How Many People Are Malnourished?

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Abstract

The present article reviews the strengths and weaknesses of the three main methods for estimating the prevalence of malnutrition in populations: self-reported hunger, estimates based on food supplies, and anthropometrics. Although far from flawless, anthropometrics is found to be the most reliable method and also the most useful for directing policy. The main form of malnutrition among adults is overweight, not only in developed countries, but also in almost all developing countries. Only in a few developing countries is adult underweight more prevalent. By the conventional anthropometric indicators, about one-quarter of all children below the age of 5 in the developing countries are stunted or underweight, and about 10% are wasted. The total burden of malnutrition among young children, as measured by the Composite Index of Anthropometric Failure, is considerably higher, about 60% in India, the country with the largest child population in the world.

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INTRODUCTION

The important question posed in the title of this review cannot be answered with the precision warranted for three main reasons. The first is that malnutrition is not a single-dimension state of a person (or any living creature) that is easily defined and delineated from other adverse conditions, such as ill health in various forms. The second is that even if one agrees on a particular way of conceptualizing and defining malnutrition, there are measurement problems that can only be imperfectly resolved with the methods presently available. The third is that there is little evidence on the nutritional status of individuals other than infants and young children and their mothers; school children, adolescents, and the elderly are not covered in the data.

The objective of this review is to provide an analysis of the main conceptual and measurement issues encountered when relying on the most common approaches to assess the prevalence of malnutrition in the world: self-reported hunger, estimates based on food supplies, and anthropometrics. Even though not all the conceptual and measurement difficulties can be fully overcome, a hopefully best-possible answer to the question of how many people are malnourished is provided.

A few caveats are warranted already at this stage. The present review is confined to macro-level measurements of malnutrition; that is, how malnutrition is defined and measured in large populations by international organizations and researchers. The review hence does not attempt to tackle the difficulties encountered in measuring specific aspects of malnutrition at the level of individuals; malnutrition that is related to disease, metabolic disorders, and malabsorption of micronutrients; or any of the chemical, biological, genetic, epidemiological, and specific-micronutrients aspects of malnutrition. Moreover, this review is limited to conceptual and measurement issues; the causes and consequences of malnutrition are touched upon only when directly related to these issues.

Why is it important to know as accurately as possible how many people are malnourished in a population? When it comes to infants and young children, almost all are routinely examined by medically trained professionals on a more or less regular basis in most rich countries. The main purpose is, quite obviously, to detect as early as possible any sign of malnutrition and/or ill health so that treatment can be set in without delay. In poor countries, home to the great majority of malnourished people—whatever definition of malnutrition is applied—it is of no less importance that malnutrition is detected and subjected to treatment. The great differences are that the medical and other facilities for early detection and remedy are often lacking, or are not affordable, for large parts of the population (11). Therefore, policies are often targeted to broad groups of people (children) according to income (poverty) levels, geographical areas, or rural-urban lines.

In order to target and design interventions efficiently, not only the geographical distribution of malnutrition but also which population segments that are most affected need to be known. Accurate assessment of the overall prevalence of malnutrition is important for deciding at what level interventions are best made. If the incidence of malnutrition is very high—say nearly half the population—broad-based interventions have to be undertaken at the national level (e.g., through lowering consumer prices). If the prevalence is smaller, 10% to 15%, interventions can be targeted directly to those in need (if identified). This is what Brazil and Mexico have successfully done in recent years through well-targeted conditional cash transfer programs (1, 3, 17).

The review is organized as follows. Following this Introduction, the next section assesses how the concept of "hunger," frequently used in policy and advocacy documents, fits into the broader realm of malnutrition. The third section focuses on the estimates of "undernourishment," based on food supplies, calorie intakes, and caloric norms, championed mainly by the United Nations Food and Agriculture Organization (FAO). The fourth section deals with the strengths and weaknesses associated with the conventional anthropometric method for defining and measuring malnutrition. This approach is nowadays the predominant one used by the World Health Organization (WHO), the United Nations Children's Fund (UNICEF), and Micro International [provider of the Demographic and Health Surveys (DHS)] and in most other assessments of malnutrition. In the fifth section, I expand on my suggestion for a broader and at the same time more disaggregated anthropometric measure, the Composite Index of Anthropometric Failure (CIAF) (30). This index can be used to estimate the Total Burden of Child Malnutrition, which is not captured by any other measure. It can also identify various combinations of anthropometric failures that have been shown to be sharper predictors of morbidity risk and poverty than the conventional indicators. Section six presents a comparative synthesis, and main conclusions are contained in the seventh section.

MALNUTRITION AS ESTIMATED BY SELF-REPORTED HUNGER

In the vocabulary of many international organizations, various nutritional disorders are lumped together and referred to as "the hunger problem." It is notable that the first United Nations Millennium Development Goal is formulated as "reducing poverty and hunger by half before the year 2015." The questions are how relevant and operational the term "hunger" is and how it actually relates to what is considered to constitute malnutrition in the scientific literature. The word "hunger" has a natural appeal to agencies and experts whose laudable and important aim is advocacy of food and nutrition problems in the world. Probably every human being, irrespective of income, wealth, and status, has at least on a few occasions suffered from being very hungry without a possibility to satiate it for some time. Hunger, the body's signal that it requires more instantly absorbable energy, is painful. Invoking that such pain is what hundred of millions of people in the poor countries suffer every day, or very frequently, may be an efficient way of bringing attention to severe problems that the scientific community dresses in terms that can sound antiseptic and noncompassionate.

Catastrophes in the form of famine, with mass starvation leading to drastically raised mortality in specific regions, are no longer frequently experienced anywhere in the world. The perhaps largest famine ever took place in China from 1958 to 1961 as a consequence of massive crop failure and policies related to the "great leap forward" (2). On the Indian subcontinent, the latest large famine struck in West Bengal in 1943. It was not mainly caused by crop failure, but rather by drastic shifts in relative purchasing power of different population segments related to the war (26). In Africa, there were large-scale famines in some countries in the 1980s, the worst in Ethiopia from 1984 to 1985 (40).

Self-Reported Hunger

There are occasional reports about rural people going without sufficient food in the "hunger season" in African countries with high seasonality in agriculture. At the level of populations, however, not much quantitative research has been carried out on the extent and frequency to which people living in poor countries "go hungry" on a regular basis in normal times, i.e., not during war or in connection with large natural catastrophes. There are studies from India, though, the country with the highest prevalence of child and maternal underweight of the 86 countries for which there are recent and comparable estimates (34). The assessments of "hunger" in India, brought to attention and summarized recently by Deaton & Drèze (10), are part of the large Household Consumption Expenditure assessments carried out by the National Sample Survey Organisation (NSSO) about every fifth year, based on more than 200,000 households. The households that are subjected to the "hunger" questions comprise a smaller, but representative, subsample at the all-India level.

The questions to be answered for assessing self-reported hunger in India have changed over time. In the 1980s and early 1990s, the question was whether everyone in the household "got two square meals a day." In the surveys from the late 1990s and the most recent one, undertaken in 2004–2005, the main question had been changed to whether "everyone in the household got enough food everyday." The results are not what one may anticipate. In the latest survey, the self-reported frequency of hunger in all-India was only 2.5%, and it was less than 10% in all but one state, West Bengal (11.7%). In the two preceding surveys the share of households reporting that not everyone got enough food every day was somewhat higher, but not much (10).

Food Consumption by the Poorest

The extent of widespread hunger on a regular basis can also be assessed by consulting data from the Indian NSSO reports on food consumption in the lowest expenditure (income) classes. The lowest class reported is for the 0–10 expenditure percentiles, or the 10% poorest of all Indian households. These households had an average monthly per capita consumption expenditure (MPCE) of 370 rupees and 471 rupees in rural and urban areas, respectively, in 2007–2008, the latest year with comprehensive data (**Table 1**). These MPCEs correspond to about 60% of the official poverty lines in rural and urban India at the time, poverty lines that are less than half of the World Bank's $1.25 a day. These households are the poorest of the poor in India, which should make them entitled to purchase food grains at especially low subsidized prices in so-called fair price shops.

However, in 2004–2005, the latest year with the required data, only about one-third of households below the official poverty lines actually possessed the ration cards allowing them to buy subsidized grains, signifying that they had to buy the bulk of the grains consumed at market prices. It is hence surprising that the 10% poorest households consume about the same amount of cereals as households in higher income brackets, or the average household in India, about one-third of a kilo per person and day (**Table 1**). These amounts of cereals, mainly rice and wheat, contain enough calories required for basic metabolism at a "normal"

Table 1 Monthly per capita consumption expenditures (MPCE) of the poorest households in India and consumption of food grains in rural and urban areas, 2007–2008

	Rural	Urban
Average MPCE among 10% poorest households (Rs/month)	370	471
Average MPCE among all households (Rs/month)	772	1472
Poverty line (Rs/month)	448	661
Expenditures on cereals among the 10% poorest households (Rs/month)	95	99
Expenditures on cereals by average household (Rs/month)	124	131
Amount of cereals consumed by 10% poorest households (kg/person/day)	0.34	0.32
Amount of cereals consumed by average household (kg/person/day)	0.39	0.32

Source: Calculations based on data from National Sample Survey Organization, Report 530 (22).
Abbreviation: Rs, rupees.

body weight (per adult equivalent), but for only little physical activity according to the assessments made by the WHO (41). Although consuming one-third kilo of cereals per day is probably enough to avoid permanent hunger feelings, which squares with the low self-reported hunger noted above, it is massively inadequate in most other respects.

How does one reconcile the observation that the poorest households consume not ample, but rather sufficient, amounts of staple grains to avoid hunger with the observation that 41% of young children in India and 33% of their mothers are underweight? The short answer is that underweight (and other manifestations of malnutrition) is only partly caused by underconsumption of calories. The main causes of malnutrition, especially as manifested in stunting, are frequent and infectious disease and diets that are deficient in vitamins and minerals (4, 38).

MALNUTRITION AS ESTIMATED BY FOOD SUPPLIES

The FAO Model

The FAO's estimates of undernourishment (the term used) are based on the per capita availability of food in individual countries (their own production and net imports) as compiled in the organization's food-balance sheets. The calorie content of the available food items is obtained from standardized conversion tables, and the per capita availability of calories is used as a proxy for per capita calorie intake. The distribution of the available calories across households in a country is estimated from household food consumption surveys. Finally, the FAO establishes a norm for the minimum per-person calorie requirement in a household. The share of the households in the distribution that has an availability (intake) of calories below the norm is classified as undernourished.

The FAO estimation method is highly data demanding, and the data required for estimating each of the three main building blocks in its model have weak empirical underpinnings. Food availability is notoriously difficult to estimate in countries lacking scientifically based methods for acreage enumeration and crop yield assessment—as in most African countries but also elsewhere—and food production estimates are reported with considerable time lags. The FAO's alarmist estimates of steeply increasing undernourishment in the world in 2008 are to a large extent built on food production data from 2003 to 2005 (12). This is the most recent period for which estimated per capita calorie supplies are presented on FAO's Website (as of November 2010).

The distribution of the calorie intakes across households in each and every country is estimated on the basis of a handful of food consumption surveys, most of which were conducted in half a dozen countries some 20 years ago. How representative these estimated calorie distributions are for other countries, and in more recent times, is an unknown.

When it comes to setting up calorie cutoff points, the FAO has to consider that households have different per capita calorie requirements (expenditures) because the habitual amount of calories burned in physical activities (such as work) differ, and that populations have different age and sex compositions. The FAO handles the first issue by making a distinction between average per capita energy requirements and minimum requirements. The average requirement is meant to reflect what the FAO finds to be the per person requirement for the average household in a population. The minimum requirement is set about 15% lower so as to take into account that adults in some households have less than average requirements because they are occupied in relatively sedentary and, hence, less energy demanding work activities. This is a rather crude shortcut. In order to estimate the prevalence of undernourishment in a country with the FAO method in a theoretically correct way, one would have to know not only the distribution of calorie intakes across household, but also how this distribution is related to the distribution of calorie expenditures. Such data have never been collected.

In establishing its calorie cutoff points, the FAO takes into account that the age and sex composition of the population varies across countries and hence the per capita energy requirements for basic metabolism. This is laudable, and the FAO has made very detailed calculations of metabolic requirements for children, adolescents, and adults of both sexes, which are considered in the cutoff points (13).

Robustness Tests of the FAO Model

In previous work, I have made two types of tests of the reliability and validity of the FAO method and its estimates of undernourishment. The first is a test of robustness of results. As argued above, all three main building blocks in the FAO estimation model have a shaky empirical foundation. The robustness tests revealed that even very small alterations in the uncertain values of their main parameters in the model have large effects on estimated undernourishment (29, 31). The benchmark was FAO's own estimate of prevalence of undernourishment in sub-Saharan Africa, in the 1990–1992 period, at 43% of the population.

The test was conducted by altering the three main parameters in the FAO estimation model—the per capita calorie intake, the distribution across households and the calorie cutoff point—by plus-minus 10% in 27 ($3 \times 3 \times 3$) combinations. The ensuing estimates of "undernourishment" were found to be in the 21% to 61% range. The results were the most sensitive to alterations in the per capita calorie availability and in the cutoff point. The alterations in the distribution parameter did not have any notable impact on the outcomes, which indicates that the crude way the FAO has derived this particular parameter is not of paramount importance.

The second test was aimed at checking which of the main building blocks in the FAO model drove the ensuing "undernourishment" estimates the most. The question was whether the differences in estimated undernourishment across countries and over time were driven mainly by differences in the per capita calorie availability (proxy for intake), the distribution across households, or in the calorie cutoff points. The test was conducted by simply running a log-regression with prevalence of "undernourishment" as the dependent variable and per capita calorie availability as the independent variable. Data on both variables were from the FAO and the 1990–1992 period. The number of observations (developing countries) was 96. The fit of the regression turned out at 89%, as measured by an adjusted R-square of 0.89 (30). As part of the preparation of the present review, the same regression was run on data from around 2005, and the result turned out to be very similar (**Figure 1**).

The two tests reveal the weaknesses of the FAO method for estimating the prevalence of "undernourishment" on the basis of food supplies. First, the model is highly sensitive to small alterations in the value of the three main parameters, which have shaky empirical foundations. Second, estimated "undernourishment" is almost entirely determined by national food production; the distribution of income (calories) and differences in calorie requirements due to differences in population composition matter only marginally. Moreover, the focus is entirely on calories; the role of micronutrients is disregarded.

MALNUTRITION AS ESTIMATED BY ANTHROPOMETRICS

Main Advantages

Most assessments of the nutritional status of populations in recent times rely on anthropometric indicators of weight and height failure. There are many well-known advantages with these indicators. One is that there is no need for assessing how many calories (and other nutrients) a person consumes; neither is there a need for trying to measure how many calories she or he spends for metabolism and in physical activity. Anthropometric indicators simply reflect the (im)balance between intakes and expenditures. When the habitual intakes are short of expenditures, body weight falls, eventually, below the level consistent with unimpaired health, the anthropometric cutoff points. In young children and adolescents, linear growth in stature may also be adversely affected by low calorie intake, but stunting is mainly a consequence of underconsumption of essential micronutrients (vitamins and minerals) (38).

A second advantage with anthropometric indicators is that they (in sharp contrast to the FAO method) can provide detailed maps of the concentration of malnutrition along age and gender lines as well as rural and urban areas and districts and provinces in countries. This is of importance in directing and targeting interventions efficiently.

A third advantage is that the anthropometric norms are universal, at least for children below the age of 5. In 2006, after several years of investigation, the WHO published revised height and weight norms for infants and young children based on healthy and nutritionally unconstrained breast-fed children in six diverse countries (42). These norms replaced the earlier National Center for Health Statistics (NCHS)/WHO norms that were based on U.S. children several decades ago. The work to establish new norms also led the experts involved to reconfirm that the average genetic potential for child growth to the age of 5 is very similar, if not identical, in all ethnic groups. The new norms have been universally adopted, which makes unbiased intercommunity comparison feasible. A drawback with the new norms is that they may compromise intertemporal comparisons, but the WHO has recalculated the results from many earlier surveys in its recent database, applying the new norms.

When it comes to anthropometric measurements for adults, there is almost complete reliance on the body mass index (BMI), which is also agreed to be universally applicable. The index measures weight in relation to height (kg/m^2). It is applied for identifying underweight, overweight, and obesity, the cutoff points for which are below 18.5, above 25, and above 30, respectively. Deaton has come up with another way of screening whether nutritional standards among adults improve over time (9). In short, he assesses the height of adults of different ages. He found, on the basis of observations from India, that younger adults were relatively taller than their older compatriots, which indicates that the nutritional status of children and adolescents—at the age when final growth in height is determined—has improved over decades. The method is promising, but as of yet, too few anthropometric surveys report on heights of adult women by age, and hardly any [except the Indian National Family Health Survey (NFHS)-3] reports on adult males, for the method to be widely applied.

Inherent Limitations with Anthropometrics

The anthropometric norms, or cutoff points, are statistical constructs rather than norms derived from epidemiological or other evidence on health impairments following low weight and height. In all unconstrained populations, the weight and height of individuals varies more or less in accordance with a normal distribution. The anthropometric norms are set at the 2% to 3% lower tail in such distributions, signifying that it is only a 2% to 3% risk that a person in a constrained population falls below the norm because of his or her genetic inheritance. Albeit statistical constructs, anthropometric failure according to these norms are correlated to adverse outcomes, such as elevated morbidity and mortality risk (23). Weight and height scores are hence reasonably reliable indicators of the nutrition-cum-health status in large populations. However, failure according to these norms is not sufficient for diagnosing a particular individual as malnourished without supplementary medical assessment.

Another limitation is that anthropometric failure does not reveal the underlying cause of weight and height failure. Malnutrition and frequent and prolonged illness are intertwined in a complicated and multifaceted pattern, making it very difficult to say what comes first and what follows. To do so, medical examination beyond anthropometric assessment is required, which is out of reach for the great majority of failed children and adults in developing countries. Anthropometric failure in the form of retarded skeletal growth (stunting) is related to micronutrient deficiencies that are not known with the accuracy warranted (4, 5, 6).

A further inherent limitation is that anthropometric indicators do not take physical activity into account. This is a problem because we do not have sufficient knowledge of how children normally adjust to unduly low intakes of calories and other nutrients. If the first response is weight loss, anthropometrics is capturing also physical inactivity; if the other way around, anthropometrics may miss the children who are too inactive, which can have adverse consequences for health as well as for cognitive and motoric development.

Rectifiable Limitations with Anthropometrics

Anthropometrics as a vehicle for diagnosing and measuring malnutrition has several limitations that are—in principle—possible to overcome. So far, most anthropometric assessments have been focused on infants and children below the age of 5. Since about 10 years ago, most anthropometric surveys have also covered adult women (aged 15 to 49 years); typically the mothers of the children are examined. Older children, adolescents, adult males, and people above 50 are still seldom assessed, but adult males are on the way to be included in the DHS.

Another problem is that the exact age of many children is not known in some of the least-developed countries. This problem can be circumvented, if the number of children surveyed is large, by simply omitting the children for whom age is uncertain, but we cannot be certain that the omitted children are not special. A third problem (seldom reported) is that there are often substantial numbers of "missing" observations, i.e., the children targeted for measurement cannot be found, or their mothers will not allow them to be measured. In the 1998–1999 NFHS survey for India, for instance, about 12% to 13% of the children were "missing." Moreover, one would think that measuring correctly the weight and height of children would be very simple undertakings, but measurement errors are not infrequent. The WHO has a rule to delete the most obvious observation errors, which are defined as children with observed height or weight that are plus-minus 6 standard deviations (SD) from the norms. One can doubt that there could be children alive with a weight-for-age 5 SD below norm. For a 36-month-old boy with a norm weight of 14.3 kilo, 5 SD below norm implies a weight of 7.7 kilo, the norm for a 6-month-old (42).

Yet another problem is that anthropometric surveys are costly to undertake in countries lacking the basic infrastructure for concurrent health surveillance of the (child) population. Only a few developing countries, e.g., Bangladesh, Argentina, Chile, and Venezuela, have annual surveillance systems covering all or most children. In other countries, anthropometric surveys are carried out rather sporadically, each third or fourth year. This means that the surveys are seldom helpful for identifying incipient large-scale changes in nutrition standards. To take a recent example, food prices rocketed worldwide in 2008, and food riots broke out in some 30 countries. Without much evidence to lean on, various international organization claimed drastic increases in malnutrition and poverty.

There is no substantiated evidence of widespread starvation or famine in 2008, or in 2009, when food prices started to decline (although not back to pre-2008 levels). However, the extent to which the food price shock in 2008, and the still ongoing economic crisis in many countries, has aggravated malnutrition in the world is not known in sufficient detail. The most promising way to assess this is to look at data on anthropometric failure rates, at best in combination with mortality rates. If these rates went up noticeably in 2008 and early 2009 in many countries, we can be reasonably assured that a common cause would be higher food prices worldwide.

Unfortunately, given the infrequency with which anthropometric surveys are carried out, it is not feasible to test this hypothesis on a grand scale. Only about a dozen anthropometric surveys were undertaken during 2008–2009, and so far results have been reported for seven of them (**Table 2**). In comparison with the latest previous survey in the respective country, the incidence of all the three conventional indicators of child malnutrition—stunting, underweight, and wasting—went up quite notably in one of the seven countries, Egypt. Here, the incidence of child stunting and child underweight increased by 6.9 (statistically significant) and 1.4 percentage points, respectively, from 2005. In three of the countries—Bolivia, Madagascar, and Mauritania—both stunting and underweight declined (statistically

Table 2 Examination of possible increase in child anthropometric failure in 2008–2009 as a consequence of raising food prices worldwide

		N	Age group (years)	Underweight W/A <-2 SD (%)	Stunted H/A <-2 SD (%)	Wasted W/H <-2 SD (%)	Underweight BMI <-2 SD (%)	Change
Bolivia	2003–04	9,018	0.5–5	5.8	34.6	1.4	1.4	
	2008	7,679	0.5–5	4.3	29.1	1.1	1	Down*
Egypt	2005	12,830	0–5	5.4	23.8	5.3	5.4	
	2008	10,053	0–5	6.8	30.7	7.9	8.5	Up*
Ghana	2006	3,237	0–5	13.9	28.1	6.1	5.2	
	2008	2,666	0–5	14.3	28.6	8.7	8.6	Flat
Kenya	2003	5,536	0–5	16.5	35.8	6.2	5.5	
	2008–09	5,726	0–5	16.4	35.2	7	6.1	Flat
Madagascar	2003–04	5,905	0–5	36.8	52.8	15.2	13.3	
	2008–09	5,845	0–5	NA	49.2	NA	NA	Down*
Mauritania	2007	7,405	0.5–5	24.4	31.1	12.9	11.5	
	2008	5,615	0.5–5	16.7	24.2	8.4	NA	Down*
Nigeria	2007	16,133	0–5	25.7	42.8	13.4	12.8	
	2008	23,702	0–5	26.7	41	14.4	13.5	Flat

*Indicates that change is statistically significant at 0.05 level by Chi-square test.

Abbreviations: BMI, body mass index; H/A, height for age; N, number; NA, not applicable; SD, standard deviation; W/A, weight for age; W/H, weight for height.

Source: Calculations based on data from World Health Organization 2010 (43).

significant). In the remaining three countries—Ghana, Kenya, and Nigeria—there were small changes, all statistically insignificant (19, 43).

The little anthropometric evidence at hand presently hence does not corroborate the drastic rise in undernourishment reported by the FAO and some other international organizations. The number of comparative surveys from 2008 to 2009 is simply too small to allow any definitive conclusion regarding the possible nutritional impact of the recent food price spike. What one can say is that the available surveys are of high quality. In six of the seven countries (the exception being Mauritania), the 2008–2009 survey, as well as the previous one, was undertaken by Micro International (DHS) and based on the same age cohorts and sufficiently large samples. However, at least 20 Demographic and Health Surveys conducted in 2009–2010 are ongoing, and in about a year's time, we will have the results and can say more definitely to what extent, if any, the lingering high food prices in 2009–2010 have affected the nutritional status of populations (19).

Coverage of Anthropometric Surveys

The number of anthropometric surveys conducted has grown considerably over the past 20 years, and many are included in the WHO's Global Database on Child Growth and Malnutrition and in Micro International's DHS databank, both easily accessed on the Internet. As of 2010, recent anthropometric surveys (from the mid 2000s and onward) are available for about 100 poor and middle-income countries. The WHO does not carry out anthropometric surveys itself, but it does provide expertise and streamlines the reporting of results. All surveys that are included in the WHO database are vetted according to several quality criteria, and the same applies to the DHS.

Along with the extended coverage, there have been vast improvements in survey design, sampling, and reporting of results, which have enhanced atemporal and intertemporal comparability. In some recent surveys, there has also been an extension of coverage along age lines; not only young children, but also their mothers and, less often, adolescents and adult males are covered.

Representativity of Anthropometric Surveys

All Demographic and Health Surveys are claimed to be nationally representative, and the WHO explicitly states when it does and does not consider a survey to be nationally representative. From a global perspective (e.g., the Millennium Development Goal), it is especially important that the surveys from the most populous countries are reliable and that the samples are well taken.

India has the largest child population of all countries (about 128 million under age 5 in 2005); at the same time, it has the highest prevalence of underweight children of all 86 countries with recent national surveys (34). India has undertaken three national surveys based on a very large number of children, the NFHS (1992–1993, 1998–1999, and 2005–2006). The surveys have been produced in close cooperation with Micro International, a U.S.-based organization with funding from USAID that has carried out more than 240 Demographic and Health Surveys over the past 25 years. At least 75 articles based on DHS data have been published in peer-reviewed scientific journals in recent years. If there are serious defects in the DHS standardized sampling or other procedures, this ought to be known by now.

The collaboration with Micro International should ensure that the survey methodology used in the Indian NFHS is up to international standards and that the results are reported in a correct way. Consequently, there has been little objection to the NFHS estimates, although Deaton & Drèze reported puzzling discrepancies between these and estimates from the Indian National Nutrition Monitoring Bureau (10). However, a more detailed examination revealed that once the comparison is restricted to strictly comparable units—the same states, areas, age cohorts, and years of observation—the differences are largely eliminated (35).

When it comes to China, with the second-largest child population (about 88 million under age 5 in 2005) in the world and very low reported levels of child anthropometric failure, it is different. In its May 2010 update of its Global Database, the WHO labels seven Chinese surveys undertaken between 1990 and 2005 as "national" and one as "national rural" (the latest, from 2008). There are reasons to challenge this claim. All the surveys included in the new WHO database have been conducted by the Chinese Center for Disease Control and Prevention within the Nutrition Surveillance System. The surveys have not been undertaken in open collaboration with an international agency, such as the Micro International or the UNICEF, the samples are worryingly small, and the sampling method is unconventional.

The two surveys from the first half of the 1990s covered only 7 out of the 31 provinces in China, and the number of children assessed was 4,332 and 2,832, respectively. The claim that these small and local samples would be nationally representative is not convincing. The two subsequent surveys, from 1998 and 2000, covered about 16,000 children each, obtained in 40 sites from 26 provinces, with approximately 400 children per site. These somewhat larger surveys most likely are also not representative at the national or province levels. With an average of 1.5 sites per province, it seems legitimate to raise the question of how one or two sites can be chosen as to be representative of all children in the provinces, some of which have 100 million inhabitants and more than 5 million children below the age of 5. These populations are larger than in almost all countries in Africa, Latin America, the Middle East, and Southeast Asia. It should be recalled that for the WHO to include a country survey in its database, the number of children covered has to be at least 400. The approximately 400 children covered in the Chinese province surveys are hence not sufficient to ensure representativity.

Moreover, the choice of sites in the 1998 and 2000 surveys was probably not even intended to be representative of the province or the country as a whole. The main objective with these surveys seems to have been to gauge to what extent the large and mounting income disparities within China carry over to (child) malnutrition. The 40 sites were selected on the basis of being representative of very-high- (14 big cities), middle- (17 general rural), and low-income (9 poor rural) areas. It would be surprising if these 40 sites happened to be representative of all China.

The 40 sites (the same in the 1998 and 2000 surveys) have been geographically identified (7). The sites can hence be located to Western, Eastern, and Central provinces. Child stunting was found to be about 70% more prevalent in the 9 sites in Western provinces than in the 31 sites in Eastern and Central provinces. However, many more sites from big cities were obtained in Eastern-Central provinces and more poor rural sites were located in the Western provinces, which may have compromised representativity. A related problem is that none of the about 45,000 small cities, towns, and townships, with about 25% of the Chinese population, were surveyed in 1998 and 2000. This omission indicates that these surveys underestimated the prevalence of child stunting in urban China at the time.

The 2002 survey differs from the preceding two in that the number of sites was increased to 132, but at the same time, the number of children covered in each site was reduced to about 125, leaving the total number of observations unaltered at about 16,000 (45). The subsequent two surveys from 2005 and 2008 report decreasing levels of child stunting and underweight and were probably designed in the same way as the earlier surveys and covered about the same number of children.

The estimated prevalence of height and weight failure for children below the age of 5 in rural China, included in the "new" WHO database and based on the 2006 norms (43), is plotted in **Figure 2**. The pattern revealed is suggestive of changes in survey methodology and coverage rather than genuine developments at the national level. The most striking puzzle is for height-for-age. In the two surveys from the early 1990s, based on observations of a few thousand children in seven provinces, about 40% of the children were stunted. There was then a drastic decline over three years, by 12 percentage points, or to 27.8% in 1998. In the two subsequent surveys from 2000 and 2002, presumably carried out with the same methodology, and each covering about 16,000 children, the prevalence of stunting remained largely unaltered, followed by a new drastic decline over three years, down to 16% in 2005, with a further small drop in 2008.

All in all, there is ample reason to doubt that the Chinese surveys, claimed by the WHO to be nationally representative, actually are so. The sampling method used does not follow established international practice, the samples are uncomfortably small, and there are selection biases in many, if not all, the surveys.

Estimated Prevalence of Malnourished Children

The only method available for estimating the prevalence of malnourishment among infants and young children—at the level of countries—is anthropometrics. Given the limitations of this method discussed above, it is clear that the available estimates have to be interpreted with some caution.

The UNICEF brings together estimates from the DHS, its own surveys, and those from many other national and international agencies, and updates its compilation of surveys each year. The latest (November 2009) summary of estimated underweight, stunting, and wasting, both moderate and severe failure (<-2 SD) and severe (<-3 SD), is replicated in **Table 3**. Child malnutrition, as manifested in all three anthropometric indicators, is the most prevalent in South Asia, followed by sub-Saharan Africa. The Middle Eastern, North African, and East Asian countries (dominated by China) take a middle position, while the anthropometric failure rates are the lowest in Latin America and in the former Soviet Union Republics in Eastern Europe and Central Asia. There are, of course, large differences between individual countries in each region that for the lack of space cannot be highlighted here.

The UNICEF compilation of surveys is the most extensive available, but it is also quite heterogeneous. It mixes high-quality surveys from Micro International (DHS) with surveys from national sources that are difficult to validate. Moreover, some of the surveys are based on the

Table 3 Estimated prevalence of underweight, stunting, and wasting among female and male children 0 to 5 years old, rural and urban areas (latest available data, November 2009)

	Underweight W/A<-2 SD (%)	W/A< -3 SD (%)	Stunted H/A< -2 SD (%)	H/A< -3 SD (%)	Wasted W/H< -2 SD (%)	W/H< -3 SD (%)
Sub-Saharan Africa #	28	8	38	17	9	2
Middle East and North Africa #	17	4	23	10	8	2
South Asia #	46	17	44	22	15	3
East Asia and Pacific ¤	15	0	19	0	0	0
Latin America and Caribbean ¤	7	1	16	5	2	0
CEE/CIS ¤	5	1	14	4	3	1
All developing countries (121) #	27	10	31	16	10	2

Abbreviations: ¤, on track to reach the first U.N. Millennium Development Goal according to United Nations Children's Fund assessment (underweight <-2 SD); #, not on track; CEE/CIS, Central and Eastern Europe and the Commonwealth of Independent States; H/A, height for age; SD, standard deviation; W/A, weight for age; W/H, weight for height.
Source: United Nations Children's Fund 2009 (36).

WHO 2006 norms, whereas others are based on the old norms. It is nevertheless notable that the UNICEF aggregated estimates for all developing countries and most large regions square quite well with those reported by the WHO (43) and affiliated researchers (8) as well as my own data compilation (32), based on fewer but more homogenous surveys. The weighted average for all developing countries is almost identical in the compilations.

We can hence conclude that in the mid 2000s, around 27% of all the children in developing countries were underweight, about 30% were stunted, and 10% were wasted. The share of children with one or more anthropometric failures is substantially larger, as discussed in the section below titled The Total Burden of Child Malnutrition and the CIAF.

Estimated Prevalence of Malnourished Adults

Over recent years, the WHO has built up a database on the body mass index (BMI) status of adults in a large number of countries, published online in 2009 (44). For most developing countries, the estimates cover females only. The database contains such estimates for about 100 countries, developing and developed, obtained between 2000 and 2009. The WHO databank can hence provide a relatively extensive, even if far from complete, and up-to-date map of the nutritional status of adults in the world.

The estimated relative shares of women who are underweight (BMI <18.5) and overweight (BMI >25), respectively, in 66 developing countries are plotted in **Figure 3**. The pattern revealed is quite distinct. The countries with the highest prevalence of underweight women have relatively low shares of overweight women, and vice versa. Not a single country deviates from this pattern in a noticeable way. Ten countries have an incidence of female underweight above 20%, and in all these countries, less than 10% of women are overweight. At the other extreme, there are nine developing countries where more than 60% of women are overweight (and more than 30% are obese)—and less than 5% are underweight. It hence seems to be an "iron law" that as adult underweight in a country falls, overweight increases irrevocably (the so-called nutritional transition) (24).

The distribution of women with different BMI status in the major developing regions is presented in **Table 4**. There are, indeed, regional differences. In the Middle East and North Africa, East Asia, the Pacific, Latin

Table 4 Body mass index (BMI) of adult women in 64 developing countries and of adults of both sexes in 22 developed countries in or near the year 2005

	Number of countries	Population (million)	BMI <18.5 underweight (%)	BMI >25 overweight (%)	BMI >30 obesity (%)	BMI 18.5–24.99 normal (%)
Sub-Saharan Africa	30	649	14.8	19.4	6.2	65.8
Middle East & NA	6	210	4.1	56.6	28.4	39.3
South Asia	3	1886	33.2	12.2	2.4	54.6
East Asia	2	50	6.4	28.3	4	65.3
Pacific	3	1	5.6	69.7	40	24.7
Southeast Asia	5	275	17.3	23.9	5.9	58.8
LA & Caribbean	10	443	3.2	50.7	20.4	46.1
CEE/CIS	5	47	6.1	33.5	10.9	60.4
All above	64	3561	22.4	22.4	7.3	55.2
Developed countries	22	694	2.9	53.6	20	41.9

Calculations based on World Health Organization database on body mass index (accessed Nov. 2010) and United Nations Population Division (37, 44).
Abbreviations: CEE/CIS, Central and Eastern Europe and the Commonwealth of Independent States; LA, Latin America; NA, North Africa.

America, and Caribbean, and in the former Soviet Union Republics in Eastern Europe and Central Asia [Central and Eastern Europe and the Commonwealth of Independent States (CEE/CIS)], the share of underweight women is only marginally higher than in the Western developed countries. Underweight is by far the most prevalent in South Asia, followed by Southeast Asia and sub-Saharan Africa. The main omission in the databank is China, home to 1.35 billion people. The only entry for China is an estimate of the share of overweight adults of both sexes in 2000–2001, at 28.9% (15, 44). In most developed countries, half the adult population or more is overweight, and 15% to 25% is obese.

When it comes to adult males, the empirical evidence is much scarcer, but there are 20 developing countries for which comparable recent estimates for both males and females are reported in the WHO database. Across these 20 countries, the correlation between the shares of males and females who are underweight is quite strong (R-square = 0.83), and the same holds for overweight (R-square = 0.81). There is consequently also a relatively strong correlation (R-square = 0.69) between shares of males and females with normal weight (BMI 18.5–24.99).

The WHO warns that "it is important to note that the data presented [in this databank] are not directly comparable since they vary in terms of sampling procedures, age ranges and year(s) of data collection" (44). There is no doubt reason to be more cautious in interpreting the adult anthropometric indicators than those for young children. It is further notable that even if coverage of age and sex groups has been expanded, there are still few estimates of anthropometric failure among school-age children, adolescents, and the elderly. It is hence not yet possible to answer the question of how many people in the world are malnourished. Moreover, to answer this question we probably need more comprehensive measures of malnutrition, as discussed in the next section.

THE TOTAL BURDEN OF CHILD MALNUTRITION AND THE COMPOSITE INDEX OF ANTHROPOMETRIC FAILURE

The strengths and weaknesses of anthropometric measures as indicators of malnutrition discussed so far are well known to experts on malnutrition and nutrition-related diseases and impairments, but perhaps not to a wider audience. It is also well known that anthropometric indicators for large sections of the population in almost all countries are simply not available. But even if the question is confined to how many young children are malnourished, we have no established measure that could provide an answer. What we have are reasonably complete and reliable estimates of the share of children who are stunted, underweight, or wasted. This was the distinction made by Waterlow some 40 years ago (39) and is still the predominant way of reporting child anthropometric failure by the WHO and other international agencies.

When it comes to assessing the total burden of disease in a population, the WHO does not take a single disease or ailment, such as cancer or being crippled, as the measurement rod. The total burden of disease has since 1990 been estimated and measured by the Daily Adjusted Life Year index (DALY), a single measure of premature deaths and days lost to disease in a population. When it comes to (child) malnutrition, there is no similar comprehensive measure of the total burden of malnutrition that has been recognized by the international organizations.

The Composite Index of Anthropometric Failure Measure of Child Malnutrition

Some ten years ago (30), I proposed a measure of child malnutrition that encompasses all three conventional indicators of anthropometric failure, which I dubbed the Composite Index of Anthropometric Failure (CIAF). This index provides a comprehensive measure of overall prevalence of anthropometric failure—or the total burden of child malnutrition—and at the same time delineates subcategories of anthropometric failures that predict morbidity risk, at least for diarrhea and dysentery, more accurately than the conventional measures of stunting, underweight, and wasting (20, 21).

The CIAF model or index can be described with the help of **Figure 4**. On the horizontal axis, children's height-for-age is measured, and on the vertical axis, weight-for-age. The intersection of these two axes marks the anthropometric cutoff points for stunting and underweight. A child with a weight that deviates positively from the weight-for-age norm will hence be found to the north of the intersection; a child whose weight deviates negatively from the norm will be south of it. Conversely, a child with a height-for-age above the norm will be located to the right of the intersection and a stunted child to the left. The southwest to northeast diagonal line marks the weight-for-height norm; a child with a weight-for-height failure will be found below this line.

Suppose that we have seven children, not very affectionately named A, B, … and G, each with a different anthropometric status. Child A is the fortunate one: She has a height- and weight-for-age above the norms, as well as a weight-for-height that ensures that she is not wasted. Consequently, she does not suffer from any anthropometric failure. Child B is not stunted or underweight, but being relatively tall and thin, she is wasted. Child C is above the height-for-age norm but is underweight and wasted. Child D suffers from being simultaneously malnourished by all three conventional indicators; she is stunted, underweight, and wasted. Child E is not wasted but is both stunted and underweight. Child F is stunted but has a weight-for-age above the norm and is not wasted. Finally, child G is underweight but is not stunted or wasted. All in all, only child A is above all three norms and hence not malnourished by any of the conventional standards. Child B through child G are malnourished in at least one dimension (single burden), although some are malnourished in two (double burden) and one, D, in all three (triple burden).

Estimates of the Total Burden of Child Malnutrition

When I first suggested the CIAF index as a tool for measuring the total burden of child anthropometric failure, I did not have access to an original dataset allowing me to calculate the index properly (30). Detailed estimates provided by Nandy et al. (20) based on unit-root data from the Indian NFHS-2 survey (from 1998 to 1999), brought out roughly what I had predicted. Later on, other investigators calculated the CIAF for different populations (18, 25). Nandy & Svedberg (21) have updated the index for India, based on data from NFHS-3 (2005–2006), and also derived the CIAF for seven additional countries on the basis of unit-root data from the DHS from the late 2000s, applying the 2006 WHO norms.

The estimated CIAF and the subcategories (A to G), based on the two Indian NFHS surveys and the 2006 WHO norms, have been replicated in **Table 5** (an equivalent table calculated with the NCHS norms shows similar results). The estimated overall burden of malnutrition among Indian children is above 60% in both years; that is, less than 40% of the Indian children aged 0 to 3 years are totally free from any form of anthropometric failure. The largest category comprises those who are simultaneously stunted and underweight (E), whereas relatively few Indian children are only wasted or only underweight (B and G). About 10% of the children are stunted and underweight as well as wasted (D).

A comparison of estimates from 1998–1999 and 2005–2006 shows that some improvements have taken place. The aggregate CIAF has declined by three percentage points, or the other way around, the share of children with no failure has increased by three points. For most subcategories, the change is relatively small, but the declines in category E and F are large enough to be statistically significant (chi-square test).

In **Table 6**, the CIAF is compared with the conventional measures of child malnutrition, i.e., the prevalence of stunting, underweight, and wasting (WHO 2006 norms). The

Table 5 Composite Index of Anthropometric Failure (CIAF) failure categories for 0- to 3-year-olds in India in 1998–1999 and 2005–2006 based on World Health Organization reference norms (percent of children)

	CIAF classification category	1998–99	2005–06	Change
A	No failure	36.2	39.2	3*
B	Wasted only	3.9	5.4	1.5*
C	Wasted and underweight	6.4	7.9	1.5*
D	Wasted, stunted, and underweight	9.6	9.7	0.1
E	Stunted and underweight	24.7	20.8	−3.9*
F	Stunted only	16.9	14.5	−2.4*
G	Underweight only	2.3	2.3	0
B to G	All failure categories (CIAF)	63.8	60.8	−3*
All children		100	100	

Sources: References (20, 21), based on data from National Family Health Surveys (NFHS-2 and NFHS-3).
*Indicates that change is statistically significant at 0.05 level by Chi-square test.

estimates are derived for moderate and severe (combined) anthropometric failure as well as severe failure separately (below 3 SD of norm). The CIAF, the comprehensive measure of child anthropometric failure, is notably higher than any of the conventional subcategories, as expected. The table further reveals that while the prevalence of moderate and severe stunting and underweight has declined, that of wasting has increased (statistically significant). It is encouraging to find that the CIAF for severe failure has declined more than the equivalent index for both moderate and severe failure.

The relative size of the various subcategories in the CIAF conveys important information of what are dominating failures and, therefore, provides hints about the underlying reasons. The conventional measure of child underweight is a weight-for-age below 2 SD of the WHO norm (at 40.8% in 2005–06; **Table 6**). These children, however, comprise four subcategories. As can be calculated from **Tables 5** and **6**, the children who are "underweight only" or "underweight and wasted" make up 25% of all the underweight children. Children who are underweight in a combination with stunting hence account for three quarters. This tells us that the great majority of underweight children are so because they are short for their age and that stunting is the major problem also for most underweight children.

Children who are anthropometrically failed in one dimension make up only a little more than one-third (36.5%) of all failed children

Table 6 Comparing moderate and severe CIAF failures with conventional anthropometric indicators for 0- to 3-year-olds in India in 1998–1999 and 2005–2006 with World Health Organization reference 2006 norms (percent of children)

	Moderate and severe failure (<-2 SD)			Severe failure only (<-3 SD)		
	1998–99	2005–06	Change	1998–99	2005–06	Change
Stunted	51.2	45.1	−6.1*	27.9	22.2	−5.7*
Wasted	19.9	23.1	3.2*	6.7	8	1.3*
Underweight	42.9	40.8	−2.1*	17.8	15.9	−1.9*
CIAF	63.8	60.8	−3*	35.3	31	−4.3*

*Indicates that change is statistically significant at 0.05 level by Chi-square test.
Sources: References (20, 21), based on data from National Family Health Surveys (NFHS-2 and NFHS-3).
Abbreviations: CIAF, Composite Index of Anthropometric Failure; SD, standard deviation.

(CIAF), and "stunted only" is by far the largest such subcategory (**Table 5**). The children with multiple anthropometric handicaps hence dominate, and among these, stunting is the most predominant failure. In fact, of all the failed children, only 26% are not stunted. That stunting is such a pervasive adverse state has obvious policy implications. It has been firmly established that stunting related to malnutrition may set in already in uterus and that subsequent skeletal growth retardation occurs mainly in infancy and before the age of three; after that age, stunting is practically irreversible (27). Policies for stifling stunting must hence be implemented at early age; during pregnancy, infancy, and the next few years. The pervasiveness of stunting among malnourished children justifies the shift in focus from food quantity (calories) to food quality (micronutrients) and health care. Today it should be more appropriate to talk about nutrition-cum-health security than food security.

Extending the CIAF to Include Overweight

In recent years, mounting evidence has revealed that many young children in poor countries are overweight and even obese. In the new WHO database, the prevalence of overweight and obesity among young children is therefore reported alongside the traditional indicators of stunting, wasting, and underweight. Since the mid-2000s, the DHS have contained estimates of weight-for-height above 2 SD (overweight) and 3 SD (obesity). **Table 7** gives the most recent estimates for selected countries with repeat DHS for a uniform age cohort (usually 0 to 5 years). In four of the seven countries, the incidence of overweight and obesity is on the increase. In India, the prevalence of overweight children as of 2005–2006 was minuscule and has remained largely unaltered since the early 1990s. Only in one of the countries, Bolivia, has overweight declined. Child overweight also seems to be on the decline in China (see

Table 7 Child overweight and obesity in recent Demographic and Health Surveys for selected countries with strictly comparable estimates for an earlier year

	Year(s) of survey	N	Age group (years)	W/H >2 SD Overweight (%)	W/H >3 SD Obesity (%)	BMI >2 SD Overweight (%)	BMI >3 SD Obesity (%)	Change
Bolivia	1998	6,005	0–5	10.7	2.9	13.5	3.4	
	2008	8,527	0–5	8.7	1.9	11.2	2.1	Down*
Egypt	1992–93	7,650	0–5	14.4	4.4	17.5	5.2	
	2008	10,053	0–5	20.5	8.5	22.1	9.7	Up*
Ghana	1998–99	2,786	0–5	2.7	1.1	3.1	1	
	2008	2,666	0–5	5.9	2.3	6.9	2.5	Up*
India	1992–93	38,418	0–4	3.2	1.4	4.2	1.7	
	2005–06	39,468	0–4	2	0.8	2.8	1.1	Flat
Kenya	1993	5,111	0–5	5.9	1.4	7.2	1.4	
	2008–09	5,726	0–5	5	1.6	6.7	1.7	Flat
Madagascar	1992	4,530	0–5	1.6	0.4	2.1	0.4	
	2003–04	5,905	0–5	6.2	2.7	6.6	2.7	Up*
Nigeria	1990	6,401	0–5	3.2	1.1	4	1.1	
	2008	23,702	0–5	10.5	4.6	12.6	5.4	Up*

*Indicates that change is statistically significant at 0.05 level by Chi-square test.
Calculations based on data from World Health Organization 2010 (43).
Abbreviations: BMI, body mass index; H/A, height for age; N, number; SD, standard deviation; W/A, weight for age; W/H, weight for height.

Figure 2), but our earlier reservations about the Chinese surveys have precluded the inclusion of this country in **Table 7**.

Counting overweight and obesity as yet other forms of malnutrition seems justified and should be included in an extended CIAF (33), which is illustrated in **Figure 5**. This figure and **Figure 4** are identical save for the fact that a line delineating a weight-for-height norm for overweight has been added (W/H = OW). The two new children on the block, H and I, are both overweight, but H is at the same time stunted. Is there evidence suggesting that such a combination has been observed among children? The answer is yes. In a survey from rural Mexico, Fernald & Neufeld (14) found 5% to 10% of the children being overweight and concurrently stunted. Among children with a calorie-rich diet poor in micronutrients and living under unsanitary conditions, the outcome is not unexpected. This form of individual double-burden malnutrition may not be common, but it should not be overlooked in future surveys. Because child overweight and obesity are infrequent in India, including these categories in **Tables 5** and **6** would not change the estimated CIAF much, but for other countries, such as Egypt, where child overweight is highly prevalent, the index would increase significantly.

The subcategories of the CIAF offer tools for examining whether these have a greater predictive power of risk of morbidity than do the conventional indicators. Results from such tests are reported in Nandy et al. (20) and Nandy & Svedberg (21). The aggregated CIAF had about the same predicative power as stunting or underweight, with odds ratios around 1.5 for dysentery. However, some of the subcategories of the CIAF have higher odds ratios for dysentery than do any of the conventional indicators. Children who are simultaneously stunted, underweight, and wasted have an odds ratio of 1.80, and those who are stunted and underweight have a ratio almost as high (1.76). The children in these subcategories also live in the poorest households (as measured by a wealth index), and the children with no failure are from the most well off households. It hence seems that the CIAF subcategories may be more precise predictors of at least some morbidity risks and also of household poverty. No estimates of how child overweight and obesity are correlated to health status and poverty have yet been derived.

SYNTHESIS

It could be argued that it is fortunate that we have different measures of malnutrition to consult; that this gives a richer and more multifaceted picture of the problem. The two main methods, the FAO calorie-intake-based estimates and the WHO/UNICEF/DHS anthropometrically based estimates, are to some extent complementary. The FAO estimates are obtained for the entire population in countries, while being silent on which population groups are the most undernourished and where they are found geographically. Anthropometric estimates for entire populations are not available, but for subpopulations they give detailed information about where child malnutrition is concentrated and identify differences along gender lines and, increasingly, among adults (although schoolchildren, adolescents, and the elderly are still seldom measured).

The complementarity hypothesis can be tested by examining how well the FAO and anthropometric indicators correlate. The FAO purports to estimate the share of the population in the various countries that has a calorie intake below the norm for what it considers consistent with metabolism at a normal body weight for adults and children plus some light physical activity. One would hence expect that this share would be closely correlated to the share of adults and children who by anthropometric standards are underweight.

In previous work, I ran regressions between the FAO's estimates of "undernourishment" and the prevalence of child underweight (30). The correlation turned out significant at a low level, but the overall fit of the regression was very weak. A potential problem with that investigation was that child underweight is probably to a large extent due to illness and micronutrient deficiencies rather than to low calorie intake. Now, 11 years later, we have a much richer dataset on adults, allowing a test of the hypothesis that malnutrition in adults (women), as measured by a BMI below 18.5, should be more closely correlated to the share of households consuming unduly low amounts of calories, according to the FAO.

The correlation between the prevalence of underweight in adult women and the prevalence of undernourishment, as estimated by the FAO in years around 2005 for the 48 developing countries with data on both variables, is shown in **Figure 6**. The correlation is statistically significant at the 0.05 level, but the observations are spread all over the graph and the fit is very low (R-square = 0.11). That is, there is practically no congruence between estimated prevalence of malnutrition with the two methods.

Why should we put more trust in anthropometric indicators than in the FAO's estimates? A major strength with the anthropometric estimates, as opposed to those from the FAO, is that they are simple to obtain and reasonably free of measurement error because only a few pieces of information are required (i.e., the height, weight, and age of individuals). As mentioned above, the FAO method is highly data demanding, and the required data are of dubious quality.

There are also advantages with anthropometrics from a policy perspective. To be able to design and target interventions, policy makers need to know where the malnourished are found and who they are; the FAO method is silent on that. Thoughts on what is the main underlying cause of malnutrition are led astray with the FAO method. The chief reason for undernourishment, as estimated by the FAO method, is insufficient availability of food (calories) in countries; micronutrients are not considered. Extensive empirical research has convincingly demonstrated that the main reason for undernourishment is low income (poverty), but other factors include maternal illiteracy and subjugation and inadequate basic health-care facilities (16, 28, 30). Except in connection with wars and large natural disasters, there is no scarcity of food in any country for those who can afford to buy it. The main problem is affordability, not availability, as purported by the FAO.

SUMMARY AND CONCLUSIONS

This article has reviewed the strengths and weaknesses of the three main methods for estimating the prevalence of malnutrition in populations: self-reported hunger, estimates based on food supplies, and anthropometrics. The available estimates of self-assessed food deficiencies and hunger at the level of countries are too few to permit generalizations. It is nevertheless encouraging to find that only a few percent of Indian households report that they do not eat enough. This result squares with the estimates of how much basic food the 10% poorest households in India actually consume. The estimates provided by the FAO of undernourishment based on per capita food supplies are built on dubious assumptions and weak data and cannot be considered reliable. Although far from flawless, anthropometrics is found to be the most reliable method and also the most useful for directing policy.

The main form of malnutrition among adults is overweight, not only in developed countries, but also in almost all developing countries. Only in a few developing countries is adult underweight more prevalent at present. By the conventional anthropometric indicators, about one-quarter of all children below the age of 5 in the developing countries are found to be either stunted or underweight, and about 10% are wasted. The total burden of malnutrition among young children, as measured by the CIAF, is considerably higher, about 60% in India, the country with the largest child population in the world.

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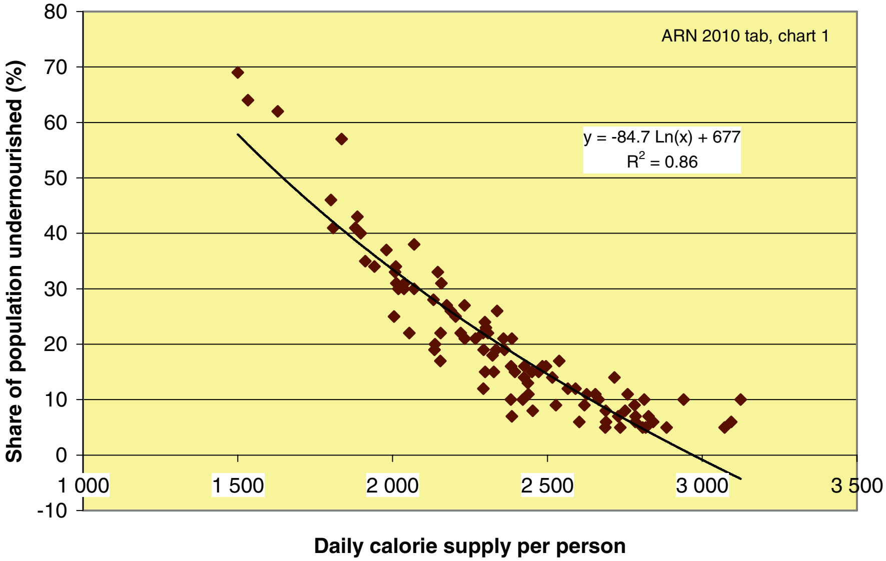

Figure 1

Plot of the prevalence of undernourishment and per capita daily calorie supply in 95 developing countries in 2005.

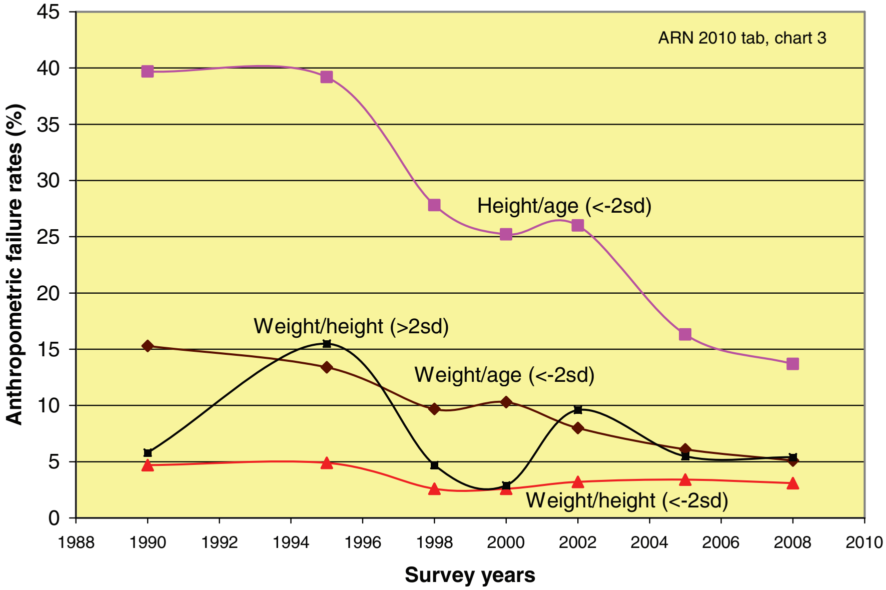

Figure 2

Child anthropometric failure in China according to national surveys reported by the World Health Organization, 1990 to 2008, rural areas.

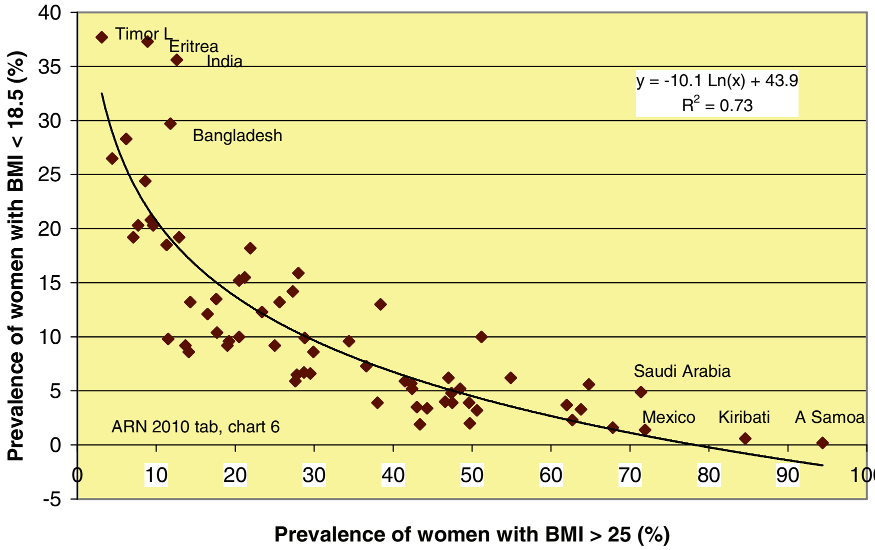

Figure 3

Prevalence of under- and overweight adult women in 66 developing countries in years around 2005.

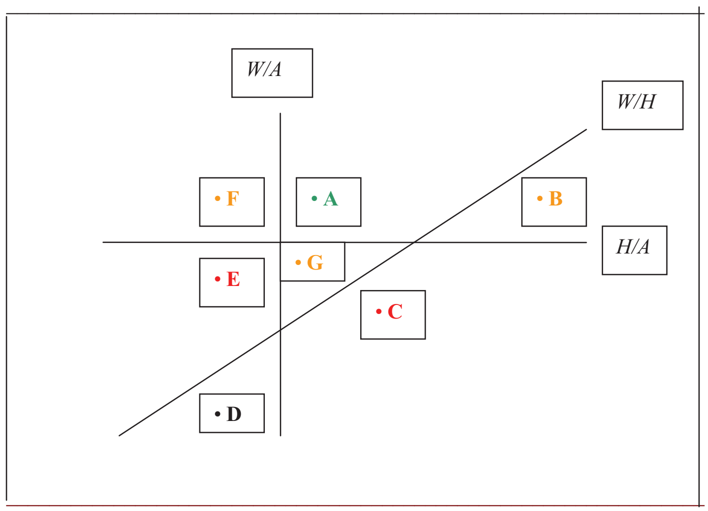

Figure 4

Description of the Composite Index of Anthropometric Failure.

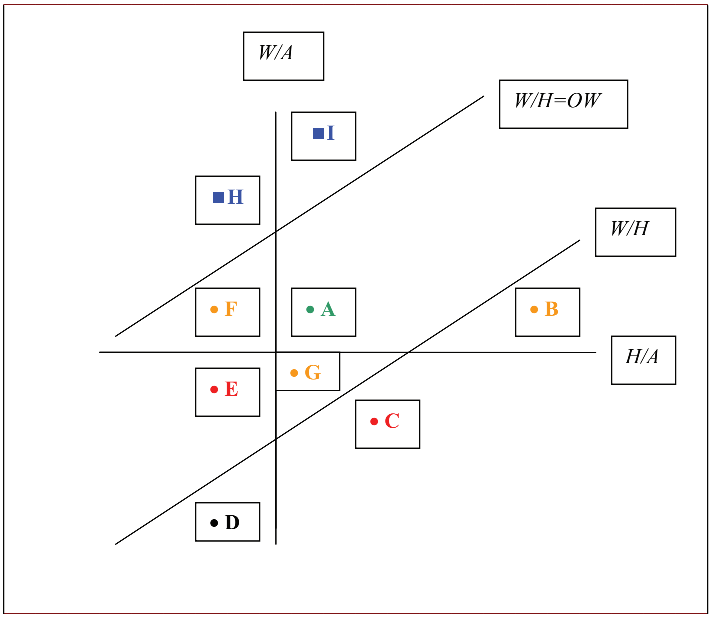

Figure 5

The Composite Index of Anthropometric Failure, extended to include overweight.

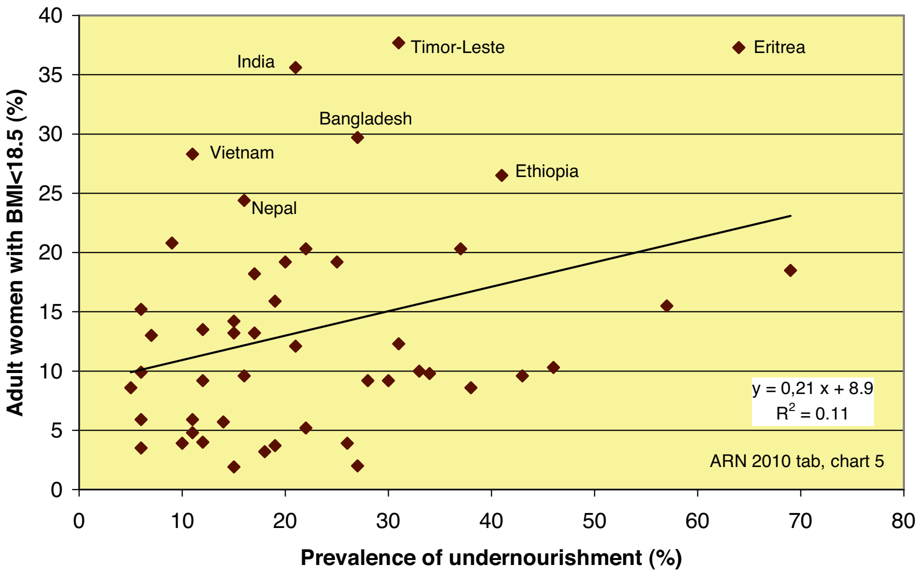

Figure 6

Prevalence of underweight adult women and undernourishment in 48 developing countries in years around 2005.

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Errata

An online log of corrections to *Annual Review of Nutrition* articles may be found at http://nutr.annualreviews.org/errata.shtml