US\$3.74 million). This may be an underestimation.

For example, MI, USAID, World Vision/Canada, and CDC together have an estimated 50 full-time equivalent (FTE) staff devoted to managing micronutrient work at their respective headquarters. More than half of these people are at MI, which has an additional 19 FTE staff at the regional level.

Funding is concentrated in South Asia and sub-Saharan Africa, even though the number of project activities may be higher in other regions. Africa is a major recipient of support from USAID (41% of funding), UNICEF (63% of countries with UNICEF-supported vitamin A supplementation programs are in the region), and MI

(45% of total funding). The World Bank directs only 14% of its resources for nutrition projects with a micronutrient component to the region, although about half the countries it supports are in Africa. Asia is important also, with MI and USAID directing, respectively, 40% and 54% of their micronutrient funding there. The World Bank sends 60% of its total financial commitment to projects with a micronutrient component to Asia; the funding goes to a relatively small number of projects and countries (primarily to Bangladesh, India, and China).

*International organizations vary in the extent of the geographic coverage of their micronutrient-related activities and their regional emphasis.** Some organizations do not target particular countries. For example, the Gates Foundation provides funding to other international organizations rather than to individual countries, and the work of Harvest Plus, CDC, and Emory/FFI is global in nature. Of the bigger players with field-based projects, some are involved in large numbers of programs scattered throughout the world: in 2004, MI supported 166 micronutrient projects in 92 countries. Others are more focused: in 2004, the World Bank supported 42 programs with micronutrient components in 29 countries.

Vitamin A programs are consistently supported by all donors reviewed and receive more support than any other micronutrient program. At least half of USAID's support and 63% of MI's projects are dedicated to vitamin A. Both iron and vitamin A are found in nearly two-thirds of World Bank projects that have a micronutrient component, and iodine is found in about one-third. USAID reports an obligation of US\$3.49 million to UNICEF for USI and IDD.

Zinc receives a relatively small amount of funds since program strategies are not well developed and have not been scaled up. One percent of MI projects and 10% of USAID projects support zinc-related activities, and there is no indication that any of the 42 World Bank projects in 2004 supported activities to address zinc deficiency. Folic acid is rarely mentioned. Projects that involve more than one micronutrient are quite common; for example, more than half of Gates Foundation investments in micronutrients and the majority of World Bank micronutrient projects are for such projects.

* It is difficult to interpret differences between organizations because of the different ways regional emphasis is measured. Where possible, we used the percentage of micronutrient funding by region. Otherwise, a proxy was employed. In the case of UNICEF, the proxy was the distribution of projects by country (and only for vitamin A programs). For the World Bank, the only information available was a list by country of nutrition projects with a micronutrient component and the total cost (not just the cost of the micronutrient component) of those projects. We have assumed that the distribution of resources to each project as a whole reflects the distribution to the micronutrient component within it.

Most funding is directed toward project implementation, almost equally for supplementation and fortification. However, in addition to project implementation, some significant basic research efforts (e.g., Harvest Plus) as well as advocacy, training, and coordination activities (Emory, CDC) are important components of strategies. The data are insufficient to draw any conclusions about overall levels of support for supplementation versus fortification programs. Several big players (e.g., USAID, CIDA, and UNICEF) focus heavily on supplementation. GAIN's country programs are for fortification. The World Bank has more supplementation than fortification activity; among the two-thirds of projects in which the type of project is indicated, most mention supplementation and only 20% mention fortification. Home gardening and the promotion of micronutrient-rich foods are strategies supported by many NGOs, by some bilaterals (such as GTZ [Deutsche Gesellschaft für Technische Zusammenarbeit]), and, less commonly, by the World Bank.

Supplementation consumes more of MI's resources (60%) than fortification (28%), with shared activities such as program design and monitoring accounting for the rest. The emphasis for MI programming differs for different regions and micronutrients. Supplementation is more important in Africa, where it accounts for 81% of resources, than in Asia (51%). In 2004, most of the projects for iron, folic acid, iodine, and zinc involved fortification (78%, 67%, 100%, and 100%, respectively). In the case of vitamin A, 88% of the projects were for supplementation.

The Gates Foundation provided important levels of support for research on plant breeding, directed to the Harvest Plus program. In 2005, Gates awarded seven grants, worth US\$9.6 million per annum, to plant-breeding projects.**

Data sources, limitations, and issues

Data on financial inputs are not normally in the public domain and are not available in a useful format. Websites and annual reports may present some information, but rarely is it specific with regard to micronutrient activities.

- » Not all organizations report in a standardized or comparable way, and not all types of activities or geographic areas are consistently reported. Analyses may include only information that is readily available, rather than presenting the complete picture.
- » Financing data, especially data related to the World Bank and the WFP, contain important gaps (see below).

** Data extracted from the list of grants awarded in the "priority diseases" and "breakthrough science" categories (<http://www.gatesfoundation.org>).

» Most organizations have some problem in readily accessing disaggregated data on their financial contributions to VMD programs.

The World Bank is a significant player—many of its nutrition projects include a micronutrient component, and nutrition lending was estimated at US\$700 to US\$750 million in 2004 [104]. However, we have no micronutrient-specific financing data to verify this estimate. HKI is another important organization for which we do not have first-hand data. HKI has been combating VAD for decades through vitamin A supplementation, nutrition education, promoting the production and consumption of vitamin A-rich foods, and encouraging food fortification with micronutrients. The organization's total expenditures in 2004, according to its annual report, were about US\$35 million, but it is not clear how much of that can be attributed to micronutrient programs as opposed to, for example, general nutrition or blindness prevention programs. Some of the HKI contribution is captured in information from other donors (e.g., CIDA's contribution to HKI of US\$4 million). There are also smaller international NGOs active in this field whose contributions we have not been able to include. Some of these contributions may be quite significant.

The WFP uses voluntary contributions to support humanitarian and development projects. Donations are made in cash; food such as flour, beans, oil, salt, and sugar; or basic items necessary to grow, store, and cook food (e.g., kitchen utensils, agricultural tools, warehouses). An estimated 20% of the total volume of food programmed by WFP was fortified with vitamins and minerals in 2002 [105]. Cereal flours made up 50% of the processed fortified foods. The WFP is the leading purchaser of fortified, blended foods worldwide. However, none of this information is captured in our calculations.

These observations suggest that our estimate of total commitment from international sources to reducing VMDs is conservative. The way organizations routinely collect and record financial and programmatic data makes it easier for some organizations than for others to identify specific micronutrient activities. For example, the coding system used at UNICEF appears to allow the organization to identify micronutrient activities relatively easily. Even so, these data were not easily retrievable, and coding has been interpreted differently over the years. It is unclear whether UNICEF's recently implemented system of thematic funding will improve or weaken the ability to disaggregate expenditure data to the level of detail needed to track funding for VMD

activities.*

The trend in some organizations (e.g., the World Bank) is toward integration (subsuming nutrition components into larger health programs), making it more difficult to identify and code not only nutrition activities but the smaller subset of micronutrient activities. DFID also does not treat nutrition, let alone micronutrient programs, in isolation.

Perhaps not surprisingly, MI, whose sole purpose is micronutrients, provided an impressively rapid and comprehensive response. Nevertheless, even MI had the following gaps: expenditures by program, country, activity, and input are not separately held or attributed (although vitamin A supplies are easily attributable by country).

The Gates Foundation has an information system that made accessing essential information about its support for VMDs straightforward. From its website, we were able to access a database that provided a complete list of projects funded by year, with a short description of the project (from which it was possible to identify micronutrient projects), the organization receiving the grant, the level of the grant, and the grant period.

It is difficult to analyze expenditures on micronutrients at the international level because of the complex financing relationships among organizations. Donors that fund micronutrient work are not always able to provide sufficiently detailed or appropriately coded data necessary for estimating funding for micronutrient activities, let alone for specific types of micronutrients, or for regions, countries, and so on. Implementing agencies are usually in a better position to do this, but relying solely on them is also problematic, in part because there are many more of them than there are donors, which makes it likely that important work will be overlooked.

Though it increases the risk of double-counting, a pragmatic combination of approaching donors and implementers is best. The task is made more difficult by the dual role many key agencies play. Some organizations are clearly donors, with funds given directly from government sources (e.g., bilateral donors such

* "Thematic contributions are based on existing programs ... or the thematic priority areas described in the [medium-term strategic plan (MTSP)], and no specific proposals are requested by the donor. The pooled funds are allocated to achieve the goals in the respective priority areas. The donors do not request any specific financial statements tracking their contribution, but rather a holistic report on results achieved in the thematic area they are supporting and the expenditures from all sources (regular resources, other resources and thematic funds) in the same thematic area, at the global, regional or country level." UNICEF Executive Board. 14 November 2005. Thematic funding in the context of the medium-term strategic plan. E/ICEF/2006/9. http://www.unicef.org/spanish/about/execboard/files/06-9-thematic_funding_final.pdf. Accessed 19 December 2005.

as CIDA, DFID, USAID, and CDC) or from private funding sources (e.g., the Gates Foundation). Some are clearly recipients, receiving funds to carry out micronutrient-related work (e.g., Harvest Plus). However, many play a dual role as donor/implementers, functioning as a conduit through which money passes. MI, for example, is funded by CIDA and in turn funds organizations such as UNICEF and HKI to implement some of its projects.

Agencies group and categorize their data differently. Variables that typically are not treated consistently include the period covered by the financial year, the definition of geographic regions, and the scope of activities included. In reporting expenditures and program information, some of the institutions we surveyed excluded shared functions such as management and administration, while others included them. Furthermore, some of the reported data refer to budgeted funds, while others use actual expenditures.

Next steps for strategic action and research

To gain an accurate picture of overall support for VMD reduction, we need to clearly document and understand the flows of international finance. Developing standard funding definitions and categories would help in piecing together the puzzle.

More complete and accurate information on the scope and nature of donor activities and financial commitments would be desirable not only as a snapshot of a single year, as we have presented here, but for several years, so that trends in support of VMD reduction can be illuminated.

There are a number of aspects of international support that we have not been able to address in this report. These aspects should be explored if an effective global strategy is to be developed.

- » The legal and regulatory framework and the broad policy framework within which agencies operate.
- » Organizations' procedures for dealing with developing countries.
- » Mechanisms that currently exist to facilitate coordination of micronutrient efforts among different supporters.
- » Agency structures and how they affect the management of micronutrient programs and the decisions made about those programs.
- » The extent to which micronutrient activities are integrated within broader programs.

Considering the number of organizations involved, effective coordination could help accelerate country programs, even with limited funding from each. At least a consistent set of objectives, technical approaches and protocols, and commitment to working harmoniously

are essential. At best, a common strategy with stated milestones and results and a monitoring framework would be developed and actively used. Coordination mechanisms at the global and country levels would need to be strengthened. Coordination among donors and international implementing agencies appears to be most urgently needed on the following topics that are of concern among stakeholders:

- » Databases on prevalence, food consumption, consumer behavior and forecasting.
- » Public education and communications (including advocacy).
- » Strengthening food-delivery systems (including fortification and biofortification).
- » Strengthening healthcare-delivery systems (including supplementation and linking with other health interventions such as deworming, malaria, EPI, antenatal care).
- » Addressing special needs: emergencies, children ages 6 to 24 months.
- » Research agenda for securing rapid global impact (including micronutrients and infectious diseases)
- » Capacity building and leadership development.
- » Monitoring global and country results and costs/cost-effectiveness.

The experience of other results-oriented global initiatives that have functioned well in the past suggest that a more sharply focused and prioritized global strategy would require the functioning of the following types of mechanisms:

- » A broad, participatory *global forum* where all stakeholders at various administrative levels and regions and from the private and public sectors could meet to renew their commitments and share experiences and concerns, perhaps every two years (e.g., adapted IVACG/INACG conferences).
- » A "*board of directors*" working on global priorities and policies related to the rolling out, implementation and monitoring of the global initiative. There might be regional boards with the support of regional development banks.
- » A small secretariat or *working committee* for day-to-day tasks.
- » A technical advisory or reference group or panel of experts meeting annually to help interpret new research findings and concerns from the field, possibly with subgroups for each key micronutrient.
- » Working groups or task forces with annual funding and defined results/products related to the topics listed above to solve operational problems getting in the way of achieving global results. They could develop guidelines and tools, carry out lessons learned reviews, monitor progress or conduct program and "analytic" reviews, help build country or regional capacity, identify success stories, etc.

Conclusions and recommendations

There is a significant level of international support for various VMD reduction activities, but funding levels are much less than for other health initiatives with less favorable cost-benefit ratios and less impact on objectives such as health, education, productivity, and, ultimately, the MDGs.

Many international agencies are engaged in vitamin A programs, and many are working in the Africa region. Both the fortification and supplementation needs of countries are supported. Currently, there is no effective way to ensure that donors are speaking with one voice. The potential for overlap and gaps are high because of the lack of comprehensive and inclusive coordination mechanisms.

Information on relative strengths, the niche areas of various organizations, and organizational funding is not well documented. Lessons learned include the following:

- » Direct contact with the organization is usually essential, but it can be difficult to identify the persons who have access to data and the authority to make it available.
- » The data requested are not always easily assembled, even by the organization itself, because of the way organizations categorize and summarize their financial information.
- » Identifying all the components related to VMDs can be problematic. It is easy to overlook some elements when an organization is funding health service support programs from one pool of financial resources, research conducted by multilateral organizations from another, and training provided by universities from a third. Many programs and projects may be related to VMDs, but the micronutrient elements may be so deeply embedded that it is difficult to tease out the finances related to them.
- » Even when reliable, complete, and specific data are collected from individual organizations, it can be difficult to build an accurate global picture. The data may not be directly comparable (e.g., definitions of financial years vary, and some organizations have data on financial allocations but not on expenditures). Also, the complex financial interactions that exist among organizations can be difficult to untangle, especially as these organizations are a mix of primary donors, intermediate financial managers, and implementing agencies.
- » Currently available financial data are not sufficiently comprehensive to provide an accurate picture of the overall levels of international funding for VMD reduction activities. Nevertheless, they do provide some indication of the general level of support and

the emphasis given to particular micronutrients, activities, and regions.

- » Annual international support for micronutrient activities in developing countries is probably on the order of at least US\$124 million.
- » Vitamin A consistently receives the bulk of the resources, while folic acid and zinc appear to be low priorities.
- » The Africa region appears to benefit from about half the resources available for micronutrient programs, and substantial investments are also being made in Asia.
- » Research on plant breeding appears likely to receive more emphasis in the future.
- » Improved estimates of the extent and nature of donor support for VMD reduction activities would help planning and coordination and might encourage new donors to invest.
- » The creation of a coordinated global strategy and mechanisms for donors and implementers to discuss and resolve emerging issues would help countries and donors alike.
- » Developing a more transparent, accessible, and consistent way of tracking micronutrient funding, at least for major supporters, might encourage greater accountability on the part of donors for the commitments they make to micronutrient programs.* The first steps in developing such a system would be to gain agreement on what is needed and how it is to be used and to understand how donors currently collect, code, and analyze their financial and project data.
- » A jointly agreed upon framework for coordination is needed with buy-in from the major micronutrient stakeholders. Funding is also needed, and it should build on existing coordination mechanisms. It would facilitate more efficient planning and use of donor and country resources; include mechanisms for timely, ongoing alignment of programs and policies based on the latest evidence; make better use of resources for higher quality documentation and tracking of process and outcome indicators, including the cost-effectiveness of programs; monitor emerging threats to public health impacts from micronutrient programs; and guide investments in country-level leadership and evidence-based strategies. There are several functioning models that can be explored and adapted for the micronutrients sector.

* The Gates Foundation website is a good example of clear presentation of funding information: <http://www.gatesfoundation.org>

Conclusions and the way forward

“The unequivocal choice now is between continuing to fail, as the global community did with HIV/AIDS for more than a decade, or to finally put nutrition at the center of development so that a wide range of economic and social improvements that depend on nutrition can be realized” (World Bank 2006).

This review shows that a substantial amount of information is available to guide the use of resources for accelerating progress in reducing VMDs. A Global Ten Year Strategy could serve as a powerful planning and advocacy tool, outlining regional and global scenarios for impacts and costs of planned activities. Following the pattern of other successful initiatives, strategic plans could be developed for key operational components of the strategy, and mechanisms for coordination, information exchange, and technical support could be established. The thematic focus of actions would be the virtual elimination of VMDs as a basis for campaign development.

The following are the main inferences that can be drawn from the review of current literature.

Rationale for investing in reducing VMDs

Poverty alleviation and equity strategies should give priority to nutrition. Micronutrient interventions are highly cost-effective and produce rapid favorable impacts on the poor, women, and young children. Reducing vitamin A, iron, iodine, folic acid, and zinc deficiencies in particular have high payoffs.

- » Proven interventions can reduce maternal and child mortality and prevent crippling disabilities (such as childhood blindness, NTDs in newborns, and mental impairment/cretinism) that erode learning ability, physical capacity, and well-being.
- » The threat of large-scale infectious disease outbreaks leading to death and disability can be partly reduced by strengthening the innate immune function by ensuring adequate micronutrient status.
- » Nutritional deficiencies (e.g., of iron and iodine) can

impair mental development and affect schooling. Interventions to prevent such deficiencies should be given priority in education strategies.

Magnitude of the problem

Despite the availability of effective interventions, the global prevalence of VMDs remains high. Some countries have experienced declines in the deficiencies, but these declines have not substantially affected global levels, except for the reduction in clinical and subclinical signs of IDD and clinical signs of VAD.

- » The global prevalence of VMDs will not decrease unless large-scale intervention programs improve micronutrient intake in South Asia and sub-Saharan Africa, particularly among hard-to-reach groups in large countries.
- » Improving national prevalence data and establishing surveillance and monitoring mechanisms are worthwhile investments. Factors closely related to trends in prevalence, particularly food intake at the individual level, should be a part of the monitoring function of an accelerated global strategy. Indicators for some of the deficiencies should be reviewed and reassessed. Modeling provides useful insights when measured prevalences are unavailable; it could be used judiciously to complement data. Representative surveys such as DHS and MICS help to validate data from routine monitoring systems.

Implementing programs at scale

Transitions in food procurement and consumption patterns that are accompanying global transformations in urbanization, food production, incomes, family structures, and lifestyles have major repercussions for nutrition, particularly micronutrients.

- » Immunization and antenatal healthcare contacts and the use of processed foods in the food sector provide good opportunities for effectively delivering

- vitamins and minerals. The rise of retail food sales through large supermarket chains provides another opportunity to engage the private sector in the delivery of a large variety of micronutrient-rich products at reasonable cost along with appropriate consumer information.
- » Food fortification is highly cost-effective but for most micronutrients does not reach the most critical target populations with levels of nutrients needed to prevent or reduce dietary deficiencies; supplementation and/or special products are needed to complement fortification. In many countries, food fortification can form the core of a comprehensive strategy that also includes other interventions selected on the basis of careful analysis on which target populations require supplemental interventions. Fortification is also a safe and cost-effective way to address multiple deficiencies not only of the five main vitamins and minerals but others as well (e.g., vitamin B group and vitamin C).
 - » Economic growth will not necessarily reduce VMDs unless it is accompanied by micronutrient interventions. Much of the industrialized world depends on fortified foods to meet micronutrient needs; high-need groups such as infants and pregnant women also consume supplements.
 - » There needs to be an explicit strategy for the very-high-risk groups—refugees, populations in emergency situations, and young children 6 to 24 months of age.
 - » Delivery strategies for iron and iodine will need to reach a broad range of populations, since a wide spectrum of ages and groups are affected. Young children need specially targeted interventions for vitamin A, iron, and zinc; pregnant women require targeted supplementation; and all women of reproductive age need folic acid.
 - » Owing to the role of infections in determining micronutrient status, programs aimed at reducing VMDs should establish close links with health interventions, especially malaria control, deworming, and measles immunization.
 - » Global partnerships for USI and vitamin A supplementation have addressed critical planning, supply, and monitoring needs at the country level. Current partnerships provide a good starting point for building a more comprehensive micronutrient alliance. Several working models exist for global public health initiatives (e.g., Stop TB Partnership and GAIN; certain elements of these models can be adapted to the micronutrient sector.

Costs of interventions

The micronutrient literature includes studies that, although frequently cited, are very old and lack spe-

cificity and precision in their treatment of program costs.

- » Great caution should be used in generalizing the unit costs of micronutrient programs, especially vitamin A supplementation.
- » The cost-effectiveness of vitamin A supplementation programs can be further improved by bundling programs with other services (such as NIDs or CHWs/days) and using volunteers.
- » The noncomparability of methods precludes making a more definitive statement, but it appears that programs implemented exclusively by NGOs are roughly 25% more expensive per beneficiary than programs implemented primarily or predominantly by a public-sector entity.

External assistance in the micronutrient sector

The urgency of the problem of VMDs combined with potential high payoffs and current inadequate program levels point toward development of a carefully planned strategy for fundraising and better coordination among donors in their financing and implementation approaches. Many donors may not be aware of the comparative high return on investment in the VMD sector with regard to health, education, and productivity relative to other development options.

- » The current mechanisms used for information gathering, retrieval, and use are limited in scope, representation, and function, but they could be excellent building blocks and should form the foundation for a joint global planning effort.
- » To ensure consistency and transparency, resources should be invested to establish a mechanism for completing and updating the key information on international efforts that is needed for further program planning.
- » Urgent next steps are to make a short list of the most critical information essential for joint strategy analysis and planning, and to explore the best methods of obtaining this information. A commitment is needed for ongoing maintenance of the tracking mechanism for such information.
- » The feasibility of developing an ongoing, harmonized mechanism for capturing donor investments should be carefully explored. The use of a common framework for application within each organization's coding system or the use of periodic surveys of key informants are two options. Good examples of formats are discussed in this report. A common set of indicators and definitions should guide this activity.

Strong evidence exists for public health and development impacts arising from micronutrient programs that have successfully reached high-risk populations.

We know a lot about the strengths and limitations of delivering the appropriate micronutrients to the most vulnerable groups in the fastest, safest, and most cost-effective way. But gaps in coverage, lack of clarity about current investments, and uncertainties about future

funding remain. A mechanism for donors and implementers to share information and agree on emerging issues would help countries and donors alike. This review has identified some elements of a globalized approach for the micronutrient sector.

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