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Relationships between undernutrition prevalence among children and adult women at national and subnational level

M Nubé[1]*

[1]Centre for World Food Studies (SOW-VU), Vrije Universiteit, Amsterdam, Netherlands

Objectives: The objective of this study is to analyze the relationships between undernutrition prevalence rates among children and adults, both at the level of countries and at the level of smaller geographical subunits within countries (districts, provinces). Results are considered of relevance for evaluation and proper usage of anthropometric information in poverty and food security assessment.
Design: Anthropometric information on both children and adults, as reported in the Demographic and Health Surveys, has been the primary source of data. In addition, data published by WHO, FAO, and data from some country specific reports have been used. The final analysis is based on data from 289 subnational geographical units divided over 56 countries in Africa, Asia and Latin America. Ordinary least squares has been used for regression analysis and F-tests for testing differences of variances.
Results: At the level of countries, results reveal a strong positive relationship between undernutrition prevalence rates among children and adults. At the level of smaller geographical units, high levels of undernutrition in adult women are almost invariably associated with high levels of undernutrition in children. At the same time, however, low or intermediate levels of undernutrition among adult women are no guarantee that undernutrition levels among children are also low or moderate.
Conclusion: At the level of countries, information on undernutrition prevalence in children can be considered a proximate of the overall nutritional and food security conditions in a country. At the level of smaller geographical units, relationships are less straightforward, and are hypothesized to depend, at least partially, on the relative importance of food and nonfood factors in the causation of undernutrition.
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Introduction

Information both on absolute levels and on trends with respect to undernutrition prevalence in low-income countries are considered of relevance for, at least, two reasons.

In the first place, malnutrition by itself is considered an unacceptable infringement of human well-being and human dignity, and its eradication is a development goal by itself. One of the Millennium Development Goals is to reduce between 1990 and 2015 the global prevalence of hunger by 50% (World Bank, 2002). In the second place, the prevalence rate of undernutrition in children is one of the most widely used nonmonetary indicators to characterize poverty and food security conditions in developing countries or regions (Food & Agriculture Organization, 2004; World Bank, 2004). Thus, where a significant and lasting decrease in undernutrition prevalence has been observed, it is generally considered a confirmation or at least a strong indication of an overall reduction in poverty and an improvement in the food security situation. And *vice versa*, where over a certain period of time an increase in undernutrition is being observed, it is considered an indication of overall deteriorating conditions with respect to general human well-being.

In line with this role of nutrition data in poverty and food security assessment, over the past decades the collection of representative data on undernutrition prevalence in children, generally the under fives, has become common

*Correspondence: M Nubé, Centre for World Food Studies (SOW-VU), Vrije Universiteit, De Boelelaan 1105, 1081 HV Amsterdam, The Netherlands.
E-mail: m.nube@sow.vu.nl
Guarantor: M Nubé.
Contributors: MN is nutritionist and responsible for study design, analysis and manuscript writing.
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practice in most developing countries, and for many countries the first reliable nationally representative estimates date back to the 1980s or even before (World Health Organization, 2004a).

While thus for young children, a rather complete database on undernutrition prevalence is available, the question can be asked whether observed undernutrition prevalence rates in children, and trends over time, are similar for other age groups, such as older children, adolescents, adults, or the elderly. In fact, with undernutrition being considered a strong indicator of poverty and food insecurity, at least a positive correlation is expected to exist between undernutrition prevalence rates among different age segments. Yet, studies that report on the relationships between undernutrition prevalence among different age groups are limited, and until recently broad community or country wide assessments of undernutrition prevalence, covering various age groups, were not or hardly available.

For one specific segment of the population, however, namely women of reproductive age, past years have seen a rapid increase in data availability. The main source of these data are the so-called Demographic and Health Surveys (DHS), which have been implemented and are still being implemented in a large number of developing countries, and in which nationally representative data are being collected on fertility, family planning, and maternal and child health (DHS, 2004). Since the early 1990s, in most of these surveys the collection of anthropometric data in children and adult women is included.

With information now being available, for a large number of developing countries, both on undernutrition prevalence in children and in one group of adults, women of reproductive age, the question whether prevalence rates in these two different age segments are well correlated or whether there are major differences or anomalies can in principle be addressed.

In the present study, a systematic analysis is being made of the relationships between undernutrition in children and adult women, utilizing national and subnational data from developing countries in Africa, Latin America and Asia. In principle, a positive correlation is expected to exist between the undernutrition prevalence rates in these two population groups, as poverty is considered to be the underlying cause of both undernutrition in children and in adults. However, it is also anticipated that the strength of the relationship between undernutrition prevalence rates in these two age groups may vary between countries, or between regions within countries. It is hypothesized that information on patterns of undernutrition, as these occur among different age groups within a population, can give further direction in the identification of direct or indirect causative factors of undernutrition, whether in children, in adults, or both. Where undernutrition prevalence rates in children and adults run closely parallel, the same factors are probably affecting the nutritional status of both age segments. Where the relationship is much weaker, factors responsible for undernutrition in children are probably different from factors that cause a poor nutritional status in adults.

Methods

The main source of data for the present study are the Demographic and Health Surveys (DHS, 2004). These surveys started in the 1980s and since the early 1990s in the majority of the DHS-surveys anthropometric information is being collected both in children and in adults. In many countries two or more survey rounds have been implemented, and where this is the case the most recent data have been used for the present study. Only for an analysis of trends results from two surveys from one country have been used.

With respect to children, the prevalence rate of children with low weight-for-age has been selected as an indicator of undernutrition, using the cutoff point of the median of the reference population minus two standard deviations (M-2sd). This indicator is generally considered to reflect the combined effects of both chronic and acute undernutrition (World Health Organization, 1995a). The surveyed age group is either 0–3 or 0–5 y. Differences between these two age brackets in prevalence rates of undernutrition, expressed in percentage children with low weight-for-age, are generally small, generally less than 5%. Thus, for example for Benin, DHS reports a 23.8% prevalence of low weight-for-age among children 0–3 y and a 22.9% prevalence among children 0–5 y, a difference of 3.8% (DHS-Bénin, 2002). For those countries where DHS surveys cover children up to 5 y, the national undernutrition prevalence rates were recalculated for the 0–3 y age group. With respect to women, the DHS-surveys provide information on undernutrition prevalence in the women of reproductive age, and the covered age group is generally 18–45 y. In some surveys, the surveyed age group is slightly different, but no attempts have been made to correct for (small) differences in age brackets. Women included in the DHS-samples have at least one child aged 3–59 months, and for the present analysis pregnant women are excluded. The indicator used for quantifying undernutrition prevalence in adult women is the percentage of women with a body mass index (BMI, weight in kg divided by square height in meters) below 18.5 kg/m^2.

For the analysis of the relationships between undernutrition in children and adults at national level, for a few countries sources other than DHS were used. This was, in particular, the case for some countries from South and Southeast Asia, as DHS surveys which include anthropometry both on children and adults are less widely available for this region (see Supplementary data of Annex I provides the complete listing of surveys that have been consulted for the present study).

The analysis of the relationships between undernutrition in children and in adults at subnational level was also mainly based on data reported in the DHS studies, as in these reports undernutrition prevalence rates are generally not only given at national level but also at the level of districts, provinces,

or other subnational geographical units. In principle, only those geographical units have been considered for which the sample sizes for both children and adults were 200 or more. Provinces or districts in which smaller samples were surveyed were either excluded from the analysis or combined in order to arrive at a sample size of at least 200. For two countries, Chad and Kazakhstan, DHS-reports did not provide a subregional breakdown. Here, a breakdown of national level data was realized using results on undernutrition prevalence rates in urban and rural areas. For the subnational analysis, the only data that were not from DHS are those for Vietnam.

The analysis of the relationships between undernutrition prevalence rates among children and adult women was performed with simple ordinary least squares (OLS) for regression analysis and with F-tests for analysis of variance, using SAS-software (SAS Institute Inc.). In all analyses, '% low WFA' stands for percentage of children with low weight-for-age and '% low BMI' stands for percentage of adult women with low BMI. The relationships between undernutrition prevalence in children and undernutrition prevalence in adult women levels were investigated with the regression formula %lowWFA = A0 + A1 (%lowBMI) + A2 (%lowBMI)^2, both for all countries together and also for countries from the three developing regions separately.

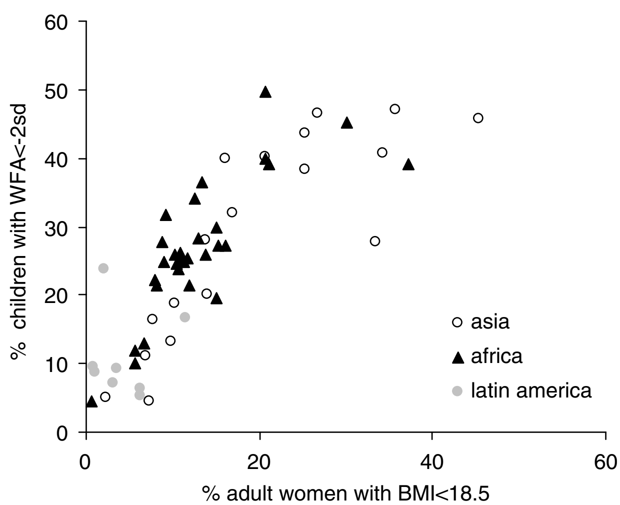

Figure 1 Relationship between undernutrition in adult women and undernutrition in children 0–3 y. *Source*: see Supplementary data of Annex I.

Data from those countries, where more than one survey reports on anthropometry in both children and adults, have been used for an analysis of trends over time, with the change over time in undernutrition prevalence being expressed as the percentage point difference between the prevalence rates at time-point one and time-point two. A positive figure denotes a decrease in undernutrition prevalence and a negative figure denotes an increase in undernutrition prevalence. Thus, when for a hypothetical country undernutrition prevalence was, for example, 32% in 1994 and 27% in 1999, the resulting change over time is 32–27 = 5%. It may be noted that the time intervals between the two surveys are generally in the order of magnitude of 5 y (mean 4 y and 11 months, see Supplementary data of Annex II). Results are presented in a diagram with four quadrants (I–IV), representing the four possible combinations with respect to the direction of change over time for undernutrition prevalence among children and adult women.

Results

National level data on undernutrition prevalence in children and adult women

Figure 1 shows for 56 countries (30 from Africa, 18 from Asia and eight from Latin America) the relationship between the national means for undernutrition prevalence in adult women (% of women with BMI < 18.5 kg/m^2) and children (% of children 0–3 y with weight for age below median −2s.d.).

The regression analysis according to the equation %lowWFA = A0 + A1 (%lowBMI) + A2 (%lowBMI)^2 has been carried out for all countries together, and also for countries from the three developing regions separately. Results are summarized in Table 1. For all 56 countries combined, the parameters A1 and A2 are highly significant (P < 0.0001), and the r^2 result is high (0.74). Results for countries from Asia and Africa separately are rather similar, with again highly significant parameters (P < 0.005), and r^2 results of the same order of magnitude (0.84 and 0.72). Only for the countries in Latin America, there is no significantly positive relationship between undernutrition in children and undernutrition in adults. In these countries overall levels of undernutrition are relatively low, while the number of countries for which data are available is also small. For all equations, except the one for Latin America, the intercept is nonsignificant.

Table 1 Regression analysis between undernutrition prevalence in children and undernutrition prevalence in adult women at national level

	N	*A0*	P	*A1*	P	*A2*	P	r^2
All countries	56	2.43	0.3137	2.26	<0.0001	−0.031	<0.0001	0.74
Asia	18	−5.15	0.3076	2.71	<0.0001	−0.037	0.0034	0.84
Africa	30	0.83	0.8351	2.70	<0.0001	−0.043	0.0014	0.72
L America	8	16.03	0.0419	−2.93	0.2993	0.253	0.2678	0.24

Regression: %lowWFA = A0 + A1 (%lowBMI) + A2 (%lowBMI)^2; %lowWFA = percentage children (0–3 y) with weight-for-age below median −2s.d.; %lowBMI = percentage adult women with body mass index <18.5 kg/m^2; *Source*: see Supplementary data of Annex I.

With respect to individual data points, Figure 1 shows that for some countries the relationship between the undernutrition prevalence rates among women and children deviates rather strongly from the general pattern. Among these are, for example, Guatemala, Niger and Sri Lanka, represented by the data points (2%, 23.9%), (20.7%, 49.6%) and (33.4%, 27.8%), reflecting the undernutrition prevalence rates among women and children in these three countries (see Supplementary data of Annex I).

Subnational level data on undernutrition prevalence in children and adult women

Results on the relationships between undernutrition prevalence in children and adult women at the level of districts, provinces, or other subnational geographical units are graphically represented in Figure 2a–d. Figure 2a gives the combined result for 289 geographical units in 56 countries for which subnational data are available, and Figure 2b–d gives the results for the subnational geographical units in African, Asian and Latin American countries separately. At this subnational level, data points appear to be more widely scattered in comparison with the data presented in Figure 1. This is the case when plotting all data points for the three developing regions in one diagram (Figure 2a) and also when plotting data points separately for Africa, Asia and Latin America (Figure 2b–d).

More remarkably, Figure 2 reveals that data points are in particular located in the upper left parts of the diagrams. This implies, among other things, that intermediate and high levels of child malnutrition are associated with widely varying levels of undernutrition among adult women. It also implies that high levels of undernutrition among adult women are almost invariably associated with high levels of child malnutrition. This pattern in the relationship between undernutrition among children and adults holds true for each of the three developing regions, and has been articulated by adding the 45° lines in Figure 2a–d.

The relationships between undernutrition in children and adults at subnational level have been estimated with the same quadratic regression formula used for estimating these relationships with national level data. Table 2 shows that, again, both for all geographical subunits from the three developing regions together, and separately for the geographical subunits from countries in Asia and Africa, most parameters of the relationships between undernutrition in

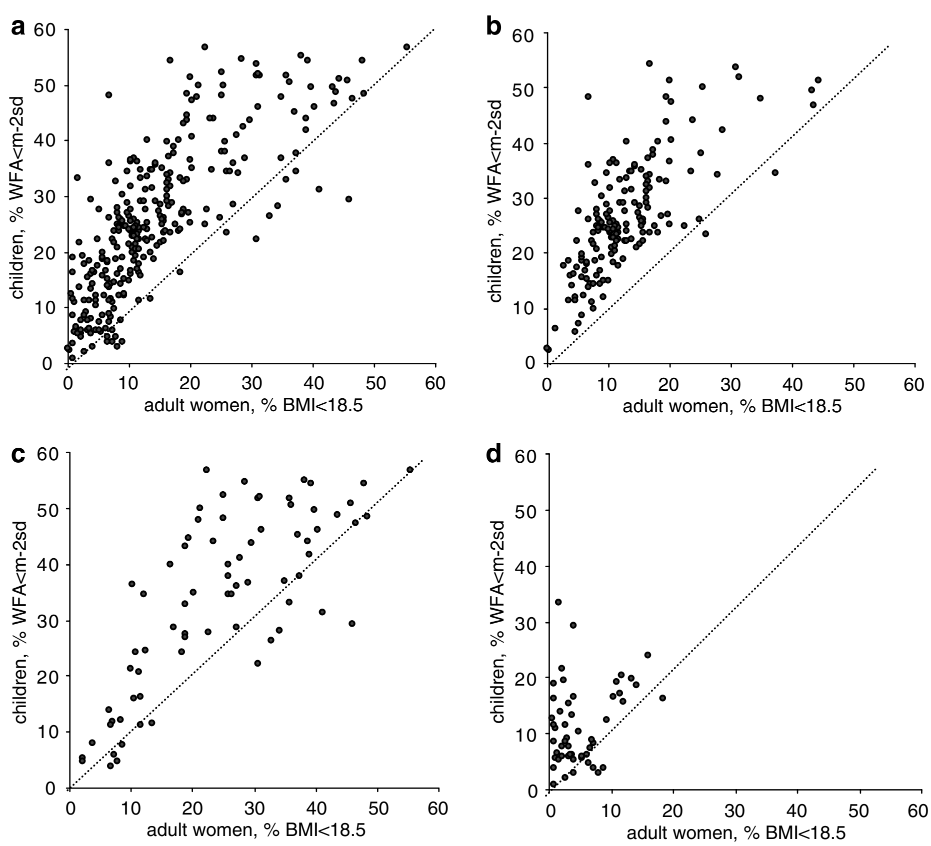

Figure 2 Relationships between undernutrition prevalence among children (0–3 or 0–5 y) and adult women at the level of subnational geographical units. (a) All developing regions, (b) Africa, (c) Asia, (d) Latin America. *Source*: see Supplementary data of Annex I.

Table 2 Regression analysis between undernutrition prevalence in children and undernutrition prevalence in adult women at subnational level

	N	*A0*	P	*A1*	P	*A2*	P	r^2
All	289	6.10	<0.0001	1.80	<0.0001	−0.020	<0.0001	0.65
Asia	73	−0.93	0.8033	2.22	<0.0001	−0.026	0.0001	0.65
Africa	164	8.51	<0.0001	1.74	<0.0001	−0.020	0.0002	0.56
L America	52	11.83	<0.0001	−0.84	0.2461	0.085	0.0604	0.15

Regression: %lowWFA = A0 + A1 (%lowBMI) + A2 $(\%lowBMI)^2$; %lowWFA = percentage children (0–3 or 0–5 y) with weight-for-age below median −2s.d.; %lowBMI = percentage adult women with body mass index <18.5 kg/m^2; *Source*: see Supplementary data of Annex I.

Table 3 Variance in undernutrition prevalence in children at different levels (tertiles) of undernutrition prevalence in adult women, and variance in undernutrition prevalence of adult women at different levels (tertiles) of undernutrition prevalence in children

	% low WFA[b]			*% low BMI*	
% low BMI tertile[a]	*Mean*[c]	*s.d.*	*% low WFA tertile*	*Mean*[c]	*s.d.*
1 (*n* = 96)	13.6	8.7*	1 (*n* = 96)	5.7	3.6*
2 (*n* = 97)	24.1	7.0* #	2 (*n* = 97)	13.3	6.8*
3 (*n* = 96)	39.2	10.0#	3 (*n* = 96)	24.4	11.6*

[a]%lowBMI = percentage adult women with body mass index <18.5 kg/m^2.
[b]%lowWFA = percentage children (0–3 or 0–5 y) with weight-for-age below median −2s.d.
[c]Means with the same symbol (* or #) indicates that variances (*F*-values) are significantly different (*P*<0.005). All prevalence rates as reported at the level of subnational geographical units. *Source*: see Supplementary data of Annex I.

children and adults are highly significant ($P<0.0005$). However, the r^2 results are now considerably lower (0.65, 0.65 and 0.56), which reflect the fact that data points are more widely scattered. For Latin America there is no significant relationship between undernutrition in children and undernutrition in adults.

For a further characterization of the distribution of the undernutrition prevalence rates in children and adult women, the 289 geographical units for which data are available have been divided into tertiles. This has been done in two ways, either on the basis of prevalence of a low BMI among adult women (% low BMI) or on the basis of the prevalence of low weight-for-age among children (% low WFA). Subsequently, for the tertiles based on the '% low BMI' ranking, the mean and standard deviation of the prevalence of '% low WFA' was calculated, while for the tertiles based on the '% low WFA' ranking, the mean and standard deviation of '% low BMI' was calculated (Table 3).

Table 3 shows that for each of the three '% low BMI' tertiles, the standard deviation for the '% low WFA' results are in the same order of magnitude, and the result for the lowest tertile (s.d. = 8.7) is not significantly different from the result for the highest tertile (s.d. = 10.0). Results for the three '% low WFA' tertiles, however, are very different as here the standard deviation for the '% low BMI' result increases strongly and significantly when going from the lowest to the highest tertile (from 3.6 to 11.6).

This pattern in the variances of prevalence rates of undernutrition among children and adult women confirms the visual observation that high levels of undernutrition in adult women are strongly associated with high levels of child undernutrition, but that relatively high levels of undernutrition in children are associated with a wide range of undernutrition prevalence rates in adult women. Thus, on the one hand, there are provinces or districts where undernutrition rates are relatively high both in adult women and in children, but on the other hand there are also many regions where malnutrition in children is high, but where undernutrition in adults is relatively low. Districts or provinces where adult undernutrition is high but child malnutrition is low are almost non-existent.

Trends in undernutrition prevalence

For a further interpretation of the available information on the relationships between undernutrition prevalence among children and adults, how changes over time in undernutrition prevalence in children are related to changes over time in undernutrition prevalence in adults has been investigated. In principle, here a positive correlation is also expected.

Results on these trends as they occur at the level of countries are presented in Figure 3. Data points in the quadrants II and III represent observations in which undernutrition prevalence rates in children and adult women are moving in the same direction, and datapoints in quadrants I and IV represent observations where undernutrition prevalence rates in children and adult women are moving in the opposite direction. In principle, it is expected that the majority of data points would be either in the second or in the third quadrant.

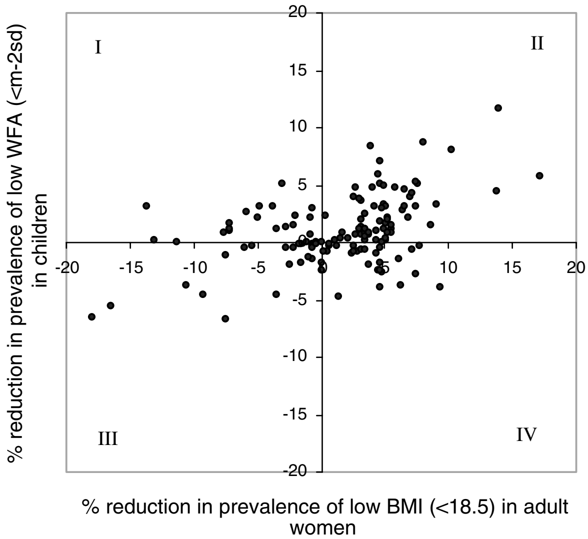

Figure 3 Relationship between changes in undernutrition prevalence among children (0–3 or 0–5 y) and undernutrition prevalence among adult women; positive changes are reductions in undernutrition prevalence, and negative changes are increases in undernutrition prevalence. *Source*: see Supplementary data of Annex II.

Figure 3 reveals that this expectation is not fully met. While indeed the larger number of data points are in the second and third quadrant, there are still a considerable number of observations in the first and fourth quadrant, indicating that in those cases undernutrition prevalence rates in children and adults move in different directions. Yet, the correlation coefficient between the changes in undernutrition prevalence in children and undernutrition prevalence in adult women is significantly positive ($r^2 = 0.44$, $P < 0.0001$), confirming the expectation that changes in the undernutrition prevalence rates tend to be in the same direction for children and adult women.

Discussion

The present study investigates, at national and subnational levels, the relationships between undernutrition prevalence rates in children and in adults in low-income, often food-insecure developing countries. As poverty and food insecurity are likely to affect, at least to some extent, all age groups of a community, a possibly weak but positive relationship between undernutrition prevalence in various age segments (children, adults, elderly) is expected. In view of limitations as regards data availability, the present report addresses the relationships between undernutrition in children and adult women.

Results reveal that there is, at the level of countries, a strong and significantly positive relationship between undernutrition prevalence rates in children and adult women. This is the case for the combined data set for countries from Africa, Asia and Latin America, and also for countries from Africa and Asia separately. Only for Latin America, where overall prevalence rates of undernutrition are much lower, both in children and adults, there is no longer a positive relationship. Results are in support of the general concept that, at the level of countries, information on undernutrition prevalence in children can be considered a proximate of the overall nutritional and food security conditions in a country. The question can be asked whether the presented results on adult women are representative for all adults, males and females together. Unfortunately, representative surveys on undernutrition prevalence rates among adult males are hardly available. Yet, it is in this respect relevant to note that in a large number of relatively small-scale studies differences in undernutrition prevalence between adult males and adult females have been shown to be generally small (Nubé & van den Boom, 2003).

With respect to individual datapoints in Figure 1, it appeared that for some countries (Guatemala, Niger, Sri Lanka) results deviate rather strongly from the general pattern. For Guatemala, a very low level of undernutrition among adult women is associated with a high level of undernutrition among children. The high prevalence of children with low weight-for-age in Guatemala can be partially explained by the fact that Guatemalan children are on average very short, also in comparison with other Latin American countries (DHS-Guatemala, 1999). With respect to Niger, the undernutrition prevalence rate among children of almost 50% appears to be exceptionally high. The year in which the survey was done, 1998, was probably in terms of nutrition a very unfavorable year, as indicated by the fact that the prevalence of wasting (low weight-for-height) was also very high in that year (20.7%). In two other surveys in Niger, one in 1992 and one in 2001, the reported undernutrition prevalence rates among children were considerably lower (36.6.% in 1992 and 40.4% in 2000) (DHS-Niger, 1992; MICS-Niger, 2000). Yet, for the present study, the 1998 results have been used, as this is the only data set that reports both on children and adults. Finally, in Sri Lanka the prevalence rate of child undernutrition appears to be considerably lower than what might be expected on the basis of the prevalence rate of undernutrition among adult women. The moderate level of child malnutrition in Sri Lanka, at least in comparison with nearby countries such as India and Bangladesh, has often been attributed to Sri Lanka's major efforts over past decades to improve health conditions and reduce malnutrition rates among children (Wijekoon *et al*, 1995).

When considering the results at the level of smaller geographical units within countries (provinces, districts), findings are different. First, the strengths of the relationships between undernutrition prevalence rates among children and among adult women, as analyzed by simple OLS, are weaker. Second, and most remarkably, the distribution of the data points appears to be highly asymmetrical. Results show that high levels of undernutrition in adult women are almost invariably associated with high levels of undernutrition in

children. At the same time, however, relatively high levels of undernutrition in children are associated with a wide range of undernutrition levels in adult women. In other words, it is not uncommon to find a combination of a relatively low level of undernutrition among adult women and a rather high level of child malnutrition.

With respect to changes over time, the relationship between changes in undernutrition prevalence rates among children and adults appears to be significantly positive but not very strong ($r^2 = 0.44$). One of the reasons for the relatively weak association might be that the time intervals between surveys in the various countries on which the trend data are based are not very long (average 4 y and 11 months, range 3–8 y).

It is important to note that the present analysis is based on undernutrition prevalence data either at the level of countries or at the level of provinces or districts within countries, but not at the level of households. In recent years, a number of studies have been published, which report on intrahousehold patterns with respect to nutritional status. These studies reveal that household members belonging to different age brackets may be differently affected by undernutrition. For example, already in 1985, the concept of family anthropometry was introduced by Dugdale, showing that households may reveal various patterns with respect to the relative prevalence rates of undernutrition among children and adults within households (Dugdale, 1985). These observations have been confirmed by several studies more recent (Bégin *et al*, 1992; Lindtjørn & Alemu, 1997; Monteiro *et al*, 1997). The most detailed study that strongly relates to the present report is a study on the relationships between the nutritional status of mothers and their children in selected population groups in India, Ethiopia and Zimbabwe (James *et al*, 1999). The study reports highly varying levels of malnutrition among children and mothers in the surveyed population groups in the various countries, and also widely varying correlation coefficients between nutritional status of mothers and their children. In addition, a number of more recent studies report on the coexistence of undernutrition and overnutrition, not only at the level of communities but also at the level of households (Doak *et al*, 2000, 2005; Florencio *et al*, 2001; Angeles-Agdeppa *et al*, 2003; Garrett & Ruel, 2003; Khor & Sharif, 2003).

Furthermore, with respect to the observed relationships between undernutrition among children and adult women, as presented in this study, it should be noted that the analysis is solely based on anthropometric information. Alhough anthropometry is widely used in assessing undernutrition, there are other important aspects of undernutrition, such as mineral and vitamin deficiencies, which are not or only partially captured with anthropometrics, and which are thus not considered in this report. Another observation, which should be made is that reported undernutrition prevalence rates depend, of course, strongly on the choice of cutoff points below which individuals are classified as undernourished. For the present report the most commonly used cutoff points have been selected, which are, for children below 3 or 5 y, the mean of the reference population minus two standard deviations, and for adults, a BMI of 18.5 (WHO, 1995a). In particular, with respect to adults the selection of the most appropriate cutoff point to discriminate between adequate and inadequate nutritional status remains a subject of debate. A cut-off point of 18.5, as promoted by WHO, is based on various studies in which quantitative relationships have been established between low BMI, work productivity, morbidity, mortality, low birth weight and other aspects of health (WHO, 1995a, b; Thomas & Frankenberg, 2002). Such relationships are generally of a gradual nature, and the selection of a cutoff point always has some element of arbitrariness. In fact, in several nutrition studies other cutoff points are also being used or propagated (Swai *et al*, 1992, Pryer, 1993, Sichieri *et al*, 1994, van der Sande *et al*, 2001). Clearly, when other cutoff points are applied, the absolute levels of undernutrition prevalence will change. However, the overall patterns in the relationships between undernutrition among children and adults are unlikely to differ strongly from the presently reported results.

Finally, the issue whether the same cutoff point is applicable to different regions in the world or to people from different ethnic backgrounds should be addressed. With respect to the occurrence of overweight and obesity, it has been shown that relationships between BMI and body composition can differ between ethnic groups, and the extent to which relationships between BMI and prevalence of degenerative diseases such as hypertension, diabetes and cardiovascular disease differ between various ethnic groups is under serious debate (Stevens, 2003; World Health Organization, 2004b). Similarly, with respect to undernutrition, ethnic differences in physical characteristics might also play a role. For example, it has been shown that differences exist in body measurements (standing height, sitting height) between, for example, Asians, Africans and Caucasians, and these body build characteristics also affect BMI. One approach in attempting to account for such differences in body build has been the introduction of the Cormic index, but its use appears not to be widely accepted (Norgan, 1995). Thus, there are still a number of critical issues to be considered for the appropriate use and interpretation of anthropometry in the assessment of undernutrition.

From a policy point of view, the most important question that follows from the present findings is what factors are responsible for the diverse patterns in undernutrition prevalence rates as, in particular, observed at subnational level among children and adults. When reviewing the various studies that have addressed the relationships between undernutrition in children and adults, a general concept emerges that overall food shortages on the one hand and poor conditions with respect to health and sanitation and with respect to education and child care on the other hand have different impacts on the nutritional conditions of, respectively, children and adults. Thus, in the study by James *et al* (1999), it is hypothesized that the combination of

wasting among children and a low BMI of the mother points to food insecurity, while the combination of wasting among children and normal BMI of the mother points to a need for public health measures (water, sanitation) and maternal education. Moreover, in a study by Armar–Klemesu, the combined occurrence of overnutrition and undernutrition in one and the same household has been attributed to factors other than absolute levels of household food availability (Armar-Klemesu *et al*, 2000).

The importance of the present study is that it is the first one in which a systematic analysis has been made on the relationships between undernutrition prevalence rates among children and adults, both at the level of countries and at the level of regions within countries (districts, provinces). In line with previous studies, it is hypothesized that in regions where poor anthropometric results are being observed in both children and adults, limited overall levels in household food supply are most likely to play an important role in the causation of undernutrition. Where problems of undernutrition in children are serious, but where adults appear to be, on average, in a relatively better nutritional condition, factors other than household level food shortages are likely to be responsible for the occurrence of undernutrition in children. Among these factors are, for example, frequent occurrence of infectious diseases, and associated poor water and sanitation conditions, poor quality of diets with deficiencies in micronutrients (vitamins, minerals), and insufficient opportunities for mothers or other caretakers to provide their children with adequate care (Stephensen, 1999).

In a more general context, the results of the present study are considered of relevance in evaluating the role of anthropometric information for the assessment of poverty and food insecurity. While for the assessment of poverty, monetary indicators (incomes, expenditures) are most widely used, their limitations, in particular in developing countries, are well known and have been extensively discussed (Ravallion, 1995; McKay & Lawson, 2003). Thus, over the past decades there have been continuing efforts to develop methods for the assessment of poverty, which are less dependant on incomes or expenditures (Baulch & Masset, 2003). At the level of countries most authorative in this area are probably the activities of the United Nations Development Programme, which developed the so-called Human Development Index (HDI), incorporating information on income, health and education into one composite indicator (United Nations Development Programme, 2004). In addition, various other related indicators have been developed such as the Human Poverty Index (HPI) and the Gender related Development Index (GDI) (United Nations Development Programme, 2004). While these indicators play an important role in assessing trends in development and in monitoring progress in eradicating or reducing poverty, there remains the disadvantage that the constructed indices still depend on, to some extent, the arbitrary weighting of the contributing factors.

Another approach in circumventing the tedious task of collecting information on incomes or expenditure has been the development of asset indicators. The information required for such asset indicators is relatively easy to collect, and it has been shown to be a useful alternative to income or expenditure information (Sahn, 2003; Sahn & Stifel, 2003). Yet, also with respect to these asset indicators, there are clearly methodological problems, for example, with respect to the choice of assets to be included or, again, the possible weighting of its various components. It is interesting to note that in the study by Sahn (2003), anthropometric information on children has been selected as the indicator against which the validity of the asset indicator has been evaluated.

Probably, partially in response to these problems with respect to the various indicators of human development and poverty, over recent years anthropometric information is increasingly being used and accepted as an indicator of overall human well being (Nubé *et al*, 1998; Srinivasan, 2000; Nubé, 2001; Carter & Maluccio, 2003). In comparison with income or expenditure data, there is no need for information on prices or on purchasing power, and also no need for inflation correction factors when analyzing trends over time. Another advantage is that anthropometric data are collected in individuals, and results are therefore directly available in the form of headcounts.

It is concluded that results of the present study, which provide detailed information on the relationships between undernutrition among children and adults, are of relevance for further evaluation and proper usage of anthropometric information in the assessment of poverty and human well being.

References

Angeles-Agdeppa I, Lana RD & Barba CV (2003): A case study on dual forms of malnutrition among selected households in District 1, Tondo, Manila. *Asia Pac. J. Clin. Nutr.* **12**, 438–446.

Armar-Klemesu M, Ruel MT, Maxwell DG, Levin CE & Morris SS (2000): Poor maternal schooling is the main constraint to good child care practices in Accra. *J. Nutr.* **130**, 1597–1607.

Baulch B & Masset E (2003): Do monetary and nonmonetary indicators tell the same story about chronic poverty? A study of Vietnam in the 1990s. *World Dev.* **31**, 441–453.

Bégin F, Alladoumgué M, Nandjingar K & Delisle H (1992): Household dietary adequacy and individual nutritional status: relationships and seasonal effects in a Sahelian community in Chad. *Food Nutr. Bull.* **14**, 304–313.

Carter MR & Maluccio JA (2003): Social capital and coping with economic shocks: an analysis of stunting among South African children. *World Dev.* **31**, 1147–1163.

DHS (2004): *Demographic and Health Surveys, Measure DHS*. Calverton, USA: Macro International Inc. Internet:http://www.measuredhs.-com.

DHS-Bénin (2002): Enquête Démographique et de Santé au Bénin, 2001, Institut National de la Statistique et de l'Analyse Economique, Cotonou, Bénin – ORC Macro, Calverton, MD, USA.

DHS-Guatemala (1999): *Guatemala Encuesta Nacional de Salud Materno Infantil 1998–1999, Measure DHS*. Calverton, MD, USA: Macro International Inc.

DHS-Niger (1992): *Enquête Démographique et de Santé Niger, 1992, Kourguéni IA, Garba B, Barrère B, Direction de la Statistique et des*

Comptes Nationaux, Direction Générale du Plan, Ministère des Finances et du Plan, Niamey, Niger. Columbia, MD, USA: Macro International Inc.

Doak CM, Adair LS, Bentley M, Monteiro C & Popkin BM (2005): The dual burden household and the nutrition paradox. *Int. J. Obes. Relat. Metab. Disord.* **29**, 129–136.

Doak CM, Adair LS, Monteiro C & Popkin BM (2000): Overweight and underweight coexist within households in Brazil, China and Russia. *J. Nutr.* **130**, 2965–2971.

Dugdale AE (1985): Family anthropometry: a new strategy for determining community nutrition. *Lancet* **2**, 672–673.

Food and Agriculture Organization (2004): *The State of Food Insecurity in the World*. Rome: Food and Agriculture Organization.

Florencio TM, Ferreira HS, de Franca AP, Cavalcante JC & Sawaya AL (2001): Obesity and undernutrition in a very-low-income population in the city of Maceio, northeastern Brazil. *Br. J. Nutr.* **86**, 277–284.

Garrett JL & Ruel MT (2003): Stunted child-overweight mother pairs: an emerging policy concern? FCND Discussion Paper No. 148, IFPRI.

James WPT, Ferro-Luzzi A, Sette S & Mascie-Taylor CGN (1999): The potential use of maternal size in priority setting when combating childhood malnutrition. *Eur. J. Clin. Nutr.* **53**, 112–119.

Khor GL & Sharif ZM (2003): Dual forms of malnutrition in the same households in Malaysia – a case study among Malay rural households. *Asia Pac. J. Clin. Nutr.* **12**, 427–437.

Lindtjørn B & Alemu T (1997): Intra-household correlations of nutritional status in rural Ethiopia. *Int. J. Epidemiol.* **26**, 160–165.

McKay A & Lawson D (2003): Assessing the extent and nature of chronic poverty in low income countries: issues and evidence. *World Dev.* **31**, 425–439.

MICS-Niger (2000): Enquête à Indicateurs Multiples de la Fin de la Décennie (MICS2), République de Niger/Unicef.

Monteiro CA, Mondini L, Torres AM & dos Reis IM (1997): Patterns of infra-familiar distribution of undernutrition: methods and applications for developing societies. *Eur. J. Clin. Nutr.* **51**, 800–803.

Norgan NG (1995): Body mass index and nutritional status: the effect of adjusting body mass index for the relative sitting height on estimates of the prevalence of chronic energy deficiency, overweight and obesity. *Asia Pac. J. Clin. Nutr.* **4**, 137–139.

Nubé M (2001): Confronting dietary energy supply with anthropometry in the assessment of undernutrition at the level of countries. *World Dev.* **29**, 1275–1289.

Nubé M, Asenso-Okyere WK & van den Boom GJM (1998): Body mass index as indicator of standard of living in developing countries. *Eur. J. Clin. Nutr.* **52**, 136–144.

Nubé M & van den Boom GJM (2003): Gender and adult undernutrition in developing countries. *Ann. Hum. Biol.* **30**, 520–537.

Pryer JA (1993): Body mass index and work-disabling morbidity: results from a Bangladeshi case study. *Eur. J. Clin. Nutr.* **47**, 653–657.

Ravallion M (1995): Issues in measuring and modeling poverty. *Econ. J.* **106**, 1328–1343.

Sahn DE (2003): Exploring alternative measures of welfare in the absence of expenditure data. *Rev. Income Wealth* **49**, 463–489.

Sahn DE & Stifel DC (2003): Urban-rural inequality in living standards in Africa. *J. Afr. Econ.* **12**, 564–597.

van der Sande MAB, Ceesay SM, Milligan PJM, Nyan OA, Banya WAS, Prentice A, McAdam KPWJ & Walraven GEL (2001): Obesity and undernutrition and cardiovascular risk factors in rural and urban Gambian communities. *Am. J. Public Health* **91**, 1641–1644.

Sichieri R, Coitinho DC, Leão MM, Recine E & Everhart JE (1994): High temporal, geographic, and income variation in body mass index among adults in Brazil. *Am. J. Public Health* **84**, 793–798.

Srinivasan TN (2000): Poverty and undernutrition in South Asia. *Food Policy* **25**, 269–282.

Stephensen CB (1999): Burden of infection on growth failure. *J. Nutr.* **129** (2S Suppl), 534S–538S.

Stevens J (2003): Ethnic-specific revisions of body mass index cutoffs to define overweight and obesity in Asians are not warranted. *Int. J. Obes. Relat. Metab. Disord.* **27**, 1297–1299.

Swai AB, Kitange HM, Masuki G, Kilima PM, George K, Alberti MM & McLarty DG (1992): Is diabetes mellitus related to undernutrition in rural Tanzania? *Br. Med. J.* **305**, 1057–1062.

Thomas D & Frankenberg E (2002): Health, nutrition and prosperity: a microeconomic perspective. *Bull. World Health Organ.* **80**, 106–113.

United Nations Development Programme (2004): *Human Development Report*. New York: United Nations Development Programme.

Wijekoon ASB, Thattil RO & Schensul SL (1995): First trimester feeding in a rural Sri Lankan population. *Soc. Sci. Med.* **40**, 443–449.

World Bank (2002): *World Development Indicators*. Washington: World Bank.

World Bank (2004): *World Development Indicators*. Washington: World Bank.

World Health Organization (1995a): Physical status: the use and interpretation of anthropometry. WHO Technical Report Series 854. Geneva: World Health Organization.

World Health Organization (1995b): Maternal anthropometry and pregnancy outcomes. A WHO Collaborative Study. *Bull. World Health Organ.* **73** (Suppl), 1–98.

World Health Organization (2004a): *WHO Global Database on Child Growth and Malnutrition*. Geneva: World Health Organization. Internet:http://www.who.int/nutgrowthdb/,accessed 26 September 2004.

World Health Organization (2004b): Appropriate body-mass index for Asian populations and its implications for policy and intervention strategies. *Lancet* **363**, 157–163.

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