Levels and Trends in Growth Failure in Developing Countries

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Undernutrition is the outcome of the interaction between poor diet and disease and contributes to most of the growth deficits observed in children in less developed countries. According to the conceptual framework of the United Nations Children’s Fund (UNICEF), inadequate dietary intake and disease result from an interaction of the underlying causes of food insecurity, inadequate maternal and child care, and poor health services and environment. These underlying causes are determined by basic causes such as political and ideological factors, economic structure, and resources (1).

The anthropometric index height for age shows the linear growth achieved prenatally and postnatally. Its deficits indicate long-term cumulative effects of inadequacies of nutrition and/or health. Shortness in height means that a child is of low height for age and may reflect either normal variation in growth or a deficit in growth. Stunting refers only to shortness reflecting a deficit or linear growth that has failed to reach genetic potential as a result of the interaction between poor diet and disease. Stunting is defined as low height for age, below −2 SD of the median value of the National Center for Health Statistics (NCHS)/World Health Organization (WHO) international growth reference (2).

The process that leads to stunting begins in pregnancy with intrauterine growth retardation, which is caused mainly by inadequate maternal nutritional status before conception and poor maternal nutrition during pregnancy in developing countries. This process then continues during the first 3 years of life, when various nutrients may be limited (e.g., protein as well as energy, vitamin A, zinc, and iron). In addition, prolonged childhood infection further contributes to deficits in growth (3). If, at the beginning of this period, exclusive breast-feeding has not been achieved and if inappropriate and untimely introduction of complementary foods has occurred, the problem is exacerbated.

In 1993, the WHO presented, for the first time, the pattern and levels of growth failure in children under 5 years of age for developing countries (4). These data were updated in 1997, when estimates of trends were also derived by WHO and by the UN
Administrative Committee on Coordination/Sub-Committee on Nutrition (ACC/SCN) (5,6).

In this chapter, we present an update of these levels and trends recently reported by the WHO (7) and included in the fourth report of the ACC/SCN (8).

**METHODOLOGY**

Multilevel modeling, the same statistical method as described in the third report (9), was used by WHO to develop the trend projections for this update (10). Multilevel modeling refers to a generalization of regression that employs multiple levels as sources of variability in estimating the prevalence of stunting. These levels are between regions, between countries within regions, and between surveys over time within countries.

Many countries had only one survey, so they could not contribute to the estimate of a trend but only to the mean prevalence. For this reason, it was decided to estimate a mean prevalence for each country but to average the trends in prevalence over time across countries. Each region and subregion was analyzed separately, which allowed region- and subregion-specific estimates for the trend in stunting prevalence over time and country-specific estimates for the mean prevalence.

A simplified version of a random coefficient model with only random intercepts was used (11). It was assumed that the availability of data for countries was not related to the prevalence of stunting. To estimate the trends by region, a random coefficient model was fitted for each region and subregion with sufficient data, using the country population as sample weights (12). Therefore, the effect of a country was proportional to its population.

The multilevel models specified a linear relation between prevalence of stunting and survey year, meaning that the rate of change in the prevalence is constant. To determine if any regional trends were speeding up or slowing down, possible nonlinear relations were examined by including quadratic and cubic polynomial terms. No evidence of nonlinear relations was found for any region or subregion.

The fitted equations were used to predict region and subregion prevalences for the years 1980, 1985, 1990, 1995, 2000, and 2005. Uncertainty in the forecasts was assessed by 95% confidence intervals estimated by SAS PROC MIXED (13). The predictions for 2010 and beyond were discarded because the 95% confidence intervals were too wide.

The anthropometric data for the statistical modeling were taken from the WHO global database on child growth and malnutrition (5). As of 1998, data were available from at least two surveys for the estimation of trends in stunting for 65 countries. For the estimation of mean stunting prevalence, data were available from at least one survey in 107 countries.

A thorough comparison of this multilevel modeling method with the method used by the ACC/SCN from 1987 to 1996 appears in the fourth report (8). The conclusion is that for future estimation and prediction of trends in undernutrition prevalence, the multilevel modeling technique is the method of choice. However, it is recommended
that model assumptions be tested periodically and different forms of regression analysis for the direct method be compared.

WHO did not find differences between prevalence rates for boys and girls for stunting, wasting, and underweight (5). The situation remains the same with the latest available data, so in this chapter, the data have not been disaggregated by gender for preschool children.

The results herein are presented for the regions and subregions used by the UN population division (see Appendix for the detailed listing of the countries within each subregion). The regional and subregional definitions used here are also close to geographic reality and hence are more easily understood by non-UN users. WHO began to use this classification in 1993 (4).

RESULTS

Table 1 shows the estimated prevalence of stunted children for the UN regions and subregions. By 2005, it is estimated that 29% of children under 5 years of age in developing countries will be stunted. East Africa (48%) and South Central Asia (39%) will have the highest levels of stunting. West Africa (35%) and South East Asia (28%) will rank next highest in prevalence, followed by Central America (24%) and North Africa (17%). The Caribbean (14%) and South America (5%) will show the lowest levels. Because of the lack of data, there were no estimates for Middle and South Africa or for East and West Asia, Melanesia, Micronesia, or Polynesia.

The majority of the above prevalence rates cannot be compared with the ones that appear in the third report (6), owing to the different composition of the regions (see Appendix). However, the prevalence rates for all developing countries and for South America can be compared with those in the third report. In both cases, the confidence intervals around the latest estimates include the midpoint estimates from

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<tr>
<th>TABLE 1. Estimated prevalence of stunted children (%) from 1980 to 2005</th>
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<td>Africa</td>
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<td>Latin America and Caribbean</td>
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<td>Central America</td>
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<td>South America</td>
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<td>All developing countries</td>
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From World Health Organization (10).
### TABLE 2. Estimated numbers of stunted children (million) from 1980 to 2005

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<tr>
<td>Eastern Africa</td>
<td>34.781</td>
<td>38.512</td>
<td>41.682</td>
<td>44.510</td>
<td>47.297</td>
<td>49.396</td>
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<td>Western Africa</td>
<td>6.005</td>
<td>6.006</td>
<td>5.549</td>
<td>4.898</td>
<td>4.438</td>
<td>3.855</td>
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<td><strong>Asia</strong></td>
<td>173.374</td>
<td>169.720</td>
<td>167.660</td>
<td>143.493</td>
<td>127.803</td>
<td>110.193</td>
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<td>South central Asia</td>
<td>89.362</td>
<td>93.449</td>
<td>93.363</td>
<td>83.616</td>
<td>78.534</td>
<td>72.281</td>
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<tr>
<td>Southeastern Asia</td>
<td>27.710</td>
<td>26.474</td>
<td>24.244</td>
<td>21.509</td>
<td>18.938</td>
<td>15.780</td>
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<td><strong>Latin America and Caribbean</strong></td>
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<tr>
<td>Central America</td>
<td>0.920</td>
<td>0.859</td>
<td>0.813</td>
<td>0.713</td>
<td>0.607</td>
<td>0.506</td>
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<tr>
<td>South America</td>
<td>3.865</td>
<td>3.810</td>
<td>3.872</td>
<td>3.944</td>
<td>3.924</td>
<td>3.820</td>
</tr>
<tr>
<td><strong>All developing countries</strong></td>
<td>221.345</td>
<td>220.103</td>
<td>219.725</td>
<td>196.594</td>
<td>181.921</td>
<td>164.696</td>
</tr>
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From World Health Organization (10).

the third report; thus, there is consistency between these estimates and those reported in 1997.

Table 2 presents the estimated number of stunted children under 5 years of age by UN regions and subregions. These estimates were derived by applying the estimated prevalences of stunting to the estimated total population under 5 years for each subregion and region, using the UN projections (14). Thus, the estimated number of children under 5 who were stunted for each region and subregion covered all countries within these regions, including those countries that did not have a survey to contribute to the estimation of prevalence values.

It was estimated that in 2000, there would be 181.9 million stunted children in the developing world, 70% of them living in Asia (especially South Central Asia), 26% in Africa, and 4% in Latin America and the Caribbean, a very unequal regional distribution. South Central Asia would have the highest stunting level in absolute numbers; this subregion accounting for 43% of the total number of stunted children in the developing world for the year 2000. East Africa would rank next highest in numbers, followed by South East Asia and West Africa.

**DISCUSSION**

As reported previously (6), the trends in stunting prevalence show wide variability between subregions. The prevalence of stunting in children under 5 has progressively fallen in developing countries from 47% in 1980 to 33% in 2000. However, East Africa shows an increase in the average prevalence of stunting of 0.08 percentage point/year. Each of the other subregions shows a decrease, with trends ranging from −0.07 to −0.98 percentage point/year. South Central Asia, South East Asia, and South America show good progress. North Africa and the Caribbean show modest progress. West Africa and Central America show very little progress.

It is estimated that the total number of stunted children under 5 years in developing countries will have decreased by 39.4 million between 1980 and 2000. However,
over the same period, East Africa, West Africa, and Central America will have shown increases of 9.15, 5.70, and 0.06 million children, respectively.

Comparing the trends in percentage rates presented in Table 1 with the numbers of stunted children in Table 2, it seems that when average decreases in trends at the sub-region levels are below −0.11 percentage point/year, they are not able to compensate for the population increase in these subregions, and therefore the number of stunted children increases. The other subregions showed a decrease in the number of stunted children; it seems that a trend decrease above −0.50 percentage point/year is required to compensate for the population growth of these subregions. There is urgent need for information about factors that determine differential trend decreases in stunting by subregion. It is likely that changes in the prevalence of intrauterine growth retardation is one of these.

A worldwide cross-sectional study looking at the determinants of stunting in children under age 5 (15) found that there was substantial variability between nations and between provinces within nations, meaning that whether or not children are undernourished is as much or more a consequence of factors at national and provincial levels as it is of individual and household level circumstances. Most of the nation-to-nation variability in stunting (76%) was explained by national factors and geographic regions within each country. The study shows that higher energy availability, female literacy, and gross national product were the most important factors associated with lower prevalence of stunting. Furthermore, the association of health expenditure and stunting differed by region, and regional differences persisted even after accounting for national idiosyncrasies.

Another recent cross-sectional analysis in Mexico of the association of maternal short stature with stunting has shown that this relation was stronger in wealthy regions and that the contribution of socioeconomic factors to this association was substantial, particularly in poorer regions (16). The prevalence of stunting was associated with lower socioeconomic status levels, overcrowding in the home, and lower maternal education, as has been found elsewhere (17). These results are consistent with findings that in less developing countries, the majority of the variation in height is the result of environmental influences on linear growth (18).

Trends in stunting of schoolchildren aged 6–9 years in Costa Rica and Honduras are illustrated in Fig. 1. Stunting in Costa Rica fell from 20.4% to 7.5% over the period 1979–97 (19). During that period, Costa Rica implemented a strong social, human, and food and nutrition security policy, which modified—among other impacts—energy availability, female literacy, and gross national product (20). Secular trend data have shown that increased access to food supplies and decreased burden of infectious diseases result in gains in height that may be observed over generations (21). On the other hand, stunting increased in Honduras from 34.9% to 40.6% over the period 1991—97 (22). This increase is probably related to the economic and sociopolitical crises faced by that country during the period in question.

Unfortunately, the Central America subregion is the only one that has school height census data available; thus, the lack of data from other subregions of the developing world prevents an analysis of stunting in school-age children elsewhere.
School height censuses provide summary statistics on the distribution of growth retardation within and between geographic units (23). A recent analysis has shown strikingly good agreement between school height census data and the results of two national nutrition surveys for children under 5 in Honduras between 1993 and 1997.

In summary, the progress shown by trends across subregions is more modest than would have been hoped. The prevalence rates of stunted children younger than 5 years remain high across all UN subregions, particularly in East Africa and South Central Asia, indicating that a subregional approach to reducing stunting is urgently needed.

Investments in interventions to modify environmental factors will decrease the prevalence of stunting and prevent its negative functional consequences throughout the life cycle.

REFERENCES


DISCUSSION

**Dr. Cassoria:** How do you define “stunting,” and how did you obtain your results in countries where there are few regional data?

**Dr. Flores:** In 1995, the WHO defined “stunting” as being below 2 z scores from the reference population, which in this case is the NCHS/WHO reference.

**Dr. Cassoria:** So, you use those standards to assess stunting in Southeast Asia or Africa?

**Dr. Flores:** Yes. In answer to the second part of your question, there were 65 countries that had at least two points in time to do the estimate of the trend. The countries that had at least one survey (107) were brought together in the analysis to contribute to the average prevalence, not to the trend. We did not make estimates for countries—we did estimates for subregions and regions.

**Dr. Uauy:** Could you comment on the trends of stunting versus underweight? We are seeing a predominance of stunting in most regions now.

**Dr. Flores:** We did not present the trends in underweight because we are talking here about linear growth. But the trends in underweight are exactly the same. However, the absolute prevalence of stunting is higher than underweight.
Dr. Rivera-Dommarco: Of the regions that you presented, are there any that are underrepresented in terms of the number of countries with available data? I'm particularly thinking of Central America. I don't think you have two points in time from Mexico, which is considered part of Central America in your report, but you used weighted data and most of the population in that region comes from Mexico. This might bias the result.

Dr. Flores: Where there was a lack of data for certain regions or subregions, we used estimates. Because there was just one national survey for Mexico and India, Dr. Frongillo—who was working on the methodology—proposed taking the data from rural surveys. For both countries, in the year for which there was a national survey, there were also disaggregated data available by rural/urban areas. This correspondence made it possible to calibrate the rural data for India and Mexico to the national survey and to estimate a series of national data for both countries (1). There are other regions that were not shown because the data are insufficient to produce reliable estimates.

Dr. Rivera-Dommarco: You said there is a linear trend globally toward a reduction in stunting. Did you find any differences in the slope according to the prevalence of undernutrition? One would expect to have different slopes for countries or regions that have higher or lower prevalence.

Dr. Flores: Well, you saw from the transparencies that the relation is linear, but clearly there are differences in the slopes, although we didn't test for that. When you change the breakdown of the regions, you can rearrange the data according to what you want to do with them. For example, if you lump together Central America and South America, South America will pull up Central America and it will appear that Central America does not have a problem.

Dr. Martorell: I would like to ask Dr. Rivera-Dommarco to tell us what the new Mexican results actually are.

Dr. Rivera-Dommarco: We recently finalized the analysis of the data. The prevalence of stunting from a national nutrition survey of about 18,000 families in 1988 was 22.3%. In 1998, in a sample of 21,000 families, it came down to 17.2%. So, the reduction was 5.1% over 10 years. For underweight, the prevalence came down from 16.8% to 7.5%, so there was an even larger fall. Wasting came down from 6% to 2%. So, as Mexico has a population of about 100 million people, I think the conclusions for Central America will probably change as a result of these findings.

Dr. Brunser: There is another factor in the etiology of stunting that does not appear in the list, and that is warfare. In East Africa, you have Somalia, Ethiopia, Uganda, Mozambique, and so on, where people have been at war for 20 years. And in Central South Asia, you have Afghanistan and some of the countries of the former Soviet Union, which have also been experiencing very important social upheavals. I think this is probably an important factor in stunting.

Dr. Flores: Remember that we are dealing with national estimates. There is another group—refugees and displaced populations—which we treat differently. There is a whole chapter in the fourth report (2) about displaced people. But we have not specifically examined warfare as a factor in stunting.

Dr. Lejarraga: I wonder if it would be helpful to introduce more variables explaining the trends: for instance, the percentage of the gross national product applied to health, or to primary care, or to the universities or hospitals, and the percentage of gross national product destined for other targets. I think that might help countries to define their policies.
Dr. Flores: I think Dr. Frongillo’s paper published in 1997 includes all the possible variables that were available at country level in trying to explain the trends (3). Three variables—higher energy availability, female literacy, and gross national product—were the most important factors associated with lower prevalence of stunting.

Dr. Frongillo: At the 1999 experimental biology meeting, Lisa Smith, Lawrence Haddad, and I all presented analyses based on taking advantage of the fact that there are many countries now with two or more points in time that allow us to look at changes in the prevalence of stunting. Smith and Haddad’s article is now available (4), and I’m still working on mine, but our results suggest a number of factors that may indicate which countries change more than others.

Dr. Flores: There is a brief summary of Smith and Haddad’s article in the appendix of the fourth report (2), related to their analysis on underweight, not on stunting.

Dr. Lala: Did you factor the whole question of HIV and AIDS in your assessment of the prevalence of stunting? I noted a paucity of data from Southern Africa, which is heavily burdened by the HIV epidemic. In Johannesburg, for example, we have seen an increase in the incidence of stunting, though when you consider HIV-uninfected infants separately, there is a decrease; however, the overall trend has been reversed owing to the impact of HIV and AIDS. I’m not sure if that in part accounts for the high prevalence of stunting in the African regions.

Dr. Flores: You are correct. We wanted to adjust for HIV in that subregion, but unfortunately there were insufficient data to put into the model to do the adjustments, so we don’t know. But in the fourth report (2), we address the issue of the possible effects of HIV.

Dr. Stoltzfus: I was also thinking about the topic of HIV. In countries with the highest prevalence, such as Zimbabwe and Botswana, about 30% of pregnant women are affected. If the transmission rate is 50%, then about 15% of children will be affected. We can think about the children in three groups: HIV infected (about 15%), exposed to maternal infection (about 15%), and uninfected by HIV infection (about 70%). HIV-infected children don’t live very long, particularly in rural Africa, so the 15% who are infected from their mothers will mostly die within the first months of life or certainly within 2 years of life. So, when you consider that we are looking at prevalence figures between 6 months and 5 years of age, it is hard to imagine that the HIV-infected infants will affect these statistics greatly because of their relatively small proportion. The HIV-exposed infants may be more important numerically because they live throughout the whole preschool period; but having visited Southern Africa recently, I think a greater impact of HIV infection will be to destabilize the economies and the family structures caring for children. A disease that is likely to kill 30% of the productive adult population in a 5- to 10-year period in some of these countries will have a enormous impact on the care-giving capacities of communities. That may turn out to be the largest impact of the HIV epidemic on child nutrition as opposed to the virus itself acting within the children.

Dr. Flores: This is an important issue. In terms of food and nutrition security, we do not as yet have very clear evidence about the possible impact of HIV. We at International Food Policy Research Institute are putting together a policy brief by Barnet and Rugalema (5) that examines the recent evidence on the impact of AIDS on food security.
Dr. Ruel: When you showed the increasing prevalence of stunting in the schoolchildren in Honduras, you mentioned the poverty and all the other problems, but I was also wondering about AIDS, which has a high prevalence in Honduras. Do you know what effect that could have on these curves?

Dr. Flores: No, I don't.

Dr. Uljaszek: What is the likely impact of opportunistic infection, particularly diarrheal infection, on the general pediatric population in communities that have a high HIV prevalence? I wonder whether this is something that could perhaps also be incorporated in a model.

Dr. Flores: Certainly it could be, but I don't think the data exist at a country level.

Dr. Grummer-Strawn: My question has to do with data quality. I know the WHO global database essentially pulls together whatever data are sent in by the countries as representative of their status at a certain point in time. However, we know that data quality on anthropometric assessments is highly variable: Cluster samples range from just a few hundred to very large samples, some samples are more like height censuses, and there are issues of actual measurement techniques in the field. It does not take much measurement error to change prevalence figures quite a lot, particularly in the ranges that we are talking about. Is there any kind of control in your modeling for assessing for data quality?

Dr. Flores: Quality control is taken care of before the data are put into the model. Not all the data received are put in the WHO database. There are strict criteria on which data are going to be used for the work. The data must be a representative sample where the techniques of measurement are documented, and with evidence that the sample is not clinically biased. Just because a ministry of health sends a particular dataset, that does not mean it goes into the WHO database.

Dr. Cassorla: But that might well bias your data quite seriously, because the areas with no usable measurements are likely to be more destitute, and the prevalence of stunting is likely to be greater, while the people performing the measurements are likely to be better trained in the places with usable measurements. Maybe this needs to be taken into account, because it is likely that you will devalue your data otherwise.

Dr. Flores: I think you are misunderstanding the source of the data that went into these projections. Remember: We are dealing with nationally representative samples for the prevalence of stunting. I agree that it is important to have controls for measurement errors if possible, so you can adjust for them in the model. But when you go to multilevel modeling, you control for many sources of variation.

Dr. Martorell: On this point, the situation is actually the reverse of what Dr. Cassorla suggested. Because the very poor developing countries have great interest in nutritional problems, there are many national nutrition surveys from such countries. So, if you look at data availability, you find that countries like Argentina have not done any surveys, whereas there are lots of African countries with excellent national nutrition surveys.

Dr. Cassorla: Are the instruments being used to perform these surveys up to an acceptable standard?

Dr. Martorell: The Demographic Health Surveys (DHSs) are standardized, and they place emphasis on data quality and training. There is a lot of foreign input that comes into participating countries to assist with quality control of data collection.
Dr. Uauy: However, I think length data are quite limited. I looked at the data myself, and if you look at the period 1980–2000, only in the last 5–8 years are there any data at all. In previous decades, the data are very scanty. I’m saying this not to downgrade the information—I think this is the best information we have—but to point out that there are serious limitations, especially over length-data-across-age groups. There are very few data after 2 or 3 years in many of the surveys.

Dr. Frongillo: The WHO nutrition unit has put a tremendous amount of effort, in the last 4 years especially, into creating a database that has all the available information, and for these analyses, only datasets that are nationally representative and of high quality have been used. So, a lot of care has been taken in terms of the construction of the database. The datasets are not, of course, perfect, but they are the best currently available and better than most national-level indicators such as literacy rates. In some areas and some countries, we know that the prevalences are an underestimate because of mortality. In places where the prevalence of stunting is 50% or 60%, we know that there has been a substantial truncation of the distribution because of mortality, and we are probably seeing an underestimate of the true effect on prevalence or the true effect of undernutrition through these prevalence estimates.

Dr. Uljaszek: A question to Dr. Frongillo: If you’ve got truncated distributions, is it not possible to manipulate those populations statistically and see what sort of prevalence you get with a modeling procedure? Wachter and Trussel, for example, have looked at anthropometry across history, using recruiting data, knowing that they’ve got a truncated distribution, and that is what they have done (6). The results, at least to me, seem plausible.

Dr. Frongillo: I agree. It is theoretically possible to do that, but, in practice, I don’t think it would change the outcome very much: That is, there has been tremendous progress over the last 15–20 years in Asia, of the order of 0.8 or 0.9 percentage point/year. Maybe this would turn out to be a slight underestimate had we made that adjustment, but it does not materially change the fact that those are the parts of the world where the prevalence of stunting has been extremely high, and there has been rapid progress.

Dr. Pelletier: It is important to realize that only about 5–10% of mild to moderately stunted children in the population will die within the next year or 2. So, as with the HIV question earlier, we have to bear in mind the proportions. When you work it out, you find that only in extreme circumstances—such as famine among refugees—will this issue be significant enough to bias the estimates of malnutrition downward.

Dr. Martorell: I want to make a comment about the factors that were found in this analysis to be related to trends in stunting, for example, economic growth, female literacy, and energy availability. One should not jump from the identification of those variables to saying that what needs to be done is to change them. For example, energy availability probably represents food availability in general. So, we might well get the same results if protein or zinc were substituted for energy. These factors may even be a proxy for things other than food availability. Determining specific policies to pursue seems to me to require a different kind of analysis.

Dr. Fagundes-Neto: I’d like to bring a little bit of gastroenterology into this discussion. In our opinion, one of the reasons for stunting is environmental enteropathy. In Brazil, we see many stunted children without diarrhea who have bacterial
overgrowth of the small bowel, associated with intestinal malabsorption as assessed by xylose absorption. Intestinal biopsies in these children show a range of abnormality in their intestinal mucosa, with subtotal villous atrophy. This is an important cause of stunting. It is associated with poor water supply, lack of sewage systems, overcrowded living conditions, and lack of breast-feeding. These are factors common to large urban centers in Latin America and around the world.

REFERENCES