



INTERNATIONAL
FOOD POLICY
RESEARCH
INSTITUTE

IFPRI Discussion Paper 01298

October 2013

**Rethinking the Measurement of Undernutrition in a
Broader Health Context**

Should We Look at Possible Causes or Actual Effects?

Alexander J. Stein

Director General's Office

INTERNATIONAL FOOD POLICY RESEARCH INSTITUTE

The International Food Policy Research Institute (IFPRI), established in 1975, provides evidence-based policy solutions to sustainably end hunger and malnutrition and reduce poverty. The Institute conducts research, communicates results, optimizes partnerships, and builds capacity to ensure sustainable food production, promote healthy food systems, improve markets and trade, transform agriculture, build resilience, and strengthen institutions and governance. Gender is considered in all of the Institute's work. IFPRI collaborates with partners around the world, including development implementers, public institutions, the private sector, and farmers' organizations, to ensure that local, national, regional, and global food policies are based on evidence. IFPRI is a member of the CGIAR Consortium.

AUTHOR

Alexander J. Stein (a.stein@cgiar.org) is a research coordinator in the Director General's Office of the International Food Policy Research Institute, Washington, DC.

Notices

¹ IFPRI Discussion Papers contain preliminary material and research results. They have been peer reviewed, but have not been subject to a formal external review via IFPRI's Publications Review Committee. They are circulated in order to stimulate discussion and critical comment; any opinions expressed are those of the author(s) and do not necessarily reflect the policies or opinions of IFPRI.

² The boundaries and names shown and the designations used on the map(s) herein do not imply official endorsement or acceptance by the International Food Policy Research Institute (IFPRI) or its partners and contributors.

Copyright 2013 International Food Policy Research Institute. All rights reserved. Sections of this material may be reproduced for personal and not-for-profit use without the express written permission of but with acknowledgment to IFPRI. To reproduce the material contained herein for profit or commercial use requires express written permission. To obtain permission, contact the Communications Division at ifpri-copyright@cgiar.org.

Contents

Abstract	v
Acknowledgments	vi
Abbreviations and Acronyms	vii
1. Introduction: The Burden of Undernutrition Moves into the Spotlight	1
2. Using DALYs to Measure the Burden of Undernutrition	3
3. Comparing DALYs with Other Measures of Food Security	7
4. Translating DALYs into More Easily Understood Terms	10
5. Greater Progress on the Millennium Development Goals	13
6. Conclusions	16
Appendix: The Burden of Undernutrition by Country	17
References	23

Tables

2.1 The global burden of hunger: DALYs lost in 1990 and 2010	5
3.1 Ranking based on different relative measures of food security, selected countries	7
3.2 Correlation between different measures of food security	8
3.3 Characteristics of different measures of food security	8
A.1 The burden of undernutrition by country	17

Figures

1.1 Food and nutrition insecurity and the burden of hunger	2
2.1 The burden of undernutrition in absolute versus relative terms: DALYs lost	4
5.1 Trends in global hunger based on different measures, 1990–2010	13

ABSTRACT

Researchers and policymakers are paying increasing attention to the nexus of hunger, malnutrition, and public health, and to the related measurement of food and nutrition security. However, focusing on proxy indicators, such as food availability, and on selected head count figures, such as stunting rates, gives an incomplete picture. In contrast, global burden of disease (GBD) studies are outcome based, they follow an established methodology, and their results can be used to derive and monitor the burden of chronic and hidden hunger (undernutrition) at the global level. Judging by this measure, the international goal of halving global hunger between 1990 and 2015 has already been achieved—which is in stark contrast to the picture that emerges if the first Millennium Development Goal's indicator for measuring hunger is used.

In view of current discussions of the post-2015 development agenda, this discrepancy highlights the need to choose carefully the indicators that are used for operationalizing any new set of goals. Better access to existing data, a more detailed coverage of nutrition-related health outcomes, and more frequent updates of GBD studies would facilitate further analyses and the monitoring of global food and nutrition security.

While the disability-adjusted life years (DALYs) that are used as a health metric in GBD studies may be somewhat abstract, they can be converted tentatively into more easily understood monetary terms using per capita income figures. The resulting preferred estimate of the annual cost of global hunger in all its forms of 1.9 trillion international dollars may be better suited to illustrate the magnitude of remaining food and nutrition insecurity worldwide. Despite the progress that has been made so far in reducing global hunger, the problem is still huge and its eradication requires continued efforts.

Keywords: food security, undernutrition, hunger, measurement, disability-adjusted life years, DALYs, global burden of disease, Millennium Development Goals, MDGs, indicators

ACKNOWLEDGMENTS

The author wishes to thank Martin R. Broadley, John L. Fiedler, Rodrigo Martínez, H. P. S. Sachdev, Matin Qaim, the participants of an IFPRI Brown Bag Seminar, and three anonymous referees for their helpful comments on various earlier versions of the manuscript.

ABBREVIATIONS AND ACRONYMS

DALYs	disability-adjusted life years
FAO	Food and Agriculture Organization of the United Nations
GBD	global burden of disease
GFSI	Global Food Security Index
GHI	Global Hunger Index
Int\$	international dollar
IHME	Institute for Health Metrics and Evaluation
MDGs	Millennium Development Goals
UN	United Nations
US\$	United States dollar
WHO	World Health Organization

1. INTRODUCTION: THE BURDEN OF UNDERNUTRITION MOVES INTO THE SPOTLIGHT

The recent food price crises have provoked a strong, resurging interest in food and nutrition security and its quantification (Pinstrup-Andersen 2009; Barrett 2010; de Haen, Klasen, and Qaim 2011; FAO 2011; Verpoorten et al. 2013; Masset 2011; FAO 2013c; Pangaribowo, Gerber, and Torero 2013; Headey and Ecker 2013; COHA 2012; Coates 2013). In this context, and to raise awareness of the hunger problem, a host of new food and nutrition security indexes have been launched (Stein 2013a; GAIN 2013; te Lintelo et al. 2013; Muthayya et al. 2013). In addition, the Food and Agriculture Organization of the United Nations (FAO) revised the methodology and data it uses to estimate the number of undernourished people in the world, adding a new set of indicators that better capture the multiple dimensions of food and nutrition insecurity (FAO 2012b).

At the same time, increasing attention is being paid to nutrition and its connections to agriculture and health, whether at IFPRI's 2020 Conference "Leveraging Agriculture for Improving Nutrition and Health" in early 2011 (Pandya-Lorch et al. 2012), in *The Lancet's* latest Maternal and Child Nutrition Series (Horton and Lo 2013), or at the Nutrition for Growth meeting in the context of the G8 Summit in June 2013 (DFID 2013)—even while it is acknowledged that undernutrition is still an area of global neglect in public health (Lancet 2012).

Following the premise that undernutrition is bad because of the negative consequences it has for people's health and well-being, especially children's, as well as for their educational achievements and overall productivity, the burden of hunger can be linked to food and nutrition security as illustrated in Figure 1.1. Hunger—understood more comprehensively to include both undernourishment and micronutrient malnutrition¹—is a product of the various factors that determine food and nutrition security. Thus, defined in broader terms—whether as lack of dietary energy or as lack of vitamins and minerals—hunger results in adverse health consequences that represent the burden of disease of undernutrition.

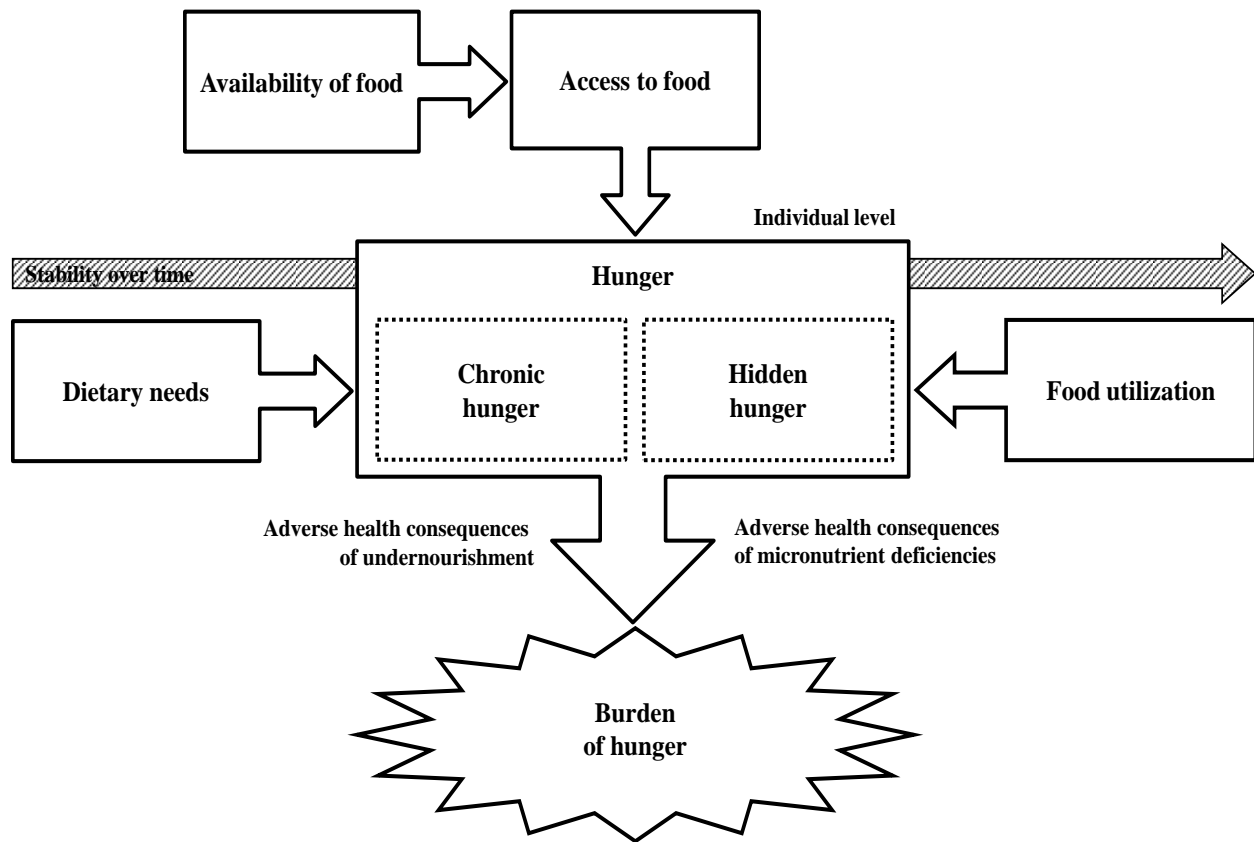
While there are numerous suggestions for quantifying hunger and measuring food and nutrition security, probably the single most important indicator is the FAO's estimate of the proportion of undernourished people worldwide, not least because it is also used to measure progress toward the first Millennium Development Goal (MDG) of the United Nations. What the FAO's indicator really measures, though, is mostly changes in food availability ("quantities available for consumption at the household level") (FAO 2012a: 5). That is, the indicator focuses on only one of the determinants of undernutrition, and it looks only at the household level, thus ignoring the intrahousehold distribution of food. Moreover, being a mere head count indicator, this measure fails to take into account the depth of undernutrition—that is, it does not indicate how big the gap is between assumed requirements and estimated intakes.

In contrast to such indicators that focus on possible causes on the input side of hunger, I argue that what matters for measuring undernutrition are its actual effects on the output side, namely the amount of ill health and related welfare losses that are caused by hunger in all its forms. Therefore, this paper aims to look through a public health lens and use data and methodologies from that field to measure undernutrition in terms of health outcomes, thus adding a different perspective to the quantification of food and nutrition insecurity, and to suggest a more comprehensive approach to measuring hunger and malnutrition² that—if accepted—can be enlarged and improved upon in the future.

¹ According to the FAO's basic definitions (FAO 2013b: online), *undernutrition* is "the result of prolonged low levels of food intake and/or low absorption of food consumed. Generally applied to energy (or protein and energy) deficiency, but it may also relate to vitamin and mineral deficiencies," whereas *undernourishment* or *chronic hunger* is limited to shortfalls of dietary energy, namely to "the status of persons whose food intake regularly provides less than their minimum energy requirements." Hence, undernutrition comprises chronic hunger but also micronutrient deficiencies, which are sometimes called *hidden hunger*.

² *Malnutrition* includes not only undernourishment and micronutrient malnutrition but also overnutrition (especially obesity). While overnutrition is not included in the current paper, which focuses on undernutrition, the proposed approach to measuring nutrition-related problems can easily be expanded to include, for example, obesity.

Figure 1.1 Food and nutrition insecurity and the burden of hunger



Source: Presentation by author.

Note: This figure shows how food insecurity affects hunger, and how hunger then contributes to the burden of disease by causing disabling health conditions. According to the World Food Summit Plan of Action, “food security exists when all people, at all times, have physical and economic access to sufficient, safe, and nutritious food to meet their dietary needs and food preferences for an active and healthy life” (FAO 1998: online). Based on this definition, usually four dimensions of food security are distinguished, (1) physical availability of food, (2) economic and physical access to food, (3) food utilization, and (4) stability of these three dimensions over time (EC-FAO Food Security Programme 2008). *Dietary needs*, which are driven by, for example, body growth, body mass, pregnancy, or level of physical activity, determine how much food is *sufficient*; actual food intake is determined by the *availability* of and *access* to food as well as by the amount of food wastage; and *food utilization* is influenced by such factors as dietary composition and diversity, food preparation, the level of antinutrients in the food, feeding practices, access to clean water, sanitation, parasite infestation, and ill health. Health conditions that are directly linked to hunger in all its forms are, for example, protein-energy malnutrition, iodine deficiency, vitamin A deficiency, and iron-deficiency anemia, which in turn are risk factors for other health outcomes and thus contribute to the burden of disease by compromising an *active and healthy life*.

2. USING DALYS TO MEASURE THE BURDEN OF UNDERNUTRITION

One challenge when trying to measure the health outcomes of undernutrition is the multitude of adverse health consequences that can be attributed to hunger in all its forms, in particular to micronutrient deficiencies: bouts of diarrhea, pneumonia, or measles in children that last days; night blindness in pregnant and lactating women that lasts months; stunting, mental retardation, or blindness in children that is irreversible and lasts their entire lives; and child mortality in the worst cases (Stein et al. 2005). Therefore the question is whether health can be measured in a consistent way across such diverse outcomes.

To do just that and to make the burden imposed by different health outcomes comparable, 20 years ago the World Bank introduced the concept of disability-adjusted life years (DALYs) (World Bank 1993)—and it continues to support it (World Bank 2013c). In this approach, different health states are weighed according to their respective severity before their durations are added up to obtain a burden of disease, which is expressed as an overall loss of what amounts to healthy life-year equivalents. Put differently, DALYs measure “person-years lost in a population owing to disability and shortened life” (Nature 2011: 132).

In its most general form, the DALYs formula can be represented as

$$\text{DALYs}_{\text{lost}} = \text{YLL} + \text{YLD}_{\text{weighted}}, \quad (1)$$

where YLL are “years of life lost” due to premature mortality and YLD are weighted “years lost due to disability,” which are summed up across all target groups and health outcomes of interest. (Obviously health outcomes of very short duration, such as diarrhea or measles, count as only fractions of a year, whereas permanently disabling conditions, such as blindness or stunting, are accounted for throughout the average remaining life expectancy at the age of onset of the condition.)

Since its introduction, the DALYs concept has been popularized by the World Health Organization (WHO 2013f) and the methodology has been expounded in a seminal book by Murray and Lopez (1996). Since then, DALYs have become a metric that is used widely for assessing the consequences of adverse health outcomes or to carry out cost-effectiveness analyses (Fox-Rushby 2002; Glassman and Chalkidou 2012).³ In particular, DALYs have been used to determine the burden of disease among the global poor (Gwatkin, Guillot, and Heuveline 1999) or to quantify the burden of disease of such diverse causes as environmental noise, civil war or poor water and sanitation infrastructures (WHO 2011; Collier and Hoeffler 2004; Rijsberman 2004). In addition, DALYs have been used to determine the burden of various forms of *hidden hunger* or to assess the potential impact and cost-effectiveness of related micronutrient interventions (Zimmermann and Qaim 2004; Sandler 2005; Stein, Sachdev, and Qaim 2006; Stein et al. 2007; Ma et al. 2008; Stein et al. 2008; Meenakshi et al. 2010).⁴

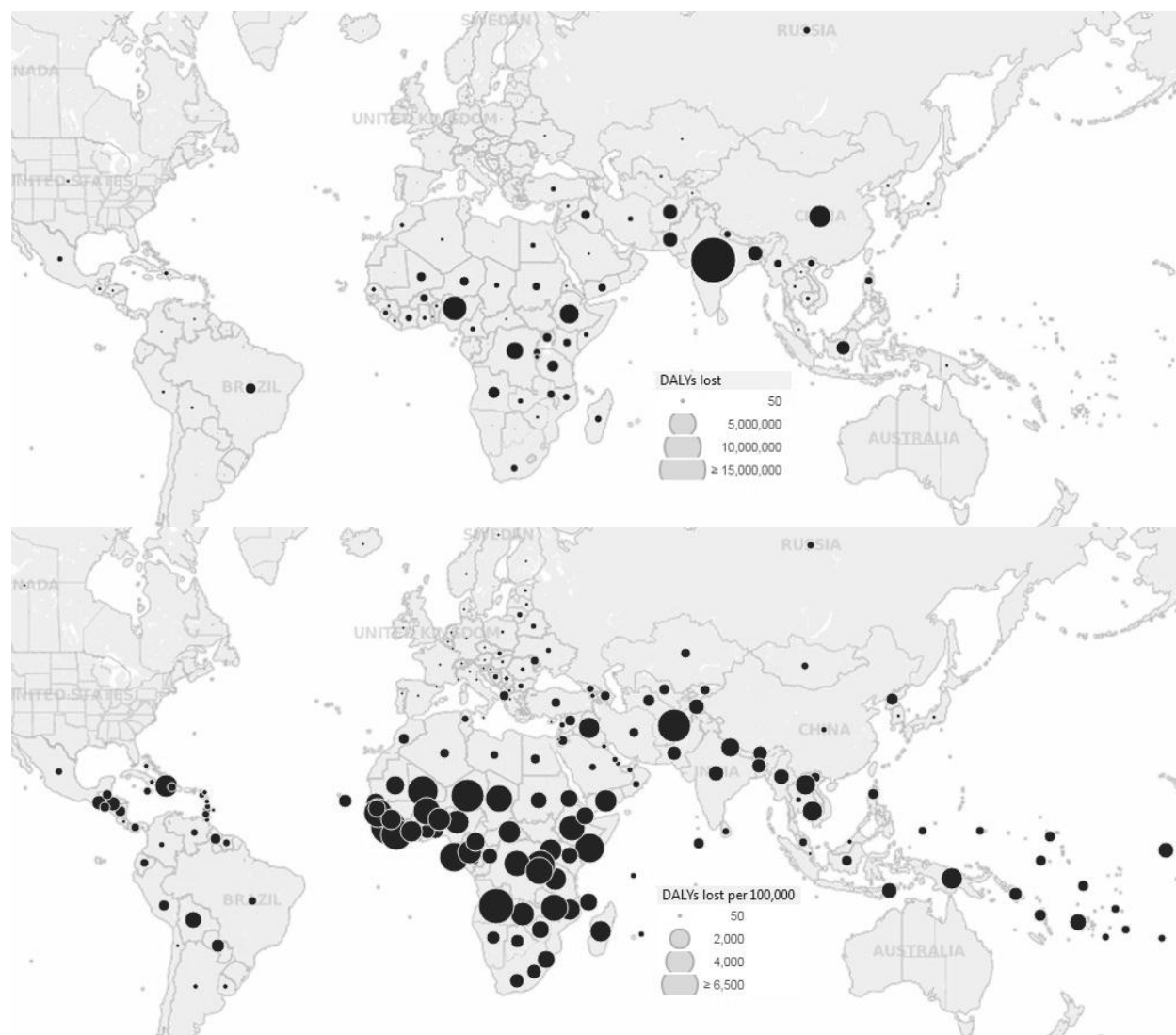
The WHO uses DALYs to quantify the global burden of disease (GBD), for which it reports results at the country level and for a range of health outcomes (WHO 2013c). Based on these readily available data, DALYs can be used to quantify the burden that undernutrition imposes on societies around the world. This is what this paper does, following the literature to attribute health outcomes to

³ A search on Google Scholar for the phrase “disability-adjusted life years” gives more than 17,000 hits—as many as a search for the phrase “computable general equilibrium” (to use a random benchmark).

⁴ Given this fairly widespread and long-standing use of DALYs (at least outside the field of agriculture), in this paper a more detailed description of the methodology is forgone and the reader is referred to the literature; DALYs themselves are not novel. The contribution of this paper is to draw attention to the possible use of DALYs to measure food and nutrition security, to generate specific estimates of the burden of undernutrition based on readily available data, to discuss related implications and trends, and to encourage further research and improvement of DALYs and the underlying data for these purposes.

undernutrition (Stein et al. 2005; Stein, Qaim, and Nestel 2009).⁵ The health outcomes that are covered in the WHO’s GBD study and that relate directly to undernutrition are protein-energy malnutrition, iodine deficiency, vitamin A deficiency, and iron-deficiency anemia. Furthermore, 18 percent of diarrheal diseases and 41 percent of lower respiratory infections can be attributed to zinc deficiency, and 5 percent of maternal mortality can be attributed to iron-deficiency anemia.

Figure 2.1 The burden of undernutrition in absolute versus relative terms: DALYs lost



Source: Map generated with Tableau Public (see www.tableausoftware.com/products/) and data from Table A.1 in the appendix.
 Note: DALYs = disability-adjusted life years. The upper panel shows estimates of the burden of undernutrition in absolute terms (DALYs lost in 2011), while the lower panel shows the burden of undernutrition in relative terms (DALYs lost per 100,000 population in 2004); given that the biggest loss of DALYs occurs in children, reporting this loss relative to the overall population might overestimate the relative burden in countries with a big, young population.

⁵ Using existing data is efficient and both time and cost saving, but on the downside, the scope of the data and any underlying assumptions are a given—missing health outcomes or the variation of assumptions for sensitivity analyses cannot be added. As argued at the end of this paper, if DALYs as such are deemed to be a more useful measure of food and nutrition security than those currently in use, efforts can be made in the future to include more detailed nutrition-related information in DALYs calculations to further improve their usefulness as a food security metric. Here the DALYs estimates from secondary sources are taken at face value.

Aggregating the DALYs lost due to these various health outcomes (and using 2011 population figures to generate DALYs estimates for 2011 from the WHO’s data for 2004) yields results for the burden of hunger in all its forms in terms of DALYs lost in 2011 at the global and country level (Table A.1 in the appendix and Table S.1 in Stein (2013b)). Globally, 44 million DALYs are lost due to micronutrient malnutrition (hidden hunger) and 21 million DALYs are lost due to undernourishment (chronic hunger). While the same individual can be both undernourished and suffering from one or another micronutrient deficiency, in the calculation of DALYs the various health outcomes are clearly differentiated by cause; that is, DALYs lost are summable (which is one of their conceptual strengths). Therefore, added together, the global burden of hunger in all its forms amounts to 65 million DALYs lost—about 4 percent of the total burden of disease.

For comparisons of the burden of hunger across countries, the loss of DALYs due to undernutrition can be visualized using absolute or relative figures. Given India’s huge population and relative poverty, the biggest absolute burden of hunger can be found in that country (Figure 2.1, upper panel). However, if the loss of DALYs is expressed in per capita terms, it is mostly countries in Africa south of the Sahara that fare poorly (Figure 2.1, lower panel). Similarly, looking at the results at the country level also shows how the importance of undernutrition relative to other health issues varies across countries. For instance, while DALYs lost due to hunger in all its forms represent less than 0.4 percent of the overall burden of disease in New Zealand and the United States, they contribute 8 percent to the burden of disease in Angola, Mali, and Sierra Leone (see Table S.1 in Stein (2013b)).

Newer Data and a Changed Methodology Indicate a Bigger Burden of Undernutrition

The results reported so far represent lower-bound estimates because of the scope and level of disaggregation of health outcomes of the WHO’s last GBD study, which limits the possibility of attributing DALYs lost due to the various forms of undernutrition. In this regard, a more recent GBD study—carried out by the Institute for Health Metrics and Evaluation (IHME) with core funding from the Bill & Melinda Gates Foundation—represents an improvement since it covers more health outcomes and risks. On the other hand, it also introduces some methodological changes, such as dispensing with discounting of future losses of DALYs (in the case of premature mortality or chronic or multiannual diseases) or the derivation of disability weights from judgments of the general public instead of healthcare professionals (Murray et al. 2012), which makes the WHO and IHME results incomparable.

Table 2.1 The global burden of hunger: DALYs lost in 1990 and 2010

Direct health losses and health risks of undernutrition	DALYs lost in 1990	DALYs lost in 2010
Protein-energy malnutrition in the general population	60,542,747	34,874,497
Additional health risks of childhood underweight	149,439,178	52,212,001
Iodine deficiency	3,273,055	4,026,746
Vitamin A deficiency	739,793	806,402
Other health risks of VAD	30,251,210	10,740,818
Iron-deficiency anemia	46,792,302	45,338,235
Other health risks of iron deficiency	5,048,479	2,886,620
Health risks of zinc deficiency	24,374,698	9,135,886
Burden of undernutrition	320,461,462	160,021,205

Source: Underlying DALYs estimates taken from IHME 2012; for more details please see Table S.2 in Stein (2013b).

Notes: DALYs = disability-adjusted life years; VAD = vitamin A deficiency.

Unfortunately, the full data of this study—disaggregated by country—are not publicly available (Veitch 2012; Mathers 2013). The aggregate data from this more recent and more comprehensive effort to quantify the GBD permit computing the global burden of hunger, though (Table 2.1). Given the comprehensiveness and greater attributability of DALYs lost to undernutrition that these data allow—and also given the fact that unlike in the WHO study future DALYs are not discounted—according to the IHME study, more than 160 million DALYs are lost per year due to hunger in its various forms, which is more than 6 percent of the total burden of disease.

3. COMPARING DALYS WITH OTHER MEASURES OF FOOD SECURITY

If countries are ranked according to their relative burden of undernutrition, and if this ranking is compared with the rankings from other measures of food and nutrition security, it becomes obvious that there are substantial differences (Table 3.1); a similar result can be seen from the correlation matrix that compares these same indicators (Table 3.2). These differences merit closer analysis in future research, but one likely reason for the discrepancies could be that these different measures simply measure different things—as a comparison of main characteristics of each measure shows (Table 3.3).⁶

Table 3.1 Ranking based on different relative measures of food security, selected countries

	DALYs ^a	Stunting ^b	FAO ^c	GHI ^d	GFSI ^e	Income ^f
Angola	2	54	29	10	19	79
Niger	3	5	60	17	15	7
Malawi	11	10	37	32	8	10
Burkina Faso	12	35	31	32	18	23
Nigeria	17	24	76	37	26	43
Tanzania	23	21	9	25	7	28
Uganda	24	33	12	37	35	24
Benin	25	17	80	42	24	29
Sudan	45	35	7	17	10	36
Tajikistan	50	30	19	37	22	44
India	54	7	47	13	40	61
Guatemala	56	7	23	46	46	74
Botswana	63	48	27	43	59	127
Paraguay	64	83	32	73	57	80
Ecuador	98	n/a	44	62	48	95
Sri Lanka	108	86	36	43	44	83

Source: Table S.3 in Stein (2013b).

Notes: Rankings are from poorest outcomes to best results. Data are generally from the last year available, ranging from 2000 to 2012, with all indicators drawing on data from different years.

^a DALYs = disability-adjusted life years. Here “DALYs” are DALYs lost due to hunger in all its forms per 100,000 population as calculated from WHO data. DALYs data cover 192 countries.

^b Stunting = prevalence of stunting in children under five. Stunting data cover 118 countries.

^c FAO = Food and Agriculture Organization of the United Nations. Here “FAO” is the prevalence of undernourishment as calculated by the FAO. FAO data cover 185 countries.

^d GHI = Global Hunger Index. Here “GHI” is the GHI score. GHI data cover 120 countries.

^e GFSI = Global Food Security Index. Here “GFSI” is the GFSI score. GFSI data cover 105 countries.

^f Income = gross national income per capita at purchasing power parity. Income data cover 192 countries.

⁶ Given these discrepancies, it is the more important to select an indicator that measures what it is expected to do, as for instance the discussion about the severity of malnutrition in India shows: “Mortality data measure mortality and anthropometric data measure child growth. India may be significantly better than many Sub-Saharan African countries at keeping children alive, but survival does not automatically equate with adequate nutrition and growth. Even though mortality trends in the long term may be similar to trends in nutrition, they are absolutely not on parallel tracks—there are many possible reasons why nutritional status [...] does not mimic trends in mortality” (Gillespie 2013: 65). DALYs measure the share of mortality and morbidity that relates to undernutrition and therefore make the burden of undernutrition comparable, also across countries where overall mortality and anthropometric data are fundamentally different.

Table 3.2 Correlation between different measures of food security

	DALYs ^a	Stunting ^b	FAO ^c	GHI ^d	GFSI ^e	Income ^f
DALYs	1.00					
Stunting	0.69	1.00				
FAO	0.58	0.67	1.00			
GHI	0.75	0.83	0.83	1.00		
GFSI	-0.74	-0.79	-0.69	-0.82	1.00	
Income	-0.51	-0.55	-0.50	-0.61	0.89	1.00

Source: Table S.3 in Stein (2013b).

Notes: ^a DALYs = disability-adjusted life years. Here “DALYs” are DALYs lost due to hunger in all its forms per 100,000 population as calculated from WHO data.

^b Stunting = prevalence of stunting in children under five.

^c FAO = Food and Agriculture Organization of the United Nations. Here “FAO” is the prevalence of undernourishment as calculated by the FAO.

^d GHI = Global Hunger Index. Here “GHI” is the GHI score.

^e GFSI = Global Food Security Index. Here “GFSI” is the GFSI score.

^f Income = gross national income per capita at purchasing power parity.

Table 3.3 Characteristics of different measures of food security

	DALYs	Stunting	FAO	GHI	GFSI
Captures outcomes of undernutrition	Several (and expandable)	One (stunting)	No	Two (mortality, underweight)	No
Captures determinants of undernutrition	No	No	One (food availability)	One (food availability)	Several
Highest level of measurement	Individual	Individual	Household	Household	Country
Measures depth of problem	Yes (disability weights, varying outcomes)	No (threshold)	No (threshold)	Partially (index)	Partially (index)
Tangible units of measurement	Yes (years)	Yes (population)	Yes (population)	No (index score)	No (index score)
Summable and comparable units	Yes (many uses of DALYs)	No	No	No	No
Data availability	192/187 countries	118 countries	185 countries	120 countries	105 countries
Updating of data	Planned annually	Annually	Annually	Annually	Annually
Timeliness of raw data	Last available before 2004 or 2010	2007–2011	2010–2012	2005–2010	2000–2012

Source: Presentation by author.

Notes: ^a DALYs = disability-adjusted life years. Here “DALYs” are DALYs lost due to hunger in all its forms per 100,000 population—information is split to reflect the two global burden of disease studies from which DALYs estimates are available (older but country-disaggregated data from WHO and recent but only aggregated data from IHME).

^b Stunting = prevalence of stunting in children under five.

^c FAO = Food and Agriculture Organization of the United Nations. Here “FAO” is the prevalence of undernourishment as calculated by the FAO.

^d GHI = Global Hunger Index. Here “GHI” is the GHI score.

^e GFSI = Global Food Security Index. Here “GFSI” is the GFSI score.

For instance, while DALYs can capture the entire burden that is caused by adverse health consequences of hunger in all its forms, stunting is but one health outcome of undernutrition (which does not capture the consequences of such factors as iron deficiency, vitamin A deficiency, or iodine deficiency), while on the other hand undernutrition is but one determinant of stunting—next to the overall disease environment, sanitary conditions, or mother’s education (Hatton 2013; Spears, Ghosh, and Cumming 2013; Emamian et al. 2013). Nevertheless, stunting is often used or suggested as a superior measure of undernutrition (Headey 2012; Misselhorn et al. 2012; Pangaribowo, Gerber, and Torero 2013; Gómez et al. 2013; Haddad 2013), not least because as an anthropometric measure it is an actual outcome of food insecurity and it captures long-term and cumulative effects of poor nutrition (beyond insufficient caloric intakes).

The WHO data that I used to generate the DALYs estimates of the burden of undernutrition include data on numerous health outcomes of undernutrition, as described above, but the data do not contain information on stunting. While this may be a shortcoming of this particular dataset, nothing prevents the inclusion of stunting—or of any other health outcome—in future DALYs calculations. In fact, stunting had been included in a calculation of the burden of zinc deficiency in India, and the overall loss of DALYs due to stunting was negligible—it is an irreversible condition (that is, DALYs lost accumulate over many years), but the loss of functioning due to stunting—reflected in its disability weight—is very small (Stein et al. 2007).

Regarding the other measures, the FAO’s estimate of the prevalence of undernourishment focuses on one cause of food insecurity by looking at food availability at the household level, which by and large ignores individual accessibility and changes in the requirements for and utilization of the food consumed; that is, its comparability with the DALYs measure is limited—if the DALYs measure produces a different ranking than the food availability measure, this may simply reflect the influence the other determinants of food security have on actual health outcomes of undernutrition (Figure 1.1). Possible avenues for these other causes to affect ultimate health outcomes will be discussed below.

The Global Hunger Index (GHI) combines two selected adverse health consequences (or effects) of hunger, namely child mortality and underweight, with the FAO’s prevalence of undernourishment (a cause of hunger) in one index (von Grebmer et al. 2012). This may be an improvement over any single indicator, but it falls short of the more comprehensive measurement of the overall health outcome of all forms of hunger that DALYs offer, and the blending of causes and effects in one index also raises conceptual questions. The Global Food Security Index (GFSI) focuses more on determinants that may influence food security at the national level (EIU 2012); that is, it also measures something very different from the outcomes of undernutrition—although a legitimate question is to what extent a food security index should be able to predict the actual effects of food insecurity. Finally, average per capita income is not an indicator for food security and is included only for information.

4. TRANSLATING DALYS INTO MORE EASILY UNDERSTOOD TERMS

While in this paper I argue that using DALYs to measure *hunger* is a better approach than using proxy indicators that either reflect the input side of hunger or focus only on selected health outcomes, one challenge for the use of DALYs is their abstractness: what exactly is a “disability-adjusted life year”? The definition that DALYs measure “person-years lost in a population owing to disability and shortened life” sums it up nicely, but reporting a number of hungry people is arguably more intuitive. Therefore, if such an intuitive figure does not fully capture the bigger picture, and if the extent of hunger is better measured in DALYs, how can the size of the problem be conveyed in more easily understood terms?

One way to address this issue is to convert DALYs into something more tangible—for instance into lives lost (instead of life years lost). According to the WHO, currently the average life expectancy at birth in low-income countries and in lower-middle-income countries (where the burden of hunger is greatest) is 60 and 66 years, respectively (WHO 2013d); that is, each life has a theoretical maximum of 66 years in it. If these 66 years are spent in good health, they correspond to 66 DALYs. Discounting these 66 years—in line with the discounting of future DALYs at a rate of 3 percent (WHO 2013a)—means that the present value of each of these lives corresponds to 28.6 life years. Accordingly, dividing the overall number of DALYs lost to hunger by 28.6 translates into a loss that is the equivalent of 2.27 million newborn lives. Doing the same for the DALYs lost due to undernutrition that are derived from the IHME study (but without discounting because in this study future DALYs are not discounted, either), translates into the equivalent of 2.43 million newborn lives lost. This also shows that—compared to the older WHO study—the change in methodology for the IHME study (no discounting of future DALYs) has a bigger impact on the final burden than the use of more recent and more comprehensive data. In communications with a more general audience, one could therefore say that the current burden of hunger is comparable to an annual loss of about 2.3 million to 2.4 million lives.

Turning DALYs into Dollars

Another way of illustrating the magnitude of the burden of hunger is to express it in money, one of the most universal units of account. And while there are obvious problems with the monetization of social costs as, ultimately, it relies on subjective valuation, it offers a coherent framework that permits conducting the kind of broad analyses and comparisons that are needed to guide policy (Jackson, McBride, and Abdallah 2007). Indeed, not only is money used to capture the value of intangibles such as nature and ecosystems (Daily 2000; IUCN, Nature Conservancy, and World Bank 2005), but in health economics it is also common practice to convert DALYs lost—or life years gained—into monetary terms to approximate their economic cost to society or to determine the cost-effectiveness of health interventions (Hirth et al. 2000; Goldie et al. 2006; Stein and Qaim 2007; Cressey 2009; Bobinac 2012; Brent 2011; Traill 2012).

Clearly, estimating the cost of hunger is not the main purpose of DALYs, but it is a way of translating the more abstract DALYs lost into units and magnitudes that are more accessible to policymakers and the general public—and the underlying rationale is that if a year of (productive) life is lost in a society, this comes at a cost. There are different ways for valuing DALYs (or related “quality-adjusted life years”), which rely on approaches such as human capital, willingness to pay, or value of a statistical life. Such estimates of the monetary value of one DALY usually equal at least the average national income per capita in the study country and often amount to a multiple thereof (Hirth et al. 2000; Eichler et al. 2004; Braithwaite et al. 2008; Towse 2009; Lee et al. 2013). In line with these studies, the WHO’s Commission on Macroeconomics and Health has also suggested that “each DALY would be valued at a multiple of annual income, perhaps three times current income” (2001, 103), arguing that the actual benefits of saving healthy life years would be much larger than the corresponding income because the benefits of improved health are expected to help spur economic growth (Commission on Macroeconomics and Health 2001).

This approach has subsequently been used widely in the literature, either to value DALYs as such or to establish a threshold for economic evaluations of health interventions (Murray et al. 2003; Chisholm 2003; Baltussen, Sylla, and Mariotti 2004; Yosefy et al. 2007; Stein and Qaim 2007; Brown 2008; Shim and Galvani 2009; John and Ross 2010; Ha and Chisholm 2011; Salomon et al. 2012; Demont and Stein 2013a). Here I follow this approach by multiplying DALYs lost due to hunger in each country by triple the gross national income per capita at purchasing power parity—that is, values are expressed in international dollars (Int\$).⁷ (For more details, see Table S.1 in Stein (2013b).) The result indicates the economic potential of a society in the absence of hunger.

The Global Cost of Hunger in All Its Forms

If approximated this way—that is, multiplying national per capita income by the DALYs lost due to undernutrition as derived from the WHO’s GBD data—the global cost of hunger amounts to Int\$0.8 trillion in 2011—or about 1 percent of total world income. This amount roughly equals the national income of rich Australia or populous Iran, and it is more than the combined income of the poorest 50 countries covered by the GBD.

To get a feeling for how the WHO data compare with the more recent and detailed IHME data, which are available only at a more aggregated level, I used the weighting of the burden of undernutrition of the WHO data to derive country estimates for the IHME data. Using this approach produces an estimate for the global cost of hunger of Int\$1.9 trillion per year, or 2.4 percent of world income. However, while the IHME produces a more comprehensive estimate of the GBD, the ad hoc disaggregation of its results may be less than robust, and therefore the figure of Int\$1.9 trillion needs to be corroborated if and when country-level data become available.

One indication that the global cost of hunger falls indeed into the trillion-dollar range is the estimate for the worldwide cost of undernutrition of US\$1.4 trillion to US\$2.1 trillion that the FAO gives in its latest report on the State of Food and Agriculture (FAO 2013d). The FAO arrived at its estimate by applying an earlier World Bank estimate for the loss in economic productivity due to undernutrition of 2–3 percent of gross domestic product in individual countries, and by building its estimate from the bottom up. The World Bank estimate, in turn, draws on different studies by different authors that, individually and for different countries, report estimates of monetary losses due to different aspects of undernutrition (World Bank 2006).

While it is interesting to note that two very different approaches yield similar results, it may also lend credence to the notion that the global cost of hunger is indeed about Int\$1 trillion to Int\$2 trillion—that is, somewhere in the range of the national income of Turkey, Indonesia, Spain, Canada, South Korea, Mexico, or Italy. This result also shows that eradicating hunger remains an important challenge for the international community.

Should Hunger Be Measured in Monetary Terms in the First Place?

So far in this paper I have argued that looking at the outcomes of undernutrition (measured in DALYs lost) could be a better way of measuring hunger in all its forms than looking at selected determinants or individual outcomes of undernutrition. In an effort to translate abstract DALYs into more commonly understood units, I have followed the literature to produce a monetary estimate of the global cost of hunger. However, monetary quantification of the “cost” of hunger is obviously influenced by a country’s economic performance and its social system, whether it is measured by aggregating cost estimates that are based on productivity losses, as is done for the FAO’s estimate, or whether by using national per capita

⁷ The UN, World Bank, and WHO, among others, use international dollars to allow more meaningful comparisons across countries whose currencies have different purchasing power than what is reflected in their currency exchange rates (UN 2012b; WHO 2013e; World Bank 2013a). As the World Bank defines it, “an international dollar would buy in the cited country a comparable amount of goods and services [that] a US dollar would buy in the United States” (2013a: online).

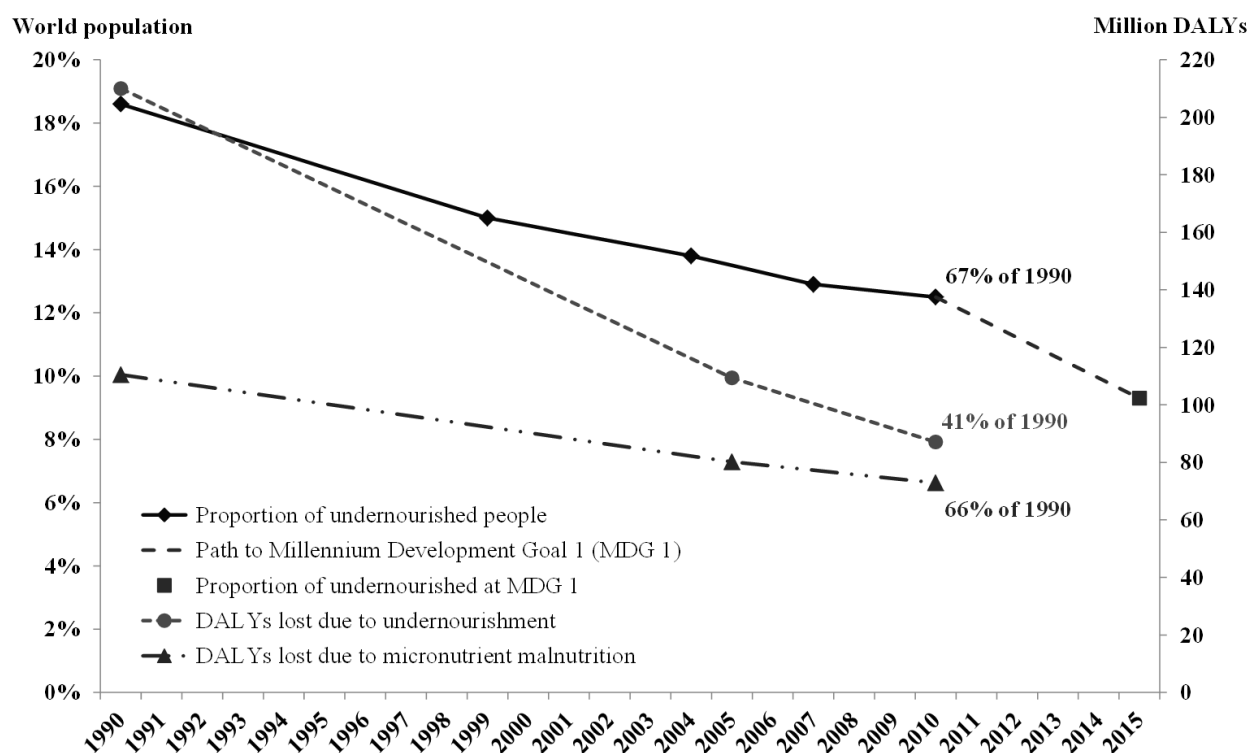
income to value DALYs—*ceteris paribus*, the monetary cost of hunger in richer and more economically productive countries is higher than in poorer countries.

This discussion shows another strength of using DALYs for measuring hunger: if normalized average life expectancies are used, a DALY lost is the same in each country. That is, quantifying the burden of hunger this way avoids many of the ethical pitfalls that come with monetary valuation. Reporting a global cost of hunger has its merits when the intention is to use it for communication or advocacy reasons, in particular to convey an approximate idea of the magnitudes involved to a nontechnical audience. However—at least when the goal is to reduce global hunger *per se*—policymaking on food and nutrition security should be guided by the impact that decisions have on related health outcomes (in the form of DALYs saved) and not by their impact on the approximated cost of undernutrition in different countries.

5. GREATER PROGRESS ON THE MILLENNIUM DEVELOPMENT GOALS

One good example for how DALYs—rather than dollars—can be used for policy purposes is the monitoring of hunger over time. While the IHME data are not publicly available at the same disaggregated level as the WHO data, the IHME study contains information that the WHO data lack: consistent global DALYs estimates over time (for 1990, 2005, and 2010), thus making it possible to assess the development of the global burden of hunger—in all its forms—over the last two decades. Incidentally, 1990, the first year for which the IHME reports a GBD estimate, is also the base year against which progress on the MDGs is measured. The first of these goals (MDG 1) includes the explicit target to “halve, between 1990 and 2015, the proportion of people who suffer from hunger.” A key indicator for monitoring this target is the proportion of the population whose dietary energy consumption remains below a minimum—which corresponds to the already discussed estimate of the proportion of undernourished people worldwide (FAO 2012b).

Figure 5.1 Trends in global hunger based on different measures, 1990–2010



Source: Author’s calculations based on FAO 2012b, UN 2013, and IHME 2012.

Notes: DALYs = disability-adjusted life years.

As the graph shows, if measured by the proportion of undernourished (hungry) people, global hunger declines very slowly—too slowly for MDG 1 to be achieved by 2015. (Target 1.C of MDG 1 is to “halve, between 1990 and 2015, the proportion of people who suffer from hunger,” and this is to be monitored using, inter alia, the “proportion of population below minimum level of dietary energy consumption” as indicator [UN 2008: online]). Since in 1990 the proportion of hungry people worldwide was 18.6 percent, or a total of 1 billion (FAO 2012b), in 2015 it has to be below 9.3 percent for MDG 1 to be achieved. Given the UN’s medium variant population projection for 2015 of 7.3 billion people (UN 2013), this corresponds to a maximum of 680 million undernourished individuals. Yet in 2010, the proportion of hungry people was still 12.5 percent; that is, it had fallen by only one-third. In contrast, if global hunger is assessed based on hunger-related adverse health outcomes, the burden of undernutrition has been halved already, having fallen from a total of 320 million DALYs lost in 1990 to 160 million DALYs lost in 2010.

Assuming that the underlying objective of MDG 1 is to reduce the burden of hunger and to increase food security (and not the mere availability of food at the household level), it is interesting to compare the estimate of the number of hungry people with that of the number of DALYs lost due to hunger over time (Figure 5.1). Judging by the FAO's indicator, the achievement of MDG 1 is not very likely. However, if the objective were indeed more generally to “reduce hunger by half” (UN 2012a), MDG 1 has already been achieved—if not by the letter, at least in spirit: as Table 1 shows, in 1990 the burden of hunger was 320 million DALYs lost, but by 2010 this burden had already shrunk to 160 million DALYs lost.⁸

Moreover, MDG 1 is a relative target, referring to the *proportion* of people who suffer from hunger; hence, in the presence of population growth, it is easier to achieve than reduction of an *absolute* figure, such as the number of DALYs lost, which (*ceteris paribus*) increases with a growing population. Therefore this halving of the burden of hunger is more comparable to another absolute target, the 1996 Rome World Food Summit target, in which world leaders committed to cutting by half the *number* of undernourished people in the world by no later than 2015 (FAO 2013b).

Perhaps more importantly, the FAO's indicator and MDG 1 focus only on undernourishment, that is, the most obvious form of hunger. Therefore in Figure 5.1 the number of DALYs lost due to undernourishment and the number of DALYs lost due to hidden hunger are shown separately to make the measures more comparable. This disaggregation of the DALYs shows that progress on undernourishment has been faster than on micronutrient malnutrition and that the burden of hunger by this more narrow definition has been halved already, well before 2010. On the other hand, the disaggregation of DALYs also indicates that soon micronutrient malnutrition may overtake undernourishment as biggest hunger-related problem and that, therefore, *hidden hunger* may merit more attention.

Food Consumption Is but One Determinant of Hunger

The discrepancy in the assessment of the development of global hunger if based on food availability versus actual health outcomes might be surprising, but as illustrated in Figure 1.1 and discussed above, food availability is but one determinant or cause of (or input into) hunger, whereas DALYs measure the outcome of hunger that results from all inputs combined. In this case—in the presence of other, uncorrelated inputs into hunger that change over time—an indicator that monitors only one input is bound to show a different development than an indicator that measures the final outcome.

For instance, if occupational or domestic physical activity levels go down, so do people's energy expenditure and dietary needs (Lanningham-Foster, Nysse, and Levine 2003; Monda et al. 2008; Ng and Popkin 2012; Qin, Stolk, and Corpeleijn 2012; Maxwell 1996). Similarly, if households waste less food, this is not captured in the FAO indicator because consumption is calculated from the quantities of food that are available at the household level—inclusive of possible food waste (FAO 2012a). And food eaten away from home can also distort the picture if hunger is measured on the input side (Smith 2013). Finally, different factors influence how much of the nutrients in the food people eat the human body can absorb (Hambidge 2010; Dangour et al. 2013; Anekwe and Kumar 2012).

If these other parameters change over time, hunger can decline even if food consumption levels remain largely unchanged. This discussion also shows the importance of thinking outside the box—or the silo: hunger can be addressed by producing more food or by distributing it better, but hunger can also be reduced by reducing people's dietary needs or by making sure that the food people already have access to is properly utilized, for example through improving sanitation or healthcare.

⁸ This steeper reduction of the burden of hunger is also more in line with the finding that absolute poverty has declined substantially over recent decades (Dhongde and Minoiu 2013; Olinto and Uematsu 2013; Chen and Ravallion 2012).

What Are the Drivers of Hunger Reduction?

Given the multiple factors that affect hunger, one could hypothesize that—in the aggregate and gradually over the last 25 years—increasing mechanization in many sectors, greater availability of motorized transportation, and the spread of information and communication technologies have reduced people’s dietary energy needs. Similarly, better storage and pest control, longer shelf life of crops, improved food preservation techniques, and expanding food retail chains could have reduced the amount of food that is wasted at the household level. And nutrition education, more informed infant feeding practices, dietary changes, improved access to clean water, better sanitation and hygiene, lower incidence of parasite infestation, higher vaccination rates, and better health statuses could have increased people’s utilization of the food they consume—a determinant of food security that is neglected in current studies (Bashir and Schilizzi 2013).

Thus the sum of many small improvements in many different fields could have contributed to a greater progress in the fight against hunger than what analyses that focus mainly on food accessibility indicate. If and when new country-level data become available, for example from the IHME project, both quantitative and qualitative analyses will have to be done across countries to go beyond speculation and to determine the drivers of the downward trend in global hunger (as measured by DALYs).

6. CONCLUSIONS

Not least in light of this year's discussion of the post-2015 development agenda and the design of sustainable development goals (UN Economic and Social Council 2013; World Bank et al. 2013)—or even the setting of a hunger eradication goal (FAO 2013a)—it is important that agreed-upon targets can be operationalized based on indicators that allow precise monitoring of progress toward such goals. Stakeholders in food and nutrition security need to be aware of the advantages of outcome-based measures like DALYs versus indicators that are linked to selected determinants or individual outcomes of hunger, even if DALYs are not (yet) specifically computed for use as a food security metric.

On the other hand, those working on GBD studies should pay more attention to undernutrition and to related health risks (Zimmermann 2013), and more frequent updates of the GBD or relevant subsets could further increase the usefulness of DALYs for the monitoring of food security. This could be part of a new drive and greater investment in health metrics (*Nature* 2013).

The present paper does not suggest that the currently available DALYs are a panacea for all questions surrounding the measurement of food and nutrition security, but researchers across disciplines, policymakers, and other stakeholders should evaluate the usefulness of DALYs for their purposes and consider how current and future work on GBD studies or the collection of underlying data could be adapted or expanded to better accommodate the measurement of food and nutrition security.

Decisionmakers in funding bodies, research institutes, or nongovernmental and international organizations may also want to reconsider whether time, money, and human resources should be spent on producing an ever-increasing “inflation” of food security indexes (Stein 2013a), or whether efforts and resources should be bundled to collect new data on nutrition and health and to update existing data more frequently. Most importantly, though, and not only in light of the emerging open access movement within the international development community (Stansbury and Alvare 2013), there needs to be transparency in the generation of the data, and new data need to be made accessible to researchers and policymakers in a timely manner (Mathers 2013; *Devex* 2013; Horton 2013).

In the present case, using DALYs to quantify the burden of hunger has shown that the international efforts to improve global welfare are bearing fruit and that progress in the fight against undernutrition has been more rapid than is generally believed. Still, the global hunger problem remains unresolved, and its magnitude becomes especially apparent when approximated in more familiar monetary terms. Once more detailed, country-level data become available, further research can determine in which countries and for which nutrition-related health outcomes the biggest reductions in the burden of hunger have been achieved—and it can help explain why, so policymakers can apply the lessons learned.

APPENDIX: THE BURDEN OF UNDERNUTRITION BY COUNTRY

Table A.1 The burden of undernutrition by country

	Total burden of disease, estimated DALYs lost (2011)	Burden of undernourishment, estimated DALYs lost (2011)	Burden of micronutrient deficiencies, estimated DALYs lost (2011)	Burden of all forms of hunger, estimated DALYs lost (2011)	DALYs lost due to hunger per 100,000 population (2004)
World	1,677,664,176	20,843,922	44,006,575	64,850,497	935
Afghanistan	27,047,550	669,592	1,286,609	1,956,201	5,538
Albania	512,016	5,621	14,831	20,452	636
Algeria	5,797,818	60,445	140,234	200,679	558
Andorra	10,210	2	68	70	81
Angola	15,646,431	612,358	637,548	1,249,906	6,371
Antigua & Barbuda	14,382	24	172	196	218
Argentina	6,358,734	37,561	44,527	82,088	201
Armenia	584,114	1,063	4,793	5,856	189
Australia	2,504,157	740	8,463	9,202	41
Austria	1,016,078	546	5,904	6,450	77
Azerbaijan	1,736,911	4,321	54,312	58,633	640
Bahamas	64,664	122	454	576	166
Bahrain	159,026	937	2,642	3,580	270
Bangladesh	39,983,937	558,197	1,286,247	1,844,444	1,226
Barbados	44,926	80	265	345	126
Belarus	2,091,232	2,524	21,503	24,028	254
Belgium	1,425,292	1,014	7,451	8,465	77
Belize	71,469	1,044	1,030	2,073	581
Benin	3,906,492	76,548	156,690	233,239	2,563
Bhutan	176,563	2,663	6,555	9,218	1,249
Bolivia	2,576,895	79,982	65,741	145,723	1,444
Bosnia & Herzegovina	603,336	1,836	8,634	10,470	279
Botswana	1,000,067	5,576	15,578	21,154	1,042
Brazil	38,298,752	422,722	568,996	991,718	504
Brunei Darussalam	46,080	1	690	691	170
Bulgaria	1,367,783	1,878	16,671	18,549	248
Burkina Faso	9,298,771	220,158	443,919	664,076	3,914
Burundi	5,199,692	115,389	214,601	329,990	3,848
Cambodia	5,216,276	119,509	204,747	324,256	2,267
Cameroon	9,168,737	138,589	258,960	397,548	1,985
Canada	3,976,260	1,195	22,040	23,236	67
Cape Verde	86,088	1,233	3,539	4,772	953
Central African Republic	2,473,741	30,514	91,243	121,757	2,714

Table A.1 Continued

	Total burden of disease, estimated DALYs lost (2011)	Burden of undernourishment, estimated DALYs lost (2011)	Burden of micronutrient deficiencies, estimated DALYs lost (2011)	Burden of all forms of hunger, estimated DALYs lost (2011)	DALYs lost due to hunger per 100,000 population (2004)
Chad	6,918,900	106,535	327,642	434,177	3,767
Chile	2,244,248	3,881	19,500	23,381	135
China	205,367,221	701,757	3,061,969	3,763,727	280
Colombia	8,982,972	53,778	84,222	138,000	294
Comoros	188,098	5,748	7,022	12,770	1,694
Congo	1,520,953	16,057	42,546	58,604	1,416
Cook Islands	2,939	20	54	74	377
Costa Rica	591,718	2,380	5,039	7,419	157
Côte d'Ivoire	12,252,016	101,237	404,856	506,092	2,511
Croatia	677,305	222	3,995	4,218	96
Cuba	1,568,451	2,622	16,995	19,616	174
Cyprus	134,102	5	1,123	1,128	101
Czech Republic	1,510,857	1,186	8,871	10,057	95
Denmark	749,524	241	4,006	4,247	76
Djibouti	320,822	5,108	9,899	15,007	1,657
Dominica	10,854	17	109	126	186
Dominican Republic	2,142,249	19,225	29,553	48,777	485
DPR Korea	5,317,881	47,119	152,040	199,158	815
DR Congo	44,418,628	816,057	1,625,107	2,441,164	3,603
Ecuador	2,597,853	36,098	36,446	72,545	495
Egypt	15,362,575	150,186	308,129	458,314	555
El Salvador	1,174,951	20,065	19,250	39,316	631
Equatorial Guinea	406,777	5,629	14,936	20,565	2,855
Eritrea	1,486,878	35,091	61,723	96,814	1,788
Estonia	253,256	205	1,861	2,066	154
Ethiopia	40,272,990	1,377,486	1,731,072	3,108,557	3,669
Fiji	154,166	886	12,232	13,118	1,511
Finland	711,332	91	3,961	4,052	75
France	8,024,100	12,215	34,851	47,066	72
Gabon	483,441	3,857	6,718	10,575	689
Gambia	640,063	6,409	19,711	26,120	1,471
Georgia	704,975	1,810	14,036	15,846	353
Germany	10,245,184	5,576	50,855	56,432	69
Ghana	8,523,596	89,524	185,263	274,787	1,101
Greece	1,336,857	72	8,409	8,481	75
Grenada	19,836	98	293	391	373
Guatemala	3,250,465	109,995	73,901	183,896	1,246

Table A.1 Continued

	Total burden of disease, estimated DALYs lost (2011)	Burden of undernourishment, estimated DALYs lost (2011)	Burden of micronutrient deficiencies, estimated DALYs lost (2011)	Burden of all forms of hunger, estimated DALYs lost (2011)	DALYs lost due to hunger per 100,000 population (2004)
Guinea	4,547,516	73,892	152,241	226,133	2,212
Guinea-Bissau	924,291	13,093	49,966	63,059	4,076
Guyana	209,163	2,041	3,587	5,628	744
Haiti	3,736,761	72,998	195,542	268,540	2,653
Honduras	1,551,619	53,087	34,008	87,096	1,123
Hungary	1,788,847	2,407	12,882	15,288	153
Iceland	31,273	9	211	220	69
India	339,121,749	4,914,269	10,852,826	15,767,095	1,270
Indonesia	57,805,176	547,414	1,264,386	1,811,800	748
Iran	13,102,798	148,554	246,016	394,570	528
Iraq	17,484,478	219,979	603,922	823,901	2,500
Ireland	524,600	119	3,694	3,812	85
Israel	778,954	141	7,327	7,468	96
Italy	6,833,421	8,194	44,610	52,804	87
Jamaica	441,990	2,693	5,814	8,508	314
Japan	12,998,794	26,968	123,201	150,169	117
Jordan	923,138	5,062	34,361	39,423	638
Kazakhstan	4,567,390	10,501	87,273	97,773	590
Kenya	17,664,302	222,913	440,946	663,859	1,595
Kiribati	24,328	730	556	1,286	1,272
Kuwait	276,982	828	3,936	4,764	169
Kyrgyzstan	1,270,268	6,983	26,755	33,738	613
Lao PDR	1,836,412	55,111	77,785	132,896	2,113
Latvia	435,463	325	3,114	3,439	155
Lebanon	773,537	3,490	9,541	13,031	306
Lesotho	903,058	12,146	15,081	27,227	1,241
Liberia	2,899,963	48,129	145,567	193,696	4,692
Libyan Arab Jamahiriya	925,760	9,233	19,958	29,191	454
Lithuania	589,376	352	8,678	9,030	282
Luxembourg	63,801	11	453	463	90
Madagascar	7,600,057	218,144	313,096	531,240	2,492
Malawi	9,036,009	256,716	357,494	614,210	3,993
Malaysia	4,218,181	47,424	72,724	120,148	416
Maldives	63,862	574	1,839	2,413	754
Mali	9,935,444	340,527	447,043	787,570	4,972
Malta	46,682	3	334	337	81

Table A.1 Continued

	Total burden of disease, estimated DALYs lost (2011)	Burden of undernourishment, estimated DALYs lost (2011)	Burden of micronutrient deficiencies, estimated DALYs lost (2011)	Burden of all forms of hunger, estimated DALYs lost (2011)	DALYs lost due to hunger per 100,000 population (2004)
Marshall Islands	13,473	128	285	413	753
Mauritania	1,265,481	19,826	48,112	67,938	1,918
Mauritius	216,067	1,415	2,127	3,543	275
Mexico	16,876,917	148,392	219,602	367,994	321
Micronesia	16,788	158	375	534	478
Monaco	3,903	0	21	22	61
Mongolia	569,628	2,011	9,371	11,382	406
Morocco	5,384,532	58,822	180,699	239,521	742
Mozambique	11,507,706	261,931	334,473	596,404	2,492
Myanmar	13,932,887	180,575	441,398	621,973	1,287
Namibia	700,242	8,565	12,969	21,533	927
Nauru	2,412	17	46	63	671
Nepal	8,997,621	191,233	387,444	578,676	1,898
Netherlands	1,917,625	1,641	11,960	13,602	81
New Zealand	511,547	67	1,374	1,441	33
Nicaragua	1,024,464	28,378	15,060	43,439	740
Niger	12,540,175	251,300	663,657	914,956	5,694
Nigeria	91,465,967	1,252,355	3,440,759	4,693,114	2,889
Niue	245	2	5	7	480
Norway	583,848	67	3,007	3,074	62
Oman	338,455	2,816	8,200	11,016	387
Pakistan	46,152,074	706,408	1,336,047	2,042,454	1,156
Palau	3,556	22	72	93	453
Panama	524,761	5,692	9,434	15,126	424
Papua New Guinea	2,008,320	95,059	71,734	166,793	2,378
Paraguay	1,105,169	11,009	55,808	66,816	1,017
Peru	5,195,628	90,179	100,730	190,909	649
Philippines	18,519,516	318,345	403,042	721,386	761
Poland	5,698,506	11,026	48,563	59,589	156
Portugal	1,448,230	418	8,442	8,860	83
Qatar	192,635	953	2,726	3,680	197
Republic of Korea	6,435,621	1,735	72,431	74,166	149
Republic of Moldova	743,543	1,065	14,155	15,220	428
Romania	3,782,796	9,061	39,405	48,467	227
Russian Federation	39,576,704	42,586	471,271	513,857	362
Rwanda	6,533,198	158,808	316,573	475,381	4,344
Saint Kitts and Nevis	9,442	61	100	161	304

Table A.1 Continued

	Total burden of disease, estimated DALYs lost (2011)	Burden of undernourishment, estimated DALYs lost (2011)	Burden of micronutrient deficiencies, estimated DALYs lost (2011)	Burden of all forms of hunger, estimated DALYs lost (2011)	DALYs lost due to hunger per 100,000 population (2004)
Saint Lucia	27,431	112	298	411	233
Saint Vincent & Grenad.	20,498	174	225	399	365
Samoa	30,957	258	685	943	513
San Marino	3,392	0	24	24	75
Sao Tome and Principe	56,880	1,888	5,651	7,539	4,474
Saudi Arabia	4,339,611	35,322	66,580	101,902	363
Senegal	4,987,831	57,388	202,505	259,893	2,036
Serbia & Montenegro	1,627,689	3,430	15,619	19,049	197
Seychelles	14,016	40	217	257	299
Sierra Leone	4,944,552	123,064	268,245	391,309	6,525
Singapore	546,491	842	5,850	6,693	129
Slovakia	834,477	1,525	7,658	9,183	169
Slovenia	287,324	366	1,547	1,912	93
Solomon Islands	106,348	2,397	2,913	5,310	961
Somalia	6,575,149	77,668	361,647	439,314	4,597
South Africa	22,332,840	229,431	367,653	597,084	1,180
Spain	5,248,621	1,307	37,546	38,853	84
Sri Lanka	5,117,228	18,031	65,627	83,658	401
Sudan	17,308,220	282,867	392,676	675,543	1,514
Suriname	112,434	961	1,013	1,974	373
Swaziland	543,068	10,107	9,260	19,367	1,814
Sweden	1,085,023	309	6,165	6,475	68
Switzerland	849,601	127	4,694	4,821	61
Syrian Arab Republic	2,844,062	35,732	121,361	157,093	755
Tajikistan	1,744,224	23,602	70,215	93,817	1,345
Thailand	14,268,936	67,066	141,838	208,904	301
The FYR of Macedonia	346,257	829	1,883	2,711	131
Timor-Leste	330,309	8,720	6,573	15,293	1,301
Togo	2,575,013	24,583	73,884	98,467	1,600
Tonga	15,482	94	322	416	398
Trinidad & Tobago	265,520	636	2,390	3,027	225
Tunisia	1,564,007	10,319	27,002	37,321	350
Turkey	11,227,359	59,010	363,787	422,797	574
Turkmenistan	1,343,718	8,438	36,899	45,337	888
Tuvalu	2,469	17	48	65	664

Table A.1 Continued

	Total burden of disease, estimated DALYs lost (2011)	Burden of undernourishment, estimated DALYs lost (2011)	Burden of micronutrient deficiencies, estimated DALYs lost (2011)	Burden of all forms of hunger, estimated DALYs lost (2011)	DALYs lost due to hunger per 100,000 population (2004)
Uganda	17,417,175	307,345	592,434	899,778	2,607
Ukraine	10,827,161	8,860	131,645	140,505	307
United Arab Emirates	791,927	8,106	13,861	21,967	278
United Kingdom	8,062,781	1,253	31,964	33,216	53
UR Tanzania	22,413,388	520,663	690,972	1,211,635	2,622
Uruguay	547,212	2,145	3,311	5,455	162
USA	43,427,612	38,864	123,010	161,874	52
Uzbekistan	5,771,148	37,922	184,727	222,649	759
Vanuatu	43,678	788	1,253	2,041	831
Venezuela	4,702,219	41,734	53,624	95,359	326
Viet Nam	13,463,026	211,282	346,194	557,476	635
Yemen	8,811,588	219,149	440,963	660,113	2,662
Zambia	8,421,790	135,562	251,964	387,526	2,876
Zimbabwe	8,667,801	123,936	88,052	211,988	1,662

Sources: WHO 2013b and World Bank 2013b; for more details please see Table S.1 in Stein (2013b).

Notes: DALYs = disability-adjusted life years.

Given that the biggest loss of DALYs occurs in children, reporting this loss relative to the overall population might overestimate the relative burden in countries with a big, young population.

REFERENCES

- Anekwe, T. D., and S. Kumar. 2012. "The Effect of a Vaccination Program on Child Anthropometry: Evidence from India's Universal Immunization Program." *Journal of Public Health* 34 (4): 489–497. doi:10.1093/pubmed/fds032.
- Baltussen, R., M. Sylla, and S. P. Mariotti. 2004. "Cost-Effectiveness Analysis of Cataract Surgery: A Global and Regional Analysis." *Bulletin of the World Health Organization* 82 (5): 338–345. www.who.int/bulletin/volumes/82/5/.
- Barrett, C. B. 2010. "Measuring Food Insecurity." *Science* 327 (5967): 825–828. doi:10.1126/science.1182768.
- Bashir, M. K., and S. Schilizzi. 2013. "Determinants of Rural Household Food Security: A Comparative Analysis of African and Asian Studies." *Journal of the Science of Food and Agriculture* 93 (6): 1251–1258. doi:10.1002/jsfa.6038.
- Bobinac, A. 2012. *Economic Evaluations of Health Technologies: Insights into the Measurement and Valuation of Benefits*. Doctoral thesis, Erasmus University Rotterdam, Netherlands. <http://hdl.handle.net/1765/32245>.
- Braithwaite, R. S., D. O. Meltzer, J. T. King Jr., D. Leslie, and M. S. Roberts. 2008. "What Does the Value of Modern Medicine Say about the \$50,000 per Quality-Adjusted Life-Year Decision Rule?" *Medical Care* 46 (4): 349–356. doi:10.1097/MLR.0b013e31815c31a7.
- Brent, R. J. 2011. "An Implicit Price of a DALY for Use in a Cost-Benefit Analysis of ARVs." *Applied Economics* 43 (11): 1413–1421. doi:10.1080/00036840802600475.
- Brown, D. W. 2008. "Economic Value of Disability-Adjusted Life Years Lost to Violence: Estimates for WHO Member States." *Revista Panamericana de Salud Pública* 24 (3): 203–209. doi:10.1590/S1020-49892008000900007.
- Chen, S., and M. Ravallion. 2012. *More Relatively-Poor People in a Less Absolutely-Poor World*. Policy Research Working Paper WPS–6114. Washington, DC: World Bank. <http://go.worldbank.org/QX3YUCY2V0>.
- Chisholm, D. 2003. "Cost-Effective Strategies for Reducing the Global Burden of Mental Ill-Health: A Generalised Approach." *Mental Health Research Review* 9: 27–29. www.pssru.ac.uk/archive/mhrr9.htm.
- Coates, J. 2013. "Build It Back Better: Deconstructing Food Security for Improved Measurement and Action." *Global Food Security*. Published electronically June 24. doi:10.1016/j.gfs.2013.05.002.
- COHA (Cost of Hunger Study in Africa). 2012. "The Cost of Hunger in Africa: Social and Economic Impact of Child Undernutrition." *COHA Monthly Update* 1. [www.au.int/ar/sites/default/files/September COHA Newsletter FINAL.pdf](http://www.au.int/ar/sites/default/files/September%20COHA%20Newsletter%20FINAL.pdf).
- Collier, P., and A. Hoeffler. 2004. *The Challenge of Reducing the Global Incidence of Civil War*. Copenhagen Consensus Challenge Paper. Lowell, MA, US: Copenhagen Consensus Center. www.copenhagenconsensus.com/projects/copenhagen-consensus-2004/research/conflicts.
- Commission on Macroeconomics and Health. 2001. *Macroeconomics and Health: Investing in Health for Economic Development*. Geneva: World Health Organization. <http://apps.who.int/iris/handle/10665/42435>.
- Cressey, D. 2009. "Health Economics: Life in the Balance." *Nature* 461 (7262): 336–339. doi:10.1038/461336a.
- Daily, G. C. 2000. "The Value of Nature and the Nature of Value." *Science* 289 (5478): 395–396. doi:10.1126/science.289.5478.395.
- Dangour, A. D., L. Watson, O. Cumming, S. Boisson, Y. Che, Y. Velleman, S. Cavill, et al. 2013. "Interventions to Improve Water Quality and Supply, Sanitation and Hygiene Practices, and Their Effects on the Nutritional Status of Children." *The Cochrane Database of Systematic Reviews* 8 (CD009382). doi:10.1002/14651858.CD009382.pub2.
- de Haen, H., S. Klasen, and M. Qaim. 2011. "What Do We Really Know? Metrics for Food Insecurity and Undernutrition." *Food Policy* 36 (6): 760–769. doi:10.1016/j.foodpol.2011.08.003.

- Demont, M., and A. J. Stein. 2013. "Global Value of GM Rice: A Review of Expected Agronomic and Consumer Benefits." *New Biotechnology* 30 (5): 426–436. doi:10.1016/j.nbt.2013.04.004.
- Devex. 2013. "Global Burden of Disease Estimates: Secret Recipes or Spoiled Ingredients?" March 12. www.devex.com/en/news/global-burden-of-disease-estimates-secret-recipes/80479.
- DFID (Department for International Development UK). 2013. "UK Hosts High-Level Meeting on Global Nutrition and Growth." April 26. www.gov.uk/government/news/uk-to-host-high-level-meeting-on-global-nutrition-and-growth.
- Dhongde, S., and C. Minoiu. 2013. "Global Poverty Estimates: A Sensitivity Analysis." *World Development* 44: 1–13. doi:10.1016/j.worlddev.2012.12.010.
- EC–FAO Food Security Programme. 2008. *An Introduction to the Basic Concepts of Food Security*. Rome. www.foodsec.org/web/publications/pubshome/pubshome/en/c/47189/.
- EIU (Economist Intelligence Unit). 2012. "The Global Food Security Index 2012: An Assessment of Food Affordability, Availability and Quality." <http://foodsecurityindex.eiu.com/>.
- Eichler, H. G., S. X. Kong, W. C. Gerth, P. Mavros, and B. Jönsson. 2004. "Use of Cost-Effectiveness Analysis in Health-Care Resource Allocation Decision-Making: How Are Cost-Effectiveness Thresholds Expected to Emerge?" *Value in Health* 7 (5): 518–528. doi:10.1111/j.1524-4733.2004.75003.x.
- Emamian, M. H., M. Fateh, N. Gorgani, and A. Fotouhi. 2013. "Mother's Education is the Most Important Factor in Socio-Economic Inequality of Child Stunting in Iran." *Public Health Nutrition*, September 4. doi:10.1017/S1368980013002280.
- FAO (Food and Agriculture Organization of the United Nations). 1998. *Rome Declaration on World Food Security and World Food Summit Plan of Action*. Rome. www.fao.org/docrep/003/w3613e/w3613e00.htm.
- _____. 2011. *Measuring Food Insecurity: Meaningful Concepts and Indicators for Evidence-Based Policy Making*. Technical Background Paper for Committee on World Food Security Round Table on Monitoring Food Security, Rome, September 12–13. www.fao.org/cfs/cfs-home/cfsroundtable1/rt-papers/.
- _____. 2012a. *FAO Methodology to Estimate the Prevalence of Undernourishment*. Technical note on The State of Food Insecurity in the World 2012. Rome. www.fao.org/publications/sofi/.
- _____. 2012b. *The State of Food Insecurity in the World 2012*. Rome. www.fao.org/docrep/016/i3027e/i3027e00.htm.
- _____. 2013a. "FAO Director-General Urges Time Frame for Hunger, Poverty Eradication." February 14. www.fao.org/news/story/en/item/170015/icode/.
- _____. 2013b. "Hunger Portal." www.fao.org/hunger/.
- _____. 2013c. "New Metric to Be Launched on Hunger and Food Insecurity." March 13. www.fao.org/news/story/en/item/171728/icode/.
- _____. 2013d. *The State of Food and Agriculture 2013*. Rome. www.fao.org/docrep/018/i3300e/i3300e00.htm.
- Fox-Rushby, J. A. 2002. *Disability Adjusted Life Years (DALYs) for Decision-Making? An Overview of the Literature*. London: Office of Health Economics.
- GAIN (Global Alliance for Improved Nutrition). 2013. *Access to Nutrition Index: Global Index 2013*. Geneva. www.accesstonutrition.org.
- Gillespie, S. 2013. "Myths and Realities of Child Nutrition." *Economic & Political Weekly* 48 (34): 64–67. www.epw.in/discussion/myths-and-realities-child-nutrition.html.
- Glassman, A., and K. Chalkidou. 2012. *Priority-Setting in Health: Building Institutions for Smarter Public Spending*. Washington, DC: Center for Global Development. www.cgdev.org/publication/priority-setting-health-building-institutions-smarter-public-spending.

- Goldie, S. J., Y. Yazdanpanah, E. Losina, M. C. Weinstein, X. Anglaret, R. P. Walensky, H. E. Hsu, et al. 2006. "Cost-Effectiveness of HIV Treatment in Resource-Poor Settings: The Case of Côte d'Ivoire." *The New England Journal of Medicine* 355 (11): 1141–1153. doi:10.1056/NEJMsa060247.
- Gómez, M. I., C. B. Barrett, T. Raney, P. Pinstrip-Andersen, J. Meerman, A. Croppenstedt, B. Carisma, et al. 2013. "Post-Green Revolution Food Systems and the Triple Burden of Malnutrition." *Food Policy*. Published electronically July 26. doi:10.1016/j.foodpol.2013.06.009.
- Gwatkin, D. R., M. Guillot, and P. Heuveline. 1999. "The Burden of Disease among the Global Poor." *Lancet* 354 (9178): 586–589. doi:10.1016/S0140-6736(99)02108-X.
- Ha, D. A., and D. Chisholm. 2011. "Cost-Effectiveness Analysis of Interventions to Prevent Cardiovascular Disease in Vietnam." *Health Policy and Planning* 26 (3): 210–222. doi:10.1093/heapol/czq045.
- Haddad, L. 2013. "How Should Nutrition Be Positioned in the Post-2015 Agenda?" *Food Policy*. Published electronically July 30. doi:10.1016/j.foodpol.2013.05.002.
- Hambidge, K. M. 2010. "Micronutrient Bioavailability: Dietary Reference Intakes and a Future Perspective." *The American Journal of Clinical Nutrition* 91 (5): 1430S–1432S. doi:10.3945/ajcn.2010.28674B.
- Hatton, T. J. 2013. "How Have Europeans Grown So Tall?" *Oxford Economic Papers*, September 1. doi:10.1093/oenp/gpt030.
- Headey, D. 2012. "Turning Economic Growth into Nutrition-Sensitive Growth." In *Reshaping Agriculture for Nutrition and Health*, edited by S. Fan and R. Pandya-Lorch, 39–46. Washington, DC: International Food Policy Research Institute. doi:10.2499/9780896296732.
- Headey, D., and O. Ecker. 2013. "Rethinking the Measurement of Food Security: From First Principles to Best Practice." *Food Security* 5 (3): 327–343. doi:10.1007/s12571-013-0253-0.
- Hirth, R. A., M. E. Chernew, E. Miller, A. M. Fendrick, and W. G. Weissert. 2000. "Willingness to Pay for a Quality-Adjusted Life Year: In Search of a Standard." *Medical Decision Making* 20 (3): 332–342. doi:10.1177/0272989X0002000310.
- Horton, R. 2013. "The Global Burden of Disease: A Work in Progress." *Lancet* 381 (9866): 520. doi:10.1016/S0140-6736(13)60251-2.
- Horton, R., and S. Lo. 2013. "Nutrition: A Quintessential Sustainable Development Goal." *Lancet* 382 (9890): 371–372. Published electronically June 6. doi:10.1016/S0140-6736(13)61100-9.
- IHME (Institute for Health Metrics and Evaluation). 2012. Global Burden of Disease Study 2010 (GBD 2010) Data Downloads. Accessed December 26. <http://ghdx.healthmetricsandevaluation.org/global-burden-disease-study-2010-gbd-2010-data-downloads>.
- IUCN (World Conservation Union), Nature Conservancy, and World Bank. 2005. *How Much Is an Ecosystem Worth? Assessing the Economic Value of Conservation*. Washington, DC: World Bank. <http://jncc.defra.gov.uk/page-4024>.
- Jackson, T., N. McBride, and S. Abdallah. 2007. "(Regional) Index of Sustainable Economic Welfare (ISEW)." In *Beyond GDP: Measuring Progress, True Wealth, and the Well-Being of Nations*. Brussels, Belgium: European Commission. www.beyond-gdp.eu/download/bgdp-ve-isew.pdf.
- John, R. M., and H. Ross. 2010. "Economic Value of Disability Adjusted Life Years Lost to Cancers: 2008." *Journal of Clinical Oncology* 28 (15): S1561. http://meeting.ascopubs.org/cgi/content/abstract/28/15_suppl/1561.
- Lancet*. 2012. "UK Leads a Global Effort to Tackle Hunger and Malnutrition." 380 (9842): 622. doi:10.1016/S0140-6736(12)61354-3.
- Lanningham-Foster, L., L. J. Nysse, and J. A. Levine. 2003. "Labor Saved, Calories Lost: The Energetic Impact of Domestic Labor-Saving Devices." *Obesity Research* 11 (10): 1178–1181. doi:10.1038/oby.2003.162.

- Lee, B. Y., K. M. Bacon, M. E. Bottazzi, and P. J. Hotez. 2013. "Global Economic Burden of Chagas Disease: A Computational Simulation Model." *Lancet Infectious Diseases* 13 (4): 342–348. doi:10.1016/S1473-3099(13)70002-1.
- Ma, G., Y. Jin, Y. Li, F. Zhai, F. J. Kok, E. Jacobsen, and X. Yang. 2008. "Iron and Zinc Deficiencies in China: What Is a Feasible and Cost-Effective Strategy?" *Public Health Nutrition* 11 (6): 632–638. doi:10.1017/S1368980007001085.
- Masset, E. 2011. "A Review of Hunger Indices and Methods to Monitor Country Commitment to Fighting Hunger." *Food Policy* 36 (Suppl 1): S102–S108. doi:10.1016/j.foodpol.2010.11.007.
- Mathers, I. 2013. "Scientists Strive to Make Global Disease Data More Useful." *SciDev.Net*, February 21. www.scidev.net/en/health/health-policy/news/scientists-strive-to-make-global-disease-data-more-useful-1.html.
- Maxwell, S. 1996. "Food Security: A Post-Modern Perspective." *Food Policy* 21 (2): 155–170. doi:10.1016/0306-9192(95)00074-7.
- Meenakshi, J. V., N. Johnson, V. M. Manyong, H. De Groote, J. Javelosa, D. Yanggen, F. Naher, et al. 2010. "How Cost-Effective Is Biofortification in Combating Micronutrient Malnutrition? An Ex Ante Assessment." *World Development* 38 (1): 64–75. doi:10.1016/j.worlddev.2009.03.014.
- Misselhorn, A., P. Aggarwal, P. Ericksen, P. Gregory, P. Horn-Phathanothai, J. Ingram, and K. Wiebe. 2012. "A Vision for Attaining Food Security." *Current Opinion in Environmental Sustainability* 4 (1): 7–17. doi:10.1016/j.cosust.2012.01.008.
- Monda, K. L., L. S. Adair, F. Zhai, and B. M. Popkin. 2008. "Longitudinal Relationships between Occupational and Domestic Physical Activity Patterns and Body Weight in China." *European Journal of Clinical Nutrition* 62 (11): 1318–1325. doi:10.1038/sj.ejcn.1602849.
- Murray, C. J. L., and A. D. Lopez, eds. 1996. *Global Burden of Disease: A Comprehensive Assessment of Mortality and Disability from Diseases, Injuries, and Risk Factors in 1990 and Projected to 2020*. Cambridge, MA, US: Harvard University Press. http://whqlibdoc.who.int/publications/1996/0965546608_eng.pdf.
- Murray, C. J. L., J. A. Lauer, R. C. Hutubessy, L. Niessen, N. Tomijima, A. Rodgers, C. M. Lawes, et al. 2003. "Effectiveness and Costs of Interventions to Lower Systolic Blood Pressure and Cholesterol: A Global and Regional Analysis on Reduction of Cardiovascular-Disease Risk." *Lancet* 361 (9359): 717–725. doi:10.1016/S0140-6736(03)12655-4.
- Murray, C. J. L., T. Vos, R. Lozano, M. Naghavi, A. D. Flaxman, C. Michaud, M. Ezzati, et al., 2012. "Disability-Adjusted Life Years (DALYs) for 291 Diseases and Injuries in 21 Regions, 1990–2010: A Systematic Analysis for the Global Burden of Disease Study 2010." *Lancet* 380 (9859): 2197–2223. doi:10.1016/S0140-6736(12)61689-4.
- Muthayya, S., J. H. Rah, J. D. Sugimoto, F. F. Roos, K. Kraemer, and R. E. Black. 2013. "The Global Hidden Hunger Indices and Maps: An Advocacy Tool for Action." *PLoS ONE* 8 (6): e67860. doi:10.1371/journal.pone.0067860.
- Nature*. 2011. "Brain Burdens." 477 (7363): 132. doi:10.1038/477132a.
- . 2013. "Vital Statistics." 494 (7437): 281. doi:10.1038/494281a.
- Ng, S. W., and B. M. Popkin. 2012. "Time Use and Physical Activity: A Shift away from Movement across the Globe." *Obesity Reviews* 13 (8): 659–680. doi:10.1111/j.1467-789X.2011.00982.x.
- Olinto, P., and H. Uematsu. 2013. *The State of the Poor: Where Are the Poor and Where Are They Poorest?* Washington, DC: World Bank. www.worldbank.org/en/news/press-release/2013/04/17/remarkable-declines-in-global-poverty-but-major-challenges-remain.
- Pandya-Lorch, R., H. Fritschel, Z. Karelina, and S. Yosef. 2012. "Agriculture, Nutrition, and Health: Connecting the Dots." In *2011 Global Food Policy Report*, 54–61. Washington, DC: International Food Policy Research Institute. www.ifpri.org/publication/2011-global-food-policy-report.

- Pangaribowo, E. H., N. Gerber, and M. Torero. 2013. *Food and Nutrition Security Indicators: A Review*. Working Paper 5. The Hague, Netherlands: FOODSECURE. www3.lei.wur.nl/FoodSecure/PublicationDetail.aspx?id=13.
- Pinstrup-Andersen, P. 2009. "Food Security: Definition and Measurement." *Food Security* 1 (1): 5–7. doi:10.1007/s12571-008-0002-y.
- Qin, L., R. P. Stolk, and E. Corpeleijn. 2012. "Motorized Transportation, Social Status, and Adiposity: The China Health and Nutrition Survey." *American Journal of Preventive Medicine* 43 (1): 1–10. doi:10.1016/j.amepre.2012.03.022.
- Rijsberman, F. 2004. *The Challenge of Sanitation and Water*. Copenhagen Consensus Challenge Paper. Lowell, MA, US: Copenhagen Consensus Center. www.copenhagenconsensus.com/projects/copenhagen-consensus-2004/research/sanitation-and-water.
- Salomon, J. A., N. Carvalho, C. Gutiérrez-Delgado, R. Orozco, A. Mancuso, D. R. Hogan, D. Lee, et al. 2012. "Intervention Strategies to Reduce the Burden of Non-communicable Diseases in Mexico: Cost Effectiveness Analysis." *BMJ* 344: 355. doi:10.1136/bmj.e355.
- Sandler, B. J. 2005. "Biofortification to Reduce Vitamin A Deficiency: A Comparative Cost-Benefit Analysis of Golden Rice and Orange-Fleshed Sweet Potato." Master's Thesis, Stanford University, CA, US.
- Shim, E., and A. P. Galvani. 2009. "Impact of Transmission Dynamics on the Cost-Effectiveness of Rotavirus Vaccination." *Vaccine* 27 (30): 4025–4030. doi:10.1016/j.vaccine.2009.04.030.
- Smith, L. C. 2013. *The Great Indian Calorie Debate: Explaining Rising Undernourishment during India's Rapid Economic Growth*. IDS Working Paper 430. Brighton, UK: Institute of Development Studies. <http://opendocs.ids.ac.uk/opendocs/bitstream/123456789/2877/1/Wp430.pdf>.
- Spears, D., A. Ghosh, O. Cumming. 2013. "Open Defecation and Childhood Stunting in India: An Ecological Analysis of New Data from 112 Districts." *PLoS ONE* 8 (9): e73784. doi:10.1371/journal.pone.0073784.
- Stansbury, G., and L. M. Alvare. 2013. "Knowledge Is Power: Open Access in 2012." In *2012 Global Food Policy Report*, 120. Washington, DC: International Food Policy Research Institute. www.ifpri.org/publication/2012-global-food-policy-report.
- Stein, A. J., 2013a. "New Food Security Indexes." In *2012 Global Food Policy Report*, 113. Washington, DC: International Food Policy Research Institute. www.ifpri.org/publication/2012-global-food-policy-report.
- Stein, A. J. 2013b. *Replication Data for 'Rethinking the Measurement of Undernutrition in a Broader Health context: Should We Look at Possible Causes or Actual Effects?'* Washington, DC: International Food Policy Research Institute. doi:10.7910/DVN/22765.
- Stein, A. J., and M. Qaim. 2007. "The Human and Economic Cost of Hidden Hunger." *Food and Nutrition Bulletin* 28 (2): 125–134. www.ingentaconnect.com/content/nsinf/fnb/2007/00000028/00000002/art00001.
- Stein, A. J., M. Qaim, and P. Nestel. 2009. "Zinc Deficiency and DALYs in India." In *Handbook of Disease Burdens and Quality of Life Measures*, edited by V. Preedy and R. R. Watson, 1151–1170. Heidelberg, Germany: Springer.
- Stein, A. J., H. P. S. Sachdev, and M. Qaim. 2006. "Potential Impact and Cost-Effectiveness of Golden Rice." *Nature Biotechnology* 24 (10): 1200–1201. doi:10.1038/nbt1006-1200b.
- Stein, A. J., J. V. Meenakshi, M. Qaim, P. Nestel, H. P. S. Sachdev, and Z. A. Bhutta. 2005. *Analyzing the Health Benefits of Biofortified Staple Crops by Means of the Disability-Adjusted Life Years Approach: A Handbook Focusing on Iron, Zinc and Vitamin A*. HarvestPlus Technical Monograph Series 4. Washington, DC; Cali, Colombia: International Food Policy Research Institute; International Center for Tropical Agriculture. www.harvestplus.org/content/analyzing-health-benefits-biofortified-staple-crops-means-disability-adjusted-life-years-app.
- Stein, A. J., P. Nestel, J. Meenakshi, M. Qaim, H. Sachdev, and A. Bhutta. 2007. "Plant Breeding to Control Zinc Deficiency in India: How Cost-Effective Is Biofortification?" *Public Health Nutrition* 10 (5): 492–501. doi:10.1017/S1368980007223857.

- Stein, A. J., M. Qaim, J. V. Meenakshi, P. Nestel, H. P. S. Sachdev, and Z. A. Bhutta. 2008. "Potential Impacts of Iron Biofortification in India." *Social Science and Medicine* 66 (8): 1797–1808. doi:10.1016/j.socscimed.2008.01.006.
- te Lintelo, D., L. Haddad, R. Lakshman, and K. Gatellier. 2013. *The Hunger and Nutrition Commitment Index (HANCI 2012): Measuring the Political Commitment to Reduce Hunger and Undernutrition in Developing Countries*. Brighton, UK: Institute of Development Studies. www.ids.ac.uk/files/dmfile/HANCI_2012_reportv2.pdf.
- Towse, A. 2009. "Should NICE's Threshold Range for Cost per QALY Be Raised? Yes." *BMJ* 338: b181. doi:10.1136/bmj.b181.
- Traill, W. B. 2012. "Economic Perspectives on Nutrition Policy Evaluation." *Journal of Agricultural Economics* 63 (3): 505–527. doi:10.1111/j.1477-9552.2012.00356.x.
- UN (United Nations). 2008. "Official List of MDG Indicators." *Millennium Development Goals Indicators: The Official United Nations Site for the MDG Indicators*. Updated January 15. <http://mdgs.un.org/unsd/mdg/host.aspx?Content=indicators/officiallist.htm>.
- _____. 2012a. *Millennium Development Goals: 2012 Progress Chart*. New York. <http://mdgs.un.org/unsd/mdg/News.aspx?ArticleId=67>.
- _____. 2012b. "Purchasing Power Parities (PPP) Conversion Factor, Local Currency Unit to International Dollar." *Millennium Development Goals Indicators: The Official United Nations Site for the MDG Indicators*. Accessed August 23. <http://unstats.un.org/unsd/mdg/SeriesDetail.aspx?srid=699>.
- _____. 2013. "World Population Prospects: The 2012 Revision." Accessed August 23. http://esa.un.org/unpd/wpp/unpp/panel_population.htm.
- UN Economic and Social Council. 2013. "Millennium Development Goals and Post-2015 Development Agenda." www.un.org/en/ecosoc/about/mdg.shtml.
- Veitch, E. 2012. "Estimates from the Global Burden of Disease Can Become a Global Public Good Only if the Data Are Made Public." *PLOS Medicine Community Blog*, December 14. <http://blogs.plos.org/speakingofmedicine/2012/12/14/estimates-of-the-global-burden-of-disease-can-become-a-global-public-good-only-if-the-data-are-made-public/>.
- Verpoorten, M., A. Arorab, N. Stoop, and J. Swinnen. 2013. "Self-Reported Food Insecurity in Africa during the Food Price Crisis." *Food Policy* 39: 51–63. doi:10.1016/j.foodpol.2012.12.006.
- von Grebmer, K., C. Ringler, M. W. Rosegrant, T. Olofinbiyi, D. Wiesmann, H. Fritschel, O. Badiane, et al. 2012. *2012 Global Hunger Index: The Challenge of Hunger*. Bonn, Germany; Washington, DC; Dublin, Ireland: Welthungerhilfe; International Food Policy Research Institute; Concern Worldwide. doi:10.2499/9780896299429.
- WHO (World Health Organization). 2011. "Burden of Disease from Environmental Noise: Quantification of Healthy Life Years Lost in Europe." Copenhagen, Denmark. www.who.int/quantifying_ehimpacts/publications/e94888/en/.
- _____. 2013a. "Disability Weights, Discounting and Age Weighting of DALYs." *Health Statistics and Health Information Systems*. www.who.int/healthinfo/global_burden_disease/daly_disability_weight/.
- _____. 2013b. "Disease and Injury Country Estimates: Death and DALY Estimates for 2004 by Cause for WHO Member States." *Health Statistics and Health Information Systems*. Accessed January 3. www.who.int/healthinfo/global_burden_disease/estimates_country/.
- _____. 2013c. "About the Global Burden of Disease (GBD) Project." *Health Statistics and Health Information Systems*. www.who.int/healthinfo/global_burden_disease/about/.
- _____. 2013d. "Life Expectancy: Life Expectancy by World Bank Income Group." Accessed August 23. <http://apps.who.int/gho/data/view.main.700>.
- _____. 2013e. "Purchasing Power Parity 2005." *WHO-CHOICE*. Accessed August 23. www.who.int/choice/costs/ppp/en/.

- _____. 2013f. “WHO Global Burden of Disease Publications.” *Health Statistics and Health Information Systems: Publications*. www.who.int/healthinfo/global_burden_disease/publications/en/index.html.
- World Bank. 1993. *World Development Report 1993: Investing in Health*. Washington, DC; New York: World Bank; Oxford University Press. http://wdronline.worldbank.org/worldbank/a/c.html/world_development_report_1993/abstract/WB.0-1952-0890-0.abstract1.
- _____. 2006. *Repositioning Nutrition as Central to Development: A Strategy for Large-Scale Action*. Washington, DC. <http://go.worldbank.org/UGPWFYHNU0>.
- _____. 2013a. “What Is an ‘International Dollar’?” *World Bank Data Help Desk Knowledge Base*. <https://datahelpdesk.worldbank.org/knowledgebase/articles/114944-what-is-an-international-dollar->.
- _____. 2013b. “World Development Indicators.” Accessed July 26. <http://data.worldbank.org/indicator>.
- _____. 2013c. “Health Landscape in Six Regions Reveals Rapid Progress Made and Daunting Challenges from Hundreds of Diseases, Injuries, Risk Factors.” September 4. www.worldbank.org/en/news/press-release/2013/09/04/health-landscape-six-regions-rapid-progress-daunting-challenges-hundreds-diseases-injuries-risk-factors.
- World Bank, Bill & Melinda Gates Foundation, Bread for the World, The 1000 Days Partnership, IFPRI (International Food Policy Research Institute), and CIDA (Canadian International Development Agency). 2013. *Nutrition in the Post-2015 Development Agenda*. Washington, DC: SecureNutrition. www.securenutritionplatform.org/Pages/DisplayResources.aspx?RID=174.
- Yosefy, C., G. Ginsberg, R. Viskoper, D. Dicker, and D. Gavish. 2007. “Cost-Utility Analysis of a National Project to Reduce Hypertension in Israel.” *Cost Effectiveness and Resource Allocation* 5 (1): 16. doi:10.1186/1478-7547-5-16.
- Zimmermann, M. 2013. “Flawed Approach in the GBD 2010 for Iodine Deficiency Compromises Its Findings.” *IDD Newsletter* 41 (1): 12–13. www.iccid.org/p142000595.html.
- Zimmermann, R., and M. Qaim. 2004. “Potential Health Benefits of Golden Rice: A Philippine Case Study.” *Food Policy* 29 (2): 147–168. doi:10.1016/j.foodpol.2004.03.001.

RECENT IFPRI DISCUSSION PAPERS

For earlier discussion papers, please go to www.ifpri.org/pubs/pubs.htm#dp.
All discussion papers can be downloaded free of charge.

1297. *Public-sector agricultural research priorities for sustainable food security: Perspectives from plausible scenarios*. Gerald C. Nelson and Dominique van der Mensbrugghe, 2013.
1296. *Sustainability of EU food safety certification: A survival analysis of firm decisions*. Catherine Ragasa, Suzanne Thornsbury, and Satish Joshi, 2013.
1295. *Efficiency and productivity differential effects of land certification program in Ethiopia: Quasi-experimental evidence from Tigray*. Hosaena Ghebru Hagos and Stein Holden, 2013.
1294. *Women's empowerment and nutrition: An evidence review*. Mara van den Bold, Agnes R. Quisumbing, and Stuart Gillespie, 2013.
1293. *An evaluation of poverty prevalence in China: New evidence from four recent surveys*. Chunni Zhang, Qi Xu, Xiang Zhou, Xiaobo Zhang, and Yu Xie, 2013.
1292. *Cost-benefit analysis of the African risk capacity facility*. Daniel J. Clarke and Ruth Vargas Hill, 2013.
1291. *Agricultural mechanization patterns in Nigeria: Insights from farm household typology and agricultural household model simulation*. Hiroyuki Takeshima, Alejandro Nin Pratt, Kinshen Diao, 2013.
1290. *Land constraints and agricultural intensification in Ethiopia: A village-level analysis of high-potential areas*. Derek Headey, Mekdim Dereje, Jacob Ricker-Gilbert, Anna Josephson, and Alemayehu Seyoum Taffesse, 2013.
1289. *Welfare and poverty impacts of India's national rural employment guarantee scheme: Evidence from Andhra Pradesh*. Klaus Deininger and Yanyan Liu, 2013.
1288. *Links between tenure security and food security: Evidence from Ethiopia*. Hosaena Ghebru Hagos and Stein Holden, 2013.
1287. *Economywide impact of maize export bans on agricultural growth and household welfare in Tanzania: A dynamic computable general equilibrium model analysis*. Kinshen Diao, Adam Kennedy, Athur Mabiso, and Angga Pradesha, 2013.
1286. *Agricultural commercialization, land expansion, and homegrown large-scale farmers: Insights from Ghana*. Antony Chapoto, Athur Mabiso, and Adwinmea Bonsu, 2013.
1285. *Cambodian agriculture: Adaptation to climate change impact*. Timothy S. Thomas, Tin Ponlok, Ros Bansok, Thanakvaro De Lopez, Cathy Chiang, Nang Phirun, and Chhim Chhun, 2013.
1284. *The impact of food price shocks in Uganda: First-order versus long-run effects*. Bjorn Van Campenhout, Karl Pauw, and Nicholas Minot, 2013.
1283. *Assessment of the capacity, incentives, and performance of agricultural extension agents in western Democratic Republic of Congo*. Catherine Ragasa, John Ulimwengu, Josee Randriamamonjy, and Thaddee Badibanga, 2013.
1282. *The formation of job referral networks: Experimental evidence from urban Ethiopia*. Antonio Stefano Caria and Ibrahim Worku Hassen, 2013.
1281. *Agriculture and adaptation in Bangladesh: Current and projected impacts of climate change*. Timothy S. Thomas, Khandaker Mainuddin, Catherine Chiang, Aminur Rahman, Anwarul Haque, Nazria Islam, Saad Quasem, and Yan Sun, 2013.
1280. *Demand for weather hedges in India: An empirical exploration of theoretical predictions*. Ruth Vargas Hill, Miguel Robles, and Francisco Ceballos, 2013.
1279. *Organizational and institutional issues in climate change adaptation and risk management: Insights from practitioners' survey in Bangladesh, Ethiopia, Kenya, and Mali*. Catherine Ragasa, Yan Sun, Elizabeth Bryan, Caroline Abate, Atlaw Alemu, and Mahamadou Namori Keita, 2013.
1278. *The impact of alternative input subsidy exit strategies on Malawi's maize commodity market*. Mariam A. T. J. Mapila, 2013.

**INTERNATIONAL FOOD POLICY
RESEARCH INSTITUTE**

www.ifpri.org

IFPRI HEADQUARTERS

2033 K Street, NW
Washington, DC 20006-1002 USA
Tel.: +1-202-862-5600
Fax: +1-202-467-4439
Email: ifpri@cgiar.org