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Eliminating Malnutrition Could Reduce Poor Countries' Disease Burden by One-Third

Worldwide, about 130 million children are undernourished, and in Sub-Saharan Africa, the numbers are increasing. The consequences of childhood malnutrition are intergenerational: Undernutrition in childhood diminishes intellectual ability and work capacity in adulthood, leading to economic hardships for individuals and families. Undernourished women tend to deliver premature or small babies who are more likely to die or get sick. Surviving babies are less likely to develop into strong, healthy adults, so they pass the problems on to the next generation.

With improved diets, affordable food fortification and supplementation programs, and carefully planned community and school programs, nutrition can be improved and the human and economic consequences of an undernourished population avoided.

Overnutrition, which until recently was common only in high-income countries, is now a problem for the developing world as well. People are eating more unhealthy foods, resulting in a rise in obesity, heart disease, and other avoidable life-style and nutrition-related diseases. Programs that encourage healthier eating and a more active lifestyle can mitigate or reverse this deadly trend.

The Causes and Burden of Undernutrition

In children, undernutrition means:

- Stunting, low height-for-age, which results from chronic undernutrition;
- Wasting, low weight-for-height, which results from acute undernutrition; and
- Underweight, low weight-for-age, encompassing both stunting and wasting.

Adequate nutrition is essential for healthy human development, especially between conception and age 2. Inadequate nutrition during this period may irreversibly retard mental development and physical growth.¹

For many children in low- and middle-income countries, growth typically begins to falter around six months of age, as children transition from breastfeeding to foods that are often inadequate in quality and quantity. As malnourished children get older, their immune systems weaken and they are more susceptible to infectious diseases. When sick, their nutrient requirements increase but their appetites and ability to absorb nutrients typically decrease – furthering nutrient loss. Globally, this cycle contributes to 53 percent of deaths in young children – mostly in South Asia and Sub-Saharan Africa. With adequate nutrition, most of these deaths could be prevented.

Because it interacts with disease, undernutrition does not kill directly; rather, it is a risk factor for death (and other consequences for health). While children who are extremely underweight – more than two standard deviations below the mean weight-for-age in a healthy population – are most likely to die, more deaths occur among the more numerous children who are less severely malnourished. Table 1 shows estimates of the numbers of deaths and associated loss of Disability-Adjusted Life Years (DALYs)² by World Bank region, for all children up to age four whose weight-for-age is at least one standard deviation below the healthy mean. Underweight contributes to 2.67 million deaths a year, half of them in Sub-Saharan Africa, and more than any other form of malnutrition.

Essential Nutrients and Interventions

Besides not getting enough protein and calories to eat, children often suffer deficiencies of four essential

TABLE 1. ESTIMATED DEATHS AND DALYS LOST BY CHILDREN FROM BIRTH THROUGH AGE FOUR ATTRIBUTABLE TO SELECTED NUTRITIONAL DEFICIENCIES BY REGION (THOUSANDS)

REGION	WFA < -1SD		VITAMIN A		IRON (ANEMIA*)		ZINC		IODINE
	DEATHS	DALYS	DEATHS	DALYS	DEATHS	DALYS	DEATHS	DALYS	DALYS
EAP	125	5,777	11	994	18	241	15	1,004	66
ECA	14	489	0	1	3	66	4	149	409
LAC	22	725	6	218	10	109	15	587	83
MENA	305	10,308	70	2,403	10	109	94	3,290	381
SA	870	27,879	157	4,761	66	704	252	8,510	366
SSA	1,334	45,131	383	13,552	21	596	400	14,094	748
High-income	0	0	0	0	6	40	0	2	2
Total	2,670	90,309	627	21,034	134	1,865	780	27,636	2,055

*Only deaths and DALYs directly attributable to iron-deficiency anemia in children. Does not include consequences of perinatal deaths attributable to maternal iron deficiency anemia.

WFA = Weight-for-age SD = Standard deviation, EAP = East Asia and the Pacific, ECA = Europe and Central Asia, LAC = Latin America and the Caribbean, MENA = Middle East and North Africa, SA = South Asia, SSA = Sub-Saharan Africa.

Source: D. T. Jamison, J. G. Breman, A. R. Measham, G. Alleyne, M. Claeson, D. B. Evans, P. Jha, A. Mills, and P. Musgrove. 2006. Disease Control Priorities in Developing Countries, 2nd ed. New York: Oxford University Press, Tables 28.2 and 28.3

micronutrients: vitamin A, iron, iodine and zinc. Each deficiency leads to specific health problems, sometimes a disease and sometimes as a risk factor for susceptibility to infection or more severe illness. Table 1 also shows the deaths and DALY losses attributable to these deficiencies. Only iodine deficiency does not lead to death, but it still causes substantial health loss, both physical and mental. Table 2 shows estimates of how the consequences of general malnutrition (underweight) and micronutrient deficiencies are distributed between direct effects (disease) and risk factor contributions. Adding both effects, for both kinds of malnutrition, leads to the estimate that nearly one-third of the disease burden in developing countries is directly or indirectly due to poor nutrition. Risk factor effects are more than twice as important as direct effects. For micronutrients, the two effects are almost equal because deficiencies cause specific diseases or conditions, in addition to increasing the risk from infections.

Vitamin A Deficiency

While the numbers are dropping in most regions, between 250,000 and 500,000 children go blind each year from vitamin

TABLE 2. CONTRIBUTION OF NUTRITION DEFICIENCIES TO DISEASE BURDEN IN DEVELOPING COUNTRIES DALYS LOST (PERCENTAGE)

FACTOR	DALYS LOST (PERCENTAGE)		
	DIRECT EFFECT	AS RISK FACTOR	TOTAL
General malnutrition	1.0	14.0	15.0
Micronutrient deficiencies	9.0	8.5	17.5
Total	10.0	22.5	32.5

Source: Disease Control Priorities in Developing Countries, 2nd ed., Table 56.1.

A deficiency (VAD). Of those, only one-half will survive another year. VAD also increases the severity and duration of infectious disease by decreasing immune function. It is believed to contribute to almost 630,000 deaths each year – mostly from measles, diarrhea, and malaria.

Higher intakes of vitamin A-rich foods including liver, milk, egg yolks, dark green leafy vegetables, and yellow and orange vegetables and non-citrus fruits, can prevent VAD.

Vitamin A supplementation effectively (and quickly) alleviates acute VAD, and can significantly decrease mortality of children under age 5. Several studies have shown that giving a newborn vitamin A drops within 48 hours of birth reduces mortality in the first three months by between 21 percent and 74 percent. In highly deficient areas, high-dose oral supplementation is recommended every four to six months for children under age 5. Supplementation is highly effective for reducing both mortality and ocular problems. Studies in Ghana and Zambia show that supplementation programs are quite affordable and highly cost-effective, costing between US\$0.90 and US\$1.23 per child per year, or between US\$6 and US\$11 per DALY saved.

Fortification of foods, including oil, monosodium glutamate, butter, wheat flour, sugar, and rice, is another effective way to increase vitamin A intake. Fortification of white sugar has reduced VAD in Central America. In Guatemala and El Salvador, fortified sugar is the primary source of vitamin A and accounts for 30 percent of the recommended dietary intake. The Guatemala program costs an estimated US\$0.17 per child per year.

Iron Deficiency

Iron deficiency, the primary cause of anemia, afflicts more than 2 billion people worldwide. It affects mostly women and children, and is most prevalent in South Asia and Sub-Saharan Africa. While it is not believed to retard children's physical growth, iron-deficiency anemia is an underlying factor in 841,000 deaths per year from maternal and perinatal causes. It directly causes 134,000 deaths annually in children older than one month of age. It can also cause neurological impairment, which affects learning capacity and school performance and may be irreversible.

Iron is found in all plant foods, but is more plentiful in meat. Deficiency results from insufficient absorption of iron or excess loss, often caused by blood loss from parasitic infections such as schistosomiasis and hookworm.

Iron deficiency can be combated with improved diet and either iron supplements or food fortification programs. Supplementation programs cost from US\$3.17 to US\$5.30 per child per year. Supplements are also often provided to pregnant women. Many countries use fortification of flours, noodles, sugar, condiments, and milk to fight iron deficiency. The scant evidence that fortified foods reduce iron deficiency and anemia suggests that it is effective and affordable. Programs typically cost between US\$0.09 and US\$1.00 per child per year.

Other strategies to combat iron deficiency, including iron-fortified food sprinkles, spreads, or foodlets (a food-tablet hybrid) may be more practical for regions where infrastructural constraints make other methods more difficult. The promotion of iron-rich organ meats and other animal products also helps increase iron intake, although it is not clear by how much. Poverty, however, is an obstacle.

Iodine Deficiency

Relatively few child deaths are attributed to iodine deficiency, but it causes considerable loss of DALYs (see Table 1). Insufficient intake of iodine can result in impaired intellectual development and physical growth. It can cause a range of problems referred to as iodine deficiency disorders (IDD): fetal loss, stillbirth, goiter, congenital anomalies, and hearing impairment. Iodine-deficient individuals usually experience mild mental retardation, which decreases work capacity and economic potential. Cretinism, caused by severe deficiency, is associated with extreme mental retardation.

Iodine is found naturally in seafood and sea-plants, but few other foods. However, it can be easily and inexpensively added to salt, which essentially everyone eats. Consequently, iodizing salt is an effective, practical, and affordable way to fight iodine deficiency. Iodizing programs can cost as little as US\$0.02 to US\$0.05 per child per year. Iodized salt is virtually indistinguishable from non-fortified salt and, because countries generally have few salt producers, fortification regulations are relatively easy to enforce. Programs to add iodine to salt have reduced deficiency in most regions, but deficiency rates appear to be increasing where such programs do not exist.

For regions with severe endemic iodine deficiency, high-dosage supplements, usually tablets, can curb the problem until longer-term food fortification programs are put into place. Where populations prefer local, unprocessed salt, adding potassium iodate to irrigation water is another alternative. Injecting children with iodized oil is another effective intervention, but requires trained personnel to administer. The annual cost of injections cost ranges between US\$0.80 and US\$2.75 per child.

Zinc Deficiency

Zinc deficiency is associated with about 800,000 deaths annually from diarrhea, pneumonia, and malaria in children

under age 5. Mild to moderate deficiency can increase susceptibility to infectious diseases. Severe deficiency can cause growth retardation, impaired immune function, skin disorders, hypogonadism, anorexia, and cognitive dysfunction.

Meat and seafood, particularly shellfish, are the best sources of zinc. Plant-based diets generally do not provide enough zinc for healthy growth and development.

Interventions include food fortification and supplementation and diet diversification and modification. Few programs have been established in developing countries, but Mexico has introduced several large-scale programs, including fortification of maize and wheat flours and distribution of complementary food and fortified milk to low-income children. Reliable cost estimates are limited, but one supplement program is estimated to cost US\$0.47 per child annually, or US\$73 per DALY saved.

Other Programs to Improve Nutritional Status

PROMOTING BREASTFEEDING AND COMPLEMENTARY FEEDING

After delivery, breastfeeding should be immediate and exclusive for the first six months of life to provide a healthful diet and to protect against infection. Other nutritious foods should be introduced after six months of age; however, the baby's diet should still be mostly breast milk until early in the second year. Breastfeeding promotion through health education, media campaigns, and other professional and lay support – often provided by community health programs – has been shown to make mothers between 22 percent and 34 percent less likely to stop exclusive breastfeeding.

Based on data from Brazil, Honduras, and Mexico, hospital-based programs promoting breastfeeding cost US\$0.30 to US\$0.40 per child, or only US\$3 to US\$7 per DALY saved, making these programs a highly cost-effective intervention.

Complementary feeding (introducing semi-solid and solid foods into a baby's diet while still breastfeeding) should begin at six months. Foods are often introduced too early or too late, or they are not nutritious enough to sustain healthy development. Often, cultural norms help maintain unhealthy practices. However, with media campaigns and supplemental

training of community health workers (who in turn can teach mothers), introducing foods into the diet can be a healthy transition. Effective programs promoting complementary feeding could reduce deaths of children under 5 by about 6 percent in developing countries.

Using Community and School-Based Nutrition Programs

Community health and nutrition programs (CHNPs) can incorporate specific efforts to combat micronutrient deficiencies, promote healthful feeding of infants and young children, and reduce undernutrition, usually without the need for supplementary feeding for most children. Such programs typically involve a mix of community volunteers and paid workers, with one supervisor overseeing between 10 and 20 volunteers. Each volunteer looks after between 100 and 300 children, providing specific interventions, monitoring child growth, and teaching mothers about nutrition and healthful practices. CHNPs improve access to knowledge and resources, but they also promote behavior change. And, they may mobilize communities' demand for services and for improved policies. CHNPs are generally run by the health sector, but often operate outside of health facilities in homes or at a central location within a community. For a program to succeed, community organization and involvement is essential from day one. Success is also more likely in communities with higher literacy (especially among women), an absence of social exclusion, and political commitment.

Evidence from programs in Tanzania, Bangladesh, India, Indonesia, the Philippines, Thailand, Costa Rica, Jamaica, and Nicaragua shows that community programs can reduce underweight or stunting prevalence by 1 percentage point per year above the pre-program trend, sometimes by as much as 2 or 3 percentage points. Results are sometimes much greater in the first year of operation, if malnutrition is initially widespread. When programs reduce the prevalence of underweight, infant mortality rates often fall dramatically as a result. However, lives can be saved even before nutritional status is improved. Teaching mothers how to protect their children and providing micronutrients and immunizations can reduce deaths among children who have yet to achieve normal weight for age. These achievements cost as little as US\$2 to US\$3 per child per year, but are more often US\$10 to US\$20. Costs vary according to the ratio of paid workers to children

and whether the program includes supplementary food distribution, among other factors. The cost per DALY saved from reduced underweight alone is estimated as US\$50 to US\$60 in the initial phase, when gains are most rapid, and US\$200 to US\$250 in sustained programs. Programs look still more cost-effective to the extent that they also reduce other health risks and disease burden. However, they may make some interventions, especially measles immunization, look less cost-effective as they reduce the risks of dying from infection.

Using school systems to deliver simple health interventions and promote better nutrition practices can be another cost-effective way to reduce the malnutrition burden and, at the same time, to improve students' classroom performance and eventual productivity. School nutrition programs can include health, hygiene, and nutrition messages in the regular classroom curriculum. Health education interventions delivered through school nutrition programs are virtually cost-free, requiring only a policy change that ensures appropriate messages are taught. Using schools and teachers to deliver nutrient supplements to children is equally as effective, and may be only one-tenth the cost of using traditional mobile health units. Teacher training costs, however, also need to be considered.

School programs can be particularly effective in combating intestinal worm infections, and schistosomiasis, as well as treating deficiencies of vitamin A, iron, and iodine. These interventions cost only pennies per child per year. Testing children's eyesight and providing spectacles as needed costs US\$2.50 to US\$3.50; full physical examinations to diagnose clinical conditions raise the cost to around US\$11.50 per child per year if the examinations are given annually. Supplementary feeding is often warranted because children come to school hungry, and that costs much more, US\$20 to more than US\$100 depending on the number of children fed and the composition of school meals. The long-term positive economic effects of improved child and adolescent health are particularly important.

Preventing Overnutrition

In recent years, overnutrition and lack of exercise have increased rates of non-communicable diseases (especially heart attack, stroke, diabetes, and certain cancers) making them the leading cause of illness and death worldwide. In the developing world, processed foods high in trans fats, sugars, and sodium are becoming more popular. At the same time, motorized transportation (versus walking or bicycle-riding) is becoming the norm. Consequently, waistlines are expanding, arteries are clogging, and prevalence of avoidable non-communicable diseases is on the rise across the globe.

However, countries can take action to help people make healthy choices:

- **Promote walking and bicycle-riding.** Designing roads to accommodate safe walking and bicycle-riding can discourage the use of motorized vehicles.
- **Build efficient, affordable, public transportation systems.** Users of public transportation tend to exercise and walk more than those who rely on private motorized vehicles.
- **Regulate food manufacturing.** Providing incentives or requirements for food manufacturers to reduce or eliminate trans fats and sodium from foods is an effective way to lower consumption without requiring behavior change. In Mauritius, the government was able to reduce country-wide serum cholesterol levels by replacing palm oil with healthier soybean oil for everyday cooking.
- **Subsidize healthier foods.** Food subsidies often affect grains, dairy products, sugar, and beef. If policies lowered the price of fruits, vegetables, nuts, legumes, and whole grains, people would eat more of these healthier foods, and subsidies would help improve health rather than damage it.
- **Protect consumers from aggressive marketing of unhealthy foods.** The food industry spends billions of dollars each year advertising unhealthy foods. Regulations limiting advertising depend on a country's political culture, but can be an effective way to reduce the intake of unhealthy foods.

For More Information

Please see the following chapters in D. T. Jamison, J. G. Breman, A. R. Measham, G. Alleyne, M. Claeson, D. B. Evans, P. Jha, A. Mills, and P. Musgrove. 2006. *Disease Control Priorities in Developing Countries*, 2nd ed. New York: Oxford University Press.

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2 DALY (disability-adjusted life year) is a composite measure that combines the number of years lived with a disability and the number of years lost to premature death.