Socioeconomic Inequalities in Child Malnutrition in the Developing World

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The findings, interpretations and conclusions expressed in this paper are entirely those of the authors. They do not necessarily represent the views of the World Bank, its Executive Directors, or the countries they represent. Without wishing to incriminate them in any way, we would like to acknowledge the helpful comments of Peter Lanjouw and Milla McLachlan on an earlier draft of this paper. The work towards the paper was supported by a grant from the World Bank's Research Support Board (grant # 683-47), as well as by the Bank's Visiting Fellow Program and the Japanese Trust Fund.

I. Introduction

Major progress has been made over the last 30 years in reducing the prevalence of malnutrition amongst children. Between 1970 and 2000 the proportion of malnourished children was reduced by 20 % in developing countries [1, 2]. Despite this, approximately 27% of children under the age of five in developing countries are still malnourished [1]. Malnutrition currently claims about the half of the 10 million deaths each year among under-five children in the developing world, and is the risk factor responsible for the greatest loss of DALYs globally, accounting for 16% of total DALYs [3]. Furthermore, malnutrition is highly associated with poverty—levels of malnutrition are higher in poor countries than in better-off countries. In low income countries 36 % of children are malnourished compared with 12% and 1% in middle income countries and the United States, respectively [4]. There is also growing evidence (see below) that, *within countries*, the poor suffer from higher rates of malnutrition than the nonpoor. This has led for calls for the focus to be on reducing levels of malnutrition *amongst the poor* [5-7]. And yet the goals and targets of international development and bilateral aid agencies continue to be couched in terms of improving population averages [8]. For example, the only nutrition-focused target of the OECD's Development Assistance Committee (DAC) is couched in terms of population averages—to reduce the proportion of children under-five who are underweight by one half between 1990 and 2015 [9].

Part of the reason for this gap between rhetoric and reality is lack of data—until recently, only patchy data existed on poor-nonpoor differences in malnutrition rates. This is now changing. Two recent studies of malnutrition in Africa [10, 11] documented the gaps in malnutrition across consumption groups in that continent, while a new dataset [12] allows comparisons to be made across 48 countries of malnutrition differentials across quintiles of "assets".

This paper contributes to this growing empirical literature on poor-nonpoor inequalities in child malnutrition. It differs from the aforementioned studies in a number of respects. First, by using concentration indices and corresponding standard error estimates, it attempts to draw systematic conclusions about cross-country differences in malnutrition inequalities. In this respect, the paper is the analog for child malnutrition of the analysis of inequalities in infant and under-five mortality reported in Wagstaff [13]. The results in the present paper suggest that several countries have high inequalities on more than one indicator of malnutrition, while several have low levels of inequality. We also find, however, that in many of the pairwise comparisons between countries, the differences in inequality are not statistically significant. Second, we present some evidence—albeit very limited—on the issue of *why* some countries have higher levels of inequality in malnutrition than others. Specifically, we explore the possibility that inter-country differences in inequalities in malnutrition reflect inter-country differences in inequalities in consumption. Third, we emphasize the evidence on both inequalities *and* population averages. We find some countries that do well on both dimensions, but find many that perform well on one dimension but badly on the other. We therefore go on to compute values of a summary index that captures how well a country does both on its average rate of malnutrition and on its inequality in malnutrition. We find some swapping of positions—

countries that do well in terms of average malnutrition slip down the "league table" when account is taken of the degree of inequality between poor and nonpoor children.

The plan of the paper is as follows. Section II outlines the methods we use for measuring and testing for inequalities in malnutrition. Section III sets out the data and variable definitions we employ. In doing so, we emphasize the interrelationships between the three measures of malnutrition we use (underweight, stunting and wasting) and compare our overall average rates of malnutrition with those reported elsewhere. In Section IV we report malnutrition rates by consumption quintile. We also report the values of the inequality index we employ (the concentration index) and go on to test for significant differences across countries. In Section III, we also explore the sensitivity of our results to changes in definitions. Section V presents a brief analysis of the extent to which inequality in malnutrition at the country level are associated with inequalities in consumption. In short, are countries that have high inequalities in household consumption also the countries that have high inequalities in malnutrition between poor and less poor children? Finally, in Section VI, we compare average malnutrition rates with inequalities. We show scatter plots to allow easy identification of countries that do well on both counts, as well as an index that allows one to compare the "achievement level" of countries that do well on, say, average malnutrition but badly on inequality in malnutrition with the achievement level of countries that do well on inequality but badly in terms of average malnutrition. Section VII contains our conclusions.

II. Measuring and Testing for Inequalities in Malnutrition

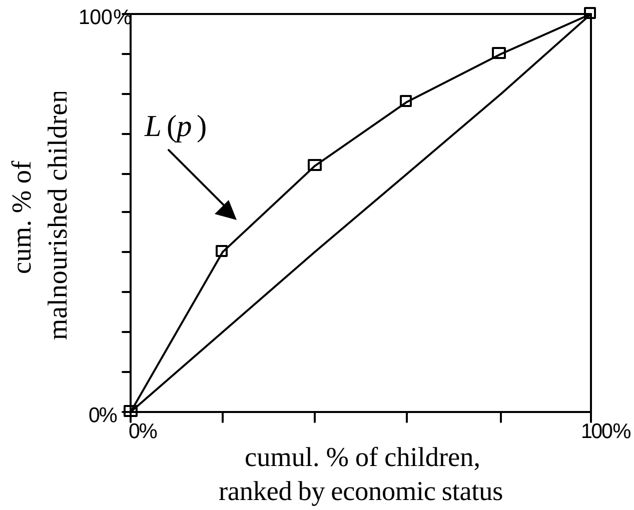
In this section, we outline the index we use for measuring inequalities in malnutrition amongst children, and the methods used to estimate standard errors for the index.

THE CONCENTRATION INDEX

We measure a household's living standards by equivalent consumption, but the method outlined below can be used for any socioeconomic ranking variable. We rank children by their household's equivalent consumption. We also have a variable indicating whether or not a given child is malnourished. The curve labeled $L(p)$ in Figure 1 is a malnutrition concentration curve. It plots the cumulative proportion of malnourished children (on the y-axis) against the cumulative proportion of children (on the x-axis), ranked by equivalent household consumption, beginning with the most disadvantaged child. The similarity with the Lorenz curve is obvious. However, one should bear in mind that here we are not ranking by the variable whose distribution we are investigating—we are looking here at the distribution of malnutrition, not by levels of malnutrition, but rather by equivalent consumption.

If $L(p)$ coincides with the diagonal, all children, irrespective of their household consumption, suffer from the same malnutrition rates. If, as is more likely, $L(p)$ lies above the diagonal, inequalities in malnutrition favor the better-off children; we will call such inequalities *prorich*. If $L(p)$ lies *below* the diagonal, we have *propoor* inequalities in malnutrition (inequalities to the disadvantage of the better-off). The further $L(p)$ lies from the diagonal, the greater the degree of inequality in malnutrition across quintiles of living standards. If $L(p)$ of country X is everywhere closer to the diagonal than that of country Y, then country X's concentration curve is said to *dominate* that of country *Y*. It seems reasonable in such cases to conclude that there is unambiguously less inequality in malnutrition in country *X* than in country *Y*.

Fig 1: Malnutrition concentration curve



Where concentration curves cross, or where, in any case, one wants a numerical measure of inequality in malnutrition, one can use the concentration index, denoted below by *C* and defined as twice the area between $L(p)$ and the diagonal. This index, as has been shown elsewhere [14, 15], is related to the relative index of inequality (RII), used extensively by epidemiologists and others in analyses of socioeconomic inequalities in health and mortality [16-20].[1] *C* takes a value of zero when $L(p)$ coincides with the diagonal and is negative (positive) when $L(p)$ lies above (below) the diagonal. It can be calculated as

(1) $$C = \frac{2}{n \cdot \mu} \sum_{i=1}^{n} x_i R_i - 1 \ ,$$

where n is the sample size, x_i is the malnutrition indicator for child i, $\mu = (1/n)\sum_{i=1}^{n} x_i$ is the mean level of malnutrition and R_i is the relative rank in the consumption distribution of the ith child (the best-off child having a value of R of 1). Alternatively, and more simply [15], the value of C can be obtained from the following "convenient regression"

(2) $$2\sigma_R^2 [x_i / \mu] = \gamma_1 + \delta_1 \cdot R_i + u_i$$

[1] This measure, like the Gini coefficient (the analog in the case where individuals are ranked by the variable whose inequality is being measured), implicitly assumes a particular set of value judgements about where inequality matters most. This issue is explored in Wagstaff [21].

where s_R^2 is the variance of *R*. The estimator of d_1 is equal to

$$(3) \qquad \hat{d}_1 = \frac{2}{n \cdot m} \sum_{i=1}^{n} (x_i - m)(R_i - \tfrac{1}{2})$$

which, from eqn (1), shows that $\hat{d}_1$ is equal to *C*. Readers familiar with the RII will note that eqn (2) is essentially the same as the regression equation used to compute the RII, the difference being that the RII is typically computed using grouped rather than individual-level data. The division of the LHS through by m simply means that the coefficient d_1 is the RII rather than the Slope Index of Inequality (SII) [18]. The only difference, then, between eqn (2) and the equation used to compute the RII is that the LHS contains the variance of the rank variable. This, however, approaches 1/12 as the sample size grows, and can therefore be treated approximately as a constant across samples. Thus the RII and *C* ought to rank distributions the same—there is little to choose between the two measurement approaches, though the concentration curve has the attraction of facilitating graphical comparisons of malnutrition inequalities.

STATISTICAL INFERENCE

When undertaking cross-country (or temporal) comparisons, one needs to bear in mind that the malnutrition data are derived from survey data and are hence subject to sampling variation. It is useful, therefore, to couple numerical comparisons of the index *C* with statistical tests to assess the statistical significance of any inter-country (or temporal) differences. An attraction of the convenient regression—eqn (2) above—is that it provides a standard error for the concentration index *C*. This standard error is not, however, wholly accurate, since the observations in each regression equation are not independent of one another due to the nature of the R_i variable. The following standard error estimator, derived by Kakwani et al. [15], takes into account the serial correlation in the data:

$$(5) \qquad \mathrm{var}(C) = \frac{1}{n}\left[\sum_{i=1}^{n} (1/n) a_i^2 - (1+C)^2\right],$$

where

$$(6) \qquad a_i = \frac{m_i}{m}(2R_i - 1 - C) + 2 - q_{i-1} - q_i \text{, and}$$

$$(7) \qquad q_i = \frac{1}{m} \sum_{g=1}^{N} m_g f_g \ ,$$

being the ordinate of $L(s)$, with $q_0 = 0$. It is this estimator that is used, rather than that in eqn (2), which is used in section IV.

III. Data and Variable Definitions

The surveys used are listed in Table 1. Surveys are nationally representative except for Bangladesh, Brazil, China, Guatemala, Indonesia and the Philippines whose coverage is regional. Survey years range from 1987 to 1997. In selecting countries and surveys, we wanted to achieve a degree of geographic heterogeneity. In addition, however, the surveys included also needed to include (i) data on consumption or income, (ii) anthropometric data to measure malnutrition (height, weight, age and gender of children under 5), and (iii) an acceptably large sample size of children. There are 20 countries and surveys in total, of which 11 are Living Standards Measurement Study (LSMS) surveys, 9 are similar multi-topic surveys, which satisfy the above criteria. However, we need to keep in mind that quality standard, sampling method and variable definitions may not be uniform across surveys, especially when conducting agencies are different.

MEASURING LIVING STANDARDS

As the main focus of this survey is to see the poor-nonpoor inequalities in malnutrition, choosing a variable according to which households are ranked is of paramount importance. Consumption is usually considered a better indicator of living standards than income, as ranking by the latter is generally more unstable than the former over the years. This reflects the fact that households can smooth out their consumption by saving and dissaving, while income fluctuates yearly depending on factors such as the household's employment situation and agriculture yield [22]. Therefore, whenever possible, consumption was used to rank households. Consumption variables were available for all countries except for China and the Philippines.

In addition to the choice between consumption and income, different methods by which consumption/income is aggregated reduce data transparency and comparability. It is therefore ideal to use consumption/income aggregates constructed using the same method. Due to lack of such data in some cases, however, we aggregated various consumption components, following the methodology proposed by Hentschel and Lanjouw [23] and Deaton and Zaidi [22].[2] Even in cases where consumption data exist, their comprehensiveness varies across surveys. For example, the LSMS is the most comprehensive of all, including consumption items such as home-produced food, the imputed rental value of the household's dwelling, and the annual service value of the durable goods, as well as spending on food, non-food items, health services and education. By contrast, some surveys—such as that for Guatemala—offer only a very limited range of consumption categories with only food and certain non-food items. Readers are advised to bear the above caveats in mind when interpreting the results presented in this paper.

We equivalize household consumption to take into account inter-household differences in household size. The two extreme positions on equivalization are (a) to assume that there are no economies of scale in household consumption (it costs two people twice as much to live as one) and (b) to assume that there are maximum economies of scale (two can live as cheaply as one). These two extremes, and the various possible intermediate positions, can be represented by the following relationship between equivalent consumption and actual consumption:

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[2] This was the case for the following countries: Guatemala, Philippines, Russia and Zambia.

(8) $E = A/H^e$

where E is equivalent consumption, A is actual consumption, H is household size, and e an equivalence scale elasticity [24]. Under the assumption that there no economies of scale, e is set equal to 1, and equivalent consumption is simply per capita consumption. Under the assumption that two (or three, or four, of five,…) can live as cheaply as one, e is set equal to 0, and equivalent consumption is simply aggregate household consumption. Although it is not uncommon to find to find e set equal to one (the per capita adjustment), a more plausible position, at least in countries where a sizeable proportion of consumption is on non-food items, is that there are some economies of scale, but that the elasticity e is greater than zero. In their survey of equivalence scales in OECD countries, Buhmann et al. [24] found that most equivalence scales could be approximated quite closely by eqn (8) and that, on average, the implied value of the elasticity e was around 0.4. Hentschel and Lanjouw (op. cit.), in their work on Ecuador, experiment with three values of e: 0.4, 0.6, and 1.0. In what follows, we set e equal to 0.5, which seems a reasonable intermediate position.

MEASURING MALNUTRITION

Growth assessment is the single measurement that “best defines the health and nutritional status of children as disturbances in health and nutrition, regardless of their etiology, invariably affect child growth” [25]. Among various growth-monitoring indices, there are three commonly-used anthropometric measures that offer a comprehensive profile of malnutrition: stunting, underweight and wasting.

The term “stunting” is used to describe a condition in which children fail to gain sufficient height, given their age. Stunting is therefore an extremely low “height-for-age” (H/A) score. Stunting is often associated with long-term factors such as chronic malnutrition, especially protein-energy malnutrition, and sustained and frequent illness. It is therefore an indicator of past growth failure and is often used for long-term planing of policies and intervention programs in non-emergency situations. The term “underweight” is used to describe a situation where a child weighs less than expected, given his or her age. Underweight is thus an extremely low “weight-for-age” (W/A) score. Unlike height, weight fluctuates over time and therefore reflects current and acute as well as chronic malnutrition. The term “wasting” refers to a situation where a child has failed to achieve sufficient weight for height (W/H). Wasting often results from recent and continuing severe weight loss due to inadequate energy intake, recent and continuing poor health, or a combination of both.

The preferred reporting system of H/A, W/A and W/H is in terms of Z-scores[3]— a statistical measure of the distance from the median (mean) expressed as a proportion of the standard deviation. The most common cutoff point is -2Z-score, i.e., two standard deviations below the median values of the international reference. This is the cutoff risk level used to differentiate malnourished children from those adequately nourished. Children whose H/A, W/A and W/H scores fall below this point are therefore considered, stunted, underweight and wasted,

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[3] $$\text{Z - score} = \frac{\text{(Observed value)} - \text{(Median value of the reference value)}}{\text{Standard deviation of the reference population}}$$

respectively. The World Health Organization adopts US National Child Health Survey (NCHS) anthropometric data as the international reference to estimate its malnutrition indicators. To be comparable with WHO global estimates and other similar studies this paper follows the same methodology.

The three dimensions of malnutrition are interrelated. This is shown in Figures 2 and 3 which map the incidence of wasting against H/A and W/A Z-scores for Bangladesh and Brazil, respectively. Children located towards the right end along the x-axis have a high H/A score (i.e. are tall), while those towards the left end have a low H/A score (i.e. are short). Those to the left of -2Z line are classified as stunted. Children towards the top end of the *y*-axis have a high W/A score (i.e. are heavy), while those towards the bottom end have a low W/A score (i.e. are light). Those below -2Z line are classified as underweight. Children at the bottom-left corner (the framed area) of the figures are both stunted and underweight. Since wasting is reflected in a low W/H score, and since the axes already capture weight and height (albeit adjusted for age), we can also speculate where wasted children lie in the figures. Children who are both light and short (i.e. children in the bottom-left quadrant) will tend to have W/H scores in the normal range. These children, some of whom will be both stunted and underweight, will be most unlikely to be wasted (i.e. to have a very low W/H score). Likewise, children who are both heavy and tall (i.e. children in the top right quadrant) will tend to have W/H scores in the normal range. For the most part, wasted children will be those in the bottom right quadrant—children who are fairly tall but also fairly light in weight.

In Figure 2 the oval circle diagonal to the x- and y-axes capturing most wasted children lies outside the framed area. Thus, it makes it clear most children who are both stunted and underweight are not wasted, i.e., children can be stunted and underweight, and be underweight and wasted, but are unlikely to be stunted *and* wasted. In Figure 3 the principal cluster lies more to the direction of south-west than the one in Figure 2, indicating higher incidence of stunting and underweight in Bangladesh than in Brazil. Although there are more cases of simultaneous stunting, underweight and wasting in Bangladesh, only 9% of children fall in this category. We would therefore not expect to see a country with high inequalities in all three dimensions of malnutrition.

COMPARISONS OF MALNUTRITION LEVELS WITH OTHER SURVEYS

Malnutrition indicators computed along the lines indicated in section III were checked against WHO Global Database on Child Growth and Malnutrition to ensure their comparability [26]. Table 2 shows that the discrepancies between WHO reference values and our estimates are within +/-10% for most cases. Exceptions are: Egypt (stunting) and Romania (stunting) probably due to the different survey years from reference survey years; Guatemala (stunting) and the Philippines (all) most likely attributable to the regionally representative surveys; and Nicaragua (stunting) and Pakistan (wasting) possibly because of dropped observations due to insufficient consumption information.

IV. Inequalities in Malnutrition

QUINTILE-SPECIFIC MALNUTRITION RATES

Table 3 shows rates of stunting, underweight and wasting by quintile of equivalent consumption. A glance at the table reveals the first finding of the paper: *in almost all countries, the poorest quintile has the highest rate of malnutrition—however malnutrition is measured*. This is less clear in the case of wasting than in the cases of stunting and underweight but is evident there too. Another finding also emerges from Table 3: it is not simply a question of the poor having elevated rates of malnutrition; rather, *the rate of malnutrition declines with living standards, although not always monotonically so*. The extent to which the rates decrease indicates how much more the poor suffer from higher rates of malnutrition than the better off. For example, in Peru the rate of stunting among the lowest quintile is about 50%, whilst in the second quintile it is 44%. Then it decreases continuously until it reaches 10%. The prevalence of stunting among the poorest segment of the Peruvian population is relatively high compared with other countries, while that of the richest quintile is among the lowest. This points to a third finding—*inequalities in malnutrition appear to vary across countries*. Inequalities seem to be more pronounced in Peru than other countries. The opposite applies to Egypt where the poor-nonpoor gap in underweight is very small. We examine this issue in more detail in the next two subsections.

CONCENTRATION INDICES

Quintile comparisons do not lend themselves easily to inter-country comparisons of inequalities. The concentration index, introduced in section II, provides a straightforward way of capturing these inequalities. It also provides a means of testing the significance of inequalities in malnutrition.

Table 4 shows concentration indices for stunting, underweight and wasting amongst under-five children ranked by equivalent consumption. All concentration indices for stunting and underweight are negative, reflecting the higher rates of malnutrition amongst the poor. The values of the *t*-statistics bring us to another finding: *inequalities in stunting and underweight are statistically significant in all countries, except in the cases of Egypt (both) and Russia (underweight).* In other words, the tendency of poorer children to have higher rates of stunting and underweight is not due to chance or sampling variability. In the case of wasting, the picture is rather different—only eight countries have statistically significant concentration indices.

Looking at the average concentration indices in the bottom row reveals another interesting result: *inequalities in underweight tend to be larger than inequalities in stunting, which in turn tend to be larger than inequalities in wasting*. There are, of course, exceptions to this pattern. In China, Ghana and Nicaragua, inequalities in wasting are more pronounced than inequalities in either stunting or underweight.

The indices also reveal some interesting cross-country differences. Peru has the most negative concentration indices for stunting and underweight, and Nicaragua for wasting. Egypt exhibits the most pro-poor distribution of stunting and underweight, while Vietnam leads the ranking of wasting with a positive concentration index. It is not surprising that the top and bottom of the ranking for wasting did not coincide with those for stunting and underweight, as it is rare to observe children who are stunted, underweight *and* wasted at the same time (cf. Figures 2 and 3) The overall concentration index rankings of all three categories are similar to some extent. Peru, Morocco, Nicaragua are found on the lower side of the spectrum and Egypt, Vietnam, Romania and Pakistan on the opposite side and the other countries somewhere in the middle.

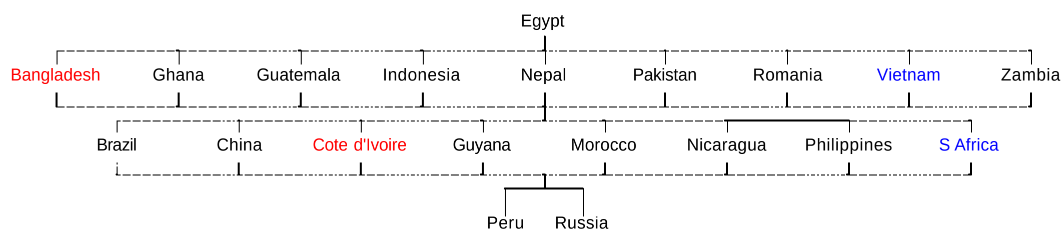
TESTS OF SIGNIFICANT DIFFERENCES BETWEEN CONCENTRATION INDICES

We now rank countries by inequality in a statistically more rigorous way. The standard errors of the concentration indices shown in Table 4 enable us to rank countries according to whether they have significantly more inequality than others. Tables 5-7 report the results of *t*-tests indicating the significance of the difference between the concentration indices of the column and row countries. Thus, for example, in Table 5, Bangladesh has a significantly less inequality in stunting than Brazil (hence the plus sign in front of the 4.05). Bangladesh also has less inequality in stunting than Côte d'Ivoire, but the difference in this case is not statistically significant. Bangladesh has *more* inequality in stunting than Egypt, but the difference is again not statistically significant.

A glance across Tables 5-7 reveals one important point—*in the majority of cases, whatever the indicator, the differences in inequality between countries are not statistically significant*. Thus in only 44% of the 190 pairwise comparisons for stunting inequalities is the *t*-ratio larger than 1.96 in absolute size, while the equivalent percentages for underweight and wasting are 42% and 23% respectively. This warns against reading too much into concentration index differences unless accompanied by statistical tests.

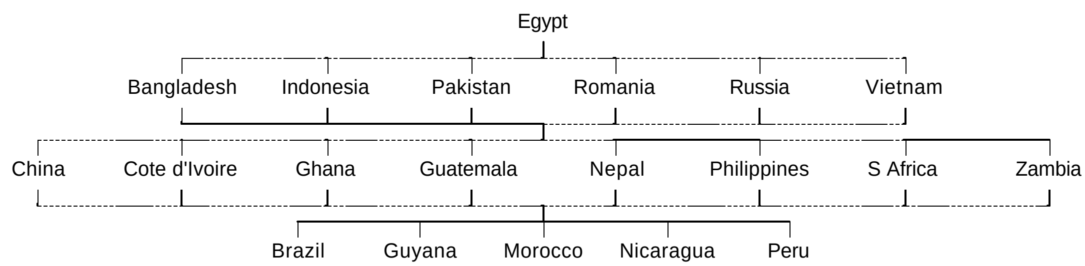
A Hasse diagram indicating the hierarchical order of countries makes it easier to grasp which inter-country differences *are* significant. The principle of the chart is that the concentration indices of all countries on the same level are *not* significantly different from one another, but *are* significantly larger (or smaller) than those of all countries on a different level. However, with a large number of countries, a perfectly accurate chart would become extremely cumbersome and would make it *harder*—rather than easier—to grasp the essential results. The Hasse charts presented here are therefore *simplified* Hasse charts, intended to convey the broad results of the various pairwise comparisons.

Figure 4. Simplified Hasse diagram for under-five stunting by equivalent consumption



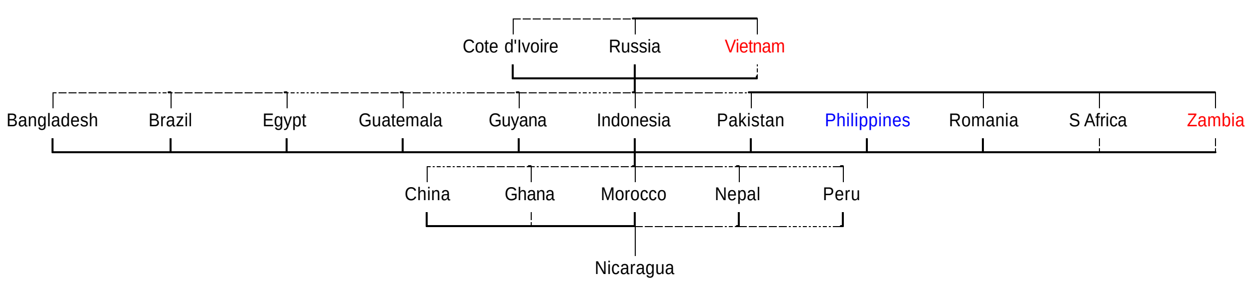
The simplified Hasse diagram for under-five stunting (Figure 4) exhibits a four-level structure, characterized by a few countries at the top and the bottom, and a bulge in the middle levels. Egypt heads the hierarchy, although its concentration index is not in actuality significantly larger than *all* the countries in the lower levels. It is followed by a set of a large number of countries that more or less cluster together with those in the same concentration-index level. Peru and Russia have the most unequal distributions of stunting among children, with only Peru's concentration index being significantly the lowest of all.

Figure 5. Simplified Hasse diagram for under-five underweight by equivalent consumption



In the case of underweight (Figure 5), Egypt again appears at the top of the diagram and Peru at the bottom along with four other countries. Unlike the case of inequalities in stunting, there is no country that is significantly different from all the other countries. In other words, it is not clear whether inter-country differences in concentration indices are due to *actual* differences in inequality or to sampling variations.

Figure 6. Simplified Hasse diagram for under-five wasting by equivalent consumption



As for wasting, the concentration indices of Côte d'Ivoire, Russia and Vietnam are the largest and are not significantly different from one another or from those of the countries one level down, except in the case of Vietnam (Figure 6). The concentration indices of all the countries in the same level are not significantly different from one another, with the exception of Philippines whose concentration index is significantly lower than Zambia. The Nicaraguan concentration index is the lowest of all and is statistically significantly lower than that of any other country.

Although the ranking of countries differs across the indicators, some broad conclusions can be drawn from the observation of the Hasse diagrams. *Egypt and Vietnam recurrently emerge as countries with the least prorich distributions of malnutrition. By contrast, the most unequal distributions are to be found in Peru and Nicaragua, followed by Morocco.*

SENSITIVITY ANALYSES

When interpreting the above results, two cautionary points merit attention. First, there are certain variations in the sample of children in terms of age interval and age range across countries. As Table 1 shows, all countries adopt age in months except for the Philippines (age in years) and the upper age limit of 4.99 years except for Nepal (3.99 years). Table 8 shows the effects on the concentration index of changing the age interval from monthly to yearly. Although the results are not identical, they are very comparable with only small gaps occurring in 5 of 12 comparisons. By contrast Table 9 suggests that progressively narrowing down the sample, first to children below the age of four and then to children below the age of three, causes significant changes in the concentration indices. On the whole, reducing the upper age limit may increase or reduce concentration indices, but larger gaps emerge when the limit is reduced from four to three than when it is reduced from five to four. Despite such discrepancies it is important to note that changes in the age limit do not systematically produce an upward or downward bias in concentration indices.

Second, throughout we have adopted -2 standard deviations below the median (-2Z-score) as the cut-off point below which children are classified as malnourished. The term "severe malnutrition" is applied to children who fall below the more demanding threshold of -3Z-score. Table 10 shows the effect of reducing the threshold for four Asian countries—Bangladesh, Nepal, Pakistan and Vietnam. The comparisons for stunting and underweight show that there is more pro-rich inequality when the more demanding cut-off point is used. One exception is for underweight in the case of Vietnam. In the case of Nepal, the value of the concentration index is especially sensitive to the change of cut-off point.

V. Inequalities in Malnutrition vs. Inequalities in Consumption

It is beyond the scope of this paper to answer the question of *why* countries vary so much in their inequalities in child malnutrition. But there is one interesting question that can be answered readily with the data to hand: Are the countries with the most unequal distributions of malnutrition the countries with the most unequal distributions of consumption? We report here scatter plots and bivariate regressions showing the relationship between inequality in malnutrition, measured using the concentration index, and the Gini coefficient for consumption inequality. Although the Gini coefficient for consumption is available from various published sources (e.g., World Development Indicators), we chose, for various reasons, to compute Ginis for our samples, not least because several of our surveys are not nationally representative.

The results are shown in Figure 7-9. The following is evident: *especially in the case of stunting, and to a lesser extent in the case of underweight as well, it is indeed the case that countries with unequal income distributions also tend to have unequal distributions of malnutrition.* This is not altogether surprising. Unequal distribution of purchasing power, prima facie, leads to an unequal distribution of food spending (intake), health spending and utilization of health services, and consequently unequal health outcomes. It is also in line with the theoretical results of Contoyannis and Forster [27]. They showed that if the relationship between health and income is concave, a mean-preserving reduction in income inequality, with the new Lorenz curve for income strictly dominating the old, will result in a reduction in the concentration index for health inequality.

What is more interesting, perhaps, is the fact that the fit of the bivariate regressions is fairly bad—*there are, in other words, many countries that buck the trend.* Nepal and Peru, for example, have roughly the same level of income inequality, and yet Nepal has far lower levels of inequality in stunting and underweight than Peru. This implies that there must be some form of mechanism in these countries that breaks the link between poverty and malnutrition. For example, in the case of Egypt, which tends to positively deviate from the mainstream trend, it would be of interest to explore what factors, given the level of consumption inequality, contribute to relatively low inequalities in malnutrition. Similarly, it would be of interest to investigate why, in Peru, the level of inequality in malnutrition is higher than one would expect, given what other countries appear to achieve at the same level of consumption inequality. These questions are left for future research.

VI. Inequalities in Malnutrition vs. Average Rates of Malnutrition

Given the focus in international development targets on average rates of malnutrition, it is of some interest to establish how countries compare on average rates of malnutrition and inequalities in malnutrition. Ideally, one would like policymakers and target-setters to concern themselves with both dimensions.

SCATTER PLOTS: AVERAGES VS. INEQUALITIES

Figures 10-12 show scatter plots with the prevalence of malnutrition (i.e. the average rate) on the *x*-axis and the concentration index (i.e. the degree of inequality) on the *y*-axis. As far as stunting is concerned, countries can be roughly classified into four groups based on their stunting rate and their concentration index. The first group can be characterized by a "win-win" situation with a relatively low prevalence of stunting along with a small rich-poor gap (Egypt and Romania). The second group combines a low stunting rate with a relatively high concentration index (Guyana, the Philippines, Nicaragua, Brazil and China). The third group combines a relatively high stunting rate with a low concentration index (Russia, South Africa, Morocco and Peru). The last group consists of all the other countries with a relatively high stunting rate *and* a low concentration index (Figure 10).

For underweight, the overall picture is similar to that of stunting, but a clearer trend emerges in the scatter plot. Starting from Brazil, Nicaragua and Peru in the bottom-left corner, countries move up both along the *x*-axis and the *y*-axis toward the top-right corner. Generally speaking, a country that enjoys a low malnutrition rate at the national (or regional) level is likely to suffer from a relatively wide poor-nonpoor gap in prevalence. By contrast, in a more egalitarian society in terms of health outcomes, the prevalence of adverse outcomes is higher across the socioeconomic distribution (Figure 11).

The story is slightly different for wasting. The countries are distributed in a bipolar fashion with the Philippines, Bangladesh and Pakistan clustering between prevalence rates of 20-25%, and others having rates below 15%. In the latter cluster, Vietnam, Cote d'Ivoire, Russia, Zambia, Egypt and South Africa demonstrate a pro-poor distribution of wasting. The opposite is observed for Nicaragua, China, Morocco and Peru, although Nicaragua lies far from the other countries with an extremely unequal distribution (Figure 12).

Some countries clearly do better in term of both the average (the prevalence of malnutrition) and the distribution (equality), e.g., Egypt vs. Peru for stunting. However, the scatter plots show the danger of setting targets and comparing countries in terms solely of average malnutrition rates. Brazil, for example, has a far lower overall stunting rate than Bangladesh (below 20% in Brazil, compared to in excess of 50% in Bangladesh). Without knowledge of the inequality, one would conclude that malnutrition is worse in Bangladesh than in Brazil. But knowing that there is a much larger inequality in stunting rates between poor and nonpoor children in Brazil than there is between poor and nonpoor children in Bangladesh makes it much harder to jump to this conclusion. The two countries simply perform differently in the two dimensions.

AN ACHIEVEMENT INDEX CAPTURING INEQUALITY AND AVERAGE MALNUTRITION

In an earlier paper [28], one of us proposed an index that captures the goals of policymakers—a low average level of malnutrition, and a small gap in malnutrition rates between poor and better-off children. This index is a weighted average of the nutrition rates of the various consumption groups, where poorer groups are assigned higher weights than richer groups. The general form for the achievement index is:

(9) $$I = \frac{1}{N}\sum_{i=1}^{N} w_i h_i \ ,$$

where N is the number of people in the sample, h_i is the ill-health of person i, and w_i is a weight attached to person i's ill-health when computing the index I. The weights used are simply the person's absolute rank in the distribution of living standards, denoted by r_i. This is equal to 1 for person 1, 2 for person 2, and N for person N. Then the weights are defined as

(10) $$w_i = 2\frac{N+1-r_i}{N} \ .$$

Thus w_i is equal to 2 for the most disadvantaged person, declines by $2/N$ for each one-person step up through the living-standard distribution, and reaches $2/N$ for the least disadvantaged person. Thus the difference in w_i between the most disadvantaged person and the second most disadvantaged person is the same as the difference between the second most advantaged person and the most advantaged person. When the w_i are so defined, the index I is equal to

(11) $$I_R = m(1-C),$$

where I_R denotes the value of I when the weights are based on the person's rank in the socioeconomic distribution, and C is the concentration index for ill health, defined along the lines of eqn (1).

The implications of the index in eqn (11) are straightforward. When everyone—irrespective of their living standard—has the same level of malnutrition, C is zero, and I_R equals m. When poor individuals have higher levels of malnutrition than better-off individuals, C will be negative (but larger in numerical size than minus one). In this case, I_R will be *larger* than m—the inequality in the distribution of malnutrition forces the index I_R above the mean. For example, in the case where C=-0.25, I_R will be 25% higher than m. The opposite will happen when inequality in malnutrition favors the disadvantaged. In this case, C will be positive (and less than one), and I_R will fall below m. Evidently, the index I_R allows some trade-off to be made between the average nutritional status of the population and socioeconomic inequality in the distribution of malnutrition. Suppose the average level of malnutrition, m, is lower in country X than in country Y. Then the index I_R could still be higher in country X than in country Y if the distribution of malnutrition in country X is that much more pro-rich than in country Y. It is worth noting that the particular weighting scheme for the w_i in eqn (10) is precisely the same scheme that underlies—albeit implicitly—the concentration index, C, as well as the aforementioned RII. Insofar as these indices are considered acceptable health inequality measures, the index I_R ought also to be considered an acceptable index that combines information on inequality with information on the average level of malnutrition.

ACHIEVEMENT INDICES FOR TWENTY COUNTRIES

Table 11 shows the values of the index I_R for the 20 countries for the three measures of malnutrition. In the low-inequality countries, I_R is, inevitably, close to the sample average, whilst in the high-inequality countries, it exceeds the average. In the case of Peru, for example, although the sample average rate of stunting is only 0.31, I_R is over 0.40, reflecting the high inequality in that country. Despite the relatively few countries included in the analysis, moving from the sample mean, m, to the achievement index, I_R, produces several rank reversals. In the case of stunting, there are two sets of rank reversals. In one of the two cases, these simply involve two adjacent countries swapping places—Zambia slips behind Nepal. In the other, there is more movement—Egypt (a low inequality country) moves from sixth position to fourth, overtaking Russia and Brazil (two high inequality countries). In the cases of underweight and wasting, there are three and five rank reversals respectively, all involving two adjacent countries swapping places.

Evidently as the number of countries in the sample increases, the chances increase of high-inequality countries falling behind low-inequality countries as one moves from a focus on the mean of the distribution of malnutrition to a focus on the poverty-sensitive achievement index I_R.

VII. Conclusions

Our aim in this paper has been to shed light on the extent of inequalities in malnutrition between poor and nonpoor children in 20 countries in the developing world. We can summarize our main conclusions as follows:

1) Inequalities in malnutrition almost always disfavor the poor. In almost all countries, the poorest quintile has the highest rate of malnutrition, however malnutrition is measured. This is less clear in the case of wasting than in the cases of stunting and underweight but is evident there too.

2) It is not simply a question of the poor having elevated rates of malnutrition. Rather the rate of malnutrition declines continuously with rising living standards, although not always monotonically.

3) Inequalities in stunting and underweight, as measured by the concentration index, are statistically significant in all countries, with the exceptions of Egypt (both indicators) and Russia (underweight). In other words, the tendency of poorer children to have higher rates of stunting and underweight is not due to chance or sampling variability. In the case of wasting, the picture is rather different—only eight countries have statistically significant concentration indices.

4) Inequalities in underweight tend to be larger than inequalities in stunting, which in turn tend to be larger than inequalities in wasting. There are exceptions to this pattern—in China, Ghana and Nicaragua, inequalities in wasting are more pronounced than inequalities in either stunting or underweight.

5) Although there are large cross-country variations in inequality, as measured by the concentration index, in the majority of cases, whatever the malnutrition indicator, the differences in inequality between countries are not statistically significant. Thus in only 44% of the 190 pairwise comparisons for stunting inequalities is the t-ratio larger than 1.96 in absolute size. The equivalent percentages for underweight and wasting are even smaller—42% and 23% respectively. This warns against reading too much into concentration index differences unless accompanied by statistical tests.

6) Even if attention is restricted only to those cross-country differences in inequality that are statistically significant, interesting conclusions still emerge. Egypt and Vietnam emerge as countries with the least pro-rich distributions of malnutrition, while highly unequal distributions are consistently found in Peru and Nicaragua, and to a lesser extent in Morocco.

7) Sensitivity analysis reveals that changing age range and interval in the sample causes certain variations in concentration indices although not a systematic increase or decrease. By contrast, selected Asian countries' data suggest that lowering the cutoff point from conventional -2Z-score to more demanding -3Z-score almost always leads to more pro-rich inequality in stunting and underweight.

8) Especially in the case of stunting, and to a lesser extent in the case of underweight as well, there is an association at country level between an unequal income distribution and an unequal distribution of malnutrition. However, the fit of the bivariate regressions on these

data is fairly bad—*there are, in other words, many countries that buck the trend.* Nepal and Peru, for example, have roughly the same level of income inequality, and yet Nepal has far lower levels of inequality in stunting and underweight than Peru.

9) Some countries do well in terms of both the average (the prevalence of malnutrition) and the distribution (equality). Examples for underweight include Egypt and Russia. Others do relatively badly on both counts. For example, Peru has a higher average level of stunting than Egypt and a larger level of poor-nonpoor inequality. In many cases, however, countries do well on one count (the average, say) while doing badly on the other (the level of inequality, say). Brazil, for example, has a far lower overall stunting rate than Bangladesh (below 20% in Brazil, compared to in excess of 50% in Bangladesh), but has *four* times as much inequality (as measured by the concentration index).

10) Use of an achievement index that captures both the average level of malnutrition and the inequality in malnutrition leads to some interesting rank reversals in the country league table. In the case of stunting, for example, moving from a focus on the average to a focus on the achievement index results in Egypt (a low inequality country) moving up from sixth position to fourth, overtaking Russia and Brazil (two high inequality countries).

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Table 1. Surveys used in under-5 malnutrition inequalities analysis

Country	Survey name	Survey year	Represen-tation	No. Households	No. Children (Stunting)	No. children (Underweight)	No. children (Wasting)	Age interval	Age range	Comments on data
Bangladesh	Matlab Health and Socioeconomic Survey	1996	Regional	4364	1512	1543	1504	Month	0-4.99	The survey only covers a rural region of Matlab, which is located just in the south of Dakha
Brazil	Presquisa sobre Padrões de Vida	1995-96	Regional	4940	1697	1791	1678	Month	0-4.99	The areas are south-east and north-east regions only.
China	China Health and Nutrition Survey	1991	Regional	3616	865	883	850	Month	0-4.99	8 provinces are covered by the survey covering both urban and rural areas within them. This sample is diverse in terms of socioeconomic factors (income, employment, education and modernization) and other related health, nutritional and demographic measures.
Côte d'Ivoire	LSMS	1988	National	1600	2121	2121	2120	Month	0-4.99	
Egypt	Egypt Integrated Household Survey	1997	National	2500	1427	1434	1430	Month	0-4.99	
Ghana	LSMS	1987-88	National	3200	2349	2350	2341	Month	0-4.99	
Guatemala	Guatemalan Survey of Family Health	1995	Regional	4792	2817	2854	2814	Month	0-4.99	The survey covers 4 departments (out of 22 in total).
Guyana	LSMS	1992-93	National	5340	590	589	587	Month	0-4.99	
Indonesia	Indonesian Family Life Survey	1993	Regional	7224	1250	1371	1233	Month	0-4.99	The survey covers 13 provinces that represent 83 % of the population.
Morocco	LSMS	1990-91	National	3323	2121	2121	2120	Month	0-4.99	
Nepal	LSMS	1996	National	3373	1597	1603	1586	Month	0-3.99	
Nicaragua	LSMS	1993	National	4200	514	520	511	Month	0-4.99	
Pakistan	LSMS	1991	National	4800	3773	4051	4127	Month	0-4.99	
Peru	LSMS	1994	National	3623	2093	2110	2075	Month	0-4.99	
Philippines	Cebu Longitudinal Health and Nutrition Survey	1991	Regional	2264	2033	2036	2139	Year	0-4.99	The survey area is the city of Cebu, the region center of Central Visayas region.
Romania	LSMS	1996	National	36000	3740	3755	3737	Month	0-4.99	
Russia	Russia Longitudinal Monitoring Survey	1997	National	3750	386	417	377	Month	0-4.99	
South Africa	LSMS	1993	National	9000	3971	3998	3947	Month	0-4.99	
Vietnam	LSMS	1992-93	National	4800	2623	2773	2609	Month	0-4.99	
Zambia	Living Conditions Monitoring Survey I	1996	National	11770	4500	8154	4545	Month	0-4.99	

Figure 2. Mapping Incidence of Wasting against H/A & W/A Z-scores (Bangladesh)

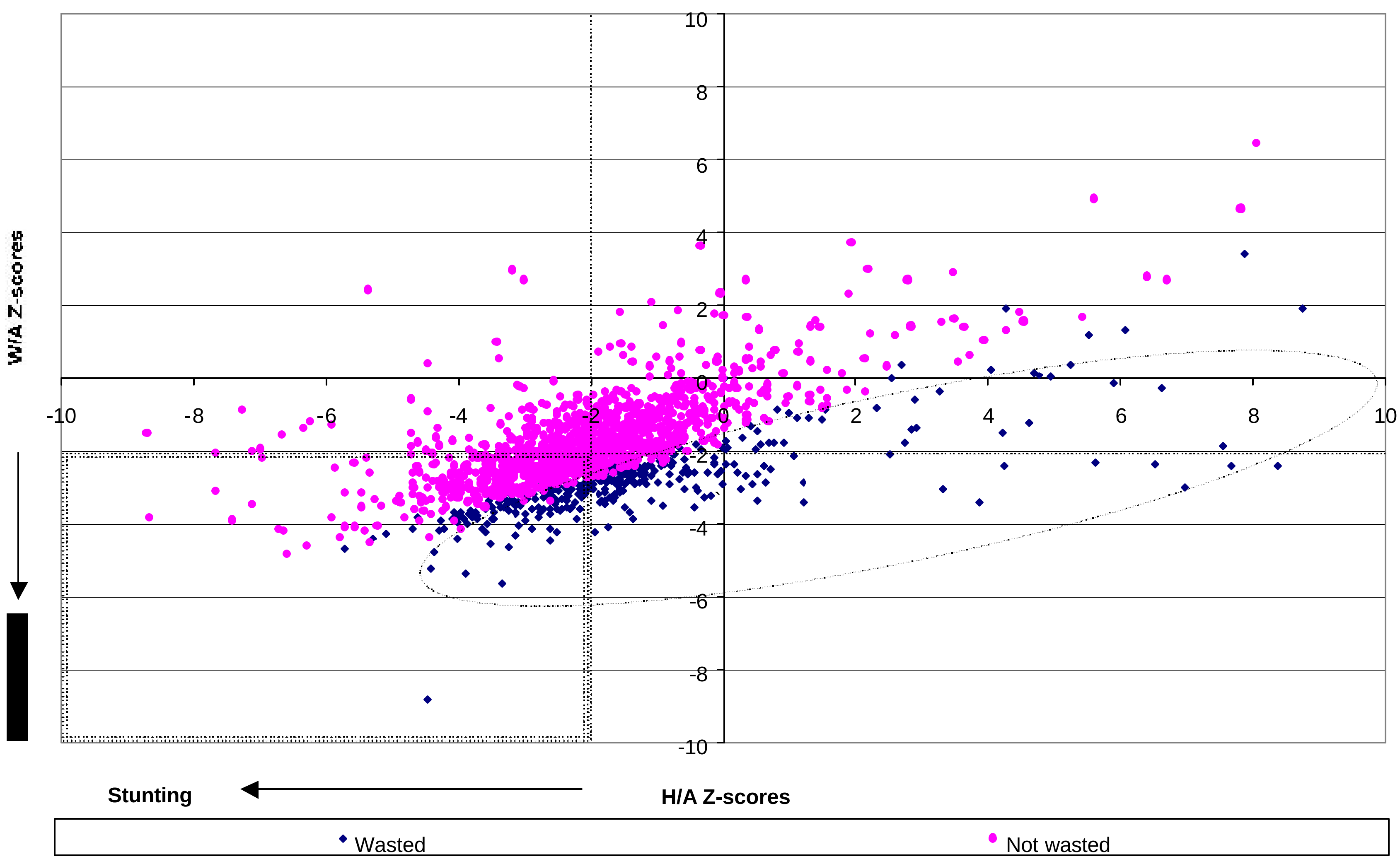

Figure 3. Mapping Incidence of Wasting against H/A & W/A Z-scores (Brazil)

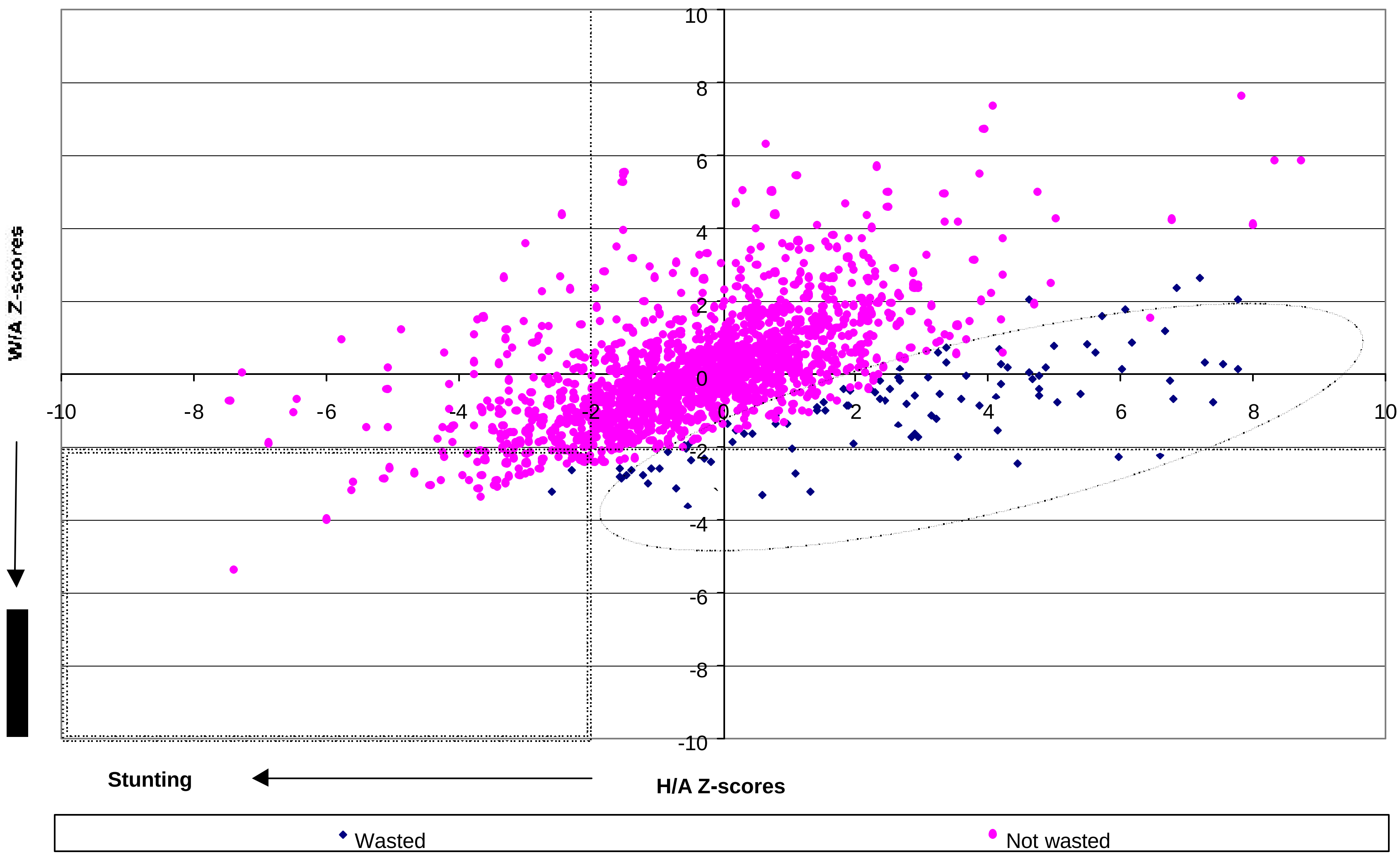

Table 2. Sample under-5 malnutrition rate estimates

Country	Survey year	Reference survey	Reference survey yr	Stunting			Underweight			Wasting		
				Sample mean	Reference Value	% discre-Pancy	Sample mean	Reference value	% discre-pancy	Sample mean	Reference value	% discre-Pancy
Bangladesh	1996	DHS	1996-97	51%	55%	-3%	54%	56%	-2%	22%	18%	5%
Brazil	1995-96	DHS	1996	15%	11%	5%	6%	6%	1%	6%	2%	4%
China	1991	The dietary and nutritional status of Chinese population	1992	31%	31%	0%	15%	17%	-2%	4%	4%	-1%
Côte d'Ivoire	1987-88	Malnutrition in Côte d'Ivoire (WB wp)	1986	20%	17%	2%	17%	12%	5%	10%	9%	2%
Egypt	1997	DHS	1995-96	17%	30%	-13%	11%	12%	-2%	5%	5%	0%
Ghana	1987-88	LSMS	1987-88	31%	31%	1%	26%	27%	-1%	5%	7%	-3%
Guatemala	1995	DHS	1995	61%	50%	12%	33%	27%	6%	1%	4%	-3%
Guyana	1992-93	Stunting and wasting: Guyana Nutritional Status Survey 1985; Underweight: HIES/LSMS	1993	12%	21%	-9%	19%	18%	1%	7%	9%	-1%
Indonesia	1993	Indonesia multiple indicator cluster survey	1995	40%	42%	-2%	37%	34%	3%	11%	13%	-2%
Morocco	1990-91	DHS	1992	28%	24%	4%	15%	10%	5%	8%	2%	6%
Nepal	1996	DHS *	1996	49%	49%	0%	47%	47%	0%	13%	11%	2%
Nicaragua	1993	LSMS	1993	15%	24%	-9%	8%	12%	-4%	3%	2%	1%
Pakistan	1991	DHS	1990-91	42%	50%	-8%	43%	40%	3%	25%	9%	16%
Peru	1994	DHS	1996	31%	26%	6%	12%	8%	4%	2%	1%	1%
Philippines	1991	Regional nutrition survey	1992	14%	35%	-21%	21%	33%	-12%	22%	7%	15%
Romania	1994	National nutrition survey	1991	24%	8%	16%	7%	6%	1%	5%	3%	3%
Russia	1996	RLMS (R6)	1995	17%	13%	4%	6%	3%	3%	6%	4%	3%
South Africa	1993	Anthropometric study **	1994-95	26%	23%	3%	18%	9%	9%	10%	3%	7%
Vietnam	1992-93	Malnutrition prevalence survey	1994	53%	47%	6%	41%	45%	-4%	6%	12%	-6%
Zambia	1996	DHS	1996-97	48%	42%	6%	22%	24%	-1%	6%	4%	1%

Notes:
* Age group 0.50-2.99.

** Age group 0.50-4.99.

Table 3. Rates of under-5 stunting, underweight and wasting, by quintile of equivalent consumption

Country	Stunting						Underweight						Wasting					
	Quintiles						Quintiles						Quintiles					
	1	2	3	4	5	Overall average	1	2	3	4	5	Overall average	1	2	3	4	5	Overall average
Bangladesh	0.56	0.55	0.52	0.50	0.43	0.51	0.59	0.62	0.55	0.50	0.44	0.54	0.28	0.21	0.24	0.19	0.21	0.22
Brazil	0.23	0.17	0.16	0.11	0.09	0.15	0.09	0.09	0.06	0.04	0.03	0.06	0.09	0.05	0.04	0.07	0.06	0.06
China	0.38	0.32	0.29	0.25	0.14	0.28	0.21	0.15	0.11	0.12	0.06	0.13	0.06	0.03	0.04	0.04	0.02	0.04
Côte d'Ivoire	0.26	0.20	0.21	0.13	0.18	0.20	0.21	0.22	0.14	0.13	0.15	0.17	0.10	0.10	0.07	0.12	0.11	0.10
Egypt	0.20	0.17	0.14	0.18	0.16	0.17	0.10	0.14	0.10	0.09	0.10	0.11	0.04	0.07	0.05	0.02	0.06	0.05
Ghana	0.38	0.36	0.32	0.27	0.25	0.31	0.32	0.29	0.26	0.24	0.19	0.26	0.06	0.05	0.05	0.04	0.03	0.05
Guatemala	0.70	0.69	0.66	0.57	0.47	0.62	0.41	0.39	0.34	0.27	0.25	0.33	0.01	0.01	0.00	0.00	0.01	0.01
Guyana	0.15	0.14	0.12	0.13	0.06	0.12	0.25	0.25	0.21	0.15	0.08	0.19	0.07	0.09	0.08	0.09	0.03	0.08
Indonesia	0.54	0.50	0.48	0.44	0.35	0.46	0.46	0.42	0.43	0.35	0.33	0.40	0.14	0.09	0.10	0.09	0.11	0.10
Morocco	0.39	0.36	0.31	0.20	0.15	0.28	0.23	0.20	0.16	0.10	0.06	0.15	0.12	0.09	0.06	0.08	0.05	0.08
Nepal	0.55	0.50	0.53	0.45	0.39	0.49	0.60	0.47	0.51	0.48	0.27	0.47	0.16	0.14	0.15	0.14	0.08	0.13
Nicaragua	0.24	0.15	0.14	0.14	0.09	0.15	0.15	0.10	0.06	0.05	0.04	0.08	0.07	0.01	0.03	0.02	0.00	0.03
Pakistan	0.46	0.48	0.47	0.37	0.31	0.42	0.48	0.48	0.43	0.40	0.35	0.43	0.28	0.29	0.24	0.21	0.22	0.25
Peru	0.51	0.44	0.32	0.20	0.10	0.31	0.22	0.14	0.13	0.06	0.05	0.12	0.04	0.02	0.02	0.02	0.02	0.02
Philippines	0.21	0.17	0.16	0.10	0.08	0.14	0.26	0.24	0.20	0.24	0.13	0.21	0.29	0.23	0.22	0.22	0.16	0.22
Romania	0.25	0.28	0.23	0.24	0.20	0.24	0.09	0.07	0.06	0.07	0.06	0.07	0.06	0.05	0.04	0.06	0.04	0.05
Russia	0.22	0.22	0.22	0.12	0.06	0.17	0.07	0.06	0.08	0.05	0.05	0.06	0.07	0.07	0.07	0.08	0.04	0.06
South Africa	0.39	0.30	0.23	0.23	0.12	0.26	0.24	0.22	0.17	0.17	0.11	0.18	0.10	0.11	0.11	0.10	0.08	0.10
Vietnam	0.60	0.61	0.56	0.50	0.38	0.53	0.48	0.46	0.42	0.42	0.29	0.41	0.04	0.05	0.07	0.07	0.07	0.06
Zambia	0.60	0.52	0.52	0.40	0.37	0.48	0.29	0.26	0.25	0.18	0.14	0.22	0.06	0.05	0.05	0.06	0.06	0.06

Table 4. Concentration indices, standard errors, t-values, and 95% confidence intervals for under-5 stunting, underweight and wasting

Country	Stunting					Underweight					Wasting				
	CI	se(C)	t(C)	Low	High	CI	se(C)	t(C)	Low	High	CI	se(C)	t(C)	Low	High
Bangladesh	-0.051	0.015	-3.491	-0.080	-0.022	-0.067	0.014	-4.939	-0.094	-0.040	-0.067	0.028	-2.391	-0.123	-0.011
Brazil	-0.194	0.032	-5.996	-0.259	-0.129	-0.241	0.047	-5.168	-0.334	-0.147	-0.067	0.057	-1.176	-0.182	0.047
China	-0.142	0.031	-4.570	-0.205	-0.080	-0.167	0.044	-3.746	-0.255	-0.078	-0.201	0.099	-2.041	-0.398	-0.004
Côte d'Ivoire	-0.109	0.035	-3.063	-0.179	-0.038	-0.101	0.039	-2.589	-0.178	-0.023	0.020	0.052	0.384	-0.084	0.124
Egypt	-0.039	0.034	-1.125	-0.107	0.030	-0.034	0.043	-0.784	-0.121	0.053	-0.036	0.067	-0.539	-0.170	0.098
Ghana	-0.094	0.017	-5.427	-0.129	-0.059	-0.105	0.020	-5.305	-0.144	-0.065	-0.138	0.053	-2.584	-0.245	-0.031
Guatemala	-0.078	0.008	-9.240	-0.095	-0.061	-0.109	0.015	-7.234	-0.139	-0.079	-0.086	0.134	-0.641	-0.355	0.183
Guyana	-0.146	0.063	-2.315	-0.272	-0.020	-0.201	0.046	-4.413	-0.293	-0.110	-0.087	0.075	-1.170	-0.236	0.062
Indonesia	-0.091	0.015	-6.033	-0.121	-0.061	-0.064	0.018	-3.513	-0.100	-0.027	-0.064	0.048	-1.337	-0.161	0.032
Morocco	-0.185	0.019	-9.808	-0.222	-0.147	-0.251	0.027	-9.251	-0.305	-0.197	-0.169	0.042	-3.994	-0.253	-0.084
Nepal	-0.065	0.015	-4.414	-0.095	-0.036	-0.120	0.034	-3.503	-0.189	-0.052	-0.108	0.046	-2.340	-0.201	-0.016
Nicaragua	-0.158	0.015	-2.695	-0.188	-0.129	-0.276	0.034	-3.246	-0.345	-0.208	-0.496	0.046	-3.680	-0.588	-0.403
Pakistan	-0.074	0.011	-6.771	-0.134	-0.015	-0.064	0.010	-6.174	-0.112	-0.017	-0.063	0.016	-4.061	-0.109	-0.017
Peru	-0.280	0.017	-16.791	-0.314	-0.247	-0.307	0.030	-10.209	-0.368	-0.247	-0.155	0.088	-1.770	-0.330	0.020
Philippines	-0.188	0.030	-6.344	-0.218	-0.159	-0.105	0.024	-4.444	-0.143	-0.067	-0.098	0.023	-4.265	-0.152	-0.044
Romania	-0.051	0.016	-3.109	-0.084	-0.018	-0.087	0.035	-2.477	-0.157	-0.017	-0.053	0.042	-1.252	-0.138	0.032
Russia	-0.221	0.058	-3.795	-0.338	-0.105	-0.077	0.105	-0.733	-0.288	0.134	0.006	0.113	0.051	-0.220	0.232
South Africa	-0.199	0.015	-13.409	-0.228	-0.169	-0.142	0.019	-7.555	-0.179	-0.104	-0.033	0.027	-1.218	-0.087	0.021
Vietnam	-0.088	0.011	-8.306	-0.109	-0.067	-0.089	0.013	-6.910	-0.115	-0.063	0.076	0.043	1.766	-0.010	0.161
Zambia	-0.099	0.027	-3.653	-0.153	-0.045	-0.144	0.011	-12.603	-0.167	-0.121	-0.016	0.023	-0.676	-0.062	0.031

Table 5. Test of significance between concentration indices for under-5 stunting

	Bangladesh	Brazil	China	C d'Ivoire	Egypt	Ghana	Guatemala	Guyana	Indonesia	Morocco	Nepal	Nicaragua	Pakistan	Peru	Philippines	Romania	Russia	S Africa	Vietnam
Brazil	4.05																		
China	2.67	-1.15																	
Côte d'Ivoire	1.51	-1.79	-0.72																
Egypt	-0.32	-3.30	-2.24	-1.42															
Ghana	1.92	-2.73	-1.36	-0.37	1.44														
Guatemala	1.65	-3.46	-1.99	-0.83	1.13	-0.81													
Guyana	1.47	-0.68	0.05	0.52	1.50	0.80	1.06												
Indonesia	1.92	-2.90	-1.49	-0.46	1.39	-0.14	0.72	-0.85											
Morocco	5.64	-0.26	1.16	1.89	3.73	3.54	5.15	0.58	3.89										
Nepal	0.70	-3.63	-2.24	-1.13	0.71	-1.27	-0.77	-1.25	-1.21	-4.99									
Nicaragua	5.21	-1.01	0.46	1.30	3.21	2.83	4.71	0.19	3.21	-1.09	4.47								
Pakistan	1.30	-3.51	-2.06	-0.92	0.99	-0.96	-0.29	-1.12	-0.89	-5.06	0.49	-4.58							
Peru	10.38	2.36	3.90	4.38	6.34	7.74	10.79	2.05	8.43	3.80	9.65	5.46	10.31						
Philippines	4.17	-0.13	1.07	1.73	3.30	2.75	3.57	0.61	2.93	0.11	3.72	0.90	3.61	-2.69					
Romania	0.03	-3.94	-2.59	-1.47	0.33	-1.79	-1.46	-1.46	-1.77	-5.33	-0.63	-4.85	-1.17	-9.77	-4.04				
Russia	2.84	0.41	1.19	1.65	2.70	2.09	2.43	0.88	2.17	0.60	2.60	1.05	2.48	-0.97	0.50	2.81			
S Africa	7.14	0.12	1.63	2.34	4.28	4.59	7.05	0.81	5.11	0.59	6.38	1.92	6.75	-3.66	0.30	6.65	-0.38		
Vietnam	2.08	-3.12	-1.65	-0.55	1.38	-0.29	0.72	-0.91	-0.15	-4.47	1.26	-3.87	0.90	-9.72	-3.18	1.88	-2.25	-6.07	
Zambia	1.57	-2.27	-1.06	-0.22	1.38	0.14	0.72	-0.69	0.25	-2.61	1.09	-1.95	0.84	-5.72	-2.24	1.50	-1.91	-3.25	0.36

Table 6. Test of significance between concentration indices for under-5 underweight

	Bangladesh	Brazil	China	C d'Ivoire	Egypt	Ghana	Guatemala	Guyana	Indonesia	Morocco	Nepal	Nicaragua	Pakistan	Peru	Philippines	Romania	Russia	S Africa	Vietnam
Brazil	3.58																		
China	2.14	-1.15																	
Côte d'Ivoire	0.82	-2.31	-1.11																
Egypt	-0.73	-3.25	-2.14	-1.15															
Ghana	1.58	-2.68	-1.27	0.10	1.49														
Guatemala	2.07	-2.69	-1.22	0.20	1.64	0.17													
Guyana	2.82	-0.60	0.55	1.68	2.66	1.94	1.92												
Indonesia	-0.15	-3.54	-2.14	-0.86	0.63	-1.54	-1.92	-2.80											
Morocco	6.06	0.20	1.62	3.17	4.25	4.35	4.58	0.94	5.74										
Nepal	2.62	-2.45	-0.98	0.47	1.89	0.62	0.53	-1.68	2.40	-4.20									
Nicaragua	10.28	0.73	2.34	4.21	5.28	6.88	7.82	1.56	8.99	0.81	7.27								
Pakistan	-0.16	-3.70	-2.24	-0.90	0.68	-1.82	-2.44	-2.93	0.03	-6.43	-3.05	-11.53							
Peru	7.27	1.21	2.62	4.20	5.19	5.62	5.89	1.94	6.93	1.39	5.55	0.92	7.63						
Philippines	1.39	-2.60	-1.22	0.09	1.44	0.00	-0.15	-1.88	1.39	-4.06	-0.55	-6.11	1.58	-5.29					
Romania	0.52	-2.64	-1.41	-0.27	0.95	-0.45	-0.59	-2.00	0.58	-3.71	-0.88	-4.97	0.61	-4.78	-0.43				
Russia	0.10	-1.42	-0.78	-0.21	0.38	-0.26	-0.30	-1.08	0.13	-1.60	-0.41	-1.87	0.12	-2.10	-0.26	-0.08			
S Africa	3.22	-1.97	-0.51	0.95	2.28	1.35	1.36	-1.21	2.99	-3.32	0.88	-5.58	3.61	-4.67	1.22	1.39	0.60		
Vietnam	1.16	-3.14	-1.68	-0.29	1.22	-0.68	-1.02	-2.37	1.13	-5.40	-1.59	-9.43	1.48	-6.68	-0.60	0.06	0.11	-2.33	

Table 7. Test of significance between concentration indices for under-5 wasting

	Bangladesh	Brazil	China	C d'Ivoire	Egypt	Ghana	Guatemala	Guyana	Indonesia	Morocco	Nepal	Nicaragua	Pakistan	Peru	Philippines	Romania	Russia	S Africa	Vietnam
Brazil	0.01																		
China	1.31	1.17																	
Côte d'Ivoire	-1.47	-1.13	-1.98																
Egypt	-0.43	-0.36	-1.39	0.66															
Ghana	1.18	0.90	-0.56	2.12	1.19														
Guatemala	0.14	0.13	-0.69	0.74	0.33	-0.36													
Guyana	0.25	0.21	-0.92	1.18	0.51	-0.56	0.01												
Indonesia	-0.05	-0.04	-1.25	1.19	0.34	-1.02	-0.15	-0.26											
Morocco	2.00	1.42	-0.30	2.81	1.67	0.45	0.58	0.95	1.63										
Nepal	0.91	0.60	-0.89	2.04	0.95	-0.47	0.16	0.25	0.73	-1.10									
Nicaragua	9.52	6.36	2.81	8.21	6.07	5.58	2.95	4.96	7.23	5.95	7.78								
Pakistan	-0.13	-0.08	-1.39	1.53	0.39	-1.35	-0.17	-0.32	-0.03	-2.35	-1.17	-11.24							
Peru	0.96	0.84	-0.35	1.72	1.08	0.16	0.43	0.59	0.91	-0.14	0.50	-3.61	1.03						
Philippines	0.86	0.50	-1.02	2.08	0.88	-0.69	0.09	0.14	0.63	-1.46	-0.24	-9.44	1.27	-0.63					
Romania	-0.27	-0.20	-1.38	1.09	0.21	-1.25	-0.23	-0.40	-0.18	-1.93	-1.00	-8.03	-0.22	-1.05	-0.94				
Russia	-0.63	-0.58	-1.38	0.11	-0.32	-1.15	-0.52	-0.69	-0.57	-1.45	-0.96	-4.24	-0.60	-1.12	-0.90	-0.49			
S Africa	-0.87	-0.54	-1.65	0.90	-0.04	-1.75	-0.39	-0.68	-0.57	-2.70	-1.69	-10.40	-0.96	-1.33	-1.83	-0.40	0.33		
Vietnam	-2.79	-2.00	-2.58	-0.83	-1.40	-3.12	-1.15	-1.89	-2.17	-4.06	-3.31	-10.31	-3.04	-2.37	-3.58	-2.14	-0.58	-2.14	
Zambia	-1.41	-0.84	-1.83	0.63	-0.29	-2.10	-0.52	-0.92	-0.91	-3.17	-2.19	-11.37	-1.69	-1.54	-2.52	-0.77	0.19	-0.49	1.88

Table 8. Concentration indices with different age intervals

Country	Stunting	Underweight	Wasting
Brazil			
Age in months	-0.19	-0.24	-0.07
Age in years	-0.19	-0.22	-0.07
Ghana			
Age in months	-0.09	-0.10	-0.13
Age in years	-0.11	-0.13	-0.13
Pakistan			
Age in months	-0.07	-0.06	-0.05
Age in years	-0.06	-0.06	-0.05
Vietnam			
Age in months	-0.08	-0.08	0.08
Age in years	-0.08	-0.07	0.08

Note: Concentration indices are at quintile (not individual) level.

Table 9. Concentration indices with different age range s

Country	Stunting	Underweight	Wasting
Brazil			
Under 5	-0.19	-0.24	-0.07
Under 4	-0.17	-0.25	-0.09
Under 3	-0.13	-0.27	-0.18
Côte d'Ivoire			
Under 5	-0.10	-0.10	0.03
Under 4	-0.09	-0.10	0.01
Under 3	-0.13	-0.09	0.03
South Africa			
Under 5	-0.19	-0.14	-0.04
Under 4	-0.18	-0.13	-0.03
Under 3	-0.18	-0.24	-0.13
Vietnam			
Under 5	-0.08	-0.08	0.08
Under 4	-0.10	-0.09	0.07
Under 3	-0.18	-0.05	0.37

Note: Concentration indices are at quintile (not individual) level.

Table 10. Concentration indices with different cut-off points

Country	Stunting	Underweight	Wasting
Bangladesh			
-2Z	-0.05	-0.06	-0.06
-3Z	-0.08	-0.10	-0.16
Nepal			
-2Z	-0.06	-0.11	-0.10
-3Z	-0.15	-0.21	0.04
Pakistan			
-2Z	-0.07	-0.06	-0.05
-3Z	-0.10	-0.10	-0.04
Vietnam			
-2Z	-0.08	-0.08	0.08
-3Z	-0.12	-0.06	0.35

Note: Concentration indices are at quintile (not individual) level.

Figure 7. Gini vs CI (stunting)

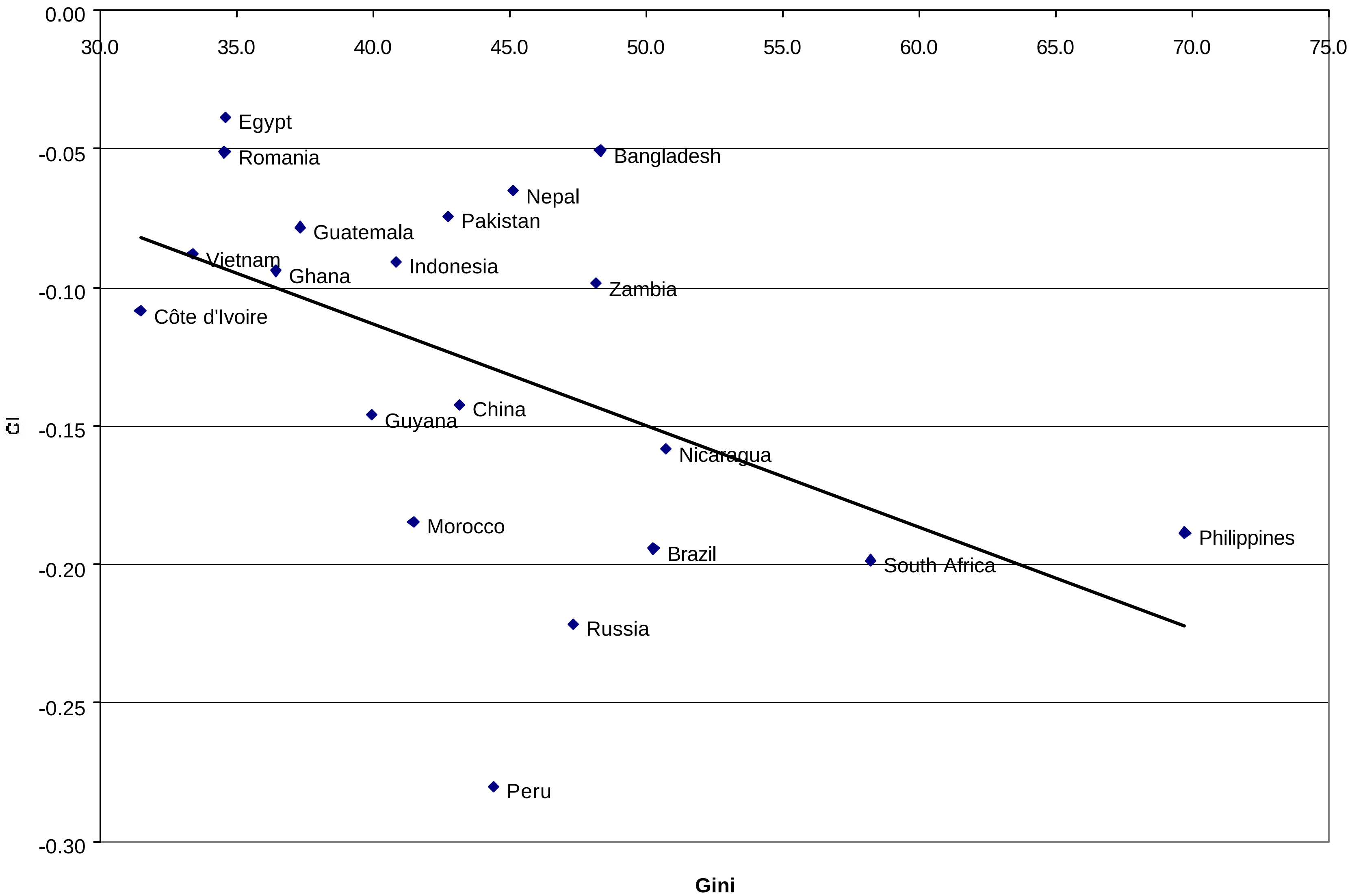

Figure 8. Gini vs CI (underweight)

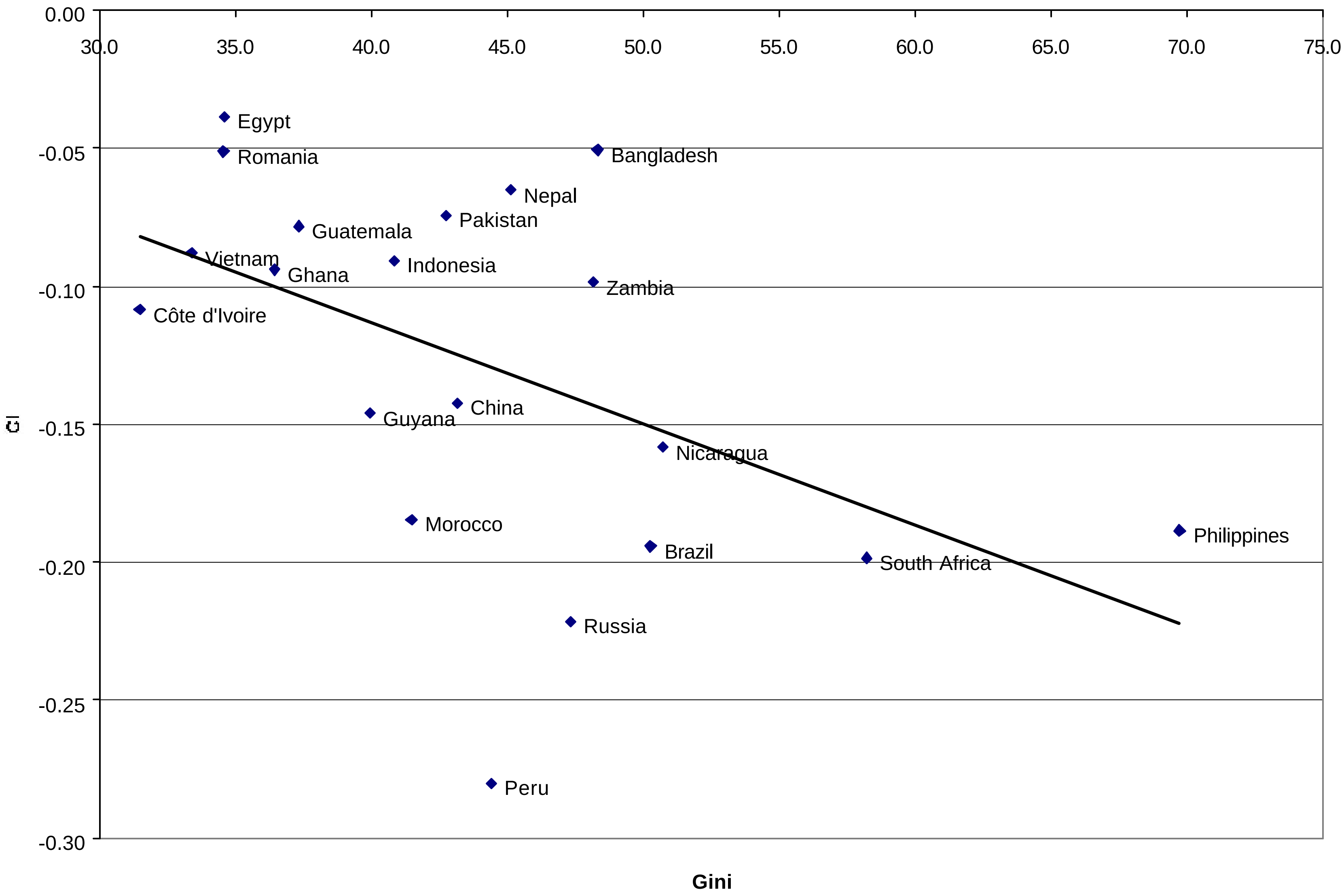

Figure 9. Gini vs CI (wasting)

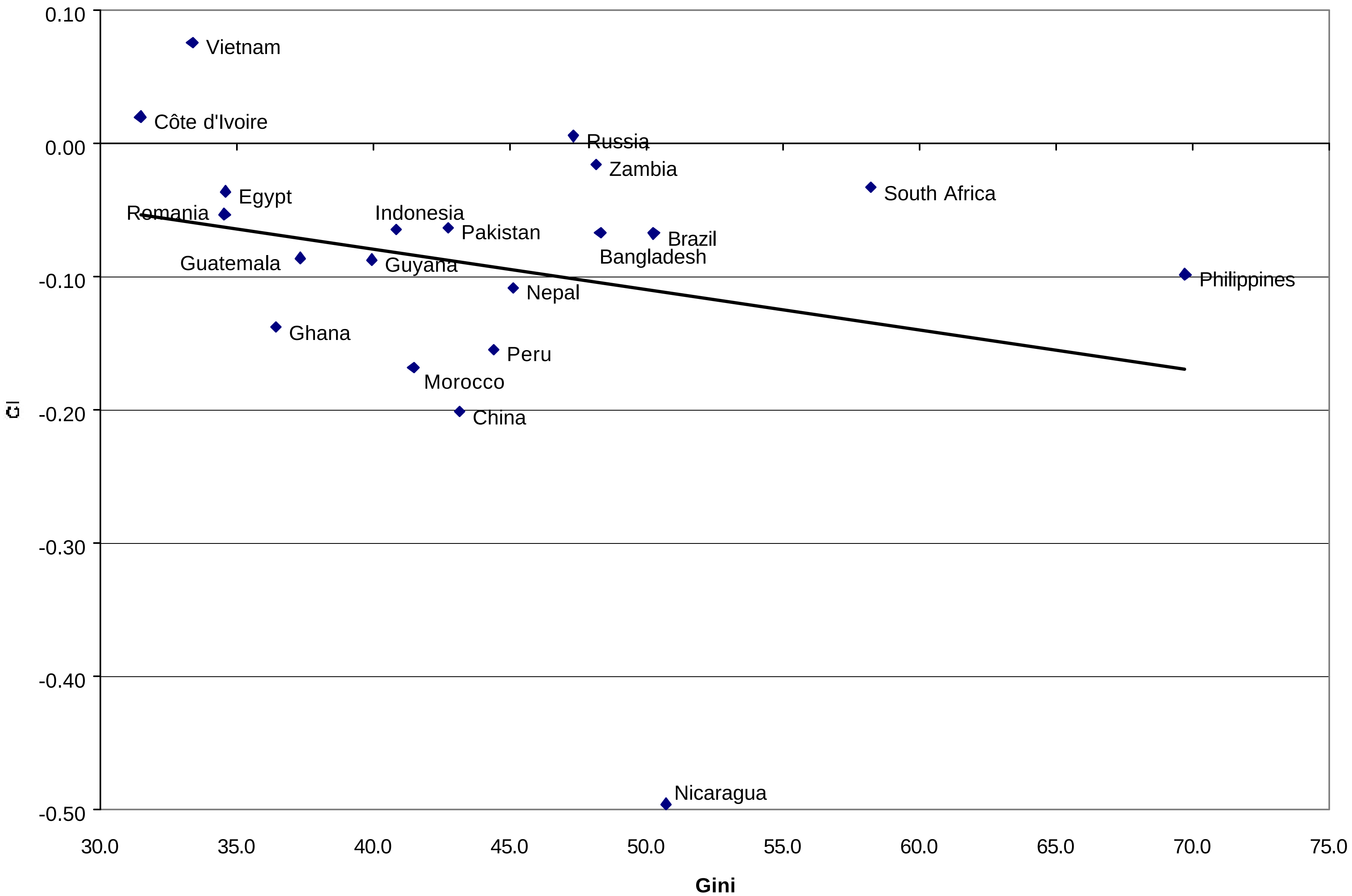

Figure 10. Prevalence of under-5 stunting vs CI

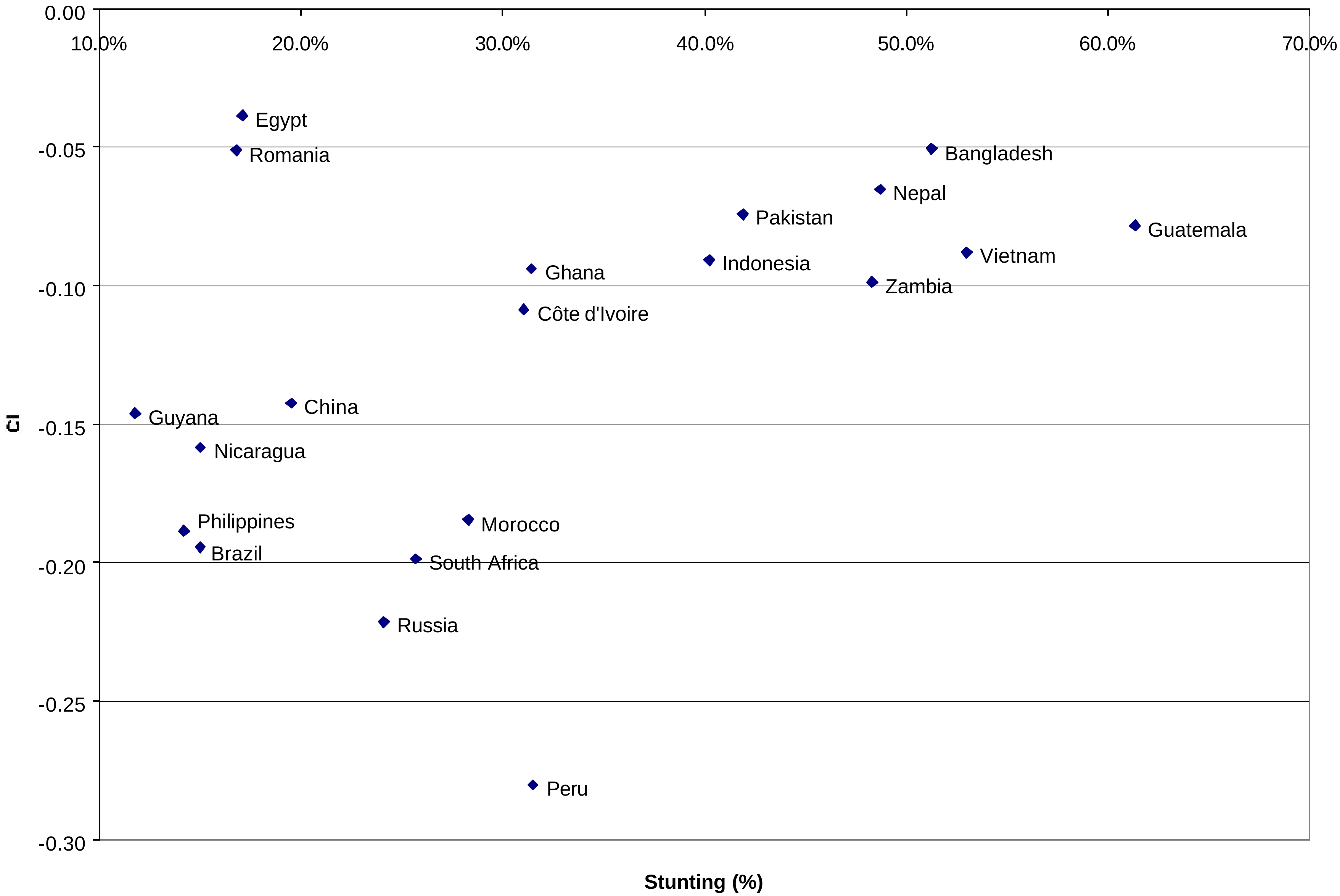

Figure 11. Prevalence of under-5 underweight vs CI

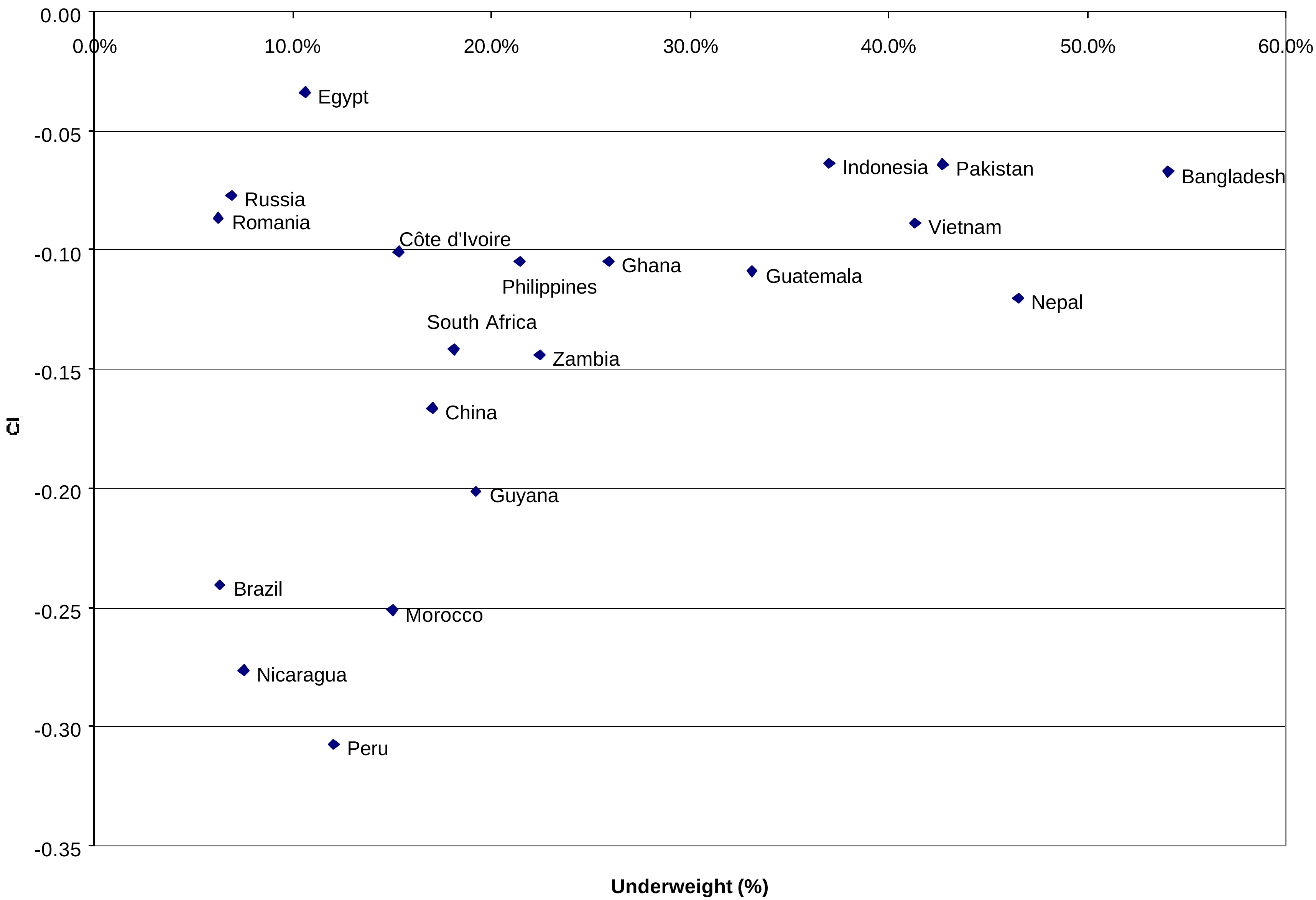

Figure 12. Prevalence of under-5 wasting vs CI

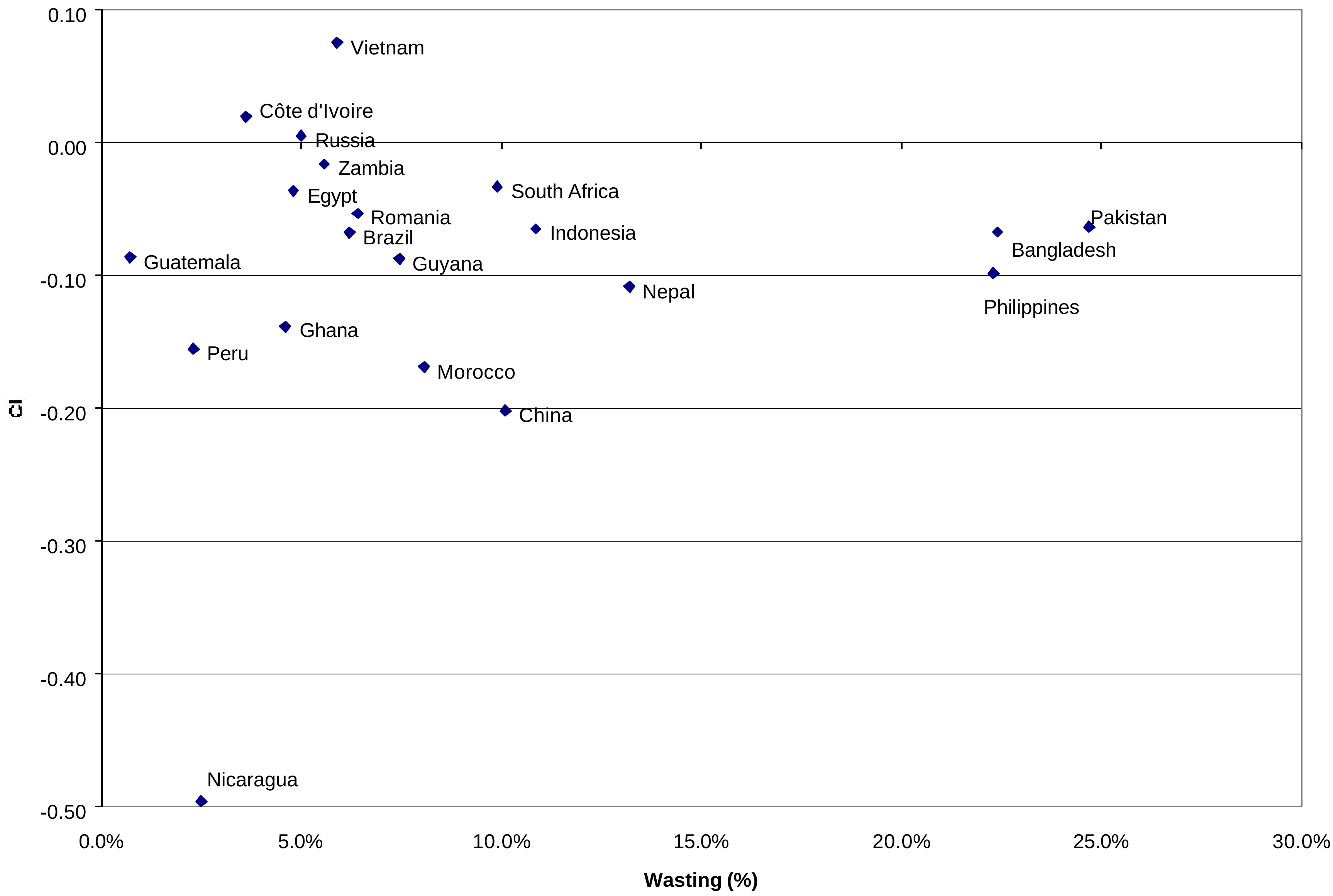

Table 11. Achievement indices

Country	Stunting		Underweight		Wasting	
	m	I_R	m	I_R	m	I_R
Bangladesh	0.5126	0.5385	0.5405	0.5767	0.2241	0.2391
Brazil	0.1503	0.1795	0.0625	0.0776	0.0620	0.0662
China	0.2775	0.3170	0.1303	0.1519	0.0365	0.0438
Cote d'Ivoire	0.1953	0.2165	0.1697	0.1868	0.1014	0.0994
Egypt	0.1710	0.1776	0.1073	0.1110	0.0483	0.0500
Ghana	0.3146	0.3442	0.2592	0.2863	0.0457	0.0520
Guatemala	0.6173	0.6656	0.3332	0.3696	0.0071	0.0077
Guyana	0.1186	0.1359	0.1867	0.2243	0.0750	0.0816
Indonesia	0.4616	0.5035	0.3982	0.4236	0.1031	0.1097
Morocco	0.2829	0.3351	0.1499	0.1876	0.0807	0.0943
Nepal	0.4865	0.5182	0.4654	0.5214	0.1324	0.1467
Nicaragua	0.1501	0.1739	0.0771	0.0984	0.0253	0.0379
Pakistan	0.4187	0.4498	0.4273	0.4548	0.2474	0.2630
Peru	0.3149	0.4031	0.1204	0.1574	0.0231	0.0267
Philippines	0.1417	0.1684	0.2142	0.2366	0.2230	0.2449
Romania	0.2406	0.2530	0.0692	0.0752	0.0498	0.0524
Russia	0.1683	0.2055	0.0624	0.0672	0.0636	0.0632
South Africa	0.2564	0.3073	0.1808	0.2065	0.0998	0.1031
Vietnam	0.5299	0.5766	0.4129	0.4496	0.0590	0.0546
Zambia	0.4822	0.5298	0.2241	0.2563	0.0559	0.0568