Chapter Five

The Economic Cost of Malnutrition

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"Money is a needful and precious thing, and when well used, a noble thing, but I never want you to think it is the first or only prize to strive for."

Louisa May Alcott, *American novelist (1832–1888)*

Key messages

- Chronic undernutrition and micronutrient deficiencies are prevalent across the developing world.
- In addition to its substantial human costs, undernutrition has lifelong economic consequences.
- There exist feasible solutions to many dimensions of undernutrition.
- Fighting undernutrition has considerable economic benefits, most notably in terms of improving schooling, cognitive skills and economic productivity.
- Spending that reduces both chronic undernutrition and micronutrient deficiencies is an excellent investment in economic terms; it is one of the smartest ways to spend global aid dollars.

The problem of widespread undernutrition

Around 165 million preschoolchildren suffer from chronic undernutrition. Because of inadequate food intake, repeated infection or both they fail to grow at the same rate as healthy, well-fed children. Millions more suffer from deficiencies in micronutrients such as vitamin A, iron, iodine and zinc – a phenomenon sometimes called 'hidden hunger'. Deprivation in a world of plenty is reason enough for investments that reduce undernutrition. Attacking these problems is also good economics.

Hunger, food insecurity and undernutrition

Hunger, food insecurity and undernutrition are related but not synonymous. Hunger is "A condition, in which people lack the basic food intake to provide them with the energy and nutrients for fully productive lives" (Hunger Task Force, 2003). Food security exists when all people, at all times, have physical, social and economic access to sufficient, safe and nutritious food which meets their dietary needs and food preferences for an active and healthy life (United Nations, Food and Agriculture Organization). As discussed here and elsewhere in this book, nutrients provided by food combine with other factors, including the

Malnourished children eating rice in Kakuma Refugee Camp, Kenya
Source: Mike Bloem Photography

health state of the person consuming the food, to produce "nutritional status." Undernutrition reflects an absence of macro- or micronutrients which may be exacerbated by debilitating health stresses such as parasites.

A powerful investment to reduce hunger and food insecurity is increased spending on agricultural research and development. This includes research that enhances drought, heat and salt tolerance, identifying and disseminating varieties with enhanced yield potential, increasing milk yields and soil diagnostics that would permit optimal combinations of organic and inorganic fertilizers. This investment has five benefit streams: i) increases in welfare gains resulting from lower prices faced by consumers; ii) welfare gains from reduced yield volatility; iii) the option value of reduced yield volatility resulting from climate change; iv) productivity gains derived from the impact of increased caloric consumption on worker productivity; and v) the income gains in adulthood resulting from reduced undernutrition in early life. An additional $8 billion dollars per year would, by 2050, reduce the number of hungry people in the world by 210 million.

Undernutrition and its consequences – physical and neurological

The first thousand days, in utero and the first two years after birth, are critical for a child's physical and neurological development. During this period, children's nutritional status is affected by the quantity and quality of food they consume. Exclusive breastfeeding in the first six months conveys critical benefits and it is vitally important that complementary foods introduced after this contain the right quantities of macro-nutrients – calories and protein – as well as micronutrients.

What happens when these are lacking? As discussed elsewhere in this book, children need energy to grow. Where this energy is absent, or where a child is repeatedly ill with infections that divert energy from growth while suppressing appetite, children fail to grow at a healthy rate. Studies that have followed children from infancy through to adulthood find that this lost growth is never fully regained and so these individuals end up shorter in height than they would have been if their diets had been adequate and they had not been subject to repeat infection. Vitamin A deficiencies kill. Current estimates suggest that more than 145,000 deaths in children under five occur each year because children lack vitamin A. This number has significantly declined in recent years due to the improved reach of vitamin A capsule distribution programs. Zinc deficiency affects children's physical growth and leads to increased susceptibility to a number of infections including diarrhea and pneumonia.

Both macro- and micronutrient deficiencies have insidious effects on neurological development. Iodine deficiency adversely affects development of the central nervous system leading to loss of IQ and mental retardation. Iron is needed to make brain chemicals (neurotransmitters) that aid in concentration; iron deficiency constrains cognitive development in children. Chronic undernutrition has neurological consequences that lead to cognitive impairments. The prefrontal cortex is especially vulnerable to undernutrition with the result that undernourished children can suffer from attention deficits and reduced working memory. Other neurological insults resulting from chronic undernutrition include damage to the parts of the brain responsible for spatial navigation and motor skills, The parts of the brain (axons) responsible for transmitting signals from one neuron (brain cell) to another are damaged by chronic undernutrition with the result that these signals are passed more slowly and inefficiently.

These malign effects can be exacerbated by the interactions that occur, or do not occur, between children and their caregivers. For example, delayed development of motor skills such as crawling and walking, together with lethargy and increased incidence of illness in undernourished infants, reduces their interactions with adults and with their environment.

Girls in a classroom in Kakuma Refugee Camp, Kenya
Source: Mike Bloem Photography

Undernutrition and its consequences – economic

The persistently malign effects of undernutrition in early life have significant economic consequences in adulthood. A number of studies show that shorter individuals have lower earnings in adulthood although the precise reason for this – the direct effect of height on physical productivity; the social benefits associated with height – vary from place to place. There is evidence that undernutrition in early life, manifested as low birth weight, increases susceptibility to coronary heart disease, non-insulin dependent diabetes, and high blood pressure – the Barker hypothesis. However, the biggest economic consequences are those resulting from neurological damage. Studies that have followed undernourished preschoolchildren find that they attain fewer grades of schooling and develop poorer cognitive skills such as those relating to problem solving. By contrast, there is strong evidence that interventions that combat undernutrition in early life convey lifelong benefits.

Everywhere in the world, schooling and cognitive skills are vital for success in the labor market. A useful rule of thumb is that every additional grade of schooling raises wages by eight to 12 percent. So individuals without such skills and with less schooling earn lower wages, which makes it more likely that they will be poor.

The fetal programming concept

"A consequence that is also emerging more clearly is the impact of stunting and subsequent disproportionate and rapid weight gain on health later in life. These long-term effects are referred to as the fetal programming concept: Poor fetal growth, small size at birth and continued poor growth in early life followed by rapid weight gain later in childhood raises the risk of coronary heart disease, stroke, hypertension and type 2 diabetes. Attaining optimal growth before 24 months of age is desirable; becoming stunted but then gaining weight disproportionately after 24 months is likely to increase the risk of becoming overweight and developing other health problems.

"As stunted children enter adulthood with a greater propensity for developing obesity and other chronic diseases, the possibility of a burgeoning epidemic of poor health opens up, especially in transitional countries experiencing increasing urbanization and shifts in diet and lifestyle. This epidemiological transition could create new economic and social challenges in many low- and middle-income countries where stunting is prevalent, especially among poorer population groups."

Source: UNICEF Improving Child Nutrition 2013

Case study

A series of studies led by Professor Reynaldo Martorell at Emory University, have shed light on the long-term benefits of improving nutritional status in young children.

More than four decades ago, between 1969 and 1977, two nutritional supplements - a high-protein-energy drink called *Atole* and a low-energy drink devoid of protein called *Fresco* – were provided to preschoolchildren in four villages in eastern Guatemala. Between 2002 and 2004, individuals who had been exposed to this intervention were traced throughout Guatemala and interviewed about their schooling, marital histories, living conditions and participation in the labor market. They took reading, vocabulary and problem-solving tests. Their heights and weights were measured as were the heights and weights of their children. Because these supplements were randomly assigned across villages, and because of the care with which the intervention was implemented and the wealth of additional information that was collected, it is possible to draw causal inferences of the effect of the high-protein-energy drink.

For both men and women, access to *atole* significantly raised scores on reading, vocabulary tests and on tests of problem-solving ability more than twenty-five years after the intervention had concluded. For men, access to *atole* increased wages by more than 40 percent. (There was no impact on women's wages largely because relatively few women participated in work outside the home.) The benefits of *atole* were intergenerational. Offspring of women exposed to *atole* had higher birth weights and were taller compared with offspring of women exposed to *fresco*.

The Guatemala study provides powerful evidence of the long-term investments that reduce chronic undernutrition.

The economics of reducing undernutrition

The human and economic costs of undernutrition would seem to make a compelling case for investments – purposive actions by governments, non-governmental organizations and the private sector – to reduce undernutrition. Some of these investments – such as increasing girls' schooling, improving the health and status of women ("healthy mothers for healthy children") and improved water and sanitation – are important development objectives in their own right. But what about direct interventions to reduce macro- and micronutrient deficiencies? Are these good investments?

A number of studies have looked at the costs of these investments relative to the economic benefits that they would provide. There is an element of uncertainty surrounding these calculations – as there is with any benefit: cost analysis – because they rely on estimating the costs of these interventions today and calculating the stream of economic benefits that accrue over the decades that follow.

With that caution in mind, a good economic investment is an investment where the benefit:cost ratio exceeds one; that is to say that for every dollar spent today on investments to reduce undernutrition, the future stream of economic benefits valued in today's terms exceeds one dollar. Measured in this way, there is overwhelming evidence that investments to reduce micronutrient deficiencies and chronic undernutrition have high benefit:cost ratios:

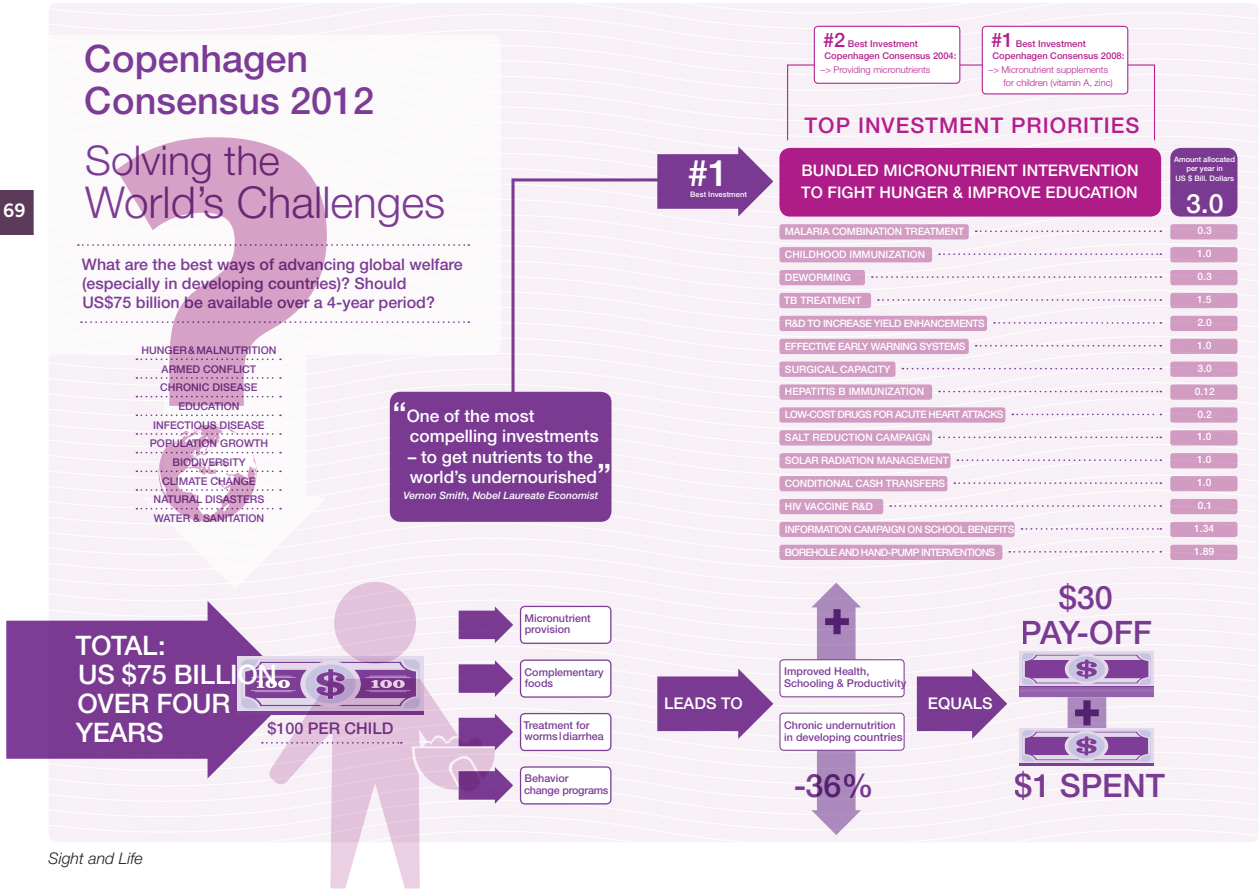
- Every dollar spent iodizing salt generates $30 in economic benefits;
- Every dollar spent on iron supplements for mothers and children aged six to 24 months generates $24 in economic benefits
- Every dollar spent on vitamin A generates economic benefits estimated to be $40 or more
- Reducing chronic undernutrition requires bundling micronutrient interventions such as those that reduce vitamin A, iodine and iron deficiencies with the provision of other micronutrients (such as zinc powders needed to reduce the duration and severity of diarrhea), and energy-dense foods. Also important is communication with mothers and other caregivers about the importance of these for healthy child growth. The costs associated with doing so vary across countries as do the benefits but in a typical developing country, every dollar spent on this bundle generates around $18 in economic benefits

By the standards of economics, these are impressively high benefit:cost ratios. Not only that, the costs of these investments are trivially low. In addition to current expenditures spent combatting undernutrition, an additional annual investment of about $650 million dollars a year – less than two dollars from every North American and western European – would be enough to eliminate vitamin A deficiency in the 95 million preschoolchildren who are vitamin A deficient, iodine deficiencies affecting nearly two billion people and anemia affecting 80 million pregnant women. A larger investment is needed for the bundle of interventions needed to reduce chronic undernutrition – current estimates suggest that around nine and half billion dollars per year would reach 90% of children in the 34 countries that account for 90% of the burden of undernutrition in the developing world.

The Copenhagen Consensus

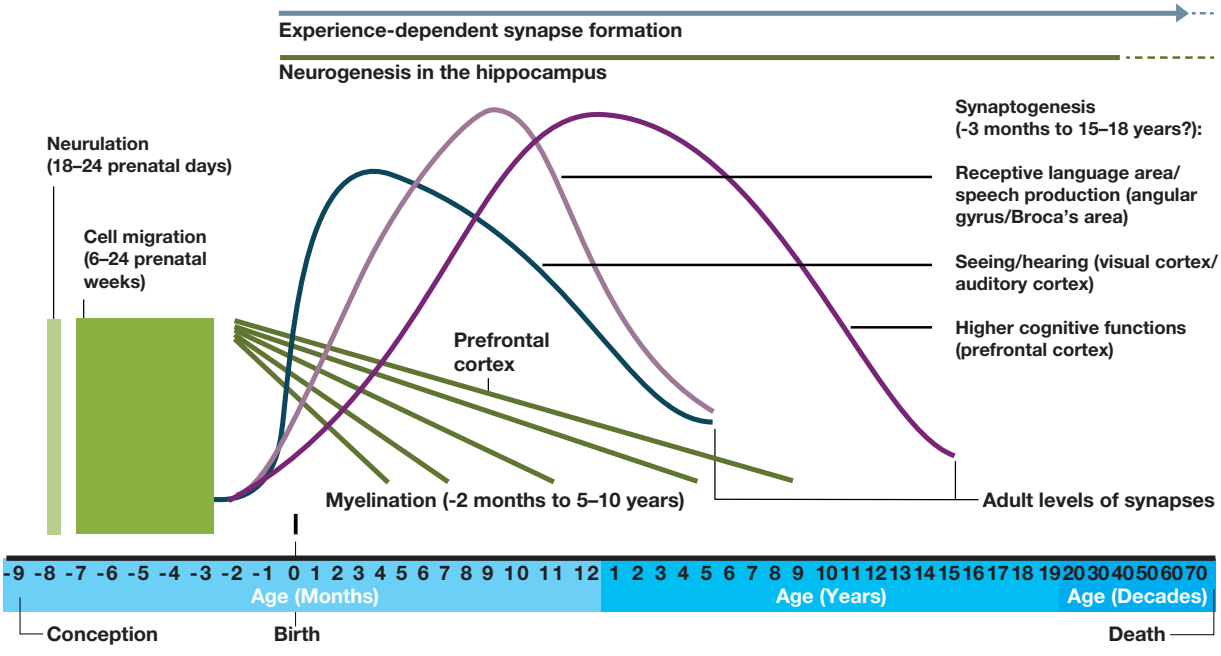
The origin of the Copenhagen Consensus dates back to 2002, and a small team of people headed by Bjorn Lomborg, then Director of the Danish Environmental Assessment Institute. Funded for a period of time by the Danish government, the Copenhagen Consensus Centre is a think tank which "commissions and conducts new research and analysis into competing spending priorities. In particular we focus on the international community's effort to solve the world's biggest challenges and on how to do this in the most cost-efficient manner."

In 2004, 2008 and 2012, the Copenhagen Consensus Centre held a series of global conferences. At each, an expert panel, including four Nobel Laureates, looked at twelve major global challenges, deliberating the question: "If you had $75 billion for worthwhile causes, where should you start?" The experts were informed by 30 economic research papers by eminent scholars which provided cost-benefit analyses for a range of potential interventions. In each round, the panel found investments to reduce micronutrient deficiencies and chronic hunger to be among the best investments that could be made with these funds. In 2012 the panel ranked 'Interventions to Reduce Chronic Undernutrition in Preschoolers' to be the highest-ranking solution.



Sight and Life

The Developmental Course of Human Brain Development



This figure shows that the rapid period of brain development occurs within the 1,000-day window between the start of a woman's pregnancy and her child's second birthday.

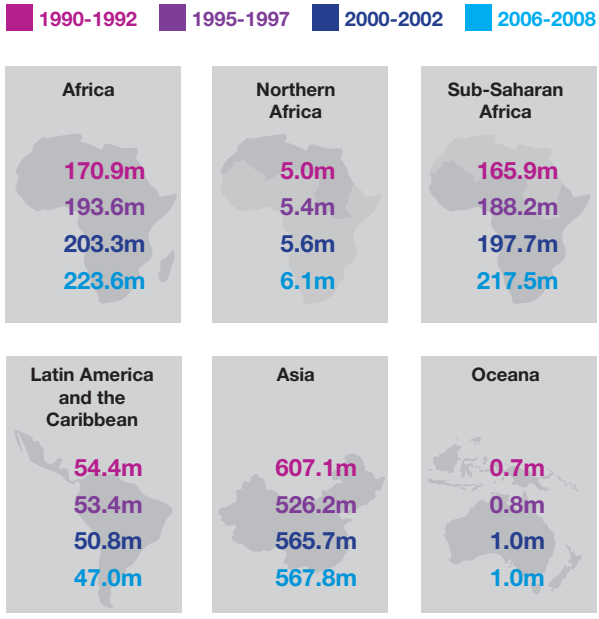
Thomson, Nelson (2001) Developmental Science and the Media

Global estimates of undernourishment (hunger) 1969-2010

Period	Number of undernourished (millions)	Prevalence (percentage)
1969-71	875	33
1979-81	850	25
1990-92	848	16
1995-97	792	14
2000-02	836	14
2006-08	850	13
2009	1023*	18
2010	925*	16

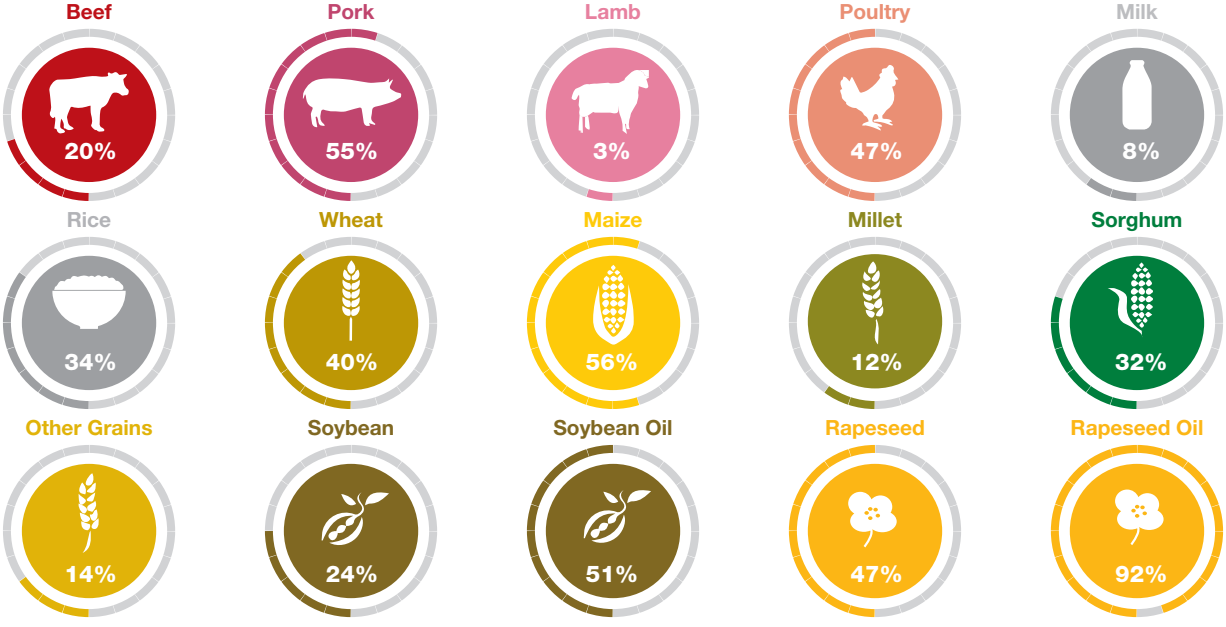
FAO, State of Food Insecurity in the World, 2012

Regional estimates of undernourishment 1990-2008



Hunger and Malnutrition, Copenhagen Consensus 2012

Projected change in World Commodity Prices presented as a percent change between baseline 2010 and baseline 2050



Hunder and Malnutrition, Copenhagen Consensus 2012

Per child cost of interventions to reduce stunting and mortality at age 36 months

Intervention	Child age range (months)	Cost per unit	Total cost per child
Community based nutrition programs that provide information on breastfeeding, complementary feeding, handwashing, and distribute micronutrient powders and iron-folate supplements	0–59	$7.50 per child	$7.50
Vitamin A supplementation	6-59	$1.20 per year	$4.80
Therapeutic zinc supplementation for management of diarrhea	6-59	$1.00 per year (assumes two or three treatments per year)	$4.00
Multiple micronutrient powders	6-23	$3.60 per course; 3 courses recommended	$10.80
Deworming	12-59	$0.25 per round; one round recommended per year	$1.00
Iron-folic acid supplementation for mothers during pregnancy		$2.00 per pregnancy	$2.00
Iron fortification of staples	12-59	$0.20 per year	$0.80
Universal salt iodization	12-59	$0.05 per year	$0.20
Providing complementary foods to 80 percent of children in South Asia, 50 percent in Africa and East Asia, 10 percent elsewhere	6-23	$0.11 per day $0.14 per day in India	$56.88
Community based management of severe acute malnutrition	6-59		$8.13

Hunger and Malnutrition, Copenhagen Consensus 2012

Benefit: cost estimages of investments that reduce stunting

			23.8% income increase		15% income increase	
		Discount rate	5%	3%	5%	3%
	**Bangladesh**	Increased income, NPV:	3647	7165	2303	4523
		Cost:	96.1	96.1	96.1	96.1
		Benefit: Cost ratio:	**38.0**	**74.6**	**24.0**	**47.1**
	**Ethiopia**	Increased income, NPV:	2289	4496	1445	2838
		Cost:	96.1	96.1	96.1	96.1
		Benefit: Cost ratio:	**23.8**	**46.8**	**15.0**	**29.5**
	**Kenya**	Increased income, NPV:	3713	7295	2344	4605
		Cost:	96.1	96.1	96.1	96.1
		Benefit: Cost ratio:	**38.6**	**75.9**	**24.4**	**47.9**
	**India**	Increased income, NPV:	7875	15470	4972	9767
		Cost:	111.62	111.62	111.62	111.62
		Benefit: Cost ratio:	**70.6**	**138.6**	**44.5**	**87.5**

NPV = net present value

Hunger and Malnutrition, Copenhagen Consensus 2012

Baseline projections for people at risk of hunger in 2010, 2025 and 2050

Region	People at Risk of Hunger (millions)		
Projected Year	2010	2025	2050
East Asia and Pacific	177	131	122
Europe and Central Asia	23	23	21
Latin America and the Caribbean	60	61	45
Middle East and North Africa	17	21	24
South Asia	318	310	235
Sub-Saharan Africa	240	275	268
Developing	835	821	716
Developed	49	50	50
World	884	870	766

Hunger and Malnutrition, Copenhagen Consensus 2012

Baseline projections of malnourished children in 2010, 2025 and 2050

Region	Number of Malnourished Children (millions)		
Projected Year	2010	2025	2050
East Asia and Pacific	20	13	8
Europe and Central Asia	4	3	3
Latin America and the Caribbean	8	7	4
Middle East and North Africa	4	3	2
South Asia	74	65	50
Sub-Saharan Africa	41	44	39
Developing	150	135	106
Developed	12	12	12
World	163	147	118

Hunger and Malnutrition, Copenhagen Consensus 2012

Benefit: cost ratios of micronutrient interventions

26 Fe Iron — Intervention: Supplements, mothers and children 6-24 months

Previous Estimates	New Estimates	Current Estimates of cost per beneficiary
-	23.8 RAJ	$0.96 RAJ

26 Fe Iron — Intervention: Supplements, pregnant mothers

Previous Estimates	New Estimates	Current Estimates of cost per beneficiary
82-140 RAJ -	8.1 HOR	$2.00 HOR 2010

26 Fe Iron — Intervention: Fortification, general

Previous Estimates	New Estimates	Current Estimates of cost per beneficiary
7.8 HAR	-	-

26 Fe Iron — Intervention: Fortification of wheat flour

Previous Estimates	New Estimates	Current Estimates of cost per beneficiary
-	9.1 HOR 6.7 CASEY 2011	$0.17 HOR

26 Fe Iron — Intervention: Home fortification

Previous Estimates	New Estimates	Current Estimates of cost per beneficiary
-	37 HOR	$1.20 HOR

26 Fe Iron — Intervention: Biofortification

Previous Estimates	New Estimates	Current Estimates of cost per beneficiary
11.6-19 BAH 16.7 HAR	-	<$0.01 HOR

53 I Iodine — Intervention: Salt Iodization

Previous Estimates	New Estimates	Current Estimates of cost per beneficiary
15-520 BAH 30 HAR	81 RAJ	$0.05 HAR

53 26 I Fe Iodine & Iron — Intervention: Doubly fortified salt

Previous Estimates	New Estimates	Current Estimates of cost per beneficiary
-	2.5 RAJ 2-5 HOR	$0.25 HOR

A Vitamin A — Intervention: Supplement

Previous Estimates	New Estimates	Current Estimates of cost per beneficiary
4.3-43 BAH 6.1-250 HAR	12.5 RAJ	$0.29 RAJ

30 Zn Zinc — Intervention: Supplement

Previous Estimates	New Estimates	Current Estimates of cost per beneficiary
-	2.85 RAJ	$1.26 RAJ

Hunger and Malnutrition, Copenhagen Consensus 2012. ***Casey*** *GJ, Sartori D, Horton SE, Phuc TQ, Phu LB, et al, 2011. Weekly Iron-Folic Acid supplementation with Regular Deworming Is Cost-Effective in Preventing Anaemia in Women of Reproductive Age in Vietnam. PLoS ONE 6(9) 23723. doi:10.1371/journal.pone.0023723.* ***BAH*** *Behrman, J., Alderman, H., and Hoddinott, J., 2004. Hunger and Malnutrition, in B. Lomborg (ed.) Global crises, Global solutions, Cambridge University Press, Cambridge UK.* ***HAR*** *Horton, S., H. Alderman and J. Rivera, 2008. Hunger and Malnutrition. Copenhagen Consensus 2008 Challenge Paper, Copenhagen Consensus Center, Copenhagen.* ***HOR*** *Horton, S., A. Wesley and M.G. Venkatesh Mannar, 2011. Double-fortified salt reduces anemia, benefit: cost ratio is modestly favorable. Food Policy, 36(5): 581-587.* ***HOR*** *2010 Horton, S., M. Shekar, C. McDonald, A. Mahal and J. Brooks, 2010. Scaling up nutrition: What will it cost? World Bank, Washington DC.* ***RAJ*** *Rajkumar, A.S., C. Gaukler, and J. Tilahun, 2012. Combating Malnutrition in Ethiopia: An Evidence-Based Approach for Sustained Results World Bank: Washington DC.*

Malnutrition and obesity

The word "malnutrition" encompasses undernutrition, deficiencies in macro- and micronutrients, and what is somewhat inelegantly termed overnutrition, excessive caloric intake, exacerbated by diseases such as diabetes and low levels of physical activity. Overweight and obese individuals are one manifestation of overnutrition. Overweight and obesity are significant public health problems in much of the developed world and increasingly in middle income countries such as Brazil and Mexico. Across the developing world, however, undernutrition is the major form of malnutrition.

An astonishing return on investment

"Improving nutrition is in fact a precondition to achieving many of the Millennium Development Goals (MDGs): eradicating poverty and hunger, reducing child mortality, improving maternal health, combating disease, empowering women and achieving universal primary education.

"Research shows that children who are well nourished, especially in the critical 1,000 day window between conception and the child's second birthday, receive the strong start in life they need to grow, fight disease, learn more in school, and earn more as adults. They also grow up to help lift their countries out of poverty: a 2010 study found that investing in nutrition can increase a country's GDP by at least 2–3 percent each year. And in May of this year, the Copenhagen Consensus panel of experts, which included no fewer than four Nobel Laureates, found that providing micronutrients to children under five is the single smartest way to spend global aid dollars. Every $1 spent yields $30 – an astonishing return on investment ratio by any measure. We cannot improve health and promote development without addressing micronutrient deficiencies. Micronutrients have a key role to play in nourishing the world's people, building strong families and creating vibrant and economically sustainable communities."

Klaus Kraemer, Sight and Life

My personal view

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There is intrinsic value in eliminating undernutrition – it is simply the right thing to do. But beyond this, it is good economics too. Investments in reducing chronic undernutrition and micronutrient deficiencies have considerable economic benefits.

Further reading

Behrman J, Alderman H, Hoddinott J. Hunger and malnutrition. In: Lomborg B (ed) Global crisis, global solutions. Cambridge: Cambridge University Press, 2004.

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Hoddinott J, Rosegrant M, Torero M. Investments to reduce hunger and undernutrition. In: Lomborg B (ed) Copenhagen Consensus 2012. Cambridge: Cambridge University Press, 2013.

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