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# Causes for the decline in child under-nutrition in Brazil, 1996-2007

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## ABSTRACT

**OBJECTIVE:** To describe the evolution of prevalence of under-nutrition among Brazilian underfives between 1996 and 2007, and to identify major factors responsible for this evolution.

**METHODS:** Data analyzed are from two Demographic Health Surveys carried out in Brazil in 1996 and 2006/7 based on probabilistic samples of roughly 4 thousand children under five years of age. Identification of factors responsible for temporal variation in prevalence of under-nutrition (height-for-age below -2 Z-scores; WHO 2006 standard) took into account changes in the distribution of four potential determinants of nutritional status. Statistical modeling of the independent association between these determinants and risk of under-nutrition, and calculation of "partial attributable fractions" were used to determine the relative importance of each factor in the evolution of infant under-nutrition.

**RESULTS:** Prevalence of under-nutrition fell by approximately 50%, from 13.5% (95%CI: 12.1%; 14.8%) in 1996 to 6.8% (5.4%; 8.3%) in 2006/7. Two-thirds of this reduction could be attributed to favorable evolution in the four factors studied: 25.7% to increased maternal schooling; 21.7% to increased purchasing power of families; 11.6% to expansion of healthcare; and 4.3% to improvements in sanitation.

**CONCLUSIONS:** The 6.3% annual rate of decline in the proportion of children with height-for-age deficits indicates that, in another ten years, child malnutrition in Brazil may no longer be a public health issue. Achieving this will depend on the maintenance of economic and social policies that have favored an increase in purchasing power among the poor, and on public investments aimed at completing the universalization of access to essential services such as education, health, and sanitation among the Brazilian population.

**DESCRIPTORS:** Child. Malnutrition, epidemiology. Child Nutrition Disorders. Nutrition Surveys. Socioeconomic Factors. Child Health (Public Health).

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## INTRODUCTION

Under-nutrition during the first years of life, as measured by anthropometric indicators of nutritional status, is a major health issue in developing countries. Exhaustive evidence shows that growth deficits in childhood are associated with higher mortality, excess infectious disease, delayed psychomotor development, academic underachievement, and lower productive capacity in adult life.<sup>3,16</sup> For these reasons, as well as due to its intimate relationship with poverty, cutting by half the prevalence of growth deficits in underfives is one of the Millennium Development Goals proposed in 2000 by the United Nations.<sup>15</sup>

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Temporal trends in under-nutrition among the Brazilian under-five population are a common subject of study and analysis thanks to the availability of nation-wide anthropometric surveys carried out regularly in the country since the mid 1970s. Based on these surveys, decreasing trends in prevalence of childhood under-nutrition have been identified between 1975 and 1989 and between 1989 and 1996. Such trends have been attributed more to increases in maternal schooling and expanded coverage of healthcare and sanitation than to changes in the purchasing power of the population.<sup>8-10</sup> Data from the latest nation-wide anthropometric survey, carried out in 2006/7, will allow us to update the temporal trends in child under-nutrition in Brazil, as well as to study in depth the factors that have influenced under-nutrition trends in the period between 1996 and 2007. This is the aim of the present study.

## METHODS

All data included in the present study originate from two surveys, carried out in Brazil as part of the international Demographic Health Surveys (DHS) program. The first of these was conducted between March and June 1996 (National Demographic Health Survey [*Pesquisa Nacional sobre Demografia e Saúde*], and will be referred to as PNDS 1996.<sup>a</sup> The second survey took place between November 2006 and May 2007 (National Woman and Child Demographic Health Survey) [*Pesquisa Nacional de Demografia e Saúde da Criança e da Mulher*], and will be referred to as PNDS 2007.<sup>b</sup>

### Sampling and data collection

The sampling and data collection procedures employed in both surveys are described in detail elsewhere.<sup>a,b</sup>

The two surveys were based on complex sampling procedures that involved the stratification of all of the country's census tracts, random selection of clusters of tracts within each stratum, and random selection of households within each sector. In the two surveys, within the selected households, eligible subjects were all women aged 15-49 years and all biological children of these women aged between zero and 59 months. The major difference between the sampling procedures employed by the two surveys was the exclusion, in PNDS 1996, of the sparsely populated rural sectors of the North Region.

The sample of children aged 0-59 months surveyed in the two studies, already excluding those living in the rural North, totaled 4.801 children in 1996 and 4.424

in 2007. Approximately 14% of children in 1996 and 9% in 2007 did not undergo anthropometric evaluation (most often because they were not home at the time of the interview) and were therefore excluded from the study. In addition to children not examined, we also excluded children whose measured weight or height were biologically incompatible,<sup>7</sup> representing under 1% of all children examined. The final sample of children with valid height (the anthropometric variable central to the present analysis) was 4.132 children in 1996 and 4.034 children in 2007. The sample with valid weight was 4.061 children in 1996 and 4.002 children in 2007.

In both surveys, weight and length (up to age 23 months) or height (24 months and older) were obtained by teams of two trained and standardized investigators, using electronic scales with 100 g precision and stadiometers with 1 mm precision. The remaining information of interest to the study was obtained by means of questionnaires adapted from the DHS model.<sup>c</sup>

### Data analysis

#### *Temporal variation in prevalence of under-nutrition*

The nutritional status of children was classified based on height-for-age and weight-for-height indices.<sup>17</sup> These indices, expressed in z-scores, were calculated using a reference standard that reproduces the distribution of these indices in children under optimal health and nutrition conditions.<sup>18</sup> Children with height-for-age below  $-2$  were classified as stunted and children with weight-for-height below  $-2$  were classified as wasted.<sup>17</sup> The temporal variation in risk of childhood under-nutrition in Brazil was established by comparing estimated prevalences of stunted and wasted children (and their corresponding 95% confidence intervals).

#### *Selection and definition of explanatory variables*

Taking into account a traditional model of causality for childhood under-nutrition,<sup>14</sup> and considering the body of information collected by the PNDSs in 1996 and 2007, we selected four determinants of child nutritional status as potential explanatory variables for the temporal variation in risk of under-nutrition between 1996 and 2007: family purchasing power, mother's schooling, access to health care, and sanitation conditions in the environment.

Family purchasing power was classified according to criteria established by the Brazilian Association of Market Research Companies [*Associação Brasileira*

<sup>a</sup> BEMFAM. Pesquisa nacional sobre demografia e saúde 1996: relatório da pesquisa. Rio de Janeiro, 1997.

<sup>b</sup> CEBRAP / Ministério da Saúde. Departamento de Ciência e Tecnologia. Pesquisa Nacional de Demografia e Saúde da Criança e da Mulher: PNDS 2006. Brasília/DF, 2008. (Research Report).

<sup>c</sup> Macro International. Measure DHS: Methodology. [cited 2008 Nov 30] Available from: <http://www.measuredhs.com/aboutsurveys/dhs/methodology.cfm>

*de Empresas de Pesquisas – ABEP*] based on a socio-economic survey carried out in 2005, which included approximately 11 thousand Brazilian families.<sup>a</sup> These criteria take into account the total score reached by a family in a scale of nine items (type and number of consumer goods in the household, characteristics of the home, and schooling of the head of household) designed to maximize the correlation between total score and family income. In the case of absence of information on one or more items in the scale, we used values imputed based on regressions of the remaining items on the missing item. The ABEP classification originally includes eight classes in order of decreasing purchasing power (A1, A2, B1, B2, C1, C2, D, and E). In the present study, given the scarcity of children in the higher purchasing power categories, the five highest classes were grouped into a single class. We also classified maternal schooling into four categories, corresponding to 0-3, 4-7, 8-11, and 12 or more years of schooling.

Access to health care was evaluated based on antenatal and delivery care. Given the strong correlation between these two components, they were combined into a single variable, which was divided into three categories: 6 or more antenatal care appointments and hospital delivery; presence of one of these two items; and absence of both items.

Sanitation conditions considered whether or not the child's home was connected to the public water supply and sewage networks. Also in this case, we constructed a single variable with three categories: connection to both networks, connection to a single network (in practice, connection to the water network), and absence of connection to water supply and sewage networks.

Valid information on purchasing power, schooling, health care, and sanitation were obtained for approximately 98% of children in 1996 and 93% of children in 2007 (4.052 and 3.741 children, respectively).

#### *Causes of temporal variation in prevalence of under-nutrition*

Given the low frequency of wasted children in the two surveys, the analysis of causes of temporal variation in prevalence of under-nutrition was restricted to stunted children.

The study of factors that influenced temporal variation in prevalence of stunted children was carried out in four stages. In the first stage, we studied the evolution of each of the four putative determinants of stunting by comparing their distribution in 1996 and 2007.

In the second stage, we examined, at the beginning and end of the period, the strength of the association

between determinants of nutritional status and occurrence of stunting. This analysis was carried out using Poisson multiple regression models<sup>1</sup> for each survey. These models, from here on referred to as 1996 model and 2007 model, generated adjusted relative risks of stunting that estimate, for each survey, the intensity and direction of independent associations between each explanatory variable in the model (determinant of nutritional status) and presence of stunting in the child.

In the third stage, we estimated the effect that changes seen in the distribution of the four determinants may have had on the evolution of prevalence of stunting across the period. In principle, this effect could have been estimated in a relatively simple fashion by comparing the predicted values for the mean probability of stunting when the 1996 risk model is applied, successively, to the PNDS 1996 database itself and to the PNDS 2007 database. Subtracting the second value from the first would provide an estimate of absolute temporal variation in risk of stunting in the period, and dividing this difference by the first value would provide an estimate of relative variation. The premise necessary for the validity of such estimates would be that the association between the explanatory variables and nutritional status remained constant between 1996 and 2007.

A second alternative to estimate the joint effect of changes in the distribution of determinants, analogous to the preceding estimation, would be to compare predicted values for the mean probability of stunting when the 2007 model is applied, successively, to data from PNDS 2007 itself and then to data from PNDS 1996. In this case, there would also be an implicit assumption of lack of change in the association between explanatory variables and risk of stunting in the two surveys. There are two options if one wants to avoid such an assumption.<sup>6</sup> The simplest of the two, which is the one employed in the present analysis, consists in adopting the mean value of effects estimated based on each of the models. The other option, which we did not consider due to its greater complexity, would be to estimate the effect of changes in the distribution of determinants employing a unique multiple regression model constructed by merging the databases of the two surveys, thus allowing for interactions between each determinant and year of survey.

The fourth – and most complex – stage of the study of causes of temporal variation in prevalence of stunting involved the decomposition of the joint effect into components attributable to each determinant. For this, we calculated the “generalized attributable fraction”, which corresponds to the proportional reduction in a disease that would result from the modification of one or more of its determinants. The “generalized attributable

<sup>a</sup> Associação Brasileira de Empresas de Pesquisas. Adoção do CCEB 2008: Critério de Classificação Econômica Brasil. [cited 2008 Nov 30] Available from: <http://www.abep.org/codigosguias/AdocaoCCEB2008.pdf>

fraction” consists, in essence, of an extension of the concept of “populational attributable fraction” for settings in which there are changes in the distribution, rather than necessarily elimination, of one or more risk factors. Given the strong correlation between the factors at hand, we used adjusted estimates of the generalized attributable fraction.<sup>2</sup>

The equation presented below estimates the generalized attributable fraction (F) associated to change in the distribution of each of the determinants of nutritional status analyzed:

$$F = \frac{((\sum_{i=1}^I P96_i \times RR96_i - \sum_{i=1}^I P07_i \times RR96_i) + (\sum_{i=1}^I P96_i \times RR07_i - \sum_{i=1}^I P07_i \times RR07_i))}{\sum_{i=1}^I P96_i \times RR96_i} : 2$$

where  $RR96_i$  and  $RR07_i$  represent, respectively, the adjusted relative risk of stunting for the  $i^{th}$  combination between the categories of the four determinants of nutritional status in 1996 and 2007 and  $P96_i$  and  $P07_i$  represent the proportion of children found in each  $i^{th}$  combination, respectively, in PNDS1996 and in a hypothetical distribution constructed by fixing the marginal distribution of the determinant of interest as observed in PNDS 2007 and the marginal distribution of the other determinants as observed in PNDS 1996. Note that there are 144 possible combinations ( $I$ ) between the categories of the four studied determinants, and that the equation above resorts again to considering the mean of effects obtained considering, successively, the risk models for 1996 and 2007.

The generalized attributable fraction calculated using this equation allows us to estimate the effect on prevalence of stunting that would be expected given the changes in distribution of each of the four determinants analyzed. However, the effects thus calculated for each determinant are not additive, and tend to total more than the previously calculated joint effect of simultaneous changes in all four determinants. This imperfect decomposition of the joint effect originates from the artificial assumption that the change in each determinant precedes changes in the other three. In order to avoid this limitation, it is necessary to resort to the concepts of “sequential attributable fraction” and partial attributable fraction.<sup>25</sup> The concept of “sequential attributable fraction” assumes that, when multiple risk factors are present, each of these factors contains  $2^{n-1}$  different values for the attributable fraction, where  $n$  is the number of exposure variables (the different attributable fraction values are a function of the number of possible combinations given the order of removal of each risk factor). The mean of the  $2^{n-1}$  attributable fraction values calculated for each risk factor is the “partial attributable fraction” of each factor, and the sum of these will coincide with the attributable fraction calculated for the entire set of risk factors.<sup>5</sup>

For each of our four exposure variables, we calculated sequential attributable fraction values obtained with the modification of the variable’s marginal distribution (between 1996 and 2007), based on four scenarios: 1) prior to change in the distribution of the other three variables; 2) after change in the distribution of each the other three variables, one by one; 3) after change in the distribution of pairs of other three variables, two by two; and 4) after change in the marginal distribution of all three remaining variables. The mean value obtained for each variable in these four scenarios is termed the “partial

attributable fraction” for each variable, i.e., its effect on the temporal variation in prevalence of stunting.

All statistical analyses in the present study were performed with the aid of Stata software, version 10. All analyses took into account the individual weighting factors of each survey as well as the effect of the complex sampling strategy on the standard error of estimates.

## RESULTS

Table 1 presents estimates for the prevalence of anthropometric deficits in the Brazilian population under five years of age in 1996 and 2007. Prevalence of child stunting fell by half in the period (from 13.5% to 6.8%), which corresponds to an annual decrease rate of 6.3%. The proportion of wasted children, which was already low at the baseline, also showed a slight reduction in the period, from 2.1% to 1.6%.

Table 2 describes the evolution of the distribution of the underfive population according to four potential determinants of nutritional status. In all cases, distributions observed in 2007 were more favorable than those found in 1996. For example, the proportion of children in the highest purchasing power classes (A, B, or C1) and of children born to mothers with at least eight years of schooling both doubled in the period (from 19.1% to 37.4% and from 32% to 61.2%, respectively). Though smaller in magnitude, there were also increases in the proportion of children with access to antenatal and delivery care (from 62.3% to 82.3%) and in the proportion of children living in homes which were connected to the public water supply and sanitation networks (from 32% to 43.4%).

Table 3 describes the association, observed at both the beginning and the end of the 1996-2007 period, between child stunting and determinants of child nutritional status. As expected, frequency of stunted children in both surveys tended to increase as both purchasing power and maternal schooling decreased,

**Table 1.** Prevalence (%) of under-nutrition among Brazilian children under five years of age according to two anthropometric indicators. Brazil,\* 1996 and 2006/7.

Indicador	1996		2006/7	
	n	% (IC 95%)	n	% (IC 95%)
HAZ < -2	4,132	13.5 (12.1;14.8)	4,034	6.8 (5.4;8.3)
WHZ < -2	4,061	2,1 (1.6;2.6)	4,002	1,6 (0.9;2.3)

HAZ and WHZ: height-for-age and weight-for-age z scores, calculated based on World Health Organization reference curves<sup>19</sup>

\* Excluding the rural North.

and with less access to health care and sanitation. Adjusted analysis for both years showed a strong inverse correlation, with a dose-response effect, between maternal schooling and child stunting. The same analysis confirms the inverse relationship between stunting and family purchasing power and access to health care and sanitation in 1996, but shows also a weakening of this relationship in 2007.

Table 4 compares predicted values for the mean probability of stunting when multiple regression models adjusted for each of the two surveys are applied,

successively, to the database of the survey that generated the model and to the database of the other survey. As expected, probabilities predicted based on risk models and distributions considered for the same survey are very close to the prevalence of stunting observed in that survey. The small differences between these values are due to the exclusion, in both surveys, of children for whom not all data necessary for modeling was available. Most importantly, however, replacing the 1996 distribution (database) with the 2007 distribution (database) determines substantial absolute reductions in mean probability of stunting:  $0.134 - 0.074 = 0.060$ , when the 1996 risk model is considered, or  $0.092 - 0.065 = 0.027$ , when the 2007 risk model is considered. The mean of these two reductions in the prevalence of stunting –  $0.0435$ , considered in the present analysis as indicative of the joint effect of favorable evolution in the four determinants of nutritional status – represents roughly one-third (32.4%) of the mean probability of stunting in 1995 (0.134), or almost two-thirds (63.0%) of the reduction effectively observed in the 1996-2006 period ( $0.134 - 0.065 = 0.069$ ).

The decomposition of the joint effect into partial effects, which is based on calculating “partial attributable fractions,” showed that improvements in purchasing power, maternal schooling, health care, and sanitation led to relative reductions in the prevalence of stunting of

**Table 2.** Distribution of children under five years according to family purchasing power, maternal schooling, access to health care, and sanitation conditions. Brazil,\* 1996 and 2006/7.

Variable	1996 (n=4.052) %	2006/7 (n=3.741) %	p
Purchasing power classes**			0.000
A, B or C1	19.1	37.4	
C2	15.1	23.5	
D	32.1	28.9	
E	33.7	10.3	
Maternal schooling (years)			0.000
12 or more	4.6	7.4	
8 – 11	27.4	53.8	
4 – 7	40.4	27.7	
0 – 3	27.6	11.0	
Health care			0.000
≥ 6 antenatal appointments and hospital delivery	62.3	82.3	
One of the above	32.1	17.0	
None of the above	5.6	0.7	
Sanitation			0.000
Public water and sewage networks	32.0	43.4	
One of the above	42.1	38.1	
None of the above	25.9	18.6	

\* Excluding the rural North.

\*\* According to the criteria of the Associação Brasileira de Empresas de Pesquisas. Adoção do CCEB 2008: Critério de Classificação Econômica Brasil. [cited 2008 Nov 30] Available from: <http://www.abep.org/codigosguias/AdocaoCCEB2008.pdf>

**Table 3.** Prevalence (%) and relative risk of stunting among children under five years according to family purchasing power, maternal schooling, access to health care, and sanitation conditions. Brazil, \* 1996 and 2006/7.

Variable	1996			2006/7		
	n	%	RR**	n	%	RR**
ABEP purchasing power classe			p=0.000***			p=0.065***
A, B or C1	619	4.3	1.00	1,269	3.8	1.00
C2	512	6.4	1.10	949	6.1	1.30
D	1,334	9.5	1.26	1,081	8.8	1.66
E	1,587	25.5	2.24	442	10.9	1.68
Maternal schooling (years)			p=0.000***			p=0.012***
12 or more	149	2.2	1.00	245	2.0	1.00
8 – 11	1,052	5.9	1.81	1,807	5.2	2.05
4 – 7	1,589	12.0	2.61	1,181	6.8	2.27
0 – 3	1,262	24.9	3.47	508	12.5	4.66
Health care			p=0.000***			p=0.654***
≥ 6 antenatal appointments and hospital delivery	2,303	8.2	1.00	2,948	5.9	1.00
One of the above	1,471	19.0	1.38	747	8.8	1.08
None of the above	278	39.7	2.00	46	13.8	1.29
Sanitation			p=0.000***			p=0.666***
Public water and sewage networks	923	5.6	1.00	1,069	4.9	1.00
One of the above	1,935	13.8	1.56	1,564	7.9	1.28
None of the above	1,194	22.6	1.65	1,108	7.1	1.09

\* Excluding the rural North.

\*\* RR: Relative risk of stunting adjusted for the remaining variables in the table by Poisson multiple regression.

\*\*\* Wald's test for linear trend.

11.1%, 13.2%, 5.9%, and 2.2%, respectively. It should be noted that the sum of these reductions corresponds exactly to the 32.8% reduction estimated previously for the joint effect associated with favorable evolution of the four determinants, or to about two-thirds of the reduction measured in the period. The figure describes the relative participation of each determinant in the total decrease in prevalence of stunting observed in Brazil between 1996 and 2007, indicating that improvement in maternal schooling (25.7%) and in family purchasing power (21.7%) would account for almost half this reduction, another 15% being attributed to expanded health care (11.6%) and sanitation (4.3%).

## DISCUSSION

Based on a comparison of two nation-wide probabilistic surveys carried out approximately 11 years apart (1996 and 2006/7), the present study has shown evidence of a reduction of approximately 50% in prevalence of child stunting in Brazil. Taking into account the association, in each of these years, between determinants of nutritional status and stunting, and also the evolution of these determinants across the period, we were able to attribute roughly two-thirds of this decline to improvements in – by order of importance – maternal schooling, family purchasing power (especially among the poorest), access to health care, and sanitation conditions.

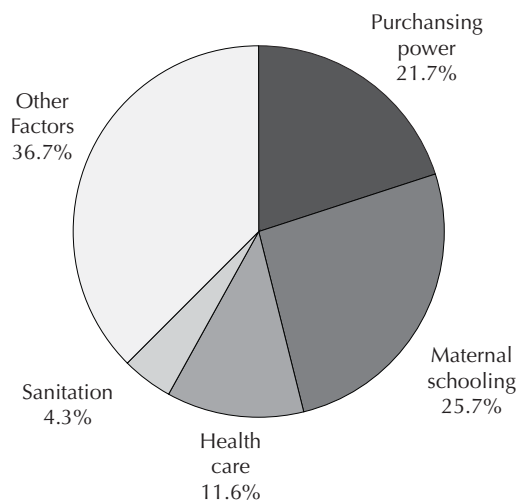
The probabilistic nature of the two surveys, their comparability in terms of procedures for data collection and analysis of anthropometric data, and the use of comprehensive indicators for evaluating nutritional status (deficits in height-for-age and weight-for-age) speak in favor of the internal and external validity of results pertaining to temporal variation in prevalence of under-nutrition. With regards to identifying the

**Table 4.** Probability of child stunting predicted based on two multiple regression models and two scenarios for the distribution of the explanatory variables included in the models. \* Brazil, \*\* 1996 and 2006/7.

Model	Population distribution	Probability of stunting (95%CI)
1996	1996	0.134 (0.128;0.141)
1996	2007	0.074 (0.070;0.078)
2007	2007	0.065 (0.062;0.068)
2007	1996	0.092 (0.090;0.096)

\* Poisson regression models having as a dependent variable the presence of height-for-age deficit (0=no; 1=yes) and as explanatory variables family purchasing power, maternal schooling, access to health care, and sanitation conditions (as expressed in Tables 2 and 3). The 1996 and 2007 denominations refer to the year of the survey upon which models were constructed and from which distributions were extracted.

\*\* Excluding the rural North.



\* Excluding the rural North.

**Figure.** Relative participation (%) of different factors in the decrease in prevalence of child stunting between 1996 and 2007. Brazil.\*

causes behind this variation, we consider the following as strengths of the present analysis: 1) the use of the same databases for quantifying risk of stunting associated with the determinants studied and for determining the evolution in the distribution of these determinants with time; 2) the use of multiple regression models that quantify the independent association between each determinant and nutritional status at the beginning and end of the period; and 3) the use of non-biased estimates of the fraction of the decline attributable to the set of determinants investigated and the perfect decomposition of this fraction into specific components.

Substantial declines in prevalence of child under-nutrition have been documented previously in Brazil based on comparisons of nation-wide surveys carried out during the second half of the Twentieth Century.<sup>8,9</sup> Such declines corresponded to a mean rate of decline in prevalence of stunting of 5.0% per year between 1975 and 1989 and of 5.7% per year between 1989 and 1996. The approximately 6.3% per year reduction found in the present analysis therefore represents an intensification of the secular declining trend in child under-nutrition in Brazil. The recent evolution in the growth of Brazilian children indicates that the United Nations' Millennium Development Goal for child under-nutrition (reducing it by half between 1990 and 2015) will be widely exceeded in Brazil.<sup>15</sup>

Factors responsible for the decline in child stunting in the time interval delimited by the surveys carried out in Brazil since 1975 are not immediately comparable due to the different analytical strategies used in their identification and in the unequal availability of data for

the corresponding periods. Be as it may, the decline in under-nutrition between 1975 and 1989 was attributed essentially to moderate gains in family income and to the exceptional expansion in the coverage of public education, sanitation, and health care services.<sup>8</sup> Improvements in maternal schooling, greater access to primary health care, and expansion of the public water supply network were considered as the factors most relevant factors to the decline in under-nutrition between 1989 and 1996, increases in family income again playing a modest role in this decline.<sup>9</sup> Thus, the decline in child under-nutrition observed in 1996-2007 apparently distinguishes itself from declines observed in previous periods by being the result of the combined effect of a strong increase in family purchasing power and of an intense expansion in population access to essential public services.

The increase in purchasing power of Brazilian families between 1996 and 2007, particularly in classes with lower purchasing power, is consistent with estimates based on the National Household Surveys [*Pesquisas Nacionais sobre Amostragem de Domicílios* – PNAD], which indicate nation-wide improvements in income distribution and the reduction in the proportion of the population living below the poverty line, especially from 2003 onwards.<sup>11</sup> According to scholars in the field, the recent trend towards improved income distribution and reduced poverty in Brazil would be a consequence of the reactivation of economic growth and of consequent reductions in unemployment, increases in minimum wage beyond inflation, and marked expansion of the coverage of income transfer programs.<sup>11</sup>

The favorable evolution in maternal schooling between 1996 and 2007, the single factor that contributed the most to the decline in child undernutrition in the period, reflects the virtual universalization of access to elementary education and the improvement in its quality indicators taken place in Brazil throughout the 1990s.<sup>4</sup> It should be noted that most mothers of children studied in 2007 either attended elementary school or were of elementary school age in the 1990s, whereas for most mothers studied in 1996, the reference period for elementary education was in the 1980s. The expansion in access of mothers and children to health care, on the other hand, coincides with the expansion in the country of the Family Health Program [*Programa de Saúde da Família* – PSF], whose aims emphasize prevention and education, as well as the promotion of equity in service supply.<sup>13</sup> In 1998, 3,062 PSF teams were present in roughly one-fifth of Brazilian municipalities, providing coverage to approximately ten million people; in 2006, 26,729 teams were present in over 90% of municipalities, covering 86 million people.<sup>a</sup> The slight improvement in the sanitation conditions of the homes of Brazilian children is consistent with the relatively slow expansion of coverage of sewage disposal and water supply networks in Brazil. Between 2001 and

<sup>a</sup> Ministério da Saúde. Atenção básica e saúde da família. [cited 2008 Dec 3] Available from: <http://dtr2004.saude.gov.br/dab/abnumeros.php>

2006, coverage of the sewage network increased from 81.1% to 83.2%.<sup>a</sup> Scholars in Brazilian social policies have drawn attention to the lesser visibility and political attractiveness of investments in sanitation, as well as to the need to prioritize this issue in the Brazilian public policy agenda.<sup>12</sup>

Finally, it is worthy of note that, if the 6.3% annual decline rate in prevalence of stunting is maintained, the proportion of Brazilian children with height-for-age deficits would drop below 3% in a little over ten years,

which would mean reaching the (genetically) expected proportion of children of low stature under optimal conditions of diet, health, and nutrition across the entire population.<sup>18</sup> However, in order to achieve this goal in another ten years – or preferably even earlier – it will be necessary to maintain or even intensify the initiatives that have fostered the increase in purchasing power among the poor, and, not less importantly, to ensure public investments that allow for the completion of universalization of access to essential services such as education, health, and sanitation among the Brazilian population.

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