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Estimates of the prevalence of child malnutrition in Brazilian municipalities in 2006

ABSTRACT

OBJECTIVE: To estimate the prevalence of malnutrition in children for all Brazilian municipalities.

METHODS: A multilevel logistic regression model was used to estimate the individual probability of malnutrition in 5,507 Brazilian municipalities in 2006, in terms of predictive factors grouped according to hierarchical levels. The response variable was child malnutrition (children aged from six to 59 months with height for age and sex below -2 z-scores, according to the World Health Organization standard). The predictive variables were determinants of malnutrition measured similarly by the National Demographics and Health Survey-2006 and the Sample from the 2000 Demographic Census. At level 1 (individual): sex and age, level 2 (household): socioeconomic variables, water and indoor plumbing, urban or rural area and level 3 (municipal): location of the municipality and coverage of the Family Health Strategy (FHS) in 2006.

RESULTS: The study detected a statistically significant chance of malnutrition in male children, those living in households with two or more individuals per room, those belonging to the lowest quintiles of the socioeconomic score, those with three or more children under five in the household, those with no access to running water or located in the North. There was a negative dose-response association between FHS coverage and the chance of malnutrition ($p = 0.007$). FHS coverage in the municipality equal to or greater than 70% showed a 45% reduction in the chance of infant malnutrition. Estimates of the prevalence of child malnutrition show that most of the cities have the risk of malnutrition under control, very low or low. Risks of greater magnitude exist only in 158 municipalities in the North Region.

CONCLUSIONS: Childhood malnutrition as a public health problem is concentrated in the cities of the North region, where FHS coverage is lower. A protective effect of FHS in relation to child malnutrition was found in the country as a whole, irrespective of other determinants of the problem.

DESCRIPTORS: Child Nutrition Disorders, epidemiology. Socioeconomic Factors. Health Inequalities. Multilevel Analysis. Family Health Program.

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INTRODUCTION

Malnutrition in childhood continues to be a public health problem in developing countries. Growth deficiencies in infancy are associated with higher mortality, repeated infectious diseases, compromised psycho-motor development, less success in education and lower productive capacity in adult life.[6,18]

National surveys are indispensable in diagnosing the nutritional situation and for drawing up intervention strategies to dace the problem in Brazil. However, these surveys do not allow for estimates to be made at a municipal level due to the organization of their sampling. This makes it difficult to identify intra-regional inequalities or more serious foci of the problem which call for differentiated interventions. The importance of the availability of municipal estimates on the frequency of childhood malnutrition resides in the fact that the municipality is a primary federal entity for the country's political organization and for implementing public policies in the social sector.[11]

The first estimates of the risk of childhood malnutrition in Brazilian municipalities were produced using statistical predictive models, developed from the nutrition survey carried out by the Brazilian Institute of Geography and Statistics (IBGE) in 1989 (National Health and Nutrition Survey – PNSN). Estimates were produced for all 4,489 Brazilian municiaplities existing at that time.[5] These estimates significantly changed the distribution of federal program resources for combatting malnutrition, reversing the former practice of identical treatment for non-identical situations. The Ministry of Health established the amount of funds transferred to each Brazilian municipality as part of the federal program"Incentives to Combat Nutritional Deficiencies (ICCN)", in 1998.[a] The same estimates were used to calculate the number of quotas allocated to each municipality in the federal "Food Grant" Program.

Estimates of the prevalence of childhood malnutrition were produced for each of the 5,507 Brazilian municipalities in existence on the occasion of the 2000 Demographic Census. The statistical predictive models were developed base on the IBGE national survey carried out in 1996 (National Demographics and Health Survey PNDS, 1996). The estimates of the prevalence of childhood malnutrition were obtained by applying the equation from the final predictive model to the children studied in more detail by the 2000 Census Sample.[b]

The PNDS carried out in 2006[c] made it possible to analyze the evolution of childhood malnutrition in Brazil. Monteiro et al[13] (2009) identified that "two thirds of the reduction identified can be attributed to the favorable evolution of four factors studied: 25.7% to the increase in maternal levels of education, 21.7% to families' increased purchasing power, 11.6% to the expansion in health care and 4.3% to improvements in sanitation".

The increased access of mothers and children to health care coincides with the expansion of the Family Health Strategy (ESF), the coverage of which increased from 6.6% of the population in 1998 to 46.2% in 2006.[d] The ESF is a strategy to reorient the care model through multi-disciplinary teams in primary health care units. The Family Health Care as a strategy for structuring the municipal health care systems aims to reorganize the health care model in the Brazilian Unified Health System (SUS) and seeks greater rationalization in the used of the other care levels.[16] The focus on establishing the ESF in the poorest and most vulnerable areas contributes to the reduction in inequalities in access to health care services in Brazil.[4]

This study aimed to estimate the risk of childhood malnutrition in Brazilian municipalities.

METHODS

This study was carried out in 5,507 Brazilian municipalities based on the data from the latest national health and nutrition survey, the PNDS-2006, and the 2000 Census Sample. The method used to estimate the risk of childhood malnutrition in Brazilian municipalities was based on the development of individual statistical predictive models, using multilevel analysis (or hierarchical models or mixed effect models).[9] This analysis was chosen due to the hierarchical organization of the population of children (Level 1) in households (Level 2) and in municipalities (Level 3) and to the existence of intra-group correlation. The models are equations which enable the probability of an illness in a specific individual to be estimated, according to the presence of absence of predictive factors organized according to pre-established hierarchical levels.[9]

[a] Ministério da Saúde. Portaria nº 2409. *Diario Oficial Uniao*. 23 mar 1998. Estabelece critérios e requisitos para implementação de ações de combate às carências nutricionais nos municípios. Brasília (DF); 27 mar 1998. Seção 1, n 59, p36-62.

[b] Benicio MHD'A, Venancio SI, Konno SC, Monteiro CA. Novas estimativas para a prevalência de desnutrição na infância nos 5507 municípios brasileiros a partir de modelos logísticos multinível aplicados à Amostra de crianças do Censo 2000. São Paulo; 2005 [cited 2012 Nov 26]. Available from: http://www.fsp.usp.br/nupens/desn_municipios_brasileiros.pdf (Série Pesquisas em Epidemiologia Nutricional do NUPENS/USP, 1).

[c] Ministério da Saúde. Pesquisa Nacional de Demografia e Saúde da Criança e da Mulher – PNDS 2006: dimensões do processo reprodutivo e da saúde da criança. Brasília (DF); 2009.

[d] Ministério da Saúde. Departamento de Atenção Básica. Projeto de Expansão e Consolidação do Saúde da Família. Expansão e Consolidação da Saúde da Família – Expansão do Saúde da Família. Brasília (DF); 2004.

The empirical base was a sample of children aged six to 59 months from the PNDS-2006 and municipal information from a variety of sources was used to construct the predictive models. The PNDS-2006 was carried out between November 2006 and May 2007 by a consortium of Brazilian academic institutions, coordinated by the Brazilian Center of Planning and Analysis (CEBRAP). The anthropometric survey was planned and supervised by the Center for Health and Nutrition Research (NUPENS/USP). The PNDS-2006 process of probabilistic sampling meant the study was nationally representative including both urban and rural areas and all five of Brazil's geographic macro-regions.[7] The survey included 3,931 children aged between six and 60 months resident in 652 Brazilian municipalities.

The response variable for the statistical predictive models was the child's nutritional state. All children with a Z score of height for age < -2 was considered to be malnourished, according to World Health Organization (WHO) growth standards.[20]

The predictive variables included in the modelling process at an individual and household level were selected considering the classic model for determining malnutrition[19] and the availability and compatibility of the data collected by the PNDS-2006 and the 2000 Census Sample. In Level 1 (individual/child), the following were considered: age (six to 24 months and 24 to 60 months) and sex. The variables in Level 2 (household) were: socio-economic score (level of education of the head of the household and the number of TVs, owning a car, fridge/freezer, DVD/video cassette player, washing machine, telephone and computer) generated based on analysis of the main components and presented in quintiles;[3] number of individuals per room (1, 2 and ≥ 3 individuals); number of children per household (1, 2 and ≥ 3 children); indoor plumbing and whether located in an urban or rural area.

Predictive variables for Level 3 (municipal) were: location of the municipality (North, Northeast and the rest regrouped into the South-Center);[e] population size in 2006 (number of inhabitants: up to 15 thousand, 15→50 thousand, 50→100 thousand and ≥ 100 thousand) and ESF coverage, according to the official indicator used by the Ministry of Health Department of Primary Care (www.siab.datasus.gov.br). This indicator corresponds to the product of the number of family health care teams established by the month of December of each year by the estimated mean number of individuals dealt for each team (3,450 individuals) for each municipality. This figure is identical for all of the Brazilian municipalities and was constant throughout 2000 and 2006. The official ESF indicator estimates its potential coverage, as it estimates the strategies user population. With the consolidation of the establishment of the ESF from 2000 onwards, the indicator came to be an increasingly good estimate of effective ESF coverage, providing data which was progressively more consistent with the percentage of the population registered by the health care workers and the percentage of families cared for by the ESF.[1]

Uni-variate analysis was carried out before modeling took place. All of the predictive variables were included in the multiple analysis as they are traditionally linked with malnutrition and poverty in the literature.[19] A multilevel logistical regression model was used for the iterative generalized least squares procedure.[9,f] The modelling was carried out in stages: age and sex of the child (Level 1) were introduced in the first stage; variables at the household level were incorporated one by one, followed by the municipal level (Level 3). The statistical significance of each parameter included in the model was evaluated using the Wald test, obtained from the ratio of maximum likelihood estimates for parameter β_1, in relation to estimates for its standard error. Interactions of interest, such as ESF – region and ESF – socioeconomic score were tested one by one in a multiple model containing statistically significant parameters.

The overall predictive capacity of the final model was assessed by the ROC curve. Its predictive capacity was reaffirmed by comparisons between the prevalence of malnutrition estimated by the model and that detected directly by PNFS-2006 in the North, Northeast and Center-South regions using the Chi-squared test, as recommended by Hosmer & Lemeshow[10] (1989).

The estimates of the prevalence of childhood malnutrition for each municipality were obtained by applying the equation from the final model to the database referring to the children (n = 1,809,744) included in the 2000 Census Sample. The questionnaire used in the households which formed part of this sample provided information on socioeconomic variables measured in a similar way to those used in the PNDS-2006.[c] The planning the Census 2000 Sample guaranteed the representation of the population of each Brazilian municipality through systematic sampling within each census tract. The sampling fraction was 10% in municipalities with populations estimated to be over 15 thousand, and 20% in the others.[g]

Applying the equation from the final model to the 2000 Census Sample allowed the individual probability of

[e] The North and Northeast have different socio-economic conditions and access to public services. The Southeast, South and Midwest were regrouped due to the fact that they are similar with regards the distribution of the predictive variables and the association between each of them and malnutrition.

[f] Young TK. MLwiN. Macros for advanced multilevel modeling. London: Institute of Education; 1999.

[g] Instituto Brasileiro de Geografia e Estatística. Amostragem na coleta dos dados do Censo Demográfico 2000: uma versão resumida. Brasília (DF); 2000 [cited 2011 Nov 26]. Available from: http://www.ibge.gov.br/censo/text_amostragem.shtm

malnutrition for each of the children studied in the 2000 Census Sample to be estimated. The prevalence of malnutrition in each municipality in 2000 was estimated by the mean of the individual probabilities of the children resident in that municipality and expresses the mean risk of malnutrition in the municipality. Factor correction was used to estimate the municipal prevalence in 2006 (ratio between estimated prevalence in 2000 and that detected directly by the PNDS 2006 in each region). The prevalence for each municipality were shown on a map, categorized into six levels of risk according to the WHO criteria;[21] under control (prevalence < 5%), very low (between 5% and 7.5%), low (between 7.5% and 10%), medium (between 10% and 15%), high-medium (between 15% and 20%) and high (≥ 20%).

The data were processed using Stata 10 software, considering the complex sample structure in the case of the PNDS-2006 using the"svy" command. The weighting recommended by the IBGE was used in the Census Sample. The multi-level analysis was carried out using MLwiN 2.16 software. The level of significance adopted for the analysis was 0.05. A cutoff level of 0.10 was adopted to test the interactions. TabWin 3.5,[h] software with the Municipal Digital Mesh, Brazil 2005 was used to create the map, with a scale of 1:250,000.

This study analyzes secondary data from the PNDS 2006, approved by the Research Ethics Committee of the of the Sao Paulo State Department of Health (Protocol CEP nº 185/05).

RESULTS

The percentage of children who live in households with three or more children aged under five (5%) or without indoor plumbing (14%) was low. The majority of the children live in urban areas and more than half in municipalities with populations between 100 thousand and one million residents. Around 40% of the children lived in municipalities with Family Health Strategy (ESF) coverage > 50%. The explanatory variables were strongly linked to the risk of malnutrition, except living in an urban or rural area and ESF coverage, although these were incorporated into the multiple analysis even so (Table 1).

The chance of malnutrition showed statistically significant increases in male children, those who lived in households with two or more individuals per room and those in household not connected to the public water supply with indoor plumbing. The variable socioeconomic score in quintiles proved to have a negative dose-response curve relationship with the outcome. The number of children under five years old in the household proved to have a positive dose-response curve relationship with childhood malnutrition (Table 2).

Children living in the Northeast had a similar chance of malnutrition as those living in the Center-South region; those who lived in the North had a higher chance of malnutrition. ESF coverage provided a positive dose-response protective effect with relation to the outcome (p of the trend = 0.007).

Children living in municipalities with ESF coverage between 15% and 30% had a 385 reduction in the chance of childhood malnutrition, compared with those who lived in municipalities with coverage between 0% and 15%. Municipal coverage between 30% and 50% reduced the chance by 40%, climbing to 48% reduced chance in municipalities with coverage between 50% and 70%. Above this level the reduction in chance was 45% (Table 2).

Interactions between ESF coverage, region and malnutrition and between ESF coverage, socioeconomic score and the response variable were not statistically significant (data not shown).

The values predicted by the model were reliable estimates of the individual probability of suffering childhood malnutrition for each of the possible combinations of the predictive variables, with a minimum value of 0.021 and a maximum of 0.431 (data not shown in the tables).

The overall predictive capacity of the final model, evaluated by the ROC curve, showed that the probability of a malnourished child being identified as such by the model was higher than that of child who was not malnourished (area beneath the curve was equal to 0.85; 95%CI 0.83;0.88), which gave the model good overall predictive capacity (Figure 1).

The reliability of the estimates produced by the final model were reaffirmed by the evidence that the predicted prevalence of malnutrition for the North (13.2%), Northeast (6.6%) and Center-South (6.1%) were close to those observed directly based on the PNDS-2006: 14.5%, 5.8% and 5.9%, respectively (p = 0.174 for the Chi-squared test).

In the period in question (2000 to 2006) there was a significant reduction (p < 0.001) in the frequency of adverse conditions for all of the determinants considered. Half of the children studied in 2000 were living in households with socioeconomic scores corresponding to the first quintile of distribution of the score in the PNDS-2006 and only 10% lived in households with socio-economic scores in the highest quintile. Between 2000 and 2006 the percentage of children living in

[h] Ministério da Saúde. Datasus. Software. Brasília (DF); 2008 [cited 2012 Nov 26]]. Available from: http://www2.datasus.gov.br/DATASUS/index.php?area=040805&item=3

Table 1. Prevalence of childhood malnutrition in children aged six to 59 months according to the factors of the study. Brazil, 2006.

Variable	n of children (n = 3,931)	%	Prevalence of malnutrition (%)	p
Individual Level				
Age (months)				0.014
6 |- 24	1,290	33.6	10.0	
24 |- 60	2,641	66.4	6.0	
Sex				0.012
Male	2,020	52.6	8.8	
Female	1,911	47.4	5.8	
Household Level				
Socioeconomic score				0.006
1 Quintile	794	21.6	9.5	
2 Quintile	644	18.4	10.0	
3 Quintile	694	20.0	6.7	
4 Quintile	706	20.2	4.3	
5 Quintile	562	19.8	2.8	
Number of individuals per room				< 0.001
< 2	3,410	92.5	6.6	
2 or more	521	7.5	17.4	
Household with indoor plumbing				< 0.001
Yes	3,192	86.5	6.4	
No	737	13.6	15.5	
Number of children under five in the household				0.001
1	2,281	67.3	5.6	
2	1,228	27.5	10.7	
3 or more	422	5.2	12.7	
Location of child's household				0.540
Urban	1,383	80.9	8.1	
Rural	2,548	19.1	7.2	
Municipal Level				
Region in which the child's household is located				< 0.001
North	881	10.8	16.1	
Northeast	769	27.3	6.4	
Centre-South	788	41.8	6.2	
Percentage of ESF coverage (%) - 2006				0.383
0 |-15	685	18.6	8.0	
15 |- 30	722	22.0	4.5	
30 |- 50	686	18.3	8.2	
50 |- 70	537	12.9	8.9	
≥ 70	1,301	28.2	7.9	
Population - 2006				0.002
< 15 thousand	751	12.3	8.7	
15 |- 50 thousand	1,012	24.3	7.3	
50 |- 100 thousand	502	10.4	14.8	
100 |- 1 million	1,022	33.9	6.7	
Over 1 million	644	19.1	3.7	

ESF: Family Health Strategy

Table 2. Odds ratio of malnutrition in children aged six to 59 months adjusted by the final multilevel model. Brazil, 2006.

Variable	OR	95%CI	p (global)
Individual Level			
Age (months)			0.126
6 |- 24	1.23	0.94;1.62	
24 |- 60	1	–	
Sex			0.038
Male	1.32	1.02;1.72	
Female	1	–	
Household Level			
Socioeconomic score[b]			0.003[a]
1 Quintile	1.76	1.16;2.65	
2 Quintile	1.90	1.29;2.82	
3 Quintile	1.41	0.94;2.12	
4 Quintile	1	–	
Number of individuals per room			0.020
< 2	1	–	
2 or more	1.57	1.07;2.29	
Household with indoor plumbing			0.041
Yes	1	–	
No	1.44	1.01;2.04	
Number of children under five in the household			< 0.001[a]
1	1		
2	1.68	1.25;2.26	
3 or more	2.21	1.46;3.04	
Municipal Level			
Region in which the child's household is located			0.037
North	1.48	1.05;2.09	
Northeast	0.91	0.61;1.38	
Centre-South	1	–	
Percentage of ESF coverage (%) - 2006			0.007[a]
0 |-15	1		
15 |-30	0.62	0.40;0.96	
30 |-50	0.60	0.38;0.94	
50 |-70	0.52	0.32;0.85	
≥ 70	0.55	0.37;0.81	

[a] P value of the trend.
[b] Score: Quintile 1: 22 to 182. Quintile 2: 183 to 234. Quintile 3: 230 to 280. Quintiles 4 and 5: 281 to 557.
ESF: Family Health Strategy

households with ≥ 2 per room or not connected to the public water supply (with indoor plumbing) was reduced by half (Table 3).

The estimates of municipal prevalence of malnutrition for the 2000 set of Brazilian municipalities were obtained by applying the equation from the final predictive model to the 2000 Census Sample. To obtain these estimates for 2006, factor correction corresponding to the ratio between estimated prevalence and that detected directly by the PNDS-2006 was used. The results confirm the heterogeneity of the distribution of the frequency of childhood malnutrition risk in Brazil. The interval of variation went from municipalities in which the risk of malnutrition was around 3% (2.8% in Santa Tereza in the state of Rio Grande do Sul and 3.7% in the municipality of Sao Caetano, Sao Paulo state) to those in which the frequency reached 29.0% (Jordão in the state of Acre).

The Brazilian municipalities were grouped in categories, according to the estimated percentage of children

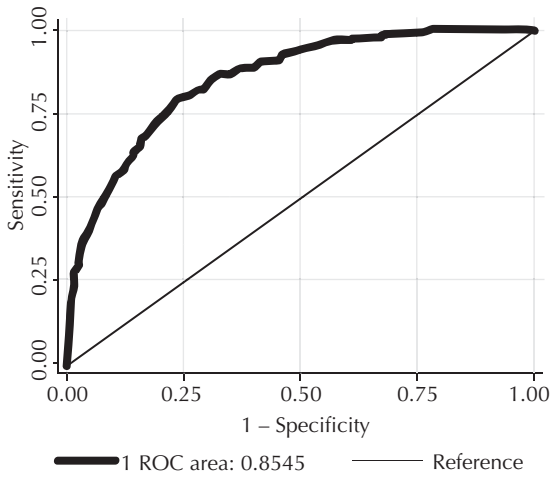

Figure 1. Evaluation of the final model's predictive capacity by ROC. Brazil, 2006.

between six and 59 months with growth deficiency. Around 25% of Brazilian municipalities were found to have the situation *under control* and more than half had a *very low* risk of childhood nutrition (57.1%). The proportions of Brazilian municipalities in the situation of medium, high medium and high risk of malnutrition were 5.6%, 2.0% and 0.9% respectively. The map of the country (Figure 2) was created to show the spatial distribution of childhood malnutrition risk in Brazil. The areas with municipalities in which the risk of malnutrition was under control are light colored. Progressively darker tones were used to color the areas in which the risk is very low, low, medium, high medium and high.

The majority of situations in which the risk of childhood malnutrition were *medium*, *high medium* and *high* were found in the North, with situations of very low or under

Table 3. Distribution (%) of the children aged six to 59 months studied in the Census Sample 2000 and in the PNDS-2006 according to the variables of prediction of the final model. Brazil, 2006.

Variable	Census 2000 (n = 1,809,744) %	PNDS-2006 (n = 3,931) %	p
Age (months)			0.364
6 |- 24	32.6	33.6	
24 |- 60	67.4	66.4	
Sex			0.117
Male	50.8	52.6	
Female	49.2	47.4	
Socioeconomic score in the PNDS-2006[a]			< 0.001[b]
Quintile 1	51.2	21.6	
Quintile 2	17.4	18.4	
Quintile 3	11.1	20.0	
Quintile 4	10.2	20.2	
Quintile 5	10.1	19.8	
Number of individuals per room			< 0.001
< 2	85.2	92.5	
2 or +	14.8	7.5	
Household with indoor plumbing			< 0.001
Yes	73.6	86.5	
No	26.4	13.6	
Number of children under five in the household			< 0.001
1	61.4	67.3	
2	30.3	27.5	
3 or +	8.3	5.2	
Region			0.024
North	10.1	10.8	
Northeast	30.9	27.3	
Center-South	59.0	62.0	

[a] Score of the socioeconomic quintiles: Quintiles 1: 22 to 182, Quintiles 2: 183 to 234, Quintiles 3: 230 to 280, Quintiles 4: 281 to 357 e Quintiles 5: 358 to 557.
[b] P value of the trend.
PNDS: National Research on Demography and Health

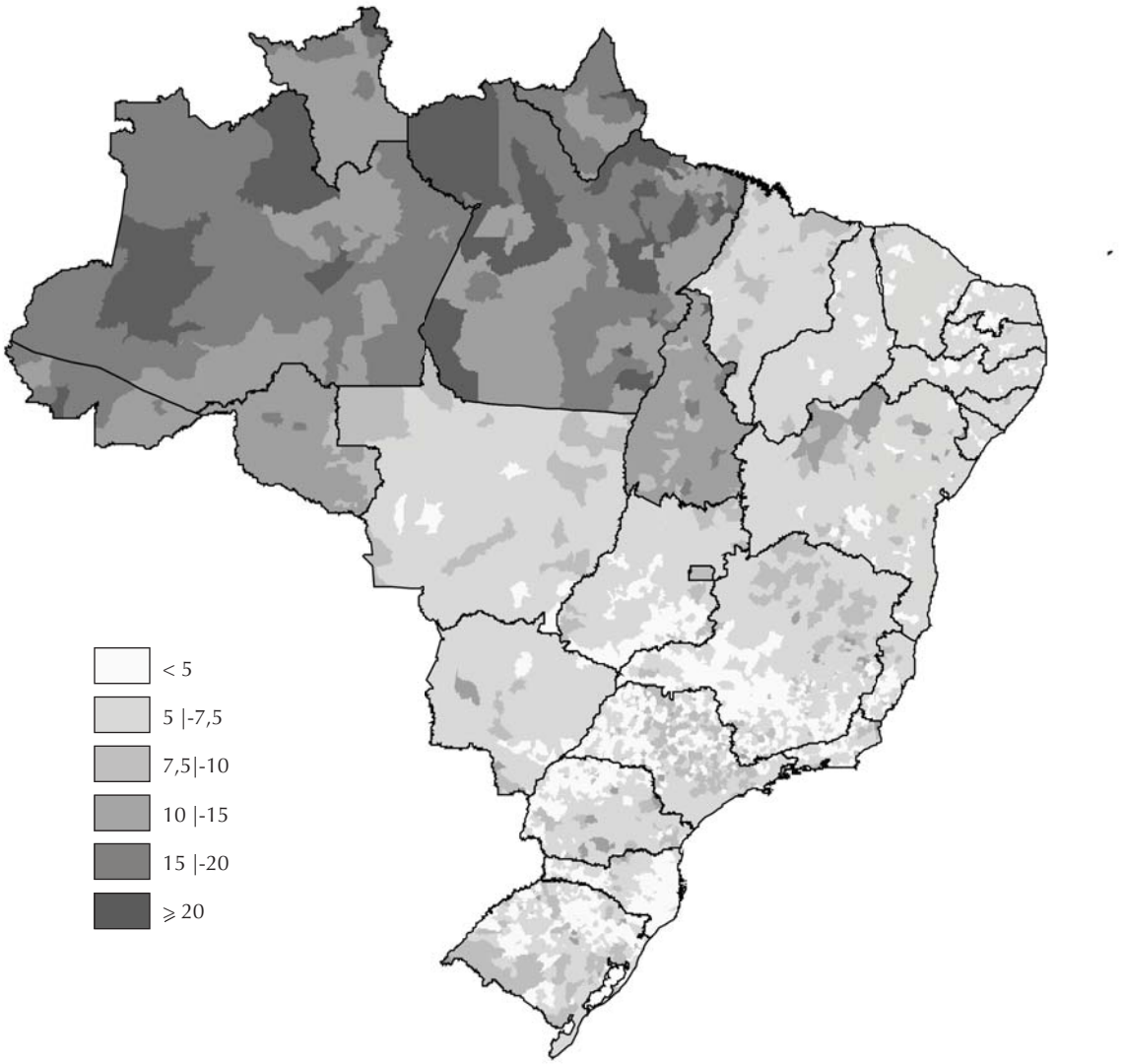

Figure 2. Spatial distribution of the estimated prevalence of growth deficiency in children. Brazil, 2006.

control predominating in the other regions. There was, however, areas of low prevalence in the North (more populous municipalities in the states of Rondônia and Tocantins) (Figure 2).

The most disadvantaged areas in the Northeast were located in the North of Bahia. Situations of risk of malnutrition being *under control* were found mainly in the state capitals and in large urban areas. The most disadvantaged situation in the Southeast was seen in municipalities occupying the northern half of the state of Minas Gerais. The municipalities in which the risk of malnutrition was *under control* were situated in the southern half of the state and extended throughout the mining area to the area of Belo Horizonte and most of Sao Paulo. The most disadvantaged areas of the South, with a *medium* risk of childhood malnutrition, were found in small, circumscribed areas of the Center South of the state of Paraná and in smaller areas in Rio Grande do Sul. This situation was even less common in the Center South of the country (Figure 2).

DISCUSSION

There was a high statistically significant chance of malnutrition in male children, those living in households with two or more individuals per room, households belonging to the lower quintiles of the socioeconomic score, those with three or more children under five, those which did not have indoor plumbing and those located in the North. The negative dose--response link between municipal ESF coverage in 2006 and the chance of malnutrition showed the protective effect of the ESF in relation to childhood malnutrition, irrespective of the other determinants of the problem.

Compared with children living in municipalities with poor or no ESF coverage (between 0% and 15%), the

other children showed progressively lower chance of being malnourished, with the lowest level being (0.52; 95%CI 0.32;0.85) in those living in municipalities with coverage between 50% and 70% and a small fluctuation (0.55; 95%CI 0.37;0.81) in the condition of municipal coverage ≥ 70%.

The results concur with those of previous studies in which male children and those living in households which are disadvantaged from a socio-economic or sanitation point of view point of view were statistically significant.[8,14,17] The higher frequency of childhood malnutrition in the North of the country has been described in the PNDS-2006 official report.[c]

Studies on the protective effect of ESF coverage on childhood malnutrition were not found in the national literature. Of those studies which sought to assess the impact of the ESF on health indicators at a national level, two were identified which looked at the outcome of infant mortality. Macinko et al[12] (2006), made use of secondary data from all federal states between 1991 and 2002, and reported that an increase of 10% in ESF coverage resulted in a 4.5% decline in infant mortality after controlling for other determinants of childhood health. Aquino et al[2] (2008), using secondary data from 721 Brazilian municipalities between 1996 and 2004, observed a statistically significant negative link between ESF municipal coverage and infant mortality rates after controlling potential confounding variables.

Considering the similarity between the determinants of infant mortality and those of childhood malnutrition,[19] the impact of ESF coverage on reducing mortality in the abovementioned articles is confirmed in this study, which suggests protection of ESF coverage with regards malnutrition.

A statistically significant association was observed between ESF coverage and a higher percentage of pregnant women receiving tetanus vaccine during the ante-natal period and higher recorded birth weight records for the children in the PNDS-2006 sample (data not shown). This makes the findings related to the protective effect of the ESF on childhood nutrition more robust as they may indicate better quality health care, presumably applicable to the prevention and control of childhood malnutrition.

The final model showed good predictive capacity evaluated by the area below the ROC curve, the size of which was greater than that shown in the previous study: 0.76; 95%CI 0.65; 0.87; however, the study did not include the variable ESF coverage, this indicator not being available at that time.[b]

A positive aspect of this study was that it estimated individual probability of malnutrition, using multi-level analysis – more appropriate when the sample is grouped into individual, household and municipal levels – rather than cluster analysis used in the other studies in the literature.[15,i,j]

A limitation of this study is the gap in time between the PNDS-2006 and the 2000 Census Sample. The possible correction factor for updating the 2000 estimates of 2006 was obtained by aggregating the results of all the regions and assuming homogeneous evolution for all of the municipalities in the same region.

The minimum and maximum estimated municipal prevalence values (2.8% and 29%) are lower than those presented in a previous Brazilian study, which contained estimates for 2000 (3.3% and 45.0%).[b] In that study, more than a third of Brazilian municipalities in the North, Northeast and Southeast (north of Minas Gerais) showed a prevalence above 15%. In this study, 2.9% of Brazilian municipalities presented this situation, all in the North of the country.

In spite of advances, inter-regional inequalities still exist. The spatial distribution of childhood malnutrition in Brazil in 2006 shows concentrations of municipalities with medium high and high risk and none at low risk or under control in some parts of the North. The Northeast is similar to the other regions of the Center-South, where almost all of the municipalities presented low or under control risk.

The information produced by this study and by others with a similar methodology (Small Area Estimation)[15,i,j] are important in supporting the managers of municipalities and other government spheres in implementing public policies.[4]

The allocation of financial resources for expanding the ESF was not very significant in the North of the country before 2006, being concentrated in the municipalities in the Northeast. From this year onwards, there was great expansion in the ESF in municipalities in the Center-South and modest implementation of new ESF teams in municipalities in the North.

In spite of advances, there are still regional inequalities which merit the attention of the formulators of public policy and reinforce the role of increased access to health care for mothers and children, expressed by ESF coverage, in the reduction of childhood malnutrition, especially in the North of the country.

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