

Review of literature on benefits of ending hunger and malnutrition (April 14 2017)

Area of benefit	Title *included in multiple areas of benefit	Authors	Year	Time period	Scale of study	Findings	
Economic Benefits	Observed increase in wages from nutrition intervention	Effect of a nutrition intervention during early childhood on economic productivity in Guatemalan adults	Hoddinott et al.	2008	2002-2004	Guatemala, 1424 individuals accounting for 60% of 2392 children enrolled in nutrition intervention study 1969-77	<ul style="list-style-type: none"> Improved nutrition (exposure to more nutritious supplement) before age 3 associated with a wage increase of \$0.67/hour, or a 46% increase in average wages
	Increase in adulthood productivity and earnings from improved childhood nutrition	Reducing the incidence of low birth weight in low-income countries has substantial economic benefits *	Alderman and Behrman	2006		Literature review and estimation of benefits	<ul style="list-style-type: none"> Total estimated present discounted value of moving one infant out of low-birth weight status is \$510 due to benefits including productivity gain from reduced stunting, and productivity gain from increased cognitive ability
		The Economic Rationale for Investing in Nutrition in Developing Countries	Behrman	1993		Literature review and estimation of benefits	<ul style="list-style-type: none"> Lower adult height, as a consequence in part of poor nutrition in childhood, is associated with reduced earnings as an adult Studies indicate growing, though qualified, evidence of positive direct effects of nutrition on labor productivity of poorer individuals in developing countries — greater productivity effects for nutrition than for formal schooling Studies on the indirect productivity effects of nutrition through cognitive achievement, schooling, and preschool ability also indicate positive productivity effects through these channels
		The politics of reducing malnutrition: building commitment and accelerating progress	Gillespie et al.	2013	NA	NA	<ul style="list-style-type: none"> Investments in maternal and early childhood nutrition that build human capital can be one way to secure the demographic dividend
		Early nutrition and later physical work capacity	Haas et al.	1996		Colombia, India, Tanzania, Guatemala	<ul style="list-style-type: none"> Poor early childhood nutritional status, as indicated by the low dietary energy intakes and subsequent stunted growth, leads to many undesirable functional consequences. The studies of physical work capacity, together with other measures such as cognitive functioning and reproductive performance, provide strong evidence in support of policies and programs designed to eliminate the causes of environmental stunting in poor populations.
		The Impact of Nutritional Status on Agricultural Productivity: Wage Evidence from the Philippines	Haddad and Bouis	1991		Philippines	<ul style="list-style-type: none"> Substantial lifetime income losses may be expected to be incurred by adults who depend heavily on agricultural wage income and who are stunted as a result of poor health and nutrition during childhood. Investments in better health and nutrition that are made during childhood result in improved adult heights, these effects are permanent and result in incremental income flows over a number of years.
		Editorial: Nutrition is an incredible investment opportunity for Ethiopia's present and future	Haddad	2015		Ethiopia	<ul style="list-style-type: none"> Every Birr invested in nutrition programs generates 12 Birrs in benefits from improved productivity in the labor force (Global Nutrition Report) Ratio of working to non-working age people to reach peak in 2050; to benefit from the demographic dividend, need to invest in nutrition today
	The economic consequences of selected maternal and early childhood nutrition interventions in low- and middle-income countries: a review of the literature, 2000—2013	Halim et al.	2015	2000-2013	Systematic literature review of 23 reproductive, maternal, newborn and child health (RMNCH) interventions, published in 29 empirical studies, using data from 13 low- and middle-income countries	<ul style="list-style-type: none"> In low- and middle-income countries, RMNCH interventions were rarely evaluated using rigorous evaluation methods for economic consequences Based on limited studies, maternal and childhood participation in nutrition interventions was shown to increase individuals' income as adults by up to 46%, depending on the intervention, demography and country Compared to females, males appeared to have higher economic returns from childhood participation in RMNCH interventions 	
	Increase in productivity and earnings from improved adult nutrition status	Nutrition and Labor Productivity in Agriculture: Estimates for Rural South India	Deolalikar	1988	1976-78	India	<ul style="list-style-type: none"> Nutritional status-as measured by weight-for-height- is important in determining labor productivity in developing agriculture The elasticity of farm output with respect to the weight-for-height of family workers is found to be as large as 2
		Information, Learning, and Wage Rates in Low- Income Rural Areas	Foster and Rosenzweig	1993		Philippines, India, Pakistan	<ul style="list-style-type: none"> There is a positive productivity effect of increased calorie consumption for piece-rate harvest wages, but not for time-rate wages
The Economics of Iron Efficiency		Horton and Ross	2003		10 developing countries	<ul style="list-style-type: none"> Median value of annual physical productivity gains from eliminating iron deficiency is projected around \$2.32 per capita, or 0.57% of GDP. Median total gains (physical and cognitive combined) are projected at \$16.78 per capita, 4.05% of GDP. Using a cost of \$1.33 per case of anemia prevented, median benefit-cost ratio is 6:1 for the 10 countries examined and rises to 36:1 including the discounted future benefits attributable to cognitive improvements. 	
Wage rentals for reproducible human capital: evidence from Ghana and the Ivory Coast		Schultz	1996		Ivory Coast and Ghana	<ul style="list-style-type: none"> Education, child nutrition, adult health/nutrition, and labor mobility are critical factors in achieving recent sustained growth in factor productivity Education and migration returns are higher in the more rapidly growing Ivory Coast, and the wage effects of child nutrition proxied by height are greater in poorer, more malnourished Ghana. 	
Iron Deficiency and the Well-Being of Older Adults: Early Results from a Randomized Intervention		Thomas et al.	2004		Indonesia	<ul style="list-style-type: none"> Males who were iron deficient prior to the intervention and who are assigned to the treatment are better off in terms of physical health, psycho-social health and economic success. These men are more likely to be working, sleep less, lose less work time to illness, are more energetic, more able to conduct physically arduous activities 	

Review of literature on benefits of ending hunger and malnutrition (April 14 2017)

Area of benefit	Title *included in multiple areas of benefit	Authors	Year	Time period	Scale of study	Findings
Return on investment in nutrition-specific interventions	Health and Wages: Evidence on Men and Women in Urban Brazil	Thomas and Strauss	1997		Brazil	<ul style="list-style-type: none"> • Height has a large and significant effect on wages: taller men and women earn more. • Body mass index (BMI) is associated with higher wages of males, especially among the less-educated, suggesting that strength may be rewarded with higher wages. • Low levels of per capita calorie and protein intakes reduce wages of market-workers, but not the self-employed. After controlling for height, BMI, and calories, the influence of proteins is greater at higher levels, presumably reflecting the impact of higher-quality diets.
	Maternal and child undernutrition: consequences for adult health and human capital*	Victora et al.	2008		Brazil, Guatemala, India, the Philippines, and South Africa	<ul style="list-style-type: none"> • Undernutrition was strongly associated with reduced economic productivity
	Challenge paper: Hunger and Malnutrition*	Behrman et al.	2004		Global (lit review/model)	<ul style="list-style-type: none"> * Reducing the prevalence of low birth weight: projected present discounted value (PDV) of \$580 per infant moved from low birth weight to non-low birth weight category (discount rate of 5%) * Infant and Child Nutrition and Exclusive Breastfeeding Promotion: projected benefit-cost ratio of 4.8:1 (5% discount rate) to 7.35:1 (3% discount rate) * Reducing the Prevalence of Iodine Deficiencies: If the cost is less than \$130 per deficient women reached, the benefit-cost ratio is greater than one (5% discount rate) * Reducing the Prevalence of Vitamin A Deficiencies: Estimated estimated benefit is \$37 (5% discount rate) * Reducing the Prevalence of Iron Deficiency Anemia: Total benefit of \$815 with a 5% discount rate (However increased benefits come at increased costs because to obtain these additional ongoing productivity gains, there must be an ongoing flow of interventions over the work life in addition to the one-time intervention working through birthweights.)
	Investments to reduce hunger and undernutrition*	Hoddinott, Rosegrant, and Torero	2012		Global (lit review/model)	<ul style="list-style-type: none"> • Investments in various micronutrient interventions have benefit-cost ratios ranging from 2:1 to 81:1 • Investmentments in a package of interventions to reduce stunting projected benefit-cost ratio between 23.8:1-138.6:1 from reducing stunting by 36% and increasing income by 23.8%
	The economic rationale for investing in stunting reduction	Hoddinott et al.	2013		17 high-burden countries: DRC, Ethiopia, Kenya, Madagascar, Nigeria, Sudan, Uganda, Tanzania, Yemen, Bangladesh, India, Burma, Nepal, Pakistan, Indonesia, Vietnam, Philippines	<ul style="list-style-type: none"> • Assuming a 11% increase in income due to stunting reduction from nutrition interventions, benefit-cost ratio of investments range from 3.6 (DRC) to 48 (Indonesia) with median of 18 (Bangladesh)
	The Challenge of Hunger and Malnutrition	Horton, Alderman, and Rivera	2008		South Asia, sub-Saharan Africa (lit review/model)	<ul style="list-style-type: none"> • Micronutrient supplementation interventions have projected benefit-cost ratio of 17.3:1 • Micronutrient fortification interventions have projected benefit-cost ratio of 9.5:1 • Biofortification interventions have projected benefit-cost ratio of 16.7:1 • Deworming preschoolers have projected benefit-cost ratio of 6:1 • Community-based nutrition promotion has projected benefit cost ratio of 12.5:1 • Total benefits of all interventions save \$12 million DALYs per year, accounting for 3% of all DALYs lost in children under 5
	The costs of stunting in South Asia and the benefits of public investments in nutrition	Shekar et al.	2016	2014-2015	DRC, Mali, Nigeria, Togo	<p>Costs and benefits of investing in a package of 10 (Lancet) nutrition-specific interventions (US dollars):</p> <ul style="list-style-type: none"> • Mali: 64mil public investment will result in 509,000 DALYs saved, 14,000 lives saved, and 260,000 cases of stunting avoided. • Nigeria: 837mil public investment will result in 6.3 mil DALYs saved, 180,000 lives saved, and 3 mil cases of stunting avoided. • Togo: 13mil public investment will result in 115,295 DALYs saved, 3,000 lives saved, and 60,000 cases of stunting avoided. • DRC: 371mil public investment will result in 2.6 mil DALYs saved, 77,000 lives saved, and 1 mil cases of stunting avoided.
Return on investment in agriculture	Challenge paper: Hunger and Malnutrition*	Behrman et al.	2004		Global (lit review/model)	<ul style="list-style-type: none"> * Investments to disseminate new cultivars with higher yield potential has projected benefit-cost ratios ranging from 8.8 to 14.7 * Investments to disseminate iron and zinc dense rice and wheat varieties has projected benefit-cost ratios ranging from 11.6 to 19 * Investments to disseminate Vitamin A dense rice, "Golden Rice" has projected benefit-cost ratios ranging from 8.5 to 14

Review of literature on benefits of ending hunger and malnutrition (April 14 2017)

Area of benefit	Title *included in multiple areas of benefit	Authors	Year	Time period	Scale of study	Findings
	Investments to reduce hunger and undernutrition*	Hoddinott, Rosegrant, and Torero	2012		Global (lit review/model)	<ul style="list-style-type: none"> Investments to accelerate crop and livestock yield enhancements increases agricultural and total GDP, and reduces commodity prices, generating welfare gains from lower prices and yield volatility at benefit-cost ratio of 16.1:1 Investments in ICTs (e.g. mobile phones) average 2.4-3.75% increase in agricultural incomes through higher prices at benefit-cost ratio range of 1.41:1-2.09:1 Investments to increase competition in fertilizer markets leads to 8-11% decrease in prices and increase crop production 3.3-4.7%, which in turn reduces poverty by around 2% over 40 years (2010-2050)
	Returns to investment in reducing postharvest food losses and increasing agricultural productivity growth	Rosegrant et al	2015		40 countries and regional aggregates, model	<ul style="list-style-type: none"> Investments to reduce postharvest losses and in agricultural research increases effective yields and are projected to decrease commodity price by 10-20% and by more than 20% respectively by 2050 The increased food availability can lead to welfare gains and declines of over 70 million hungry and 5 million children malnourished by 2050. Benefit-cost ratios range from 6:1 to 35:1
Returns to health	Reducing the incidence of low birth weight in low-income countries has substantial economic benefits *	Alderman and Behrman	2006		Literature review and estimation of benefits	<ul style="list-style-type: none"> Total estimated present discounted value of moving one infant out of low-birth weight status is \$510 due to benefits including reduced infant mortality, reduced neonatal care, reduced costs of illness, and reduced costs of chronic disease
Returns to education	The Returns to Endogenous Human Capital in Pakistan's Rural Wage Labor Market	Alderman et al.	1996			<ul style="list-style-type: none"> Reduced adult cognitive skills, conditional on grades of schooling completed, directly affect earnings
	Long Term Consequences Of Early Childhood Malnutrition	Alderman, Hoddinott, and Kinsey	2003	1983, 1984 and 1987	Zimbabwe	<ul style="list-style-type: none"> Exposure to the 1982-84 drought resulted in a loss of stature of 2.3 centimeters, 0.4 grades of schooling, and a delay in starting school of 3.7 months. Loss of stature, schooling and potential work experience results in a loss of lifetime earnings of 7-12 percent and that such estimates are likely to be lower bounds of the true losses.
	Preschool Nutrition and Subsequent Schooling Attainment: Longitudinal Evidence from Tanzania	Alderman and Hoogeveen	2009		Tanzania	<ul style="list-style-type: none"> Improved health during childhood is effective in increasing the likelihood of completing more grades of schooling. As education exhibits significantly positive returns, higher attainments imply higher future wages.
	Big numbers about small children: estimating the economic benefits of addressing undernutrition	Alderman et al.	2017	2015-2030 (projected benefits)	Global (data from 10 evidence based programs, 34 countries)	<ul style="list-style-type: none"> Estimated benefit over 2015-2030 from reduced stunting based on returns to increased schooling: <ul style="list-style-type: none"> South Asia = \$497 billion; SSA = \$144 billion; East Asia and Pacific = \$1,033 billion In South Asia example, benefit-cost ratios range from 7:1 to 81:1 across various scenarios and assumptions
	An Economic Analysis of Delayed Primary School Enrollment and Childhood Malnutrition in a Low Income Country	Glewwe and Jacoby	1995		Ghana	<ul style="list-style-type: none"> Early childhood malnutrition causes delayed enrollment Each year of delay in entry to primary school loses 3% of lifetime wealth
	Results and Implications of the INCAP Follow-up Study	Martorell	1995		Guatemala	<ul style="list-style-type: none"> Nutrition intervention found long-term effects including greater stature and fat-free mass, particularly in females, improved work capacity in males and enhanced intellectual performance in both genders.
Increase in productivity (GDP)	Returns to Birthweight	Behrman and Rosenzweig	2004	1990s	112 countries for cross-country comparison Survey of same-sex twins registered on the Minnesota Twin Registry	<ul style="list-style-type: none"> Across 112 countries, there is a strong negative association between purchasing power parity-adjusted GDP per worker and the percentage of low-birthweight babies. (confounds the effects of the health of babies on their adult productivity with the effects of income on child health and the influence of common factors, such as institutions, that both improve health outcomes and augment incomes.) Increasing a child's birthweight by 1 lb. increases her adult earnings by over 7%.
	Malnutrition: Global economic losses attributable to malnutrition 1900-2000 and projections to 2050	Horton and Steckel	2011	1900-2000; 2000-2050	Global	<ul style="list-style-type: none"> Annual loss in GDP associated with inadequate nutrition can be as much as 12% in poor countries (much of the effect occurring via cognition) Worldwide annual productivity losses associated with undernutrition fell from around 12% in 1900, to around 6% in 2000. Without nutrition improvements, world GDP would have averaged 8% lower over the century. Projected loss of world GDP for the period 2000-2050 falls to 6%, as nutrition improvements first in Latin America and then in Asia take effect
Increase in per capita consumption	Adult consequences of growth failure in early childhood	Hoddinott et al.	2013	2002-2004	Guatemala	<ul style="list-style-type: none"> A 1-Standard Deviation increase in Height-for-Age Z-score was associated with increased household per capita expenditure (21%) and a lower probability of living in poverty (10 percentage points).
Cost savings in health, education, and productivity					Egypt, country level	<ul style="list-style-type: none"> Annual cost in health = \$212.7 million Annual cost in education due to reductions in stunting = \$49.2 million Annual cost in productivity loss averted = \$3.4 billion Total cost in 2009 = \$3.7 billion (1.9% of GDP)
					Ethiopia, country level	<ul style="list-style-type: none"> Annual cost in health = \$155.2 million Annual cost in education due to reductions in stunting = \$7.9 million Annual cost in productivity loss averted = \$3.5 billion Total cost in 2009 = \$4.7 billion (16.5% of GDP)
			2013	2009	Swaziland, country level	<ul style="list-style-type: none"> Annual cost in health = \$7.1 million Annual cost in education due to reductions in stunting = \$701,600 Annual cost in productivity loss averted = \$84 million Total cost in 2009 = \$92 million (3.1% of GDP)

Review of literature on benefits of ending hunger and malnutrition (April 14 2017)

Area of benefit	Title *included in multiple areas of benefit	Authors	Year	Time period	Scale of study	Findings	
	Cost of hunger in Africa series	Folstein et al.	2015	2012	Uganda, country level	<ul style="list-style-type: none"> • Annual cost in health = \$254.1 million • Annual cost in education due to reductions in stunting = \$9.5 million • Annual cost in productivity loss averted = \$635.3 million • Total cost in 2009 = \$899 million (5.6% of GDP) 	
					Rwanda, country level	<ul style="list-style-type: none"> • Annual cost in health = \$106 million • Annual cost in education due to reductions in stunting = \$3.9 million • Annual cost in productivity loss averted = \$709.9 million • Total cost in 2009 = \$820 million (11.5% of GDP) 	
					Malawi, country level	<ul style="list-style-type: none"> • Annual cost in health = \$46 million • Annual cost in education due to reductions in stunting = \$13.9 million • Annual cost in productivity loss averted = \$536.6 million • Total cost saving in 2012 = \$597 million (10.3% of GDP) 	
		The cost of hunger: social and economic impact of child undernutrition in Central America and the Dominican Republic	Martinez and Fernandez	2008	2004	Regional: Central America and Dominican Republic	<ul style="list-style-type: none"> • Cost in health (2004): US\$433.5 million (0.41% of GDP) • Cost in education (2004): US\$30.9 million (0.03% of GDP) • Cost in productivity (2004): \$6.194 billion (5.7% of GDP) • Total cost for underweight in 2004: US\$6.7 billion
						Costa Rica	<ul style="list-style-type: none"> • Cost in health (2004): US\$10 million (0.1% of GDP) • Cost in education (2004): US\$2.6 million (0.014% of GDP) • Cost in productivity (2004): \$305 million (1.6% of GDP) • Total cost for underweight in 2004: US\$317.6 million (1.7% of GDP)
						El Salvador	<ul style="list-style-type: none"> • Cost in health (2004): US\$24.4 million (0.2% of GDP) • Cost in education (2004): US\$1 million (0.006% of GDP) • Cost in productivity (2004): \$1.15 billion (7.3% of GDP) • Total cost for underweight in 2004: US\$1.175 billion (7.4% of GDP)
						Guatemala	<ul style="list-style-type: none"> • Cost in health (2004): US\$285.3 million (1.0% of GDP) • Cost in education (2004): US\$16.5 million (0.060% of GDP) • Cost in productivity (2004): \$2.827 billion (10.3% of GDP) • Total cost for underweight in 2004: US\$3.128 billion (11.4% of GDP)
						Honduras	<ul style="list-style-type: none"> • Cost in health (2004): US\$47.5 million (0.6% of GDP) • Cost in education (2004): US\$5 million (0.067% of GDP) • Cost in productivity (2004): \$727.6 million (9.9% of GDP) • Total cost for underweight in 2004: US\$780.1 million (10.6% of GDP)
						Nicaragua	<ul style="list-style-type: none"> • Cost in health (2004): US\$26.9 million (0.6% of GDP) • Cost in education (2004): US\$1.7 million (0.037% of GDP) • Cost in productivity (2004): \$235.8 million (5.2% of GDP) • Total cost for underweight in 2004: US\$264.3 million (5.8% of GDP)
						Panama	<ul style="list-style-type: none"> • Cost in health (2004): US\$26.4 million (0.2% of GDP) • Cost in education (2004): US\$3.7 million (0.03% of GDP) • Cost in productivity (2004): \$291.4 million (2.1% of GDP) • Total cost for underweight in 2004: US\$321.5 million (2.3% of GDP)
Dominican Republic	<ul style="list-style-type: none"> • Cost in health (2004): US\$13 million (0.1% of GDP) • Cost in education (2004): US\$0.5 million (0.003% of GDP) • Cost in productivity (2004): \$658 million (3.5% of GDP) • Total cost for underweight in 2004: US\$671.6 million (3.6% of GDP) 						
	Schooling and wage income losses due to early-childhood growth faltering in developing countries: national, regional, and global estimates	Fink et al.	2016		Global, developing countries	<ul style="list-style-type: none"> • Early childhood growth deficits (stunting) in developing countries results in a global economic loss of US\$176.8 billion per birth cohort at nominal exchange rates (US\$616.5 billion at purchasing power parity-adjusted exchange rates) and an average loss of lifetime earnings of US\$1400/child • Investment in scaling up effective interventions in this area is urgently needed and likely to yield long run benefits of \$3 for every \$1 invested 	
Health Benefits	Decreased morbidity and mortality	Effects of Intrauterine Growth Retardation on Mortality and Morbidity in Infants in Young Children	Ashworth	1998		Literature review	<ul style="list-style-type: none"> • Risk of neonatal death higher if birthweight is lower • For term infants weighing 2000-2499 g at birth, the risk of neonatal death is 4 times higher than for infants weighing 2500-2999 g, and 10 times higher than for infants weighing 3000-3499 g.
		Effectiveness of Vitamin A Supplementation in the Control of Young Child Morbidity and Mortality in Developing Countries	Beaton et al.	1993		Report/Literature review	<ul style="list-style-type: none"> • Provision of vitamin A can reduce overall child mortality by about 23%
		What works? Interventions for maternal and child undernutrition and survival	Bhutta et al.	2008		Global (review of nutrition interventions/model)	<ul style="list-style-type: none"> • Existing interventions that were designed to improve nutrition and prevent related disease could reduce disability-adjusted life-years associated with stunting, severe wasting, intrauterine growth restriction, and micronutrient deficiencies by about 25%
		An analysis of anemia and pregnancy-related maternal mortality	Brabin, Hakimi, and Pelletier	2001		Literature review	<ul style="list-style-type: none"> • The average estimates for all-cause anemia attributable mortality (both direct and indirect) were 6.37, 7.26 and 3.0% for Africa, Asia and Latin America, respectively. • Strong association between severe anemia and maternal mortality but not for mild or moderate anemia

Review of literature on benefits of ending hunger and malnutrition (April 14 2017)

Area of benefit	Title *included in multiple areas of benefit	Authors	Year	Time period	Scale of study	Findings
	Nutrition and immunity: lessons from the past and new insights into the future	Chandra	1991	NA	Global	<ul style="list-style-type: none"> • General protein energy malnutrition – as measured by child growth – and specific nutrient deficiencies diminish the body's ability to resist infection, leading to a higher incidence, longer duration, and greater severity of illness
	Global Burden of Disease data tool	Institute for Health Metrics and Evaluation	2017	2015	Global	<ul style="list-style-type: none"> • Global burden of all nutrition deficiencies in 2015 was 76 million DALYs or 3.09 percent and 406,000 deaths or 0.73 percent. • Global burden of protein-energy malnutrition in 2015 was 21 million DALYs or 0.86 percent and 323,000 deaths or 0.58 percent • Global burden of iodine deficiency in 2015 was 2.5 million DALYs or 0.10 percent, and 2,000 deaths or 0 percent • Global burden of vitamin A deficiency in 2015 was 232,000 DALYs or .01 percent • Global burden of iron-deficiency anemia in 2015 was 51 million DALYs or 2.07 percent, and 54,000 deaths or 0.1 percent
	Estimating the burden of disease attributable to childhood and maternal undernutrition in South Africa in 2000	Nannan et al.	2007	2000	South Africa, population level	<ul style="list-style-type: none"> • Among children under 5 years, 11 808 deaths or 12.3% were attributable to being underweight. • Protein-energy malnutrition contributed 44.7% and diarrhoeal disease 29.6% of the total attributable burden. • Childhood and maternal underweight accounted for 2.7% of all DALYs in South Africa in 2000 and 10.8% of DALYs in children under 5.
	Global, regional, and national prevalence of overweight and obesity in children and adults during 1980–2013: a systematic analysis for the Global Burden of Disease Study 2013	Ng et al.	2014	1980-2013	Global	<ul style="list-style-type: none"> • In 2010, overweight and obesity were estimated to cause 3.4 million deaths, 3.9% of years of life lost, and 3.8% of disability-adjusted life-years (DALYs) worldwide.
	The effects of malnutrition on child mortality in developing countries	Pelletier et al.	1995		53 developing countries	<ul style="list-style-type: none"> • 56% of child deaths in developing countries attributable to malnutrition, and 83% of these were attributable to mild-to-moderate as opposed to severe malnutrition
	Iron deficiency anemia and maternal mortality	Ross and Thomas	1996		Literature review	<ul style="list-style-type: none"> • Approximately 20% of maternal mortality in SSA and South Asia was attributable to anemia primarily from iron deficiency
	Maternal and child undernutrition: consequences for adult health and human capital*	Victora et al.	2008		Brazil, Guatemala, India, the Philippines, and South Africa	<ul style="list-style-type: none"> • Undernutrition was strongly associated with lower offspring birthweight • Lower birthweight and undernutrition in childhood were risk factors for high glucose concentrations, blood pressure, and harmful lipid profiles once adult body-mass index and height were adjusted for
Anthropometric Improvements	Preschool stunting, adolescent migration, catch-up growth, and adult height in young Senegalese men and women of rural origin	Coly et al.	2006	1983-2002	Senegal	<ul style="list-style-type: none"> • Adults who were stunted as children are shorter than adults who were not stunted as children. Height increment from early childhood to adulthood differed (69.3, 70.5, and 72.0 cm, P = 0.0001, and 78.9, 80.0, and 80.3 cm, P < 0.01, for nonstunted, mildly stunted, and markedly stunted girls and boys, respectively).
	Global dietary quality, undernutrition and non-communicable disease: a longitudinal modelling study	Green et al.	2016	1980-2009	Global, model	<ul style="list-style-type: none"> • After adjustment for measures of development, increased total dietary energy availability was significantly associated with reduced stunting rates (-0.84% per 100 kcal increase in energy) • Changes in availability of energy from food groups (particularly fruit, vegetables, starchy roots, meat, dairy and sugar) was important in explaining the associations with health outcomes
	Stunting Is Associated with Food Diversity while Wasting with Food Insecurity among Underfive Children in East and West Gojjam Zones of Amhara Region, Ethiopia	Montbainorm, Worku and Kumie	2015	2013	Ethiopia, 4,000 households	<ul style="list-style-type: none"> • Food insecurity was significantly associated with wasting • Food diversity and number of meals the child ate per day were the significant determinants of stunting and underweight
	Household food (in)security and nutritional status of urban poor children aged 6 to 23 months in Kenya	Mutisya et al.	2015	2006-2012	Kenya	<ul style="list-style-type: none"> • The risk of stunting increased by 12 % among children from food insecure households. • When the joint effect of food security and wealth status was assessed, the risk of stunting increased significantly by 19 and 22 % among children from moderately food insecure and severely food insecure households in the middle poor wealth status.
	Maternal and child undernutrition: consequences for adult health and human capital*	Victora et al.	2008		Brazil, Guatemala, India, the Philippines, and South Africa	<ul style="list-style-type: none"> • Undernutrition was strongly associated with shorter adult height
Improvements in treatment	The Enabling Effect of Food Assistance in Improving Adherence and/or Treatment Completion for Antiretroviral Therapy and Tuberculosis Treatment: A Literature Review	de Pee et al.	2014	NA	Global, literature review	<ul style="list-style-type: none"> • Food transfers improved adherence and completion among populations affected by food insecurity and poverty, particularly when transfers are conditional upon clinic or pharmacy visits
	Protein-calorie malnutrition, macronutrient supplements, and tuberculosis	Koethe and von Reyn	2016	NA	Global, literature review	<ul style="list-style-type: none"> • Macronutrient supplementation during treatment confirm a 2–3 kg improvement in weight gain at 2 months, and may result in improvement in physical function, sputum conversion and treatment completion.
	Mixed-Method Quasi-Experimental Study of Outcomes of a Large-Scale Multilevel Economic and Food Security Intervention on HIV Vulnerability in Rural Malawi	Weinhardt et al.	2017		Malawi (1,000 households)	<ul style="list-style-type: none"> • Large-scale multi-level economic and food security intervention led to increased HIV testing and HIV case finding in addition to decreased food insecurity, increased nutritional diversity, and improved economic resilience to shocks.
Facilitate cognitive development	A regional model (Northeastern Brazil) of induced mal-nutrition delays ontogeny of reflexes and locomotor activity in rats.	Barros et al.	2006		Brazil	<ul style="list-style-type: none"> • Child malnutrition damages the motor cortex leading to delays in the evolution of locomotor skills
	Iron and zinc supplementation promote motor development and exploratory behavior among Bangladeshi infants	Black et al.	2004		Rural Bangladesh, 221 infants	<ul style="list-style-type: none"> • Iron and zinc administered together and with other micronutrients had a beneficial effect on infant motor development. Iron and zinc administered individually and in combination had a beneficial effect on orientation-engagement.

Review of literature on benefits of ending hunger and malnutrition (April 14 2017)

Area of benefit	Title *included in multiple areas of benefit	Authors	Year	Time period	Scale of study	Findings	
Mental health	Long-term effects of early-life malnutrition and status epilepticus: assessment by spatial navigation and CREB (Serine-133) phosphorylation	Huang et al.	2003		Study on rats	• Child malnutrition damages processes associated with spatial navigation and memory formation	
	Double Burden of Iron Deficiency in Infancy and Low Socio-Economic Status: A Longitudinal Analysis of Cognitive Test Scores to 19 Years	Lozoff et al.	2006	1981-1984; follow up 20	Urban community in Costa Rica	• Middle socio-economic status (SES) group: participants with chronic iron deficiency scored 8-9 points lower than those with good iron status on cognitive tests through age 19 • Low SES group: participants with chronic iron deficiency scored 10 points lower than those with good iron status in early childhood by that gap widened to 25 points lower by age 19	
	Maternal multiple micronutrient supplements and child cognition: a randomized trial in Indonesia	Prado et al.	2012		Indonesia, 487 children	When given multiple micronutrient supplementation to undernourished and anemic mothers, children benefit from better visual attention/spatial ability	
	Early protein malnutrition changes learning and memory in spaced but not in condensed trials in the Morris watermaze.	Valadares and de Sousa Almeida	2005		Study on rats	• Child malnutrition damages processes associated with memory consolidation	
	Food Insecurity and American School-Aged Children's Cognitive, Academic, and Psychosocial Development	Alaimo, Olson, and Frongillo	2001		USA (6-11 year olds in nationally representative survey)	• Family-level food insufficiency is associated with negative academic and psychosocial outcomes	
	Family Food Insecurity, but Not Low Family Income, Is Positively Associated with Dysthymia and Suicide Symptoms in Adolescents	Alaimo, Olson, and Frongillo	2002		USA (15-16 year olds in nationally representative survey)	• Food-insufficient adolescents were significantly more likely to have had dysthymia, thoughts of death, a desire to die and have attempted suicide.	
	Malnutrition in the first year of life and personality at age 40	Galler et al.	2013		Barbados	• Previously malnourished participants had higher scores on Neuroticism and lower scores on Extraversion, Openness, Agreeableness, and Conscientiousness than did the healthy controls	
	Food Insecurity in Rural Tanzania Is Associated with Maternal Anxiety and Depression.	Hadley and Patil	2006		Tanzania	• Rates of high maternal anxiety and depression were found to correspond most closely with food insecurity rather than with other factors.	
	Food Insecurity and the Risks of Depression and Anxiety in Mothers and Behavior Problems in their Preschool-Aged Children	Whitaker, Phillips, and Orzol	2006	2001-2003	USA (A cross-sectional survey of 2870 mothers of 3-year-old children from 18 large cities)	• Mental health problems in mothers and children are more common when mothers are food insecure.	
	Social Benefits	Stability and reduced conflict	Food security policies for building resilience to conflict	Breisinger et al.	2014		Country-level in Egypt, Somalia, Sudan, Yemen
Food Insecurity and Violent Conflict: Causes, Consequences, and Addressing the Challenges			Brinkman and Hendrix	2011		Global	• Addressing food insecurity through food price stabilization measures and safety nets are critical instruments to prevent violent conflict. • Food assistance can contribute to peacebuilding, restore trust in governments and rebuild social capital.
Do poverty and poor health and nutrition increase the risk of armed conflict onset?			Pinstrup-Andersen and Shimokawa	2008	1980-2005	Global (146 countries)	• Improving food security through investments in public goods for agriculture and rural areas can be effective tools to achieve the multiple goals of reduced poverty and armed conflict, including riots in early 2008 triggered by high food prices.
Gender Equity		The way to a man's heart is through his stomach?: a mixed methods study on causal mechanisms through which cash and in-kind food transfers decreased intimate partner violence	Buller et al.	2016	2011	Household/Individual level, 7 urban centers in Carchi and Sucumbios provinces in Northern Ecuador	• Cash and in-kind food transfers led to reductions in intimate partner violence through three pathways: i) reduced day-to-day conflict and stress in the couple; ii) improved household well-being and happiness; iii) increased women's decision making, self-confidence and freedom of movement.
		Micronutrient deficiencies and gender: social and economic costs	Darnton-Hill et al.	2005	NA	Global; literature review?	• Improvements in nutrition are accompanied by better status for women. • A well-nourished population will be at lower risk of negative impacts from complex emergencies and crises, especially women and children who are overrepresented in experiencing these negative effects. • Women could benefit more from the benefits of ending hunger and undernutrition because the costs of these issues are likely greater for females.
		The Effect of Cash, Vouchers, and Food Transfers on Intimate Partner Violence: Evidence from a Randomized Experiment in Northern Ecuador	Hidrobo et al.	2016	2011	Household/Individual level, 7 urban centers with large Colombian refugee populations in Carchi and Sucumbios provinces in Northern Ecuador	• Cash, vouchers, and food transfers targeted to women and intended to reduce poverty and food insecurity reduce controlling behaviors and physical and/or sexual violence by 6 to 7 percentage points. • Impacts do not vary by transfer modality, which implies that cash is just as effective as in-kind transfers.
Reduced interpersonal violence		Cohort Profile: The Mauritius Child Health Project	Raine et al.	2010	1972-2010	Mauritius (1795 children)	• Children who suffered malnutrition before age three and were enrolled in a preschool nutrition, education and exercise program were 53% less likely to have conduct disorder at age 17 and 63% less likely to have been involved in crime at age 23.
	Childhood Reports of Food Neglect and Impulse Control Problems and Violence in Adulthood	Vaughn et al.	2016	2001-2005	USA (nationally representative sample of non-institutionalized residents aged 18 years and older)	• Reducing child hunger may help address impulse control problems and violence, as food insecurity and hunger during childhood are associated with greater impulsivity, worse self-control, and greater involvement in interpersonal violence as adults.	
Education Benefits	Improved education outcomes	Child health and School Enrollment: A Longitudinal Analysis	Alderman et al.	2001		Pakistan	• Malnutrition decreases probability of ever attending school, particularly for girls • Nutrition is three times as important for enrollment than suggested by "naive estimates" that assume that child health is predetermined rather than determined by household choices in the presence of unobserved factors such as preferences and health endowments.

Review of literature on benefits of ending hunger and malnutrition (April 14 2017)

Area of benefit	Title *included in multiple areas of benefit	Authors	Year	Time period	Scale of study	Findings
	The Impact of Experimental Nutritional Interventions on Education into Adulthood in Rural Guatemala: Preliminary Longitudinal Analysis	Behrman et al.	2003		Guatemala	<ul style="list-style-type: none"> • Nutritional supplement increases increasing the probability of attending school and of passing the first grade, increasing the grade attained by age 13 (through a combination of increasing the probability of ever enrolling, reducing the age of enrolling, increasing the grade completion rate per year in schooling, and reducing the dropout rate), increasing completed schooling attainment, increasing adult Raven's test scores and increasing adult cognitive achievement scores.
	Returns to Birthweight*	Behrman and Rosenzweig	2004		US	<ul style="list-style-type: none"> • Increasing birthweight increases adult schooling attainment and adult height for babies at most levels of birthweight, but has no effect on adult body mass. • The effect of increasing birthweight on schooling, moreover, is underestimated by 50% if there is no control for genetic and family background endowments as in cross-sectional estimates.
	Anemia and school participation	Bobonis, Miguel, and Puri-Sharma	2006		India RCT	Iron supplementation and deworming increased preschool participation by 5.8 percentage points
	Iodine deficiency and schooling attainment in Tanzania	Field, Robles, and Torero	2009		Tanzania	<ul style="list-style-type: none"> • Children treated for iodine deficiency with supplementation attain an estimated 0.35-0.56 years of additional schooling relative to siblings and older and younger peers. • Effect was larger for girls
	Early Childhood Nutrition and Academic Achievement: A Longitudinal Analysis	Glewwe, Jacoby, and King	2001		Philippines	<ul style="list-style-type: none"> • Nourished children both start school earlier and repeat fewer grades • Better nourished children perform significantly better in school, partly because they enter school earlier and thus have more time to learn but mostly because of greater learning productivity per year of schooling. • Cost-benefit analysis suggests that a dollar invested in an early childhood nutrition program in a developing country could potentially return at least three dollars worth of gains in academic achievement, and perhaps much more.
	The Impact of Improving Nutrition During Early Childhood on Education among Guatemalan Adults	Maluccio et al.	2009	1988-1989; 2002-2004	Guatemala	<ul style="list-style-type: none"> • Exposure to the nutritional intervention from birth to 36 months of age (but not later) led to future educational dividends including higher completed grades by women (1.2 grades), higher scores on reading comprehension tests for both women and men, and higher scores on non-verbal cognitive ability tests for both women and men.
	Combined Iron Deficiency and Low Aerobic Fitness Doubly Burden Academic Performance among Women Attending University	Scott et al.	2016		USA (105 women aged 18-22y)	<ul style="list-style-type: none"> • Grade point average was higher in women with normal ferritin compared to those with low ferritin. • Grade point average was higher in women with normal ferritin and higher fitness than in those with low ferritin and lower fitness, as well as low ferritin and higher fitness.
	Effects of iron supplementation and anthelmintic treatment on motor and language development of preschool children in Zanzibar: double blind, placebo controlled study Maternal and child undernutrition: consequences for adult health and human capital*	Stolzhus et al. Victora et al.	2001 2008		Zanzibar, 614 preschool children aged 6-59 months. Brazil, Guatemala, India, the Philippines, and South Africa	<ul style="list-style-type: none"> • Iron supplementation improved language development by 0.8 (95% confidence interval 0.2 to 1.4) points on the 20 point scale. • Undernutrition was strongly associated with less schooling

Prepared by Emily Cho, Christopher Rue, Sivan Yosef, and Laura Zselecsky