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Undernutrition and the Nutrition Transition: Revising the undernutrition aspect of MDG I

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Abstract

Since the publication of the new multi-country reference standard by WHO it is likely that future progress in the fight against undernutrition will be tracked by using this new standard. The use of the new reference standard will result in clear changes in the prevalence and composition of undernutrition. This paper argues that this opportunity should be used to use stunting or a Composite Index of Anthropometric Failure instead of underweight as the indicator to measure progress in the fight against hunger. All weight based anthropometric measures, such as underweight and wasting, suffer from the fact that due to changes in the nutritional composition of diets in developing countries there is going to be a secular reduction in those measures that does not coincide with real improvements in the health of the affected children. This bias could lead to wrong conclusions concerning the fulfillment of the undernutrition aspect of MDG I.

***JEL* Classification:** I10, I32, O12 .

Key words: Nutrition transition, child undernutrition, Millennium Development Goals, composition of undernutrition

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1 Introduction

In September 2000, leaders from 189 countries adopted the eight Millennium Development Goals of which the most prominent goal is to eradicate extreme poverty and hunger. To be able to track progress on this commitment a number of relevant indicators was selected to be used to assess progress over the period from 1990 to 2015, when targets are expected to be met. With respect to hunger the explicit goal is to halve the proportion of people who suffer from hunger. The decision was made to use two different indicators to track progress with respect to the incidence of undernutrition. The first indicator is the FAO measure of access to an insufficient amount of calories.

Due to the lack of appropriate information on the household level on caloric availability, the FAO uses a macro approach that proceeds in three steps. In the first step the per capita caloric availability in a country is calculated by estimating food production (including auto-consumption), subtracting imports, making allowances for waste and use as seed, and then transforming available food into its caloric content. After dividing by population, per capita availability is computed on a 3-year rolling average basis. In the second step, an estimation of the distribution of calories among households is performed, under the assumption of a log normal distribution and with an estimate that takes into account inequality in food expenditures. In the third step the average age-sex composition and activity levels are used to calculate the cut-off point which is then applied to the log-normal distribution to calculate the share of undernourished persons [1] (Klasen 2007).

Unfortunately, there are considerable methodological as well as conceptual doubts about this FAO measure. It especially remains unclear whether the FAO measure of undernourishment really presents a reliable estimate of the proportion of the population that is 'hungry' in a given year (see e.g. Klasen 2007; Svedberg 2002). Especially the geographical composition

[1] For a detailed discussion of the method see Naiken (2003).

of undernutrition according to the FAO measure stands in strong contrast to evidence from anthropometric measures (Svedberg 1999, Klasen 2003). Therefore it is of considerable importance that the second measure for undernutrition gives a better and more reliable picture about the real incidence of undernutrition.

The second measure used in the MDGs is 'underweight', which is an anthropometric indicator that measures the weight of a child for a certain age and compares it to a reference standard to be able to categorize a child as undernourished or not. The two other well known measures of effective nutritional status are stunting (height for age) and wasting (weight for height). Anthropometric indicators have different advantages and drawbacks that are well known in the literature (see especially Svedberg 2002, Klasen 2007). Probably the largest drawback of these three anthropometric measures is, that information is almost entirely restricted to children up to the age of five years. Each of these three indicators measures a different aspect of undernutrition. While stunting is a measure for chronic hunger, wasting reflects an acute lack of energy. The interpretation of underweight is not entirely clear. Generally it is used as a summary indicator that takes account of both a low weight for age due to a very low weight for height as well as a low weight due to a low height for age.

As this paper will argue, the choice of underweight as the second measure for the hunger dimension of poverty is not very fortunate. On the one hand, there are doubts about the general construction and interpretation of underweight that make it not very suitable to be used as a summary indicator. On the other hand, and this will be the main focus of this paper, we can observe a bias in the development of underweight prevalence rates that is due to the large changes in the nutritional composition of diets in developing countries that are taking place. This so called 'nutrition transition' is characterized in large increases in the consumption of processed and semi-processed foods, that contain higher percentages of cheap fatty acids. Although this certainly means that total energy amounts taken up by children are increasing this should not be equalized with real improvements in their nutritional situation. Because of lacking vital micronutrients children might still suffer from severe growth retardations while having a weight for age that is not considerably below the growth and weight reference standard. Therefore, a secular reduction in weight based measures might show up that does not coincide with real improvements in the health of the affected children. In fact, as shown in Section 5, we can observe improvements in wasting and underweight rates in a number of countries that are not reflected in similar changes in stunting rates.

Therefore, it is argued that it would make sense to revise the undernutrition aspect of MDG I by using stunting rates or the also unbiased Composite Index of Anthropometric Failure (CIAF) instead of underweight rates. As the publication of the new multi-country reference standard by WHO is very likely to lead to a tracking of future progress using this new standard, a revision could take place during the adoption of the new reference standard.

The paper is structured as follows. Section 2 gives an overview over the differences in the incidence of undernutrition between the old and new reference standard and the advantages of the new reference standard. The following Section 3 illustrates the changes in the nutrition status that are taking place in the developing world due to the progressing of the nutrition transition. After a short description of the used data in section 4, section 5 focuses on the empirical results and emphasizes the importance of having a closer look at the exact composition of undernutrition. Scrutinizing differences in the composition of undernutrition across different subgroups and over time shows that a strong bias is inherent in weight based measures.

2 The new WHO Child Growth Standard

As is well known, there are a large number of limitations of the NCHS/WHO reference and these limitations have been documented by different authors (notably WHO Working Group on Infant Growth, 1994; de Onis and Yip, 1996; de Onis and Habicht, 1996). On the one hand the data used to construct the reference covering birth to two years of age were derived from a longitudinal study of children of European ancestry from a single community in the USA. Besides these children were measured only every three months, which is an inadequate way to describe the rapid and changing rate of growth in early infancy. Another aspect is that statistical methods have developed further in the last decades and are therefore better able to correctly model the pattern and variability of growth of children during their first five years.

As a consequence the WHO implemented the Multicentre Growth Reference Study (MGRS) which included children from six different countries: Brazil, Ghana, India, Norway, Oman and the USA. To make sure that only children were considered that are likely to have achieved their full genetic growth potential, only mothers were considered that engaged in fundamental health-promoting practices, namely breastfeeding and not smoking (de Onis et al., 2004). By selecting only privileged, healthy populations the study reduced the impact of environmental variation and is therefore very suitable to construct a truly international reference standard.

These aspects make it very likely that the new WHO reference standard will be adopted as the main indicator to track the progress in reductions in child undernutrition according to MDG I. One first consequence will be that initial undernutrition rates using the new WHO reference standard will increase compared to undernutrition rates using the old NCHS/WHO reference standard. Tab. 1 shows the prevalence rates for the four different anthropometric indicators using both reference standards for the eleven countries considered in this study.

Table 1
Prevalence rates of undernutrition
(according to NCHS/WHO and WHO 2006 reference standards)

Country	Reference	Stunting	Underweight	Wasting	CIAF
Burkina Faso 2003	NCHS/WHO	38.59	39.16	19.86	55.94
Burkina Faso 2003	WHO 2006	43.72	34.83	22.68	59.30
Bolivia 2003	NCHS/WHO	27.75	7.89	1.51	29.90
Bolivia 2003	WHO 2006	33.58	5.61	1.92	35.33
Chad 2004	NCHS/WHO	39.28	36.84	14.86	52.40
Chad 2004	WHO 2006	42.80	32.85	17.44	54.85
Cameroon 2004	NCHS/WHO	31.72	17.42	4.77	37.59
Cameroon 2004	WHO 2006	36.62	13.42	5.27	40.75
Colombia 2005	NCHS/WHO	12.06	7.63	1.67	15.40
Colombia 2005	WHO 2006	16.24	5.38	1.99	18.45
Egypt 2003	NCHS/WHO	15.78	8.62	3.68	20.76
Egypt 2003	WHO 2006	19.47	7.82	4.75	24.25
Ghana 2003	NCHS/WHO	30.90	23.43	7.69	40.17
Ghana 2003	WHO 2006	36.75	19.42	8.99	44.02
India 1998/99	NCHS/WHO	43.36	43.74	14.83	57.33
India 1998/99	WHO 2006	49.13	39.53	18.83	61.25
Tanzania 2004	NCHS/WHO	36.46	22.67	3.69	41.95
Tanzania 2004	WHO 2006	42.48	16.97	4.40	46.14
Uganda 2001/02	NCHS/WHO	37.88	21.50	3.93	42.57
Uganda 2001/02	WHO 2006	43.87	17.43	4.78	47.39
Zambia 2001/02	NCHS/WHO	47.55	28.64	4.84	53.39
Zambia 2001/02	WHO 2006	54.09	23.26	5.84	58.25

Source: DHS datasets; Own calculations.

Although the numbers in Tab. 1 show increases in stunting, wasting and the Composite Index of Anthropometric Failure (CIAF), underweight rates fall in all cases. This puzzling phenomenon will be discussed in more detail in Section 5. Besides these general trends, the numbers hide that changes in undernutrition rates due to the adoption of the new reference standard are much more complex than just a simple increases or decreases. This can be seen in Table 2 which is a mobility matrix that shows that the composition of undernutrition changes considerably. Looking for example at the first row of Tab. 2 one can observe that over 88% of children that were not malnourished according to the WHO/NCHS reference standard are also not malnourished according to the new WHO reference standard. The remaining around 11% of the children are now considered as only stunted (6.89%), stunted and underweight (0.64%), undernourished according to all three indicators (0.21%), only wasted (1.75%), wasted and underweight (0.88%) and only underweight (0.73%). But as mentioned before, the changes are not limited to increases in undernutrition rates, but a large number of individuals is now counted as not malnourished according to the new WHO reference standard that were categorized as malnourished using the NCHS/WHO reference standard. For example more than 16% of children that were only wasted according to the old reference standard are now considered as not malnourished and 39% of children that were only underweight according to the NCHS/WHO reference standard have Z-Scores above -2.0 according to the new standard.

Table 2
Mobility Matrix of NCHS/WHO to WHO reference standard
(percentage)

	A	B	C	D	E	F	G
A - "Not malnourished"	88.88	6.89	0.64	0.21	1.75	0.88	0.73
B - "Only Stunted"	1.44	95.72	2.83	0.00	0.00	0.00	0.01
C - "Stunted and Underweight"	0.25	17.63	76.25	5.69	0.00	0.07	0.11
D - "All Indicators"	0.00	0.00	7.35	91.56	0.00	0.97	0.12
E - "Only Wasted"	16.42	0.00	0.00	0.03	71.30	12.25	0.00
F - "Wasted and Underweight"	5.02	0.00	1.11	10.04	11.47	68.47	3.89
G - "Only Underweight"	39.06	11.00	16.77	3.30	0.91	9.72	19.25

Note: *In each row the 100% of the respective category of the NCHS/WHO reference standard are divided into the same categories according to the new WHO reference standard. The percentages are generated from a pooled data set of all 22 data sets used in the present study.

These complex changes necessitate the complete revision of the nutrition aspect of MDG I using the new reference standard as basis for the measurement of progress in the reduction in undernutrition. This opportunity should be used to switch to stunting as alternative indicator, since all weight-based measures are inherently biased by the consequences of the Nutrition Transition as the following Section 3 will show.

3 The Nutrition Transition

Changes in diet and activity patterns are not limited to the developed countries but are rapidly taking place in the developing regions as well. For a large set of countries marked shifts in the structure of the diet have been documented (e.g. Kim et al. 2000, Monteiro et al. 1995, Popkin 1994, Popkin 1998). Major dietary changes include large increases in the consumption of fat and added sugar in the diet and often a significant increase in animal food products. This is contrasted with a fall in total cereal intake and fiber. Although there is a great heterogeneity in the diet shifts, there seems to be a general shift to the higher fat Western diet, which is reflected by a large proportion of the population consuming over 30% of energy from fat. These diet and activity patterns are fueling the obesity epidemic that is also rapidly proceeding in the developing countries. As a consequence large increases in diet-related chronic diseases such as diabetes and cardiovascular diseases are discernable. In fact the WHO estimates that two thirds of deaths due to chronic disease worldwide now occur in developing countries and that obesity is a primary risk factor in this context (WHO 2004).

The nutrition transition and its related disease pattern might lead to the misconception that diets are moving entirely away from undernutrition toward problems of excess. Unfortunately the rapid increase in obesity does not come along with an equally rapid decrease in malnutrition or undernutrition. This could be the case due to the fact that not all individuals in a given society profit in the same way from increases in energy availability. During this transition, symptoms of under- and overnutrition logically coexist at the population level, with wealthier households exhibiting diseases of affluence including obesity, and poorer households exhibiting food insecurity and malnutrition. But recent work indicates that under- and overnutrition can coexist in the same household (Doak et al. 2000, 2002; Monteiro et al. 1997). In fact the prevalence of stunted child-overweight mother pairs is not as seldom as one could assume, with the highest level being recorded for Egypt, where 14 percent of children live in stunted child-overweight mother pairs (Garrett and Ruel 2003). Besides Kandala et al. (2001) find a nonlinear influence of the BMI of the mother that might indicate that not only parental undernutrition, but also parental malnutrition might also have negative effects on the nutritional status of children. As is argued in the following the coexistence of under- and overweight in the same household is not a very unequal distribution of diets within households but the fact that increases in total energy intake do not coincide with equal increases in all vital micronutrients and, therefore, children might on average gain weight while still being malnourished.

It is therefore possible, that the nutrition transition will have two detrimental effects on policies concerning child undernutrition. On the one hand the emerging obesity epidemic might lead to the misconception that undernutrition is a phenomenon of the past. On the other hand using the 'wrong' indicator for undernutrition might also lead to wrong conclusions concerning the prevalence of undernutrition in developing countries. On the latter aspect will be the prime focus of this article. It is argued that the use of weight-based anthropometric measures is biased by the nutrition transition that leads to increases in the weight of children that do not necessarily reflect improvements in their nutritional status. They might still suffer from micronutrient malnutrition that will have severe long-term effects (Eckhardt 2006) and that is reflected in reduced long term growth of children. This micronutrient malnutrition can be accounted for when stunting is used as the anthropometric indicator for child undernutrition or alternatively the Composite Index of Anthropometric Failure (CIAF). The fact that such a bias is present in the underweight measure will be shown in the following sections.

Although it is argued that stunting is a much better measure for undernutrition than underweight or wasting, one has to keep in mind that a certain degree of overestimation is inherent in stunting, especially in comparison to a measure of average calorie availability like the FAO measure. This results from the fact that stunting measures the effective nutritional status and an inadequate access to calories is only one of the reasons why the growth of a child can falter. Other main reasons are frequent, prolonged and untreated illness that reduce the appetite and the absorption of energy in the body. Energy may also by diverted by intestinal parasites (Svedberg 2002).

A second aspect that has to be kept in mind is the fact that comparisons between countries and regions are made by using one general reference standard, i.e. using identical height and weight norms. It has been claimed that the genetic potential for growth in children is not the same for all regions (Bogin 1988, Davies 1988, Eveleth and Tanner 1990). Besides Klasen (2007) demonstrates that even minor differences of 1-3% in median height of children at age 5 between regions can lead to significant measurement biases, that result in an overestimation of the incidence of undernutrition in regions with a growth pattern of slightly lower growth. Still the consensus view seems to be that there are no or only very small genetic differences between populations in their growth and weight development between 0 and 5 years. This view is backed up by a variety of studies that showed that differences in growth and weight patterns between affluent groups of various countries are extremely similar (e.g. Graitcer and Gentry 1981, Ramalingaswami et al. 1996, WHO 1995, Bhandari et al. 2002).

It is important to keep in mind that these two confinements are not limited to stunting but general limitations of the three anthropometric measures. They can therefore not be used to favor any of these measures.

4 Data

To get information on the prevalence and composition of undernutrition a sample of eleven countries from all developing regions is used. The data employed are nationally representative demographic and health surveys (DHS) surveys that provide information on anthropometric outcomes of children. To be able to illustrate changes in anthropometric outcomes two data sets for each country are used, bringing the total number of data sets two twenty-two (see Tab. 3).

The inclusion of countries was mainly driven by data availability. Only countries with at least two surveys were considered, with the surveys being spaced by at least 5 years and the latter survey being as recent as possible. Data availability for Asian countries was especially limited, since most surveys do not include any anthropometric information. Therefore India was used due to the well known high data quality as well as the huge number of observations.

Table 3
Data Sources: Demographic and Health Surveys (DHS)

Country	Year	Country	Year	Country	Year
Burkina Faso	1998/99	Colombia	1995	Tanzania	1996
Burkina Faso	2003	Colombia	2005	Tanzania	2004
Bolivia	1993/94	Egypt	1995	Uganda	1995
Bolivia	2003	Egypt	2003	Uganda	2000/01
Chad	1996/97	Ghana	1993	Zambia	1996
Chad	2003	Ghana	2003	Zambia	2001/02
Colombia	1995	India	1998/99		
Colombia	2005	India	1998/99		

The DHS datasets contain information on height, weight and age of all children below age 5 as well as the already computed Z-scores for the NCHS/WHO reference standard. Using a new version of the software ANTHRO published by WHO it is possible to use the anthropometric information to calculate Z-scores for the new WHO reference standard.

Besides the information on children, the DHS datasets contain a large set of other relevant covariates that play an important role in explaining child undernutrition, as for example the education of mothers or the area of residence. Unfortunately the surveys do not contain information on income or expenditure. Therefore an asset-based approach is used to define well-being (Sahn and Stifel, 2001).

In order to construct an asset index for DHS households, first, a set of household assets was identified, which were the ownership of a radio, TV, refrigerator, bicycle, motorized vehicle, floor material of housing, type of toilet, type of water source and some other assets depending on the country. Afterwards, these assets were aggregated into one single metric index for each household using the first component of principal component analysis, or, alternatively, the closely related factor analysis (see Filmer and Pritchett (2001) and Sahn and Stifel (2001)). In this case principal component analysis was used. Once the asset index is built, one can construct the cumulative distribution function of the asset index and, hence, households in the DHS can be classified into asset quintiles.

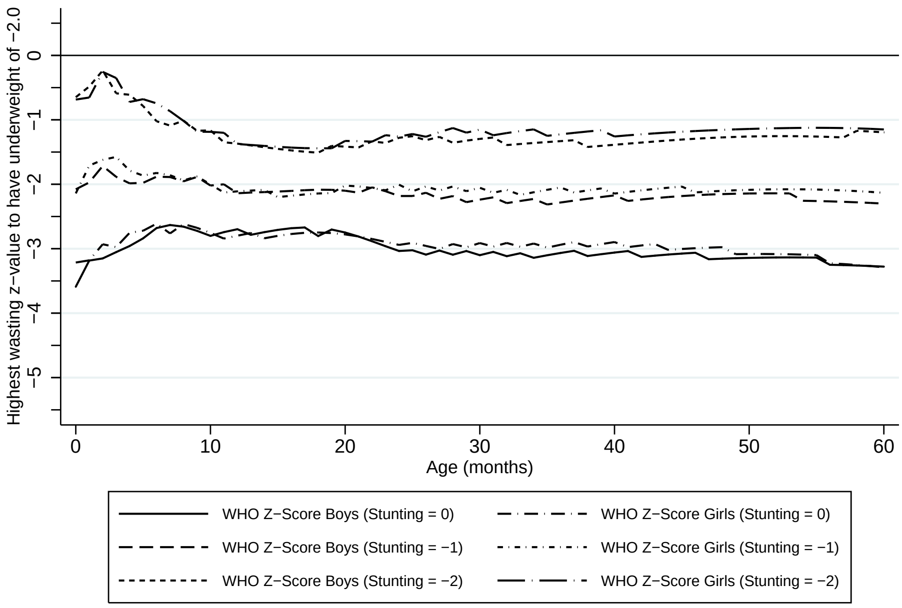
5 Results

The following section will first present some general aspects considering the construction of the underweight measure and especially point to the changes in prevalence rates between the old NCHS/WHO and the new WHO reference standard. Afterwards some empirical results with respect to the composition of undernutrition and especially the composition over time will be discussed. All results are based on own calculations using the aforementioned DHS surveys.

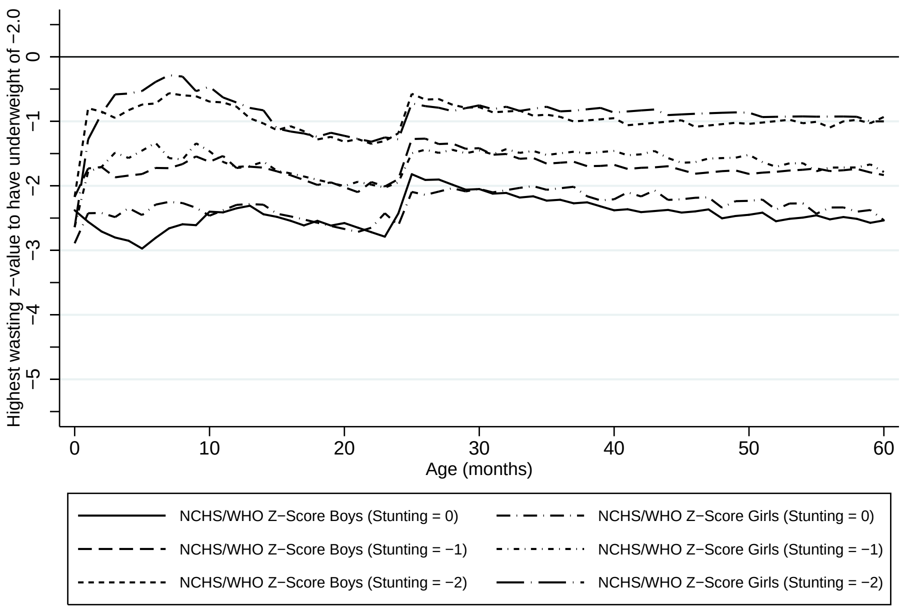
5.1 The theoretical composition of the underweight indicator

As mentioned before, undernutrition can be measured by three different anthropometric measures, namely stunting, wasting and underweight. The classical idea of undernutrition, a low weight for height, is measured by wasting which is therefore a measure of immediate undernutrition. Contrary to that a long run supply of insufficient amounts of energy will result in growth retardations which are measured by stunting (low height for age). Although it is well known that weight is more sensitive than height to seasonal influences, but height generally more responsive than weight to improved food intake in the long term (WHO 1994), the weight-based measure underweight (low weight for age) is used to track long term changes in child undernutrition. This derives from the intention to take account of both types of undernutrition, long-term as well as immediate.

Theoretically there are two reasons for a low weight for age. First, a value of more than 2 standard deviations below the reference standard can occur due to a very low weight for height. Second a underweight z-score of less than -2.0 can occur due to a very low height for age. Unfortunately underweight does not capture all individuals that are undernourished according to any of the other two measures. To demonstrate what children are really considered as 'underweight' different pairs of stunting and wasting z-scores are shown in Fig. 1-4 using both the NCHS/WHO and the WHO reference standard. These figures show that the relationship between stunting, wasting and underweight is rather complex. Besides the figures show that the underweight measures does not really capture what it is supposed to do.



Source: WHO reference standard; own calculations.



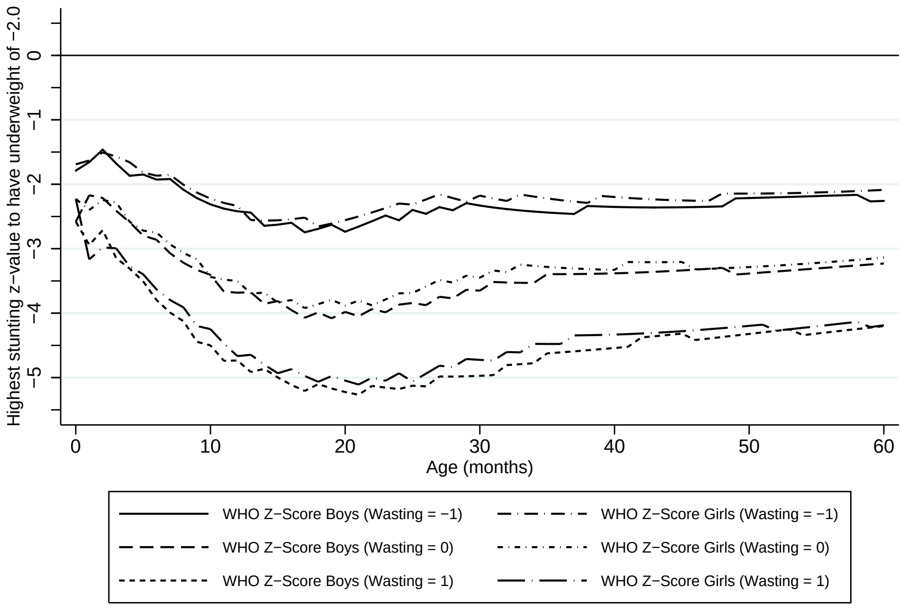
Source: NCHS/WHO reference standard; own calculations.

If underweight was really suitable as a summary indicator than for example every child that has a normal height for its age and a wasting z-score of below -2.0 would be counted as underweight. In fact as Fig. 1 shows if it is assumed that a child has a height for age that corresponds to the new WHO reference standard (i.e. a stunting z-score of 0) has to have a wasting z-score of about -3 or below to have an underweight z-score of below -2.0. That means a boy or girl with normal height has to be severely wasted to be counted as underweight. When a child has a stunting z-score of -2 it still has to be slightly wasted and has to have a wasting z-score below -1 (depending on its exact age in months).

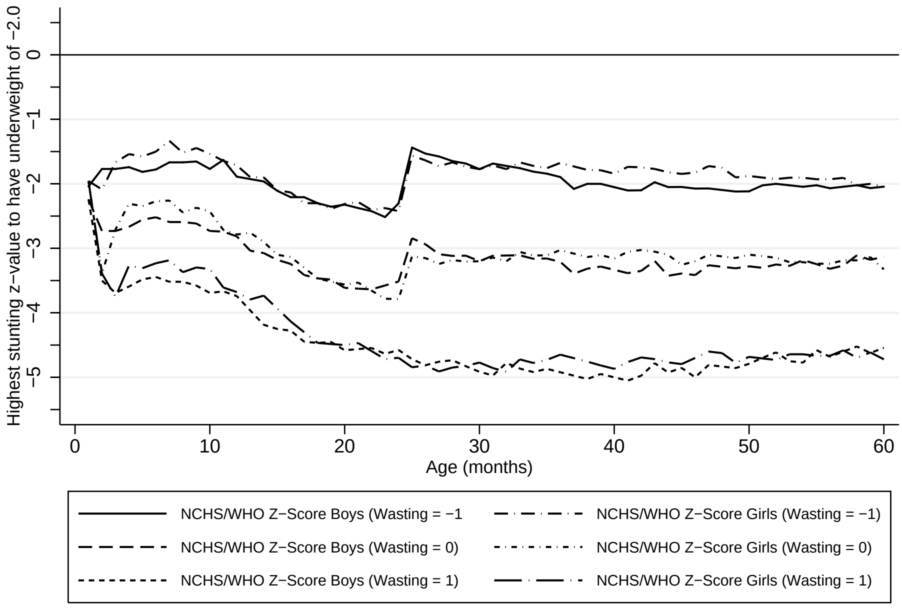
Using the old NCHS/WHO reference standard the relationship between stunting, wasting and underweight is even more complex, with a clear jump being discernable when the reference switches between length and height measures. This jump is not existent in the new WHO reference standard.

But what is even more meaningful is the fact that the z-score requirements for wasting (for given stunting z-scores) are significantly lower in the NCHS/WHO reference standard than in the WHO reference standard. A child with a height according to the old reference standard is counted as underweight, when it has an wasting z-score of about -2.5 or below. The differing z-score requirements between the two reference standards are easily observable in Tab. A1 and A2 in the appendix.

Although it is not entirely clear how this shifts comes about, one possible reason could be that children with 'unhealthy weights for length/height', i.e. observations falling above +3SD and below -3SD of the sample median were excluded prior to constructing the WHO reference standard. For the cross-sectional sample the +2 SD cut-off was applied (WHO Multicentre Growth Reference Study Group 2006). The exclusion of this observations shifts the values of the weight standard downwards and therefore increases the weight shortfall requirements.



Source: WHO reference standard; own calculations.



Source: NCHS/WHO reference standard; own calculations.

As Fig. 3 shows, the requirements for stunting z-scores, given a 'normal' nutrition status according to wasting, are even more restrictive when the WHO reference standard is used. If boys or girls have a wasting z-score of 0, children have to have a stunting z-score of significantly below -3 to be counted as underweight. Only in the first eight month a stunting z-score between -2.5 and -3 is low enough to be also considered as underweight. If a child is mildly wasted (wasting z-score of -1) a child still has to be considerably stunted (stunting z-score of below -2) to be counted as underweight.

When comparing Fig. 3 and 4, we can again discover that the NCHS/WHO reference standard is not as restrictive as the WHO reference standard. The only exception is the scenario in which a wasting z-score of +1 is assumed. In this case only children with extremely low stunting z-scores do potentially fall in the group of underweight children. As Table A2 in the appendix shows, in this case the NCHS/WHO curve is up to the age of 26 months above and afterwards below the WHO curve. It is important to keep in mind, that increases in wasting z-scores are very likely in the developing world due to the aforementioned nutrition transition. The threshold be counted as underweight is therefore becoming more and more restrictive.

As the preceding figures have shown, concentrating on a measure like underweight risks neglecting a large number of undernourished children. Although this is also the case for the other two measures, - just as the concentration on any of the other two indicators does. The only possibility to really capture all undernourished children is by using the Composite Index of Anthropometric Failure (CIAF) proposed by Svedberg (2001) and modified by Nandy et al. (2005).[2] This index indicates whether a child is undernourished according to any of the three anthropometric indicators.

[2]Nandy et al. (2005) that the CIAF consists of six subgroups contrary to the five groups proposed by Svedberg (2002), with the last group being children that are undernourished according to the underweight indicator only.

5.2 The empirical composition of the underweight indicator

Knowing the theoretical requirements for the underweight indicator it is of considerable interest to have a closer look at its actual composition. As Tab. 4a shows, more than 42% of children with an underweight z-score of below -2.0 exhibit stunting z-scores below -3.0. This already points to the strict requirements for underweight, when undernutrition is limited to long-term undernutrition and a child has a normal weight for its height. At the same time Tab. 4a shows that some children that are considered neither as stunted nor wasted can at the same time be indicated as underweight. In fact more than 12% of the 47,2222 children that are underweight according to the NCHS/WHO reference standard stem from categories C and D in both indicators at the same time and are therefore neither considered as stunted nor wasted. It is therefore unclear whether it is really appropriate to consider these children as undernourished.

Table 4a
Composition of group of underweight children
(using NCHS/WHO reference standard)

	Wasting Z-Score						
Stunting Z-Score	A	B	C	D	E	F	Total
A - lower than -3.0	1.09	5.03	14.66	15.92	5.55	0.99	42.23
B - between -3.0 and -2.0	1.09	5.42	16.41	8.20	0.21	0.00	31.33
C - between -2.0 and -1.0	1.23	5.78	10.88	0.43	0.00	0.00	18.32
D - between -1.0 and 0.0	1.05	3.54	0.80	0.00	0.00	0.00	5.39
E - between 0.0 and 1.0	0.80	0.53	0.00	0.00	0.00	0.00	1.33
F - larger than 2.0	0.37	0.03	0.00	0.00	0.00	0.00	0.40
Total	5.64	20.32	42.75	24.54	5.76	0.99	100.00

Note: *Each cell denotes the percentage of all children with an underweight z-score of less than -2.0 that is in the respective category. The categories A-F are the same for wasting and stunting. In total there are 47,222 children with an underweight z-score of less than -2.0 according to the NCHS/WHO reference standard. *Source:* Pooled dataset of all 22 DHS datasets used in this study.

The percentage of children that are only underweight and neither wasted nor stunted is much lower when the new WHO reference standard is used. In this case only 4.84% of the remaining 42,424 children are at the same time in categories C and D for both indicators. This reduction is entirely due to the fact that the nutrition status has to be worse to get an underweight z-score of below -2.0. This is demonstrated by the drop in the total number of underweight children as well as by the fact that fraction of children that have severe growth failures has increased to more than 54%.

Table 4b
Composition of group of underweight children
(using the new WHO reference standard)

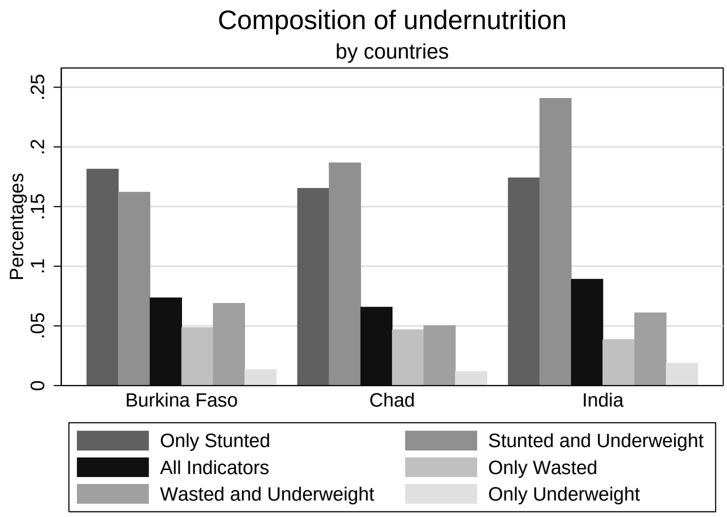
	Wasting Z-Score						
Stunting Z-Score	A	B	C	D	E	F	Total
A - lower than -3.0	4.17	7.04	15.36	18.60	6.90	2.15	54.21
B - between -3.0 and -2.0	2.69	5.46	12.90	4.51	0.24	0.00	25.81
C - between -2.0 and -1.0	2.81	5.52	4.62	0.16	0.00	0.00	13.11
D - between -1.0 and 0.0	2.38	2.12	0.06	0.00	0.00	0.00	4.56
E - between 0.0 and 1.0	1.39	0.05	0.00	0.00	0.00	0.00	1.44
F - larger than 2.0	0.87	0.00	0.00	0.00	0.00	0.00	0.87
Total	14.30	20.20	32.94	23.27	7.14	2.16	100.00

Note: *Each cell denotes the percentage of all children with an underweight z-score of less than -2.0 that is in the respective category. The categories A-F are the same for wasting and stunting. In total there are 42,424 children with an underweight z-score of less than -2.0 according to the new WHO reference standard. *Source:* Pooled dataset of all 22 DHS datasets used in this study.

Both the theoretical as well as the actual composition of the group of underweight children show that this indicator is not very suitable to be used as a summary indicator for undernutrition. In fact it is very doubtful whether it is an suitable indicator at all due to the difficulty in interpreting it and the inclusion of children that are not undernourished according to the other two better defined indicators. Besides it was shown, that the use of the new WHO reference standard will directly result in a decrease in the number of underweight children, although there are increases in stunting and wasting. Consequently it is by definition more difficult to be underweight and official figures will display decreases in the prevalence of undernutrition according to this indicator. It would therefore be highly recommendable to switch to an alternative indicator.

5.3 The Composition of Undernutrition across countries

When considering the choice of an alternative indicator it is very helpful to have a closer look at the exact composition of undernutrition across countries. As the data analysis of the 22 datasets in this study shows, this composition varies a lot between countries (see Fig. 5 - 7 below)[3]. Therefore concentrating on any of the three measures will not only neglect significant numbers of children that are undernourished according to a different indicator, but the general ranking of countries will also vary depending on which indicator is used.

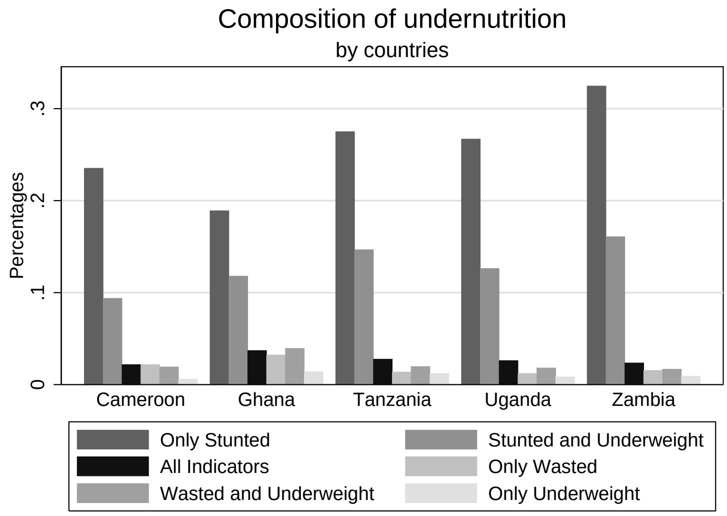


Source: DHS datasets; own calculations.

By comparing the different general compositions of undernutrition it is possible to discern three different groups of countries. The first group (Fig. 5) are those countries where large percentages of the population have insufficient energy intakes (in this study Burkina Faso, Chad and India fall into this category). In these countries the lack of energy intake results not just

[3]It is important to note, that the only left out categories in all figures is the group of children that are not malnourished according to all indicators, that means that have higher Z-values than -2.0 for stunting, wasting and underweight.

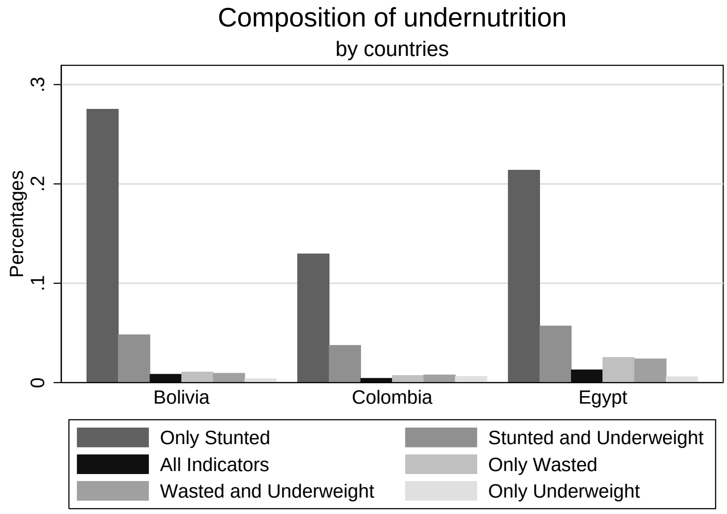
in large numbers of stunted children but these growth retardations are so severe that a similar number of children is undernourished according to both stunting and underweight as is according to stunting only. A very significant number of children can also be found that are undernourished according to all three indicators. This shows an extremely bad nutritional status. Although already an adaptation of the growth process to the insufficient energy intake has taken place the energy amounts are still insufficient to generate a normal body composition.



Source: DHS datasets; own calculations.

In the second group of countries (Fig. 6), i.e. Cameroon, Ghana, Tanzania, Uganda and Zambia, the prevalence of children that are only stunted is about twice as high as the prevalence of children that are undernourished according to both stunting and underweight. The prevalence of the other four categories is much lower than in the first group.

Finally, in the third group of countries (Fig. 7), i.e. Bolivia, Colombia and Egypt, undernutrition is almost completely confined to stunting. The ratio of stunting to stunting and underweight is even higher and the number of children with Z-values of lower than -2.0 according to all three indicators is almost negligible.

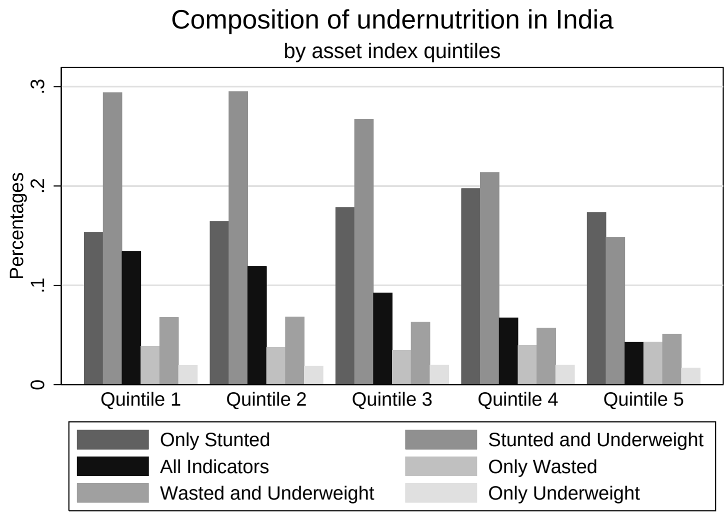


Source: DHS datasets; own calculations.

As a comparison of the three general groups shows, stunting is the most persistent measure, displaying the highest rates in the last group as well as the lowest improvements between groups. This fact can also be seen, when we compare different subgroups for children in any given country.

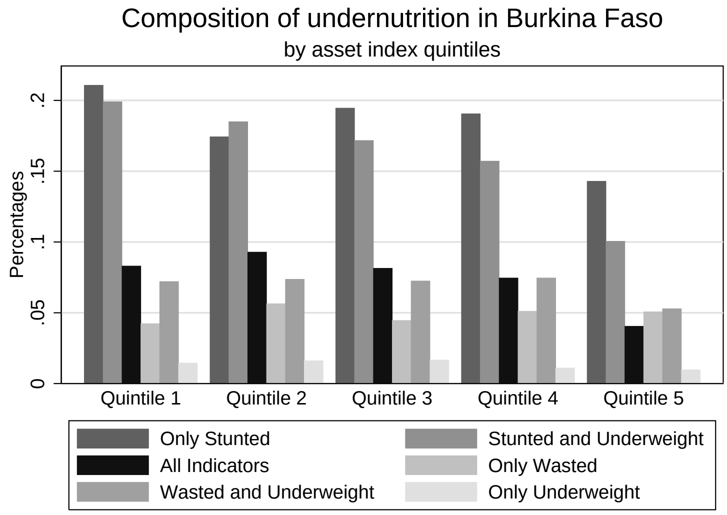
5.4 Composition of Undernutrition across subgroups

Interestingly enough the general country patterns are very consistent over different subcategories. A good way of showing this is by comparing the composition of undernutrition across different wealth groups. Since no expenditure or income data are available in the DHS datasets, an asset-based approach is used to define wealth (Sahn and Stifel, 2001).



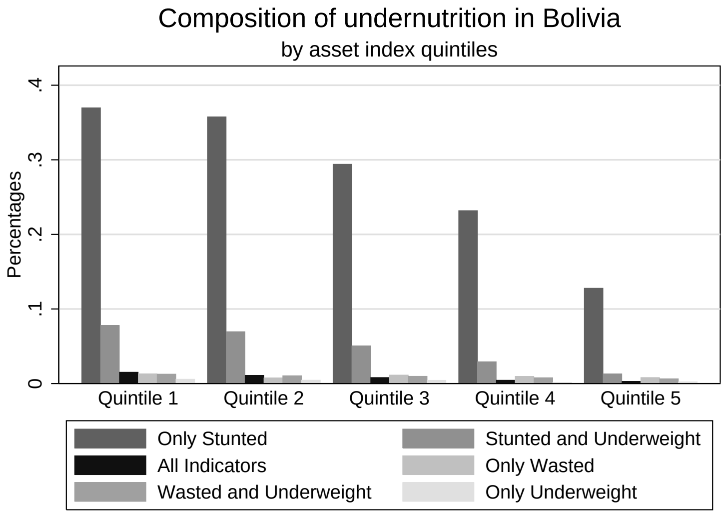
Source: DHS dataset (India 1998/99); own calculations.

The composition of undernutrition across asset index quintiles shows a strong decrease in the categories 'Stunted and Underweight' and 'All Indicators' whereas prevalence rates in the other categories remain almost constant. Therefore improvements between wealth categories are almost entirely due to differences in weight-based measures in the case of India. This tendency is found in many of the other countries as well, one other example being Burkina Faso.



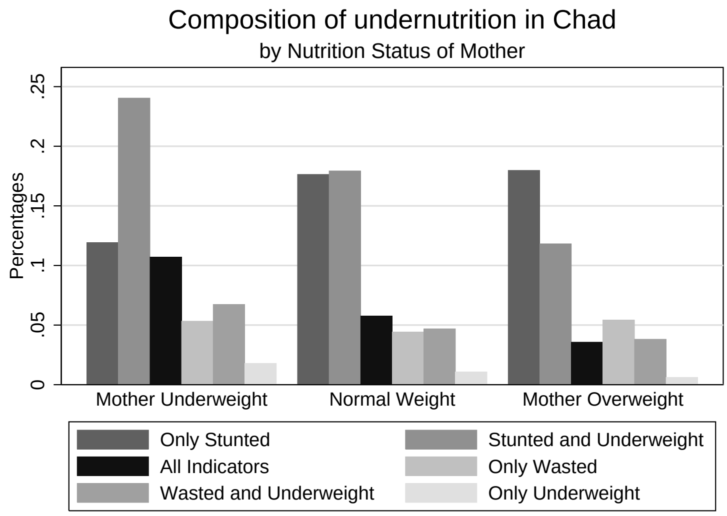
Source: DHS dataset (Burkina Faso 2003); own calculations.

In sharp contrast to India and Burkina Faso there are large reductions in the category 'Only Stunted' in Bolivia. In fact these large differences between wealth groups are a very good indicator for the high level of inequality in wealth as well as undernutrition that is found in most Latin American countries. Although there are visible improvements in stunting between asset index quintiles it is also obvious that this measure is by far the most persistent.



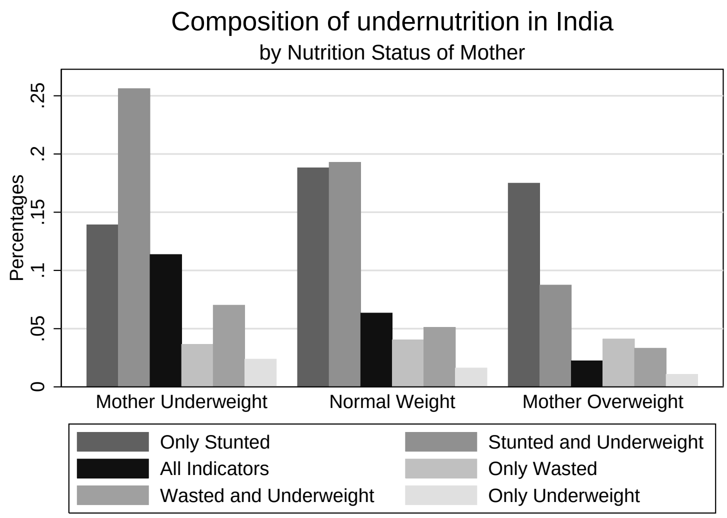
Source: DHS dataset (Bolivia 2003); own calculations.

Another possible way to demonstrate what effects changes in dietary intakes will have on the prevalence rates and composition of undernutrition is by comparing different subcategories of the nutrition status of the mother. Although an increase in the BMI of a mother, especially over 25, does not necessarily reflect an increase in well-being it still leads to reductions in the prevalence rates of all categories that include the two weight-based measures. In fact an BMI of 25 is generally used as threshold value to differentiate between normal weight and overweight (with a BMI of over 30 indicating that the respective person is obese). Being overweight has considerable negative effects of it's own on the health of the mother and should therefore influence children negatively as well. As a consequence it is not clear from a theoretical perspective why the prevalence rates of undernutrition of children of overweight mothers should be lower than the prevalence rates of children of mothers with normal weight. But as the following Fig. 11 - 13 show, prevalence rates of undernutrition seem to be lower in the subcategory of overweight mothers than in the subcategory of mothers with normal weight.



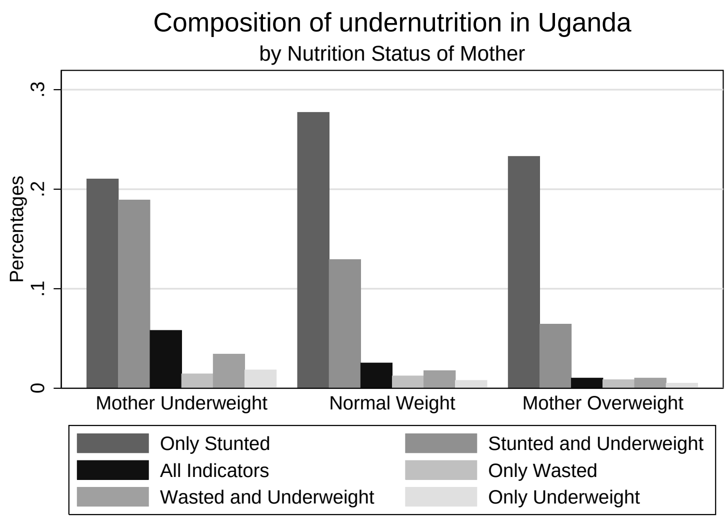
Source: DHS dataset (Chad 2003); own calculations.

The general findings for Chad are representative for all countries that were looked at in the present study and can also be seen in the figures for India and Tanzania. Namely increases in the BMI of the mother do not lead to a universal decline in the prevalence rates of childhood undernutrition. On the contrary these improvements are mainly limited to the weight-based measures and stunting remains almost unaffected.



Source: DHS dataset (India 1998/99); own calculations.

The observed patterns are not consistent with an explanation that increases in the BMI of mothers are a proxy for improvements in the wealth of households and therefore lead to general improvements in child anthropometry. The pattern is more consistent with a theory that states that the BMI of the mother is a good proxy for the dietary composition of a household. A higher BMI is consequently an indicator for a diet in the household that is rich in cheap fatty acids. A higher weight or BMI of the mother is therefore correlated with a higher weight of the child which does not necessarily reflect a better nutritional status. As mentioned before, higher amounts of energy from foods do not necessarily coincide with sufficient amounts of vital micronutrients.



Source: DHS dataset (Uganda 2000/01); own calculations.

Restrictively it has to be stated that the BMI of the mother is susceptible to a number of biases. For example, a bad nutritional status of the mother during her childhood and the resulting growth retardations can increase the likelihood of being overweight according to the BMI because of the small body height.

5.5 Changes in Undernutrition over Time

Probably the clearest and best way to show how focusing on the ‘wrong’ indicator for undernutrition will lead to a considerable bias in measurement is by comparing prevalence rates over time. Here, the secular downward trend in the prevalence of weight-based undernutrition, that is not reflected in a similar improvement in stunting or the Composite Index of Anthropometric Failure, is extremely obvious.

Looking at the following Tab. 4, it is discernable that changes over time are not the same for all three indicators of undernutrition. In fact, the magnitude of changes does not only differ between stunting, wasting and underweight but also the direction of change differs.

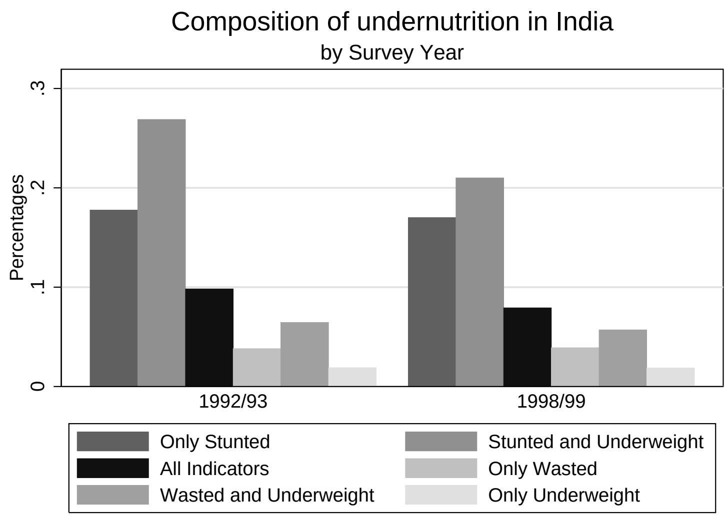
Table 4
Anthropometric indicators over time

Survey (Year)	Stunting	Underweight	Wasting
Differing Directions			
Bolivia (1993/94)	33.0%	12.2%	5.9 %
Bolivia (2003)	33.5%	5.6%	1.9%
Cameroon (1998)	33.5%	16.0%	7.8%
Cameroon (2003)	36.6%	13.4%	5.2%
Ghana (1993)	31.9%	23.8%	13.9%
Ghana (2003)	36.6%	19.4%	8.8%
Uganda (1995)	41.2%	19.5%	6.8%
Uganda (2000/01)	43.7%	17.4%	4.7%
Same Directions			
Burkina Faso (1998/99)	40.8%	29.2%	15.4%
Burkina Faso (2003)	43.4%	34.8%	22.2%
Chad (1996/97)	43.0%	32.5%	16.2%
Chad (2004)	42.5%	32.8%	17.0%
Colombia (1995)	19.7%	6.2%	1.7%
Colombia (2005)	16.2%	5.4%	2.0%
Egypt (1995)	34.1%	12.1%	7.1%
Egypt (2003)	19.3%	7.8%	4.7%
India (1992/93)	54.0%	44.4%	18.8%
India (1998/99)	48.6%	39.4%	18.4%
Tanzania (1996)	49.8%	26.7%	8.8%
Tanzania (2004)	42.4%	17.0%	4.4%
Zambia (1996)	50.0%	20.2%	5.3%
Zambia (2001/02)	53.9%	23.3%	5.7%

Note: *Children are considered as wasted, stunted or underweight if the respective z-scores are below -2 standard deviation from the median of the reference category.

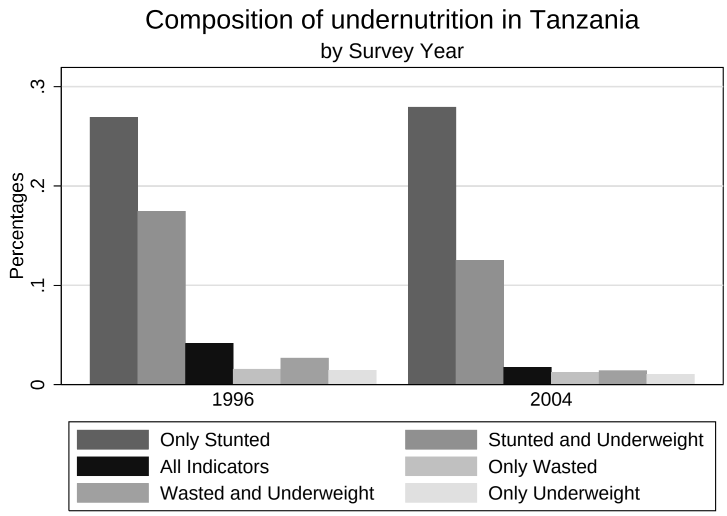
On the one hand, we can observe decreases in all three measures in Colombia, Egypt, India and Tanzania, no significant changes in any measure are observable in Chad and increases in all three measures are found in Burkina Faso and Zambia. On the other hand, the directions of change differ in Bolivia, Cameroon, Ghana and Uganda. In all these countries reductions in wasting and underweight took place, while stunting increased.

It is clear that decreases in weight-based anthropometric measures that come along with increases in stunting are only very extreme examples. Fortunately in most countries the prevalence of undernutrition was reduced according to all measures. But even in these countries the magnitude of the change is not the same for all three anthropometric indicators. A stronger decrease in weight-based measures compared to stunting are again observable when we compare the two surveys for each country.



Source: DHS datasets; own calculations.

India and Tanzania are just two examples for this general pattern that is also found in other countries.



Source: DHS datasets; own calculations.

The analysis of changes over time confirms therefore the results of the analysis of the general composition of undernutrition and the analysis of different subgroups. In all cases can be shown that the two weight-based show stronger reductions than stunting, which is by far the most persistent indicator of child undernutrition with the lowest rates in improvement. This is important to keep in mind because if the falling prevalence rates in the two weight-based measures where really due to considerable improvements in the nutrition status of children than stunting rates would fall in a similar manner. Since this is not the case, it is reasonable to assume that weight increases due to changes in dietary composition play an important role in these changes. These weight gains shouldn't counted as improvements per se and it would therefore make sense to use stunting instead of underweight as the indicator of choice.

6 Conclusion

As the preceding chapters have demonstrated it is very helpful to have a closer look at the exact composition of undernutrition. Although the general pattern is very durable in each country across subgroups there are large differences between countries that will lead to different country rankings depending on which indicator is used.

Besides this general aspect, it was argued that especially the use of underweight as the measure of choice to track the progress in the fight against undernutrition is highly problematic. Due to the way this indicator is defined, children either have to be extremely undernourished according to one indicator or have to be moderately undernourished according to both indicators. Consequently a large number of children are not considered as underweight that are significantly stunted or wasted. And some children are considered as underweight that are neither stunted nor wasted. Since the interpretation of the underweight indicator on its own is not very straightforward, there are considerable doubts whether it is a useful indicator at all.

Further it was demonstrated that the use of the new WHO reference standard alone results in significant reductions in the prevalence of underweight, although the other two indicators show increases. Adding to this reduction is the general downward trend in all weight based measures, such as underweight and wasting, that is due to changes in the nutritional composition of diets in developing countries. This secular reduction does not necessarily coincide with real improvements in the health of the affected children due to still lacking micronutrients. This bias makes the interpretation of reductions in the prevalence rates of undernutrition even more problematic and could lead to wrong conclusions concerning the fulfillment of the undernutrition aspect of MDG I.

While on a scientific level it is very useful to have a closer look at the exact composition of undernutrition, it is acknowledged at the same time, that the necessity exists on a political level to have a single indicator to count the number of undernourished persons. Consequently the opportunity of the introduction of the new WHO reference standard should be used to switch to stunting or the Composite Index of Anthropometric Failure (CIAF) instead of underweight as the indicator to measure progress in the field of undernutrition. Both measures do not suffer from biases that are introduced due to the nutrition transition that is taking place in the developing countries and are much easier to interpret.

References

Behrman, J.R., Alderman H. and J. Hoddinott (2004), Malnutrition and Hunger, In: Lomborg (ed.), *Global Crises, Global Solutions*, Cambridge: Cambridge University Press, 2004, p. 363-420.

Bhandari, N., Bahl, R., Taneja, S., de Onis, M. and M. Bhan (2002), Growth performance of affluent Indian children is similar to that in developed countries, *Bulletin of the WHO* 80(3), pp. 189-195.

Bogin, B. (1988), *Patterns of Human Growth*, Cambridge: Cambridge University Press.

Davies, D.P. (1988), The importance of genetic influences on growth in early childhood with particular reference to children of asiatic origin, In: Waterlow, J. (ed.), *Linear Growth Retardation in Developing Countries*, New York: Raven.

de Onis, M. and J.P. Habicht (1996), Anthropometric reference data for international use: recommendations from a World Health Organization Expert Committee, *American Journal of Clinical Nutrition* 64: 650-658.

de Onis, M. and R. Yip (1996), The WHO growth chart: historical considerations and current scientific issues, *Bibliotheca Nutritio et Dieta* 53: 74-89.

de Onis, M. et al. for the WHO Multicentre Growth Reference Study Group (2004), The WHO Multicentre Growth Reference Study: planning, study design and methodology. *Food and Nutrition Bulletin* 25 (Suppl 1): S15-S26.

Doak, C., L. Adair, C. Monteiro, and B. Popkin (2000), Overweight and underweight coexist within households in Brazil, China, and Russia, *Journal of Nutrition* 130 (12): 2965-2971.

Doak, C., L. Adair, M. Bentley, Z. Fendying, and B. Popkin (2002), The underweight/overweight household: An exploration of household sociodemographic and dietary factors in China, *Public Health Nutrition* 5 (1A): 215-221.

Eckhardt, C. L. (2006), Micronutrient Malnutrition, Obesity, and Chronic Disease in Countries Undergoing the Nutrition Transition: Potential Links and Program/Policy Implications, *IFPRI FCND Discussion Paper 213.*

Eveleth, P.B. and J.M. Tanner (1990), *Worldwide Variations in Human Growth*, 2nd ed., Cambridge: Cambridge University Press.

Filmer, D. and L.H. Pritchett (2001), Estimating Wealth Effects without Expenditure Data - or Tears: An Application to Educational Enrollments in States of India, *Demography*, 38 (1): 115-132.

Garrett, J.L. and M.T. Ruel (2003), Stunted Child - Overweight Mother Pairs: An Emerging Policy Concern?, *IFPRI FCND Discussion Paper 148.*

Kim, S., Moon, S. and Popkin, B. M. (2000), The nutrition transition in South Korea, *American Journal of Clinical Nutrition* 71: 44-53.

Klasen, S. (2003), Malnourished and Surviving in South Asia, better Nourished and Dying Young in Africa: What can Explain this Puzzle? in: FAO (eds.) Measurement and Assessment of Food Deprivation and Undernutrition, pp. 283-286, Rome: FAO.

Klasen, S. (2007), Poverty, undernutrition, and child mortality: Some interregional puzzles and their implications for research and policy, *Journal of Economic Inequality*, forthcoming.

Monteiro, C. A., Mondini, L., Medeiros de Souza, A. L., and Popkin, B. M. (1995), The nutrition transition in Brazil, *European Journal of Clinical Nutrition* 49: 105-113.

Monteiro, C., L. Mondini, A. Torres, and I. dos Reis (1997), Patterns of intra-familiar distribution of undernutrition: Methods and applications for developing societies, *European Journal of Clinical Nutrition* 51 (12): 800-803.

Monteiro, C., W. Conde, and B. Popkin (2002), Is obesity replacing or adding to undernutrition? Evidence from different social classes in Brazil, *Public Health Nutrition* 5 (1A): 105-112.

Morris, S. (2001), Measuring nutritional dimensions of household food security, In: J. Hoddinott (ed.), *Methods for rural development projects*, Washington D.C.: IFPRI.

Naiken (2003), FAO methodology for estimating the prevalence of food deprivation and undernutrition, In: FAO(ed) Measurement and Assessment of Food Deprivation and Undernutrition, Rome: FAO, pp.7-42.

Nandy, S., Irving, M., Gordon, D., Subramanian, S.V. and Smith, G.D. (2005), Poverty, child undernutrition and morbidity: new evidence from India, *Bulletin of the World Health Organization* 83 (3): 210-216.

Popkin, B. M. (1994), The nutrition transition in low-income countries: an emerging crisis, *Nutrition Review* 52: 285-298.

Popkin, B. M. (1998), The nutrition transition and its health implications in lower income countries, *Public Health Nutrition* 1: 5-21.

Popkin, B. M. (2001), The Nutrition Transition and Obesity in the Developing World, *The Journal of Nutrition* 131(3):871-873.

Sahn, D.E. and D. Stifel (2003), Exploring Alternative Measures of Welfare in the Absense of Expenditure Data, *Review of Income and Wealth*, 49 (4): 463-489.

Svedberg, P. (1999), 841 million undernourished?, *World Development*, 27(12): 2081-2098.

Svedberg, P. (2000), Poverty and Undernutrition: Theory, Measurement and Policy, Oxford: Oxford University Press.

Svedberg, P. (2002), Undernutrition Overestimated, *Economics of Cultural Change and Development*, 51(1): 5-36.

Svedberg, P. (2006), Declining child malnutrition: a reassessment, *International Journal of Epidemiology*, 35: 1336-1346.

WHO (1995), Physical status: the use and interpretation of anthropometry. Report of a WHO Expert Committee, Technical Report Series No. 854, Geneva: World Health Organization.

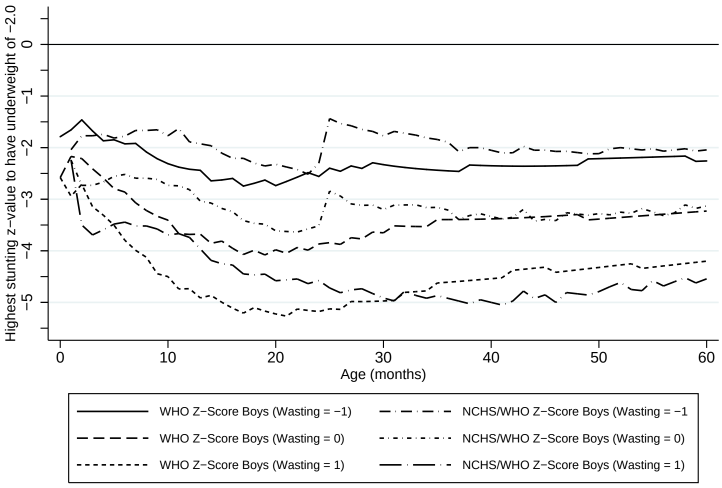
WHO (2004), Global strategy on diet, physical activity, and health, Geneva: World Health Organization.

WHO (2006), WHO child growth standards : length/height-for-age, weight-for-age, weight-for-length, weight-for-height and body mass index-for-age : methods and development, Geneva: World Health Organization.

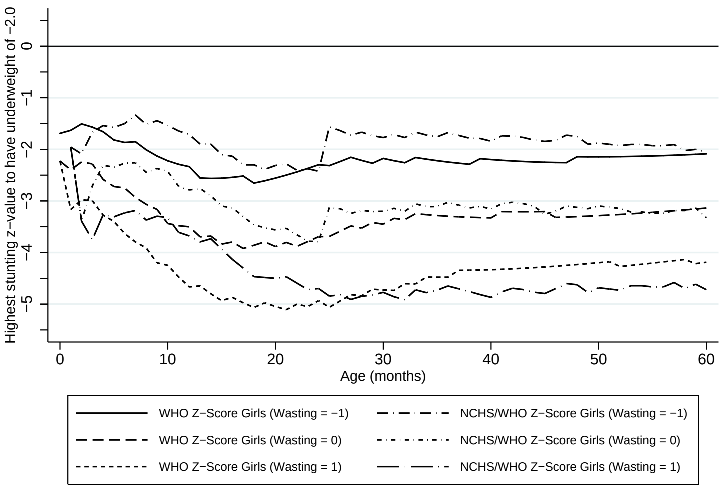
WHO Multicentre Growth Reference Study Group (2006), WHO Child Growth Standards based on length/height, weight and age, *Acta Pediatrica*, Suppl. 450: 76-85.

WHO Working Group on Infant Growth (1994), An evaluation of infant growth, Geneva: World Health Organization.

Appendix



Source: WHO reference standard; own calculations.



Source: NCHS/WHO reference standard; own calculations.