Declining child malnutrition: a reassessment

Peter Svedberg

Accepted	20 June 2006
Background	Monitoring of the progress towards the Millennium Development Goal (MDG) of halving the proportion of malnourished children before year 2015 relies on the estimated trends in child stunting and underweight from the WHO.
Methods	Two methods are used for assessing the reliability of the WHO estimates of trends in child stunting. One method is to estimate changes over time with an alternative methodology and the same data set, and the other is to evaluate the inter-temporal comparability of the child surveys from India and China, the two countries that weigh most heavily in the WHO trend estimates.
Results	The re-estimated global and regional trends in child stunting with the alternative method and same data set are similar to those derived by the WHO. The data analysis shows that the child surveys from India are not inter-temporarily comparable. When controlling for differences in state coverage and age cohorts in the surveys, the prevalence of child stunting in India remained unchanged in the 1990s. The unaltered prevalence of stunting followed a minuscule decline in poverty. In China, there was a significant increase in child stunting between 1987 and 1992 and then a decline by half up to 1998. This abrupt reversal in child stunting was matched by a parallel change in (rural) poverty.
Conclusions	The progress towards the MDG at the global level is on track owing to the large decline in China. In India, as in most of Africa, where no notable fall in child stunting took place over the 1990s, the rate of decline over the 2001–15 period must be very high for the MDG to be realized. For this to occur, large reductions in poverty through equitable and high income growth are necessary.
Keywords	child stunting, malnutrition, poverty, MDG, monitoring, progress, trends

The Global Database on Child Growth and Malnutrition, initiated by the WHO in 1986, and concurrently updated, is a major accomplishment.[1] Few researchers interested in the causes and consequences of malnutrition can do without it. The research community and policy agencies around the world are indebted to the WHO for providing this database and, not the least, to Mercedes de Onis and Monica Blössner, who in collaboration with associates have been its main architects. They have also disseminated knowledge worldwide about estimation methodologies and helped in standardizing these and the presentation of results.

The article in the December 2004 issue of the *IJE* is the latest in a series of papers by de Onis *et al.*[2–4] in which they provide updated estimates of trends in child stunting and underweight. They find that the prevalences of stunting and underweight in the developing countries have declined over the 1990s, from 38 to 30% and from 30 to 25%, respectively. These results indicate

Institute for International Economic Studies, Stockholm University, S-106 91 Stockholm, Sweden.

E-mail: peter.svedberg@iies.su.se

a step in the right direction towards the Millennium Development Goal (MDG) of reducing the incidence of child malnutrition by half before year 2015.

The WHO has consecutively enhanced the estimation technology and the inter-country comparability of the growing number of anthropometric child surveys carried out during the past decade and a half.[5] In this article, the focus will be on the inter-temporal comparability of the surveys. The more specific objectives are 5-fold. The first is to acknowledge the pros and also to discuss some cons with the methodology for estimating trends used by de Onis *et al.* The second objective is to compare the outcomes when an alternative method for deriving trend estimates is applied. This alternative method is intended mainly as a robustness check of the de Onis *et al.* estimation model; it is not claimed to be more accurate, although it is simpler and hence more transparent. The third objective is to scrutinize the inter-temporal comparability of the surveys from the two countries with the largest impact on 'global' trends, India and China, jointly with almost half the population in the developing world. The fourth is to investigate the link between reductions in child stunting and in poverty in these two

countries. Finally, I will examine the (uneven) progress so far towards the MDG and the requirements for it to be reached by 2015.

Estimation methodology

The methodology used by de Onis *et al.* for estimating trends in child stunting and underweight since the 1970s is a linear mixed effect model, which treats each country (survey) observation as a random draw.[2] The estimation model is clearly explained in their article and needs no further elaboration. As pointed out by the authors themselves, the model has many sophisticated properties that time-series statisticians will find essential and appealing. Among the advantages is that all data points (surveys) available are used, including those from countries where only one survey has been conducted. Moreover, the modelled trends are population weighted and estimates of confidence intervals are provided. There are, however, limitations with the method that need to be discussed in some more detail than what has been done by the authors themselves.

First, the methodology used for estimating trends builds on the assumption that 'countries providing data were regarded as a representative sample for all countries within their sub-region'[2] (p. 1261). The number of data points (surveys), 388 for the entire 1970–2000 period, has increased markedly over time. About half are from the 1990s, while there are only some 35 surveys from the 1970s. One may doubt whether these few early surveys are representative for the 12 sub-regions at the time. Because the observations from this early period influence the trends for the entire 1970–2000 period, this question is not unimportant.

Second, the methodology used by de Onis *et al.* presumes the estimated trends for the 1970–2000 period to be linear. With this methodology, possible shifts in the trends go undetected (the authors provide no tests for trend stationarity). Naturally, the choice of trend model should be determined by the question asked. If the question is whether there has been a change in the rate at which child stunting or underweight has declined (or increased) between the 1980s and 1990s, their model does not provide an answer. This is a relevant question considering that the decline in U5MR, which is strongly associated with changes in malnutrition,[6] decelerated during the 1990s as compared with the two earlier decades in the developing countries.[7] If the question is what progress has been made towards the MDG, it should be kept in mind that the de Onis *et al.* point estimates for the benchmark year 1990 are interpolated from observations for the 1970–2000 period.

Third, the methodology used by de Onis *et al.* for estimating regional trends, relying on country surveys as the units of observation, is highly data demanding. Therefore, it is not surprising that most of the estimated regional trends are surrounded by wide 95% confidence intervals due to relatively few observations (surveys) paired with large variations both across countries and over time. The wide confidence intervals signal that the estimated trends—and the extrapolations to the year 2005—are uncertain and should be interpreted cautiously.[8]

Finally, the estimated trends at the regional and sub-regional levels derived by de Onis *et al.* may mask significant intra-regional differences in changes in child stunting and underweight. This calls for the supplementation with estimates for individual countries, which will be provided in this paper for the selected countries with the required data.

Alternative method and estimates

The trends in the prevalence of stunting and underweight derived by de Onis *et al.* are technically rather complicated and, as argued above, have certain limitations. In this section, I will derive alternative estimates of changes over time using a much simpler method that, foremost, aims at answering the question about the extent to which child malnutrition has changed since 1990, the benchmark year for the MDG. I will rely on a subset of the same WHO data (surveys) employed by de Onis *et al.* Thereby, I can separate out the effects on results from the choice of trend model and data inaccuracies to be discussed subsequently.

To avoid the problem with different sets of countries that may not be comparable over time, I will restrict the inter-temporal investigation to those countries for which surveys exist at two specific points in time, or rather short sub-periods. I will also restrict most of the analysis to stunting, mainly to save space, and also because of the high correlation between changes in stunting and underweight (Table 1). There is also considerable overlap of stunting and underweight in individual children. In India, for which detailed data are available, 74.5% of the underweight children in 1998/99 were also stunted and 77.6% of the stunted children were underweight as well.[9]

In the WHO database, I found 40 countries where an anthropometric survey labelled national was carried out in the 1988–1992 period and also one from the 1998–2002 period. This set of countries may seem too small for gauging 'global' trends, but it includes populous India and China and the 40 countries jointly account for about two-thirds of the population in all developing countries. For two of the sub-regions, West Asia and South-east Asia, the number of countries in my sample is too small to allow reliable and representative regional estimates of changes. For the most populous sub-regions with the highest initial estimated prevalence of child stunting (and underweight), Sub-Saharan Africa, South-central Asia, and East Asia, the coverage is sufficiently large.

The method to be used here is simply to pool all data on stunting for the countries (surveys) in each of the sub-periods and regions (weighted by population size). The results are reported in Table 1 and show that the average prevalence of stunting in the 40 countries has declined by 11.8 percentage points over the 1990s. (The equivalent decline in underweight was 5.8 percentage points.) In four of the individual countries, all in Sub-Saharan Africa, there was a significant increase in child stunting. In another nine countries, five in SSA, and also Algeria, El Salvador, Iraq, and Mongolia, there was no significant change, while stunting declined in the remaining 27 countries.

For easy comparison, the trend-based regional estimates derived by de Onis *et al.* for the years 1990 and 2000 are also inserted in Table 1. The most notable difference is, perhaps, for stunting in Sub-Saharan Africa; here my results suggest a drop by 5.5 percentage points, while de Onis *et al.* find the decline to be close to nil. The main reason for the difference is that two

Table 1 Alternative estimates of child stunting in 1990 and 2000 by region, weighted by population size in comparison with estimates derived by de Onis *et al*. (in italics)

Region (N)[a]	Prevalence stunting (%)			Prevalence underweight (%)		
	1990	2000	Change	1990	2000	Change
Africa (19)	40.3	34.6	−5.7	28.1	25.9	−2.2
	36.9	*35.2*	*−1.7*	*23.6*	*24.2*	*+0.6*
North (2)	26.1	18.5	−7.6	10.0	4.7	−5.3
	27.4	*21.7*	*−5.7*	*12.3*	*9.7*	*−2.6*
Sub-Saharan (17)[b]	44.3	38.8	−5.5	33.1	31.4	−1.7
	39.2	*38.0*	*−1.2*	*26.4*	*27.0*	*+0.6*
Asia (11)	42.8	29.6	−13.2	34.5	28.4	−6.1
	41.1	*30.1*	*−11.0*	*35.1*	*27.9*	*−7.2*
South-central (4)	52.4	43.9	−8.5	51.9	45.5	−6.4
	50.8	*39.7*	*−11.1*	*49.6*	*40.8*	*−8.8*
South-East (3)	44.5	34.3	−10.2	38.8	33.5	−5.3
	41.8	*32.1*	*−9.7*	*35.2*	*27.4*	*−7.8*
East (2)	33.7	14.2	−19.5	17.6	10.0	−7.6
	30.0	*14.8*	*−15.2*	*18.5*	*9.3*	*−9.2*
West (2)	20.7	19.8	−0.9	10.9	13.9	+3.0
	25.0	*18.7*	*−6.3*	*12.9*	*11.3*	*−1.6*
Latin America & Caribbean (10)	21.5	16.3	−5.2	11.8	6.9	−4.9
	18.3	*13.7*	*−4.6*	*8.7*	*6.1*	*−2.6*
Total (40)	41.1	29.3	−11.8	32.3	26.5	−5.8
	37.9	*29.6*	*−8.3*	*30.1*	*24.8*	*−5.3*

Sources: Author's calculations based on WHO[1] and de Onis *et al*.[2]
[a] The number of countries (N) refers to the alternative estimates.
[b] Derived as a population-weighted average of the estimates provided by de Onis *et al*.[2] for Eastern, Middle, Southern, and Western Africa.

countries with large estimated declines in child stunting over the 1990s, Nigeria and Ethiopia, weigh more heavily in my investigation than in the one by de Onis *et al*., based on a larger sample of African countries. On the whole, however, the estimated changes at the global and major regional levels are relatively similar. This may seem somewhat surprising, considering the differences in country coverage, time period studied, and estimation methodology. Questions remain, however, regarding the accuracy and inter-temporal comparability of the base data included in the estimations. Since almost two-thirds of the global decline in the number of stunted children during the 1990s took place in India and China according to the de Onis *et al*. estimates, I will focus on the surveys from these two countries.

Comparability over time in Indian surveys

Six anthropometric surveys from India are included in the population-weighted trend regressions for child stunting in South-central Asia carried out by de Onis *et al*.[2] Since India has >70% of the population in this region, their linear regression line is practically linking the observations for India (see their Figure 2).

The basic features of the six Indian child anthropometric surveys from the WHO database are presented in Table 2. We notice several differences in survey coverage and size that may have compromised inter-temporal comparability. The three earliest surveys only covered eight coastal and mainly southern states in India. Moreover, these surveys were restricted to rural areas and focused on children aged 0–5 years, while the

Table 2 Basic characteristics of Indian child nutrition surveys in the WHO database

Survey years	Sample size	State coverage	Rural/ urban	Age group	Prevalence of stunting (%)		
					Urban	Rural	Total
1974/79	6526	8[a]	R	0–5	–	72.3	–
1988/90	13 548	8[a]	R	0–5	–	62.1	–
1991/92	2 948	8[b]	R	0–5	–	61.2	–
1992/93	25 580	National[c]	R + U	0–4	44.5	54.0	51.8
1996/97	22 959	National[c]	R	0–5	–	42.6	–
1998/99	24 396	National	R + U	0–3	35.2	47.9	44.9

Source: WHO.[1]
[a] The eight states are: Andhra Pradesh, Gujarat, Karnataka, Kerala, Madhya Pradesh, Maharashtra, Orissa, and Tamil Nadu.
[b] Same eight states except that West Bengal was included and Madhya Pradesh was excluded.
[c] Labelled national in the WHO database, but several large states were not included.

1992/93 and 1998/99 surveys covered 0–4 and 0–3 year olds. Only the two latter surveys are (close to) national and include both urban and rural children.

The inter-temporal comparability of the Indian (or other) surveys is not discussed by de Onis *et al*. The authors seem to have made one adjustment, though, to some of the Indian surveys to enhance comparability. From what I can read from their Figure 2, they have attempted to eliminate the 'rural bias' in the three early surveys by reducing the prevalence of stunting, as reported in the WHO database, by some 5–7 percentage points. There is no mention of these

Table 3 Comparison of prevalence of stunting in 1998/99 for 0–3 year olds in the eight states covered in earlier surveys and other states

States	N	Weight R + U	Estimated prevalence of stunting (%) Rural[a]	Urban[a]	Total
Eight states in early surveys	9732	0.399	43.1*	33.5**	40.5*
Other 11 states	14 664	0.601	50.8*	36.7**	47.8*
All 19 states	24 396	1.000	47.9	35.2	44.9

Source: Author's calculations based on WHO.[1]
*/** Indicate that the difference between groups of states is statistically significant at the 0.001 and 0.01 levels, respectively.
[a] Calculations based on rural and urban sample weights.

(and possibly other) adjustments in the data underlying their regressions.

25-year trend for reduced sample

From the data available in the open WHO database, a consistent long-term trend in child stunting in India can only be estimated for a small subset: rural children aged 0–3 years in eight states. These estimates indicate a notable decline in stunting, from 66.5 to 62.7% between 1974/79 and 1988/90 and a much sharper drop between the latter survey and that from 1998/99 (to 43.1%).

The crucial question is how representative the subset of rural children from eight states is for the Indian child population at large. Later surveys show significant inter-state and rural-urban differences. The 1998/99 survey estimates of stunting by rural and urban areas in each of the 19 states are reported, including the eight states in the early surveys. This survey (of 0–3 year olds) shows the weighted (by sample size) average stunting prevalence in the eight states to be significantly lower (40.5%) than in the other 11 states (47.8%). Furthermore, stunting in rural areas is 12.7 percentage points higher than in urban settings in the 1998/99 survey (Table 3). Although it covers fewer states, the 1992/93 survey shows similar differences.

Hence, the 1992/93 and 1998/99 surveys indicate that when the estimates from the three earlier surveys are used as proxies for the whole of India, two biases are most probably induced. The limited state coverage tends to bias the stunting estimates downwards and the confinement to rural areas upwards. Since these two presumed selection biases in the early surveys go in different directions, they should be partly off-setting. The snag is that the inter-state and the rural–urban differences may have been larger—or smaller—in the 1970s and 1980s than in the 1990s. There are simply no data to tell. Consequently, to derive a consistent long-term trend for child stunting in all of India is not possible.

Change in child stunting over the 1990s

The surveys from 1992/93 and 1998/99 include urban as well as rural children and are comparable in many dimensions. The former survey covers 12 large states (and eight union territories with 2% of the total sample). The latter survey is national and separate data are reported for the same 12 states included in the earlier survey. One difference is that they cover different age cohorts: 0–4 year olds in the 1992/93 survey and 0–3 year olds

Table 4 Estimated change in child stunting between Indian surveys in the 1990s with adjustments for comparability

	Coverage/adjustment made	Prevalence of stunting (%)[a] 1992/93	1998/99	Change
A	Unadjusted WHO estimates	51.8	44.9	−6.9*
B	12 overlapping states, different age cohorts[b]	52.1	46.7	−5.4*
C	12 overlapping states, same age cohort (0–3 years)	47.1	46.7	−0.4
D	Other states in 1998/99 survey[c]	–	41.9	–

Source: Author's calculations based on WHO.[1]
* Indicates that the change is statistically significant at the 0.001 level.
[a] Averages weighted by sample size in surveys (rural and urban children combined).
[b] The 12 states are: Assam, Bihar, Delhi, Gujarat, Haryana, Karnataka, Kerala, Maharashtra, Orissa, Punjab, Rajasthan, and Uttar Pradesh. These states account for 98% of the child sample in the 1992/93 survey and 62% in the 1998/99 survey.
[c] The largest other states in the 1998/99 survey are Andhra Pradesh, Madhya Pradesh, Tamil Nadu, and West Bengal.

in the later one. Comparing the stunting estimates in the 12 overlapping states, after adjustment for the difference in age cohorts, is the closest one can come to gauge the change in child stunting in India during the 1990s, the first MDG decade.

The unadjusted WHO data used by de Onis *et al.* show a decline in stunting between 1992/93 and 1998/99 by 6.9 percentage points (Table 4, panel A). When re-estimated for the overlapping 12 states, the decline in stunting falls to 5.4 percentage points (panel B). When stunting prevalence in the 12 states in the 1992/93 survey is re-estimated for 0–3 year olds only—to accomplish comparability with the later survey—the decline becomes an insignificant 0.4 percentage point (panel C). This means that when the comparison is restricted to the overlapping states and the same age cohort, the prevalence of child stunting in India did not change over the 1990s. The observation that child stunting in India is lower among children aged 0–3 years than among 0–4 year olds is consistent with the global age pattern in child stunting.[10]

The unaltered high prevalence of child stunting in India has been paired with growing rural–urban and inter-state divides. In the 12 overlapping states, the (weighted average) ratio of the prevalence of child stunting in rural and urban areas went up from 1.21 in 1992/93 to 1.33 in 1998/99. The inter-state variance in stunting, as measured by the coefficient of variation, increased from 0.160 to 0.173.

Economic fundamentals

In all investigations of the determinants of inter-country differences in child stunting (and underweight) based on regression analysis, per-capita real income has been identified as the crucial variable. In these studies, per-capita income alone explains 50–60% of the cross-country variation. Including also other independent economic and social variables (such as access to various public services and parental education) increases the explanatory power of the regressions, but only by a few percentage points.[11–14] The few cross-country

Table 5 Annual real per capita household income growth and changes in income distribution, poverty, and child stunting in India over the 1990s

| | Income growth 1993/94–1999/00 (% per year)[a] | | Estimated change between 1993/94 and 1999/00 | | | | | |
| | | | Income distribution | Poverty (headcount ratio) (percentage points) | | | Child stunting[b] (percentage points) | |
Area	NDP/c	APCE	Gini[c]	Official	Deaton	Sen	WHO	Altern.
Rural	–	1.5	+0.5	−10.3	−6.7	−2.8	−6.1	–
Urban	–	2.8	+2.9	−8.8	−5.8	−2.8	−9.3	–
Total	4.4	1.8	+1.1[d]	−9.9[d]	−6.5[d]	−2.8[d]	−6.9	−0.4

Sources: Deaton and Dréze[18]; Sen and Himanshu[19]; Indian 1991 Population Census[21]; author's calculations based on WHO.[1]

[a] NDP/c = National domestic product per capita; APCE = Average per capita consumption expenditure from the 50th and 55th rounds of the Indian National Sample Surveys (NSS).

[b] Change between the 1992/93 and 1998/99 child surveys as reported in Table 4 above. The data in the open WHO database are not detailed enough to permit alternative estimates for rural and urban areas separately.

[c] The Gini coefficient is a measure of relative income distribution that can assume values from 0 (completely even distribution) to 100 (one household has all the incomes).

[d] Estimates for rural and urban areas combined are not presented in the sources. The totals are derived as weighted averages, with rural (0.743) and urban (0.257) population shares from the 1991 census as weights.

investigations that have estimated how changes in stunting relate to income growth also find a significant correlation (after controls), although the explanatory power of the income variable is smaller.[11,15] Yet other investigations are based on within-country estimates of child malnutrition and household income. A recent such study estimated the link between child malnutrition (proxied by underweight) and income in each of 12 countries based on household survey data and, alternately, on cross-country observations from 61 countries. The finding was that: 'The percentage reduction in malnutrition rates [following higher incomes] estimated using survey data are remarkably similar to those using cross-country data'.[14] With both methods, an increase in income by 1% is associated with an estimated decline in the prevalence of malnutrition (underweight) by ~0.5%.

Since child stunting is normally a cumulative process over several years, a drastic decline in stunting over 1 or 2 years in a population can only occur when real incomes and other conditions improve dramatically, i.e. after a recovery from prolonged war, natural catastrophes, and/or widespread famine.[16]

At face value, the surveys in the WHO database show a decline in the prevalence of child stunting in rural India by >7 percentage points between the 1991/92 and 1992/93 surveys (Table 2). There were definitely no drastic improvements in the economic fundamentals in India at the time. Quite the contrary, the year 1991 was marked by the most severe macroeconomic crises in India over the entire 1980–2002 period: large budget and balance-of-payments deficits, inflation shot up, and per-capita income growth ceased.[17] The sharp deterioration in economic fundamentals in the early 1990s would be expected to be followed by increased child malnutrition, if anything, not by a large decline. This contradiction corroborates the previous conclusion that the various Indian child surveys before and after 1992 are not comparable.

During the rest of the 1990s, India did well according to the official and most frequently cited economic indicators. The real per-capita National Domestic Product (NDP) increased by 4.4% per annum between 1993/94 and 1999/00. The incidence of poverty declined by 9.9 percentage points, as officially estimated by the share of people below the national poverty line (Table 5). These developments seem inconsistent with an unaltered prevalence of child stunting over this period. However, the latter finding squares with other economic indicators that are less frequently cited, but more relevant for explaining child malnutrition.

Household private consumption expenditures account for about half of the NDP in India and increased less rapidly over the period concerned. Estimates based on the Indian National Sample Surveys (NSS) show annual growth in household consumption expenditures between 1993/94 and 1999/00 to be a modest 1.5% in rural areas (Table 5). More compelling, the 40% poorest in rural areas had the slowest growth in real consumption expenditures (0.2% per year) of all income groups in India during the 1990s.[19]

There are also updated estimates of changes in income distribution in India during the 1990s. They show that income inequality in all dimensions, the within rural, within urban, urban–rural, inter-state, and inter-household distribution, increased considerably between 1993/94 and 1999/00, reversing previous trends.[18–20] Moreover, the official poverty estimates have been challenged on the grounds that methodological changes in survey design between rounds have compromised comparability. Several scientists have tried to rectify the bias and find the decline in poverty to be significantly smaller than the official estimate (Table 5).

The minuscule income growth for the 40% poorest rural households and the more uneven distribution of incomes are consistent with a small reduction in poverty—and also with no change between 1992/93 and 1998/99 in stunting prevalence among children. Further, it is notable that household income growth and poverty reduction in the 1993/94 to 1999/00 period were, on average, marginally higher in the 12 overlapping states than in the other Indian states and union territories.[18] This indicates that the persistence of child stunting during the 1990s in the 12 states, with two-thirds of the population, may well carry over to the rest of India.

The increase in the ratio of rural to urban stunting in the 12 states, from 1.21 to 1.33, was matched by a larger increase in the ratio of rural to urban poverty in all of India, from 1.1 in 1990 to 1.4 in 2000.[20] Moreover, the inter-state income

Table 6 Estimated prevalence of stunting in children aged 0–5 years in China, by urban and rural areas and by Western and Eastern provinces, 1987–2002

	Estimated prevalence of child stunting (%). Survey year				
	1987[a]	1992[a]	1998[a]	2000[a]	2002
All provinces	32.1	33.7	15.6	14.2	14.3
Eastern provinces	28.1	33.6[b]	17.2	14.5	–
Western provinces	41.7	42.7[b]	31.3	30.8	–
Urban areas	14.6	11.3	4.0	2.9	2.7
Rural areas	36.2	39.8	22.0	20.2	19.5
Coverage of provinces	9	National	National	National	National
Coverage of sites	–	225	40	40	132
N	76 130	179 705	13 652	16 491	>50 000

Sources: WHO[1]; Chen et al.[25]; China SCIO.[23]
[a] Survey included in de Onis et al.[2]
[b] Rural areas only.

distribution became more uneven between 1993/94 and 1999/00 in the wake of higher household income growth in the states with the initially highest incomes.[18] Since there was a strong correlation across states between income growth and poverty reduction over this period, the inter-state difference in poverty increased. It is hence not surprising that there was an increase in the inter-state variation in child stunting as well.

Comparability over time in Chinese surveys

The estimates of the prevalence of child stunting in China from the four surveys included in the de Onis et al. regressions are replicated in Table 6. According to these surveys, there was a small, but statistically significant, increase in child stunting between 1987 and 1992, followed by a reduction by half between the latter year and 1998. This abrupt reversal is puzzling and raises the question of whether the Chinese surveys are internally comparable.

The 1987 and 1992 surveys

The 1987 survey stands out by not being national as only 9 out of 31 provinces were covered. According to the later national surveys from China, there are large spatial differences in child stunting. The main divides go between Western and Eastern provinces and between rural and urban areas (Table 6). Despite its limited coverage, the 1987 survey is included in the study by de Onis et al., presumably on the presumption that it is reasonably representative, a position that has been shared by other analysts.[22]

On closer inspection, however, it turns out that children from Western provinces, with the highest prevalence of stunting, are over-represented in the 1987 survey. They account for 37.6% of the child sample, while Western provinces only had 21.2% of the population in China at the time. A sensitivity test shows the overall prevalence of stunting in the 1987 survey to be reduced from 32.1 to 29.8% when population shares are used as alternative weights. A reduction by 2.3 percentage points is notable but does nothing to resolve the puzzling trend reversal.

On the contrary, by indicating a larger increase in the prevalence of child stunting between 1987 and 1992 than shown by the unadjusted data (3.9 rather than 1.6 percentage points), the sensitivity test reinforces the puzzle.

An alternative hypothetical explanation of the reversal is that stunting was overestimated in the 1992 survey, but this does not seem to be the case. The 1992 survey was large, national, and covered children in both rural and urban areas. The sampling methodology was multistage stratified probability sampling and the standard WHO/NCHS height norms were used.[22] Detailed analysis of the data in the 1992 survey did not reveal any major irregularity in the rural–urban, age and sex composition of the child sample.

The 1998 and 2000 surveys

A further possible reason for the marked reversal is that the survey from 1998 (and also 2000) understates child stunting; that is, the halving of stunting between 1992 and 1998 may be an exaggeration due to flaws in the latter survey. The main objective with the 1998 and 2000 surveys, which are not referred to as national by the Chinese authorities,[23] seems to have been to gauge whether the large and mounting income disparities within China carried over to child malnutrition. The 40 observation sites were selected on the basis of income differences, i.e. the most affluent urban areas (14 big cities), general rural areas (17), and poor rural areas (9). None of the approximately 45 000 small cities, towns, and townships, with ~25% of the Chinese population,[24] were surveyed. This omission indicates the 1998 and 2000 surveys underestimate the prevalence of child stunting in (urban) China as a whole at the time. However, the fact that the prevalence of child stunting in the later 2002 national survey was estimated at 14.3%, not much different than in 1998 (15.6%) and 2000 (14.1%), suggests that the possible underestimation in the surveys from the latter 2 years should not be very large. There is, hence, little reason to doubt that there was a substantial decline in child stunting in China from 1992 and onwards.

Finally, it is notable that the decline in child stunting in China at the national level since 1992 has been highly uneven. The ratio of the prevalence of stunting in rural and urban areas increased from 3.5 to 7.2 between 1992 and 2002 (Table 6). It also seems that the decline in the Western provinces, with the initially highest levels of stunting, was below the national average up to year 2000.[25] More details on East–West divide will be available when the full results from the 2002 national survey eventually are published.

Economic fundamentals

In 1992, the Chinese Government set up the policy objective to halve malnutrition in under 5-year olds by the year 2000.[22] If the estimates from the available surveys are reasonably accurate—and stunting is the chosen indicator—the objective was met on time. However, for this to have actually occurred, rather than being an undetected statistical artefact, drastic improvements must have taken place in the economic fundamentals behind child malnutrition since 1992. There must also have been a notable deterioration in the economic conditions between 1987 and 1992 when child stunting increased.

Table 7 Estimated change in average household income per person, income distribution, poverty, and prevalence of child stunting in China in selected sub-periods

Period	Household income growth per person/year (%)[a]		Income distribution (Gini) (percentage points)[b,c]		Poverty (headcount) (percentage points)[b]		Child stunting (percentage points)[b]	
	Rural	National[d]	Rural	National[d]	Rural	National[d]	Rural	National
1982–87	8.4	7.8	+4.1	+3.0	−25.9	−21.3	–	–
1987–92	−0.3	1.4	+3.5	+5.3	+6.3	+4.0	+3.6[e]	+1.6[e]
1992–98	7.3	7.0	+1.1	+1.2	−16.6	−12.7	−17.8	−18.1
1998–01	3.4	6.2	+3.4	+4.1	+0.9	−0.1	−2.5[f]	−1.3[f]

Sources: Ravallion and Chen[27]; WHO[1]; China SCIO.[25]

[a] Annualized growth of household real consumption expenditures (Yuan/person/year).

[b] Change between first and final year in sub-period (percentage points).

[c] A positive change (+) means that the Gini coefficient has increased and that income distribution has become more uneven.

[d] Adjusted for urban/rural differences in the cost of living (COL).

[e] Unadjusted estimates from WHO[1] (see text).

[f] Change between 1998 and 2002.

Income differences across households have been found to be the most 'powerful factor' affecting the nutritional status of rural Chinese children.[26] The 1998 (and 2000) survey provides separate estimates from general rural sites and poor rural sites, which show stunting prevalence to be almost twice as high in the latter, 30.1 vs 18.0%.[25] The household-survey and the cross-country investigations referred to earlier also find low per-capita income (and hence, widespread poverty) to be the strongest determinant of child stunting.[11–15]

World Bank researchers have recently derived annual estimates for the period 1980–2001 of real household mean income per person, income distribution, and incidence of poverty in rural and urban China.[27] Their estimates have been re-tabulated in Table 7 for four sub-periods and show household income growth, especially in rural areas, to have varied notably over relatively short time spans. These estimates go a long way to resolve the puzzling reversal in child stunting in China.

The 1987–92 period was dire for the rural population in economic terms. Real household income per person actually declined slightly, national income distribution became more uneven and, consequently, the incidence of poverty increased (Table 7). This dismal economic development for the rural population is consonant with the increase in child stunting at the national level between these years, be it by 1.6 (unadjusted) or 3.9 percentage points (adjusted).

The economic situation for the rural population improved dramatically during the 1992–98 period. Rural per person real income growth was ~7.3% per year, national income distribution remained largely unaltered, and poverty at the national level was reduced from 20.8 to 8.1%.[27] Hence, the halving of child stunting suggested by the 1992 and 1998 surveys is consistent with highly favourable economic developments for the rural population between these years. There was also close correlation between changes in child stunting and poverty during the 1998–2001/02 period, when rural income growth was sluggish, rural poverty increased slightly, and overall child stunting remained largely unchanged according to the available estimates (Table 7). That the change in child stunting and the change in the poverty rate in China over the 1987–2002 period
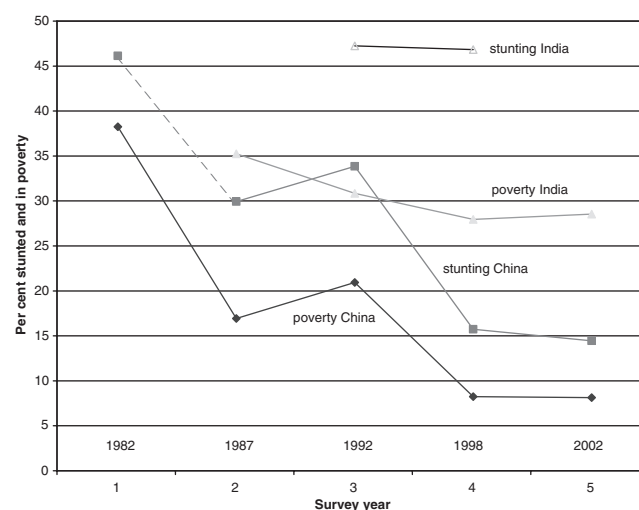

Figure 1 Estimated prevalence of child stunting and poverty in India and China 1982–2002. *Sources*: Table 4 above (stunting India); Sen and Himanshu[19] (poverty India); Table 6 above (stunting China 1987–2002, the 1987 estimate has been adjusted for overrepresentation of Western provinces and the 1982 estimate is derived as explained in text); Ravallion and Chen[27] (poverty China).

have been closely synchronized is further demonstrated by Figure 1.

The uneven progress in reducing child stunting in rural and urban areas revealed by Table 6 closely follows changes in poverty rates. Urban poverty was brought down to a few per cent already in the early 1980s. In rural areas, poverty increased by 6.3 percentage points between 1987 and 1992, to reach 28.2%, but subsequently declined to 11.6% in 1998. In the latter year, the incidence of poverty in rural areas was ~10 times higher than in urban areas. Poverty in rural areas increased slightly until the year 2001, while it fell to close to zero in urban settings.[27] The available data are not detailed enough to tell whether the persistent difference in child stunting between the Western and Eastern provinces corresponds to an equally persistent difference in poverty rates.

Table 8 Estimated annual rate of decline in child stunting required to reach the MDG by 2015 with and without China and adjusted Indian data

Countries	Estimated prevalence of stunting (%)			2015 objective[a]	Required annual decline 2001–15 (%)	Ratio of required and actual decline
	1988–1992	1998–2002	Annual decline (%)			
All 40	41.1	29.3	3.4	20.6	2.4	0.7
40 India adj.	39.9	30.0	2.9	20.0	2.8	1.0
39 China excl.	45.6	37.8	1.9	22.8	3.4	1.8
39 India adj. China excl.	43.7	38.8	1.2	21.9	3.9	3.3

Source: Author's calculations based on WHO.[1]
[a] Half of the estimated prevalence of stunting in 1988–92.

Whether the strong correlation between changes in child stunting and in poverty in 1987–2002 also applies to the early 1980s is uncertain. Economically, this initial phase of the Chinese market-orientation period, with de-collectivization of the agricultural sector as the major reform, was highly favourable for the rural population. Estimated real income growth per person in the rural areas averaged 8.4% per year between 1982 and 1987. Even though income distribution became more uneven, the incidence of rural poverty fell by an estimated 25.9 percentage points (Table 7).

The survey data at hand do not permit a firm assessment of child stunting in China before 1987. There was a national nutrition survey in 1982, but the published results (in English) only report on average height for age; no direct estimates of stunting prevalence are provided.[28] An indirect estimate, derived by calculating Z-scores from the height-for-age data and converting these into prevalence rates, using standard conversion tables,[25,29] suggests a prevalence of child stunting of 38% at the time.

A further problem with the 1982 survey is that the pre-school children sampled were mainly those attending kindergartens.[30] Only ~20% of the Chinese children were enrolled in kindergarten in that year, and these children were privileged in the sense that they received health care and meals, in special abundance, in urban areas. Here the number of nurses and cooks in the school staff actually outnumbered the teachers.[31] It is, hence, likely that the kindergarten children had better than average nutritional status and that the 38% is an underestimate of stunting for the whole of China in 1982.

An alternative estimate was, therefore, derived with the help of child mortality data. Worldwide, changes in child mortality (U5MR) are closely related to changes in the prevalence of underweight,[6] which should carry over to stunting given the high overlap between stunting and underweight.[9] In China, there has been a clear downward (exponential) trend in the U5MR over the years 1970–2004, even though the exact numbers differ depending on the source consulted.[32] From the 1987–2002 period there are five reasonably reliable estimates of stunting, which allows a crude (exponential) trend to be estimated. The estimated trends in U5MR and stunting in China over this period are almost parallel. Extrapolating the 1987–2002 trend in stunting backwards to 1982 suggests a prevalence of stunting in that year of 46% as compared with 38% for the privileged kindergarten children. The 46% estimate is inserted in Figure 1, but it should be interpreted cautiously (hence, the dashed line between 1982 and 1987).

The (uneven) progress towards the MDG

For the MDG of reducing the prevalence of malnourished children by half between 1990 and 2015 to be realized at the global level, the required average annual decline has to be at least 2.8%. The population-weighted decline in child stunting in the 40 countries in my investigation (with two-thirds of the population in the developing countries) over the 1990–2000 period was 3.4% per year. The estimate derived by de Onis et al.[2] show a somewhat smaller decline, i.e. 2.5% per year. According to my estimates, when based on unadjusted data for India (Table 1), progress towards the MDG is on track at the global level.

The worrying development is the unevenness in the progress. Both de Onis et al. estimates and my estimates show very little progress in Sub-Saharan Africa. According to the former authors, a substantial decline in child stunting occurred in South-central Asia, the region with the initially highest level. However, when correcting for the incomparability of the surveys, the prevalence of child stunting in India remained unchanged in the 1990s (Table 4). When I use the adjusted instead of the unadjusted estimates for India, the decline in child stunting in South-central Asia dwindles from 8.5 to 3.5 percentage points. Unfortunately, the surveys in my samples from the Middle East and South-east Asia are too few to allow reliable and representative trends for these regions to be estimated.

The decline in child stunting at the global level over the 1990s has been driven mainly by the rapid reduction in China, with one-quarter of the population in the developing world. When I factor out China and rely on the adjusted estimates from India, the decline in 'global' child stunting is reduced to 1.2% per year. For the MDG to be reached outside China, the average rate of progress during the period 2001–15 has to be raised to 3.9% per annum, more than three times higher than in the 1990s (Table 8).

Summary and policy discussion

The trends in child stunting estimated by de Onis et al.[2] are by and large corroborated by my alternative estimation method when based on a subset of the same WHO data—but different units of observation (children instead of country surveys). Hence, the choice of estimation method does not seem to dictate the main results. Question marks remain, however, regarding the inter-temporal comparability of the surveys in the WHO database. In this paper, I investigated the surveys from the most populous countries, India and China. Three generalizable conclusions followed from this data analysis.

First, if child stunting (or underweight) is to be used for monitoring progress towards the MDG at the sub-regional

level, effort must be made to ensure that the surveys for individual countries, especially the large ones that weigh heavily in the trend estimates, are comparable over time. If not, there will most probably be a bias in the estimated trends, as my re-estimate for South-central Asia showed when the Indian data were adjusted for comparability.

Second, it is important that countries' surveys are inter-temporarily comparable in order to provide a sound basis for policy priorities. Again, this is demonstrated by the Indian example. From a policy maker's perspective, a decline in child stunting by 13% (as shown by the unadjusted data) signals progress and may lead to the conclusion that new policy initiatives in other areas are more important. The adjusted estimates, showing no change in child malnutrition over the 1990s despite high economic growth, signal that concerted policies aimed at enhancing child welfare are urgently needed.

Third, when surveys from a country show a drastic change in child stunting over a short period, there is reason to examine closely whether the surveys are comparable in various technical dimensions. As a further check one should examine how drastic short-term changes in child malnutrition relate to changes in the underlying economic fundamentals. The importance of this was demonstrated by the Indian and, especially, the Chinese cases. The increase in child stunting in China between 1987 and 1992 followed by an abrupt decline thereafter seemed puzzling but turned out to be closely matched by parallel changes in the incidence of rural poverty.

The remedies for alleviating child malnutrition inferred by de Onis *et al.* are interventions at the household and sector levels, aimed at improving breastfeeding practices, micro-nutrient fortification and supplementation of diets, and increased provision of medical services, clean water, sanitation, and education. There is plenty of evidence showing that such interventions can be effective in small trial tests conducted by highly motivated and skilled personnel in tightly controlled environments.[33,34] When it comes to intervention programmes aimed at alleviating poverty, ill health, and/or malnutrition in countries on a large scale, recent evidence is less encouraging.

In a study commissioned by the World Bank and IFPRI, the targeting efficiency of 85 large-scale intervention programmes in 36 developing countries was evaluated.[35] Only in about a dozen of these programmes were the poor effectively targeted and one-quarter of the programmes had a regressive impact. On average, the targeting precision was low and especially so in the poorest countries with the highest shares of malnourished children.

More elaborate and detailed evaluations of large non-experimental intervention programmes in India, Bangladesh, and Mexico are now available. The largest of all such programmes, the PDS in India, which covers about two-thirds of the 600 000 villages in the country, had little impact on the children according to two recent evaluations.[36,37] Another evaluation of the cash-for-education programme in Bangladesh, involving 2 million children, concluded that it was 'mildly pro-poor'.[38] On the other hand, an evaluation of PROGRESA in Mexico reports positive results on the targeted children's nutritional status once systematic initial differences in the treated and non-treated children are controlled.[39]

The evidence is hence mixed, although most evaluations point at rather poor targeting efficiency in large-scale intervention programmes. This is not to say that such programmes cannot

help accelerating progress in the alleviation of child malnutrition in the future. That would require improved knowledge about how to increase targeting efficiency in poor countries where the political economy conditions are not conducive.

A string of recent macro-level studies, based on cross-country investigation, univocally find strong correlation between low per-capita income (poverty) and child stunting (and underweight).[11–14] Also studies of changes over time corroborate the links between income growth, poverty reduction, and child malnutrition.[11,15] The same holds for within-country studies based on household survey data.[14] A note of caution is warranted, however, since all investigations based on multiple regression analysis and cross-sectional data for identifying determinants of child malnutrition are marred by the problem of strong association between many of the explanatory variables. This means that the relative explanatory power of the various independent variables becomes sensitive to model specification and other technicalities.

The findings reported in the present paper based on estimated changes over time in the two most populous countries in the world are free from these particular estimation problems, while providing additional evidence in the same vain. The Chinese experience shows that a substantial reduction of child stunting is feasible even over a short period in the wake of exceptionally high rates of income growth and rapid poverty alleviation. In sharp contrast, in Sub-Saharan Africa as a whole, per-capita real income growth during the 1990s was nil and the poverty rate increased from 44.6 to 46.4%.[40,41] Child stunting declined—if at all—by a few percentage points only.

In concert, all these studies indicate that high real income growth comes close to being necessary for considerable alleviation of child malnutrition in the poorest countries. Without broad-based economic growth in these countries, (public) investments in health services, water and sanitation infrastructure, and education cannot be financed. Without equitable income growth and ensuing poverty reduction, poor households cannot afford a balanced, micro-nutrient rich diet, better education, shelter, and health care.

However, the Indian experience over the 1990s demonstrates that high growth of NDP per capita is not sufficient for reducing child malnutrition. Increased inequality in income distribution in all dimensions and practically no growth in the real incomes of the poorest households in rural areas left both poverty and child malnutrition largely unaltered (Figure 1). Without institutions and policies ensuring high income growth involving the poorest population segments and thereby reducing poverty, the prospects for attaining the MDG in India and most of Africa will remain bleak.

Supplementary Data

Supplementary data are available at *IJE* Online.

Acknowledgements

KEY MESSAGES

- The MDG of reducing the prevalence of child malnutrition by half before 2015 is on track at the global level, mainly due to the fast progress in populous China.

- The progress in India, and also in most of Sub-Saharan Africa, with the highest initial levels of child stunting, was close to nil over the 1990s.

- The Chinese example demonstrates that halving child stunting can be accomplished over half a decade in the wake of high income growth and rapid poverty reduction.

- The Indian example shows that high economic growth in combination with sharply deteriorating income distribution can leave poverty and child stunting unaffected.

- The rate of decline in child stunting in most countries other than China has to increase dramatically during 2001–15 in order for the MDG to be attained.

References

[1] World Health Organisation. *Global Database on Child Growth and Malnutrition*. Geneva: WHO, 2004.

[2] de Onis M, Blössner M, Borghi E, Morris R, Frongillo EA. Methodology for estimating regional and global trends of child malnutrition. *Int J Epidemiol* 2004;**33:**1260–70.

[3] de Onis M, Blössner M. The World Health Organization global database on child growth and malnutrition: methodology and applications. *Int J Epidemiol* 2003;**32:**518–26.

[4] de Onis M, Frongillo EA, Blössner M. Is malnutrition declining? An analysis of changes in levels of child malnutrition since 1980. *Bull World Health Organ* 2000;**78:**1222–33.

[5] Cole TJ. Methods to estimate trends in undernutrition: a review. In The 4th Report on the World Nutrition Situation. *SCN* 2000; 86–91.

[6] Pelletier DL, Frongillo EA. Changes in child survival are strongly associated with changes in malnutrition in developing countries. *J Nutr* 2003;**133:**107–19.

[7] Ahmad OB, Lopez AD, Inoue M. The decline in child mortality: a reappraisal. *Bull World Health Organ* 2000;**78:**1175–91.

[8] Child Mortality Coordination Group. Tracking progress towards the Millennium Development Goals: reaching consensus on child mortality levels and trends. *Bull World Health Organ* 2006;**84:**225–32.

[9] Nandy S, Kelly M, Gordon D, Subramanian SV, Smith GD. Poverty, child undernutrition and morbidity: new evidence from India. *Bull World Health Organ* 2005;**83:**210–16.

[10] Shrimpton R, Victoria CG, de Onis M et al. Worldwide timing of growth faltering: implications for nutritional interventions. *Pediatrics* 2001;**107:**75–81.

[11] Svedberg P. Hunger and malnutrition: alternative perspectives. In: Lomborg B (ed). *Global Crises, Global Solutions*. Cambridge: Cambridge University Press, 2004, pp. 421–34.

[12] Svedberg P. *Poverty and Undernutrition: Theory, Measurement and Policy*. Oxford: Oxford University Press, 2000.

[13] Smith LC, Haddad L. How potent is economic growth in reducing undernutrition? What are the pathways of impact? New cross-country evidence. *Econ Dev Cult Change* 2002;**51:**55–76.

[14] Haddad LH, Alderman H, Appleton S, Song L, Yohannes Y. Reducing child undernutrition: how far does income growth take us? *World Bank Economic Review* 2003;**17:**107–31.

[15] Milman A, Frongillo EA, de Onis M, Hwang JY. Differential improvement among countries in child stunting is associated with long-term development and specific interventions. *J Nutr* 2005;**135:**1415–22.

[16] Bégin F, Habicht JP, Frongillo EA, Delisle H. Modification of secular deterioration in child nutritional status by mother's influence on child feeding in rural Chad. *Am J Public Health* 1997;**87:**1356–59.

[17] Srinivasan TN. China and India: economic performance, competition and cooperation: an update. *J Asian Econ* 2004;**15:**613–36.

[18] Deaton A, Dréze J. Poverty and inequality in India: a re-examination. *Econ Pol Weekly* 2002;**37:**3729–48.

[19] Sen A, Himanshu. Poverty and inequality in India I and II. *Econ Pol Weekly* 2004;**39:**4247–63, 4361–75.

[20] Datt G, Ravallion M. Is India's economic growth leaving the poor behind? *J Econ Perspectives* 2005 (forthcoming).

[21] Census of India, 1991 and 2001. Government of India. New Delhi.

[22] Chang Y, Xian ZD, He W, Chang SY, Ma HJ, Chen CM. Child malnutrition in China (present status and changing trends). *Biomed Environ Sci* 1996;**9:**164–80.

[23] China State Council Information Office (SCIO). The nutrition and health status of the Chinese people. Press release. Beijing, 12 October 2004.

[24] China National Bureau of Statistics. *China Statistical Yearbook*, various issues. Beijing: China Statistics Press.

[25] Chen CM, He W, Zhenying F. *Ten Year Tracking Nutrition Status in China: 1990-2000*. Beijing: People's Medical Publishing House, 2004.

[26] Ge KY, Fu DW. The magnitude and trends of under- and over-nutrition in Asian countries. *Biomed Environ Sci* 2001;**14:**53–60.

[27] Ravallion M, Chen S. China's (uneven) progress against poverty. World Bank Policy Research Working Paper 3408, September 2004. Washington DC.

[28] Ge K, Chen CM, Shen T. Food consumption and nutrition status in China. *Food Nutr Agric* 1991;**1:**54–61.

[29] WHO. *Physical status: The Use and Interpretation of Anthropometry*. Geneva: WHO, 1995.

[30] Chen CM. The National Nutrition Survey of China, 1982: summary results. *Food Nutr Bull* 1986;**12:**58–60.

[31] Wu DY. Early childhood education in China. In: Feeney S. (ed), *Early Childhood Education in the Pacific: A Resource Book*. New York: Garland Publishing Inc, 1992, pp.1–26.

[32] Banister J, Hill K. Mortality in China 1964-2000. *Popul Stud* 2004;**58:**55–75.

[33] Allen L, Gillespie S. What works? A review of efficacy and effectiveness of nutrition interventions. ACC/SCN Nutrition Policy Paper 19, 2001.

[34] Behrman JE, Alderman H, Hoddinott J. Hunger and malnutrition. In: Lomborg B (ed). *Global Crises, Global Solutions*. Cambridge: Cambridge University Press, 2004, pp. 363–420.

[35] Coady D, Grosh M, Hoddinott J. *Targeting of Transfers in Developing Countries. Review of Lessons and Experience*. Washington DC: World Bank, 2004.

[36] das Gupta M, Lokshin M, Gragnolati M, Ivanschenko O. Improving child nutrition outcomes in India: can the integrated child development service program be more effective? World Bank Policy Research Working Paper 3647, June 2005.

[37] Kochar A. Can targeted programs improve nutrition? An empirical analysis of India's Public Distribution System. *Econ Dev Cult Change* 2005;**54:**203–35.

[38] Galasso E, Ravallion M. Decentralized targeting of an antipoverty program. *J Public Econ* 2005;**89:**715–27.

[39] Behrman JR, Hoddinott J. Program observation with unobserved heterogeneity and selective implementation: The Mexican PROGRESA impact on child nutrition. *Oxford Bull Econ Stat* 2005;**67:**547–69.

[40] World Bank. *World Development Indicators*. Washington DC, 2003.

[41] Chen S, Ravallion M. How have the world's poorest fared since the early 1980s? *World Bank Research Observer* 2004;**19:** 141–69.