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Stunting in children under five years old is still a health problem in the Western Brazilian Amazon: a population-based study in Assis Brasil, Acre, Brazil

Nanismo em crianças menores de cinco anos de idade ainda é um problema de saúde na Amazônia Ocidental Brasileira: um estudo de base populacional em Assis Brasil, Acre, Brasil

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Abstract *Despite the process of nutritional transition in Brazil, in some places, such as the Amazon region, stunting is still an important public health problem. We identified the prevalence and factors associated with stunting in children under five years old residing in the urban area of Assis Brasil. A survey was conducted in which a questionnaire on socioeconomic, maternal and children's conditions was applied, and height or length was measured. The children with height for age index below -2 Z-scores were considered stunted, according to the criteria by the World Health Organization. Four hundred and twenty-eight children were evaluated. Of these, 62 were stunted. Factors associated with stunting, according to adjusted models, were: the presence of open sewer, the wealth index for households, the receipt of governmental financial aid and the mother's height, age and education. Therefore, it was observed that family and the mother's characteristics as well as environmental and socioeconomic factors were closely related to the occurrence of stunting in the population studied, and such nutritional disturbance is still a health problem in the Brazilian Amazon.*

Key words *Nutritional status, Nutritional deficiency, Child health, Stunting*

Resumo *Apesar do processo de transição nutricional no Brasil, em alguns lugares, como a região amazônica, o nanismo ainda é um importante problema de saúde pública. Identificou-se a prevalência e fatores associados ao déficit de crescimento em crianças menores de cinco anos de idade residentes na área urbana de Assis Brasil. Um inquérito foi realizado utilizando instrumento semiestruturado sobre características socioeconômicas, maternas e das crianças, e foram aferidas medidas antropométricas. As crianças com índice de estatura para idade inferior a -2 escores-Z foram consideradas com déficit de crescimento, de acordo com os critérios da Organização Mundial da Saúde. Quatrocentos e vinte e oito crianças foram avaliadas. Destas, 62 apresentaram déficit de crescimento. Os fatores associados à baixa estatura, de acordo com modelos ajustados, foram: presença de esgoto a céu aberto, índice de riqueza para as famílias, recebimento de ajuda financeira governamental, altura materna, idade e escolaridade maternas. Portanto, observou-se que as características familiares e da mãe, bem como fatores ambientais e socioeconômicos estavam intimamente relacionados com a ocorrência de déficit de crescimento na população estudada, e que a desnutrição ainda é um problema de saúde na Amazônia brasileira.*

Palavras-chave *Estado nutricional, Deficiência nutricional, Saúde da criança,* Stunting

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Introduction

The height-for-age index measures linear growth and its deficit indicates that height increase has been compromised by the cumulative effect of inadequate living, health and nutritional conditions. Because it is associated with long-term processes, it reflects chronic forms of undernutrition, and it is, therefore, a good indicator of chronic undernutrition, having been used in several surveys on child nutrition[1-3]. Individuals with height-for-age Z-score <-2 in relation to the World Health Organization growth curves are considered stunted[4].

Chronic child undernutrition remains a major morbidity in children under five years old, with approximately 165 million children in this age group being affected by stunting worldwide in 2011[5].

In Brazil, the prevalence of child undernutrition (stunting) in 1996 was 13.5%, decreasing to 6.8% in 2006/7[6]. Concomitantly, there was an increase in excess weight in children, suggesting that Brazil is undergoing the nutrition transition. However, this process occurs unevenly in the country[7]. In 2006, the prevalence of stunting in children under five years old was 7.0% for Brazil and 14.9% in the Northern Region[8], showing the great disparity between the Amazon region and the rest of the country, even in the 21st century.

Acre, located in the Brazilian Amazon, is one of the Brazilian states where the effects of socioeconomic conditions on health are still quite evident. Studies conducted in the early 2000s in Acre state[1,2] showed a child undernutritional prevalence rate that was higher than the national average[7,8]. In 2005, the prevalence of stunting in children under five years old in inner Acre was 35.8%[2].

In this study, we evaluated the prevalence of stunting in Assis Brasil, located on the border between Acre and Peru and Bolivia, and its associated factors, providing data for planning preventive public health actions targeted at the Amazonian reality.

Material and methods

Study area

Assis Brasil is located on the Acre River Valley, 550.4 km southwest of Rio Branco, the capital of Acre state. It occupies an area of 4,974 km^2, and borders the city of Brasileia to the east, the cities of Iñapari (Peru) and Bolpebra (Bolivia) to the south, and the municipality of Sena Madureira to the north. In 2010, Assis Brasil had a total population (urban and rural) of 6,017 (3,057 men and 2,960 women), of whom 12.7% were aged with less than 5 years[9].

Study population and design

We conducted a population-based study with all children living in the urban area of Assis Brasil in 2011. These children were located by using the census records of the only Public Health Unit, which included all children at this age living in the urban area. There were 454 children identified by the Health system, and we were able to interview all 454 children. However, 26 children were excluded from the study because they were not submitted to the nutritional exam, resulting in a minimal loss of 5.72%.

The study was conducted with a cross-sectional epidemiological design. Data collection occurred between January and February 2011 by applying a questionnaire to investigate maternal, children and socioeconomic characteristics, as well as household and environmental characteristics. Maternal characteristics were collected from the children's female caregiver (biological mother, grandmother, stepmother or other), except for weight and height, which were collected only from the biological mother.

The length of children under two years old was obtained by using a portable infantometer with 0.1-cm accuracy placed on a smooth surface. The height of children over two years old was measured using a wooden stadiometer with 0.1-cm accuracy and mounted on a wall without footer at a 90° angle in relation to the floor. All anthropometric measurements were performed in duplicate. When the two measurements were discrepant, a third measurement was performed, and the two closest ones were selected. For the analysis, the mean of the duplicate measurements generated the height-for-age index. Values from the World Health Organization[4] were used as reference and calculated by using the Anthro software v.3.2.2 (Department of Nutrition, WHO, Geneva). The cutoff point used for stunting was ≤ -2 Z scores[10]. The same routine used to measure the height of children older than two years was used for the biological mother's height (whether or not she was the current caregiver), while weight was estimated on a portable digital scale (Plenna ®) with 100-g precision and maximum capacity of 150 kg, using the values from

the World Health Organization as reference[11]. The anthropometric measurements of 26 children were not performed, and they were excluded from the analysis. These excluded children differed from the others for being predominantly of indigenous origin ($p = 0.001$), for being mostly from the lower stratum of the socioeconomic index ($p = 0.001$), for receiving governmental financial assistance ($p = 0.017$) and for having mothers who did not attend school ($p < 0.001$).

Statistical analysis

Wealth index: a wealth index was established for each household, as described by Filmer and Pritchett[12], using principal component analysis by the XLSTAT software, version 7.5.2 (Addinsoft, New York, NY). The creation of the wealth index was based on the presence of 21 consumer goods (TV, radio, DVD player, gas cooker, fridge, washing machine, landline telephone, bicycle, blender, electric iron, car, sofa, satellite dish , mobile telephone, motorcycle, computer, boat, boat motor, water well, power generator and microwave oven) as described in previous studies[10,11]. The first principal component explained 51.77% of the total variance. The scores of each variable were summed to estimate the wealth index, which was stratified into quartiles and later in two groups (the poorer half and the richer half).

Exploratory analysis. The database was created by using the SPSS 13.0 software (SPSS Inc., Chicago, IL). Crude analysis utilizing the Stata software, version 10 (StataCorp, College Station, TX) was performed by examining potential associated factors and confusion. Factors associated with stunting were identified by adjusted models using the conceptual model (Chart 1) adapted from previous studies[13,14]. Poisson regression models with robust error were adjusted for individual, maternal and household variables by applying the stepwise forward method.

The quality of fit of the model was evaluated by the value of variance. No significant interactions, influential or extreme points were found. Variables open sewer, wealth index, receipt of financial aid and maternal height, age and education were maintained in the final model.

Since the maternal height of biological mothers is associated with undernutrition and can express both genetic effects and the results of socioeconomic conditions, we performed all the analysis in two separate models. The first model included all 428 children, and the second model included only 398 children who were cared for and lived with their biological mother. Among the 30 children excluded in the second model there were five children with stunting. The results were similar between the two models, except for the sewer variable, which showed p value of 0.052, and therefore only the results from the analysis on all the children are shown, regardless of type of caregiver. There were some missing values in some variables, and the final multivariate model contained 407 children.

Results

Socioeconomic and environmental characteristics of the study population

The sociodemographic and economic characteristics of the study population are shown in Table 1. Although 97.4% of children resided in households with electric power supply and 92.9% had garbage collection at their residences, the other socioeconomic conditions observed were very unfavorable, such as their house construction material, presence of open sewer, lack of shower with running water at the household, use of pit toilets or lack of latrines. About one third of the children interviewed (31.7%) received some type of individual or family governmental financial aid.

Characteristics of caregiver and gestational conditions

The mean age of the caregivers (biological mothers and others) was 27.47 years (median = 26, range = 15 - 78 years). The average height of 407 biological mothers was 156.98 cm, and 50.7% of them were overweight. Only 9.1% of the caregivers were illiterate, while 45.3% had more than eight years of schooling. Only 15 mothers (3.71%) did not attend prenatal care (Table 2).

Children's characteristics

Table 2 shows the distribution of the 428 children included in the study according to individual characteristics, birth and breastfeeding characteristics, and morbidity and access to health care. Of the children studied, 51.2% were males and 11.4% of all children were of indigenous ethnicity. Some children (6.3%) were born in the rural (or riparian) zones of Assis Brasil or other municipalities or lived outside the urban area sometime in their lives. The average age was

Chart 1. Conceptual model of factors associated with undernutrition[a].

1. Distal	**Socioeconomic and environmental conditions**	**Environmental and socio-economic variables** *Socio-economic variables* Wealth index Family income (in BMS) Household construction material Receipt of benefits *Household environmental variables* Garbage collection Presence of open sewer Presence of electric power supply Type of sanitary installation Presence of shower with running water
2. Intermediate	**Characteristics of caregiver and gestational conditions**	**Caregiver characteristics** Type of caregiver Age of caregiver Schooling of caregiver Height of biological mother Body mass index of biological mother **Gestational characteristics** Attendance of pre-natal care by biological mother
3. Proximal	**Child characteristics**	**Child characteristics** Age Sex Ethnicity Lived outside urban area before Time of residence in urban area **Characteristics of child birth and breastfeeding** Birth weight Ocurrence of breastfeeding **Morbidity and access to services and care** Attending daycare or school Monitoring through health care service Self-reportedmorbidities Hospitalisation at least once in life

[a] Adapted from Souza et al.[1] and United Nations Children's Fund[14].

2.97 years (median = 3 years), and the average length of time residing in the urban area was 2.34 years (median = 2.19 years). About 94.7% were cared for by their own biological mother. The median birth weight of 366 children with known information was 3,350 g (mean 3,320 g, range = 1,000 g - 5,000 g). The majority of children (93.7%) had seen a physician at least once in their lives, but 36.4% had been hospitalized at least once. Only 29.3% had had a health care appointment in the Health Care Unit in the previous 12 months.

Prevalence of stunting and associated factors

The prevalence of stunting found in the urban area of the municipality of Assis Brasil among children under five years old was 14.4% in 2011.

In crude analysis (Table 2), children of indigenous origin were more likely to show stunting (PR = 2.89, CI = 1.80 to 4.65, $p < 0.001$), but this variable did not remain as a factor independently associated with undenutrition when adjusted for socioeconomic factors. Living in the countryside was also a associated factor for stunting (PR = 2.20, $p = 0.015$) in crude analysis, but after ad-

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Table 1. Prevalence (%) and Prevalence Rate (PR) of stunted children under 5 years old according to socioeconomic and characteristics of caregiver. Assis Brasil, 2011.

Variables	N	% of stunting	uPR	95% CI	P value
Socioeconomic variables					
Wealth índex					
Richerhalf	212	6.1	1	-	-
Poorerhalf	216	22.6	3.69	2.06 – 6.63	< 0.001
Family monthly income					
> one Brazilian minimum salary[a]	210	10.0	1	-	-
<= one Brazilian minimum salary[a]	181	20.9	1.58	0.99 – 2.50	0.053
Type of house construction material					
Brick	56	5.3	1	-	-
Wood or other materials	372	15.8	2.96	0.95 – 9.13	0.059
Receipt of governmental financial aid					
No	289	9.0	1	-	-
Yes	136	26.4	2.87	1.81 – 4.57	< 0.001
Household environmental variables					
Eletric power supply at home					
No	11	27.2	1	-	-
Yes	417	14.1	0.51	0.19 - 1.4	NS
Type of sanitary installation					
Toilet with running water	251	9.9	1	-	-
Pit toilet	134	21.6	2.17	1.32 – 3.55	0.002
Lacking sanitary installations	43	18.6	1.86	0.90 – 3.86	0.093
Shower with running water in the house					
No	167	19.7	1	-	-
Yes	261	11.1	0.56	0.35 - 0.89	0.014
Street garbage collection by council					
No	30	20.0	1	-	-
Yes	398	14.0	0.70	0.33 - 1.49	NS
Open sewer in the house					
No	265	7.9	1	-	-
Yes	183	22.4	2.61	1.60 - 4.26	< 0.001
Characteristics of caregiver and gestational conditions					
Type of caregiver					
Biological mother	398	14.3	1	-	-
Grandmother	18	16.7	1.16	0.40 - 3.36	NS
Other	12	16.7	1.16	0.32 – 4.22	NS
Age of caregiver (in years)	428	14.4	0.97[b]	0.94 - 1.00	0.073
Schooling of caregiver					
Did not attend school	39	35.9	1	-	-
1 to 4 years inclusive	102	14.7	0.41	0.22 - 0.77	0.005
5 to 8 years inclusive	93	17.2	0.48	0.26 - 0.88	0.019
More than 8 years	194	8.8	0.24	0.13 - 0.45	<0.001
Height of biological mother (cm)	407	14.4	0.89[c]	0.86 - 0.94	<0.001
Body Mass Index of biological mother					
Below 25 kg/m2	200	20.0	1	-	-
Equal or above 25 kg/m^2	206	8.73	0.44	0.26 - 0.74	0.002
Attendance of pre-natal care by biological mother					
Yes	389	13.8	1	-	-
No	15	53.3	4.15	2.42-7.12	<0.001

NS: p-value >= 0.20; uPR: unadjusted Prevalence Rate; CI: confidence interval. [a] Brazilian minimum salary in 2010 (R$ 340 = US$ 150). [b] Per 1-year increase. [c] Per 1-cm increase.

Table 2. Prevalence (%) and Prevalence Rate (PR) of stunted children under 5 years old according to individual child characteristics. Assis Brasil, 2011.

Variables	N	% of stunting	uPR	95% CI	P value
Characteristics of child birth and breastfeeding					
Sex					
Male	219	14.1	1	-	-
Female	209	14.8	1.05	0.66 - 1.66	NS
Age (in months)					
0 to 11	86	9.0	1	-	-
12 to 23	89	23.6	2.54	1.19 – 5.42	**0.016**
24 to 35	93	17.0	1.85	0.83 – 4.10	0.131
36 to 47	70	14.3	1.54	0.64 – 3.68	NS
48 to 59	90	7.8	0.84	0.32 - 2.21	NS
Ethnicity					
Non-indigenous	375	12.0	1	-	-
Indigenous	49	34.6	2.89	1.80 - 4.63	**<0.001**
Has lived in rural or riparian zones before					
No	401	13.4	1	-	-
Yes	27	29.6	2.20	1.16 -4.14	**0.015**
Child length of time living in the urban area (years)[a]	428	14.4	0.88[b]	0.76 – 1.02	0.101
Characteristics of child birth and breastfeeding					
Birthweight (g)	366	14.4	1.000[b]	0.999 – 1.000	NS
Breast feeding at birth					
Yes	407	14.4	1	-	
No	17	11.7	1.23	0.32 - 4.63	NS
Morbidity and access to services and care					
Attendance to school or daycare					
No	311	18.0	1	-	-
Yes	114	5.2	0.29	0.12 - 0.66	**0.003**
Has seen a physician at least once in life?					
Yes	400	14.5	1	-	-
No	27	14.8	0.97	0.38 - 2.49	NS
Has seen a physician or nurse in the past 12 months?					
Yes	124	8.8	1	-	-
No	299	17.0	0.51	0.28 - 0.96	**0.038**
Hospitalization at least once in life					
Yes	154	18.1	1	-	-
No	269	12.6	1.43	0.90 - 2.27	0.121
Morbidities in the previous 30 days					
No	207	8.6%	1	-	-
Yes	219	20.0%	2.30	1.38 - 3.86	**0.001**
Fever in the previous 30 days					
No	296	11.8	1	-	-
Yes	130	20.7	1.75	1.11 - 2.77	**0.016**
Diarrhea in the previous 30 days					
No	352	11.6	1	-	-
Yes	75	28.0	2.40	1.51 - 3.82	**<0.001**
Cough in the previous 30 days					
No	316	10.4	1	-	-
Yes	111	26.1	2.50	1.59 - 3.92	**<0.001**

NS: p-value >= 0.20; uOR: unadjusted Odds Ratio; CI: confidence interval. [a] Per 1-year increase. [b] Per 1-g increase.

justment for socioeconomic factors, it failed to show an association with that outcome.

Some acute morbidities were also associated with chronic undernutrition in the unadjusted analysis (Table 2). Children with height-for-age deficit were more likely to have fever (PR = 1.75, p = 0.015), diarrhea (PR = 2.40, p < 0.001) and cough (PR = 2.50, p < 0.001) in the 30 days preceding the interview. None of these variables, however, remained significantly associated in the adjusted analysis. The other socioeconomic variables (characteristics of household and children - gender, access to daycare or school, pregnancy and breastfeeding conditions, access to health care services and previous hospitalization, Table 3) showed no statistically significant association in the adjusted analysis. The biological mothers' body mass indexes were also not associated with stunting in children in adjusted analysis. Other socioeconomic and environmental variables did not show association in the adjusted analysis either.

Adjusted models (Table 3) showed that, for the population studied, the family's socioeconomic conditions, the caregiver's age and education and the biological mother's height were independently associated variables in relation to stunting.

The presence of open sewer in the household (aPR = 1.67, p = 0.045) and economically disadvantaged situation (aPR = 2.05, p = 0.015) significantly increased the probability of a child showing stunting (Table 3). Chronic undernutrition was also more common in children whose families received governmental financial aid (aPR = 1.88, p = 0.014). (Table 3).

Children whose biological mothers were taller were less likely to show stunting (aPR = 0.92, p 0.001). Children cared for by caregivers who did not attend school were more likely to show undernutrition (aPR = 2.11, p = 0.014). Children cared for by older caregivers were less likely to be stunted, a decrease of 7 % with each additional year of the caregiver' age (p = 0.001) (Table 3).

Discussion

The prevalence of stunting found in this study is similar to the 14.8% prevalence rate found in the Northern Region, as identified by the 2006 National Demographic and Health Survey, and much higher than the national average of 7%[8]. Possible causes for this discrepancy in relation to the national average is that the Northern Region still faces many unfavorable socioeconomic conditions as compared to other Brazilian regions[6,8] which have managed to reduce child undernutrition in recent years, such as the Northeastern and the Southeastern Regions in Brazil[7,15].

In Assis Brasil, the factors associated with stunting are especially related to unfavorable socioeconomic conditions.

Close to 21.7% of the reduction in the prevalence of child undernutrion between 1996 and 2006-07 in Brazil can be attributed to the increased purchasing power of Brazilian families[6],

Table 3. Factors associated with stunting in children under 5 years obtained by multivariate modeling. Assis Brasil, AC, 2011.

Variable (n = 407)	aPR	95% CI	P value
Wealth index			
Richerhalf	1		
Poorerhalf	2.05	1.14-3.66	0.015
Receipt of governmental financial aid			
No	1		
Yes	1.88	1.13-3.13	0.014
Open sewer			
No	1		
Yes	1.67	1.01-2.76	0.045
Age of caregiver (in years)	0.93[a]	0.90-0.97	0.001
Schooling of caregiver			
Did not attend school	1		
Attended school	2.11	1.16-3.83	0.014
Height of biological mother (in cm)	0.92[b]	0.88-0.97	0.001

aPR: adjusted Prevalence Rate; CI: confidence interval. [a] Per 1-year increase. [b] Per 1-cm increase.

both in developed[16] regions and in those still under development[15]. The Brazilian government is partly responsible for this increase by granting benefits to mothers or guardians in the poorest families in the last two decades, such as the *Fome Zero* and *Bolsa Família* programs, which have managed to have impact on linear growth in children and adolescents assisted by the programs[17].

In this study, it was observed that many families do not have adequate sanitation facilities, which has been associated with stunting in other studies performed in Acre[1]. Exposure to an open sewer, besides indicating a poorer socioeconomic status, may lead to the acquisition of infectious diseases more frequently and result in stunting. In fact, cohort studies have shown that repeated episodes of diarrhea are associated with a small reduction in linear growth[18]. In our analysis children with stunting were more likely to present a recent episode of diarrhea in the unadjusted analysis, as well as fever and cough. Although it was not possible to confirm this association because of the limited number of events, it is worth emphasizing the clinical importance of this finding. Care to a child with fever and especially non-epidemic diarrhea in socially disadvantaged areas, should raise clinical suspicion of some kind of undernutrition, which should be investigated by the health service.

Maternal education has been shown in some studies to be inversely associated with growth retardation in children under five years old[19,20], probably due to lower access to information about the importance of household and personal hygiene habits and proper nutrition for children's growth and development. Drachler et al.[21], when studying non-indigenous children, claimed that the mother figure represents the bond between children and the environment, besides the fact that it is usually the mother who decides about the family's eating habits as well as about hygiene care and immunization. In our study, even after adjustment for income and housing conditions, the effect of the lack of maternal education remained associated with undernutrition.

As occurred in Assis Brasil, other studies suggest an association between maternal age and children undernutrition, and the risk of stunting is higher in children of adolescent mothers[22]. The most likely explanation is that young women are generally not prepared to take care of such a dependent being[23], which can result in nutritional deficit.

Several studies found an association between the biological mother's height and stunting in children[24,25]. Maternal height is also associated with weight at birth: children born to mothers with short stature are born with low weight[26,27]. Maternal height may be a marker of such woman's nutritional history and previous socioeconomic conditions[26,27], or even suggest a genetic predisposition to short stature, which ends up being "inherited" by the child[28], first reflected in low weight at birth and later in stunted growth. Separating such genetic effect of short maternal stature from families' socioeconomic and environmental effects that are perpetuated through generations (both the mother's and child') and lead to stunting in children[5] is not an easy task. To that end, a long-term specific epidemiological cohort design is necessary, since low maternal height is significantly associated with poverty and adverse conditions of the socioenvironmental milieu in several publications[19,24]. As our study has a cross-sectional nature and it is not possible to establish a temporal relationship between the independent variables and the outcome, it is likely that not all the socioeconomic factors that influence maternal height were controlled in the analysis. Therefore, the association between maternal height and stunted children can be confounded by unadjusted socioeconomic factors, such as maternal socioeconomic status at the time of the biological mother's growth.

This study has limitations. It is not possible to determine, for example, if the higher frequency of acute diarrhea in stunted children is a cause or a consequence of undernutrition, but only to emphasize that children with diarrhea should be investigated for the presence of undernutrition. Another limitation is a possible selection bias, since there was a selective loss of children who were not assessed anthropometrically and who were characterized by predominantly belonging to indigenous ethnic groups, to the lowest socioeconomic group, with uneducated mothers and a history of having resided in rural areas previously. Therefore, there may have been an underestimation of stunting prevalence and of the magnitude of the association of significant variables with the outcome, but which, however, does not invalidate the findings in the study regarding factors associated with chronic undernutrition.

Because of the age of the children analyzed and the cross-sectional nature of the study, some associations tested also have limitations and should be interpreted with caution. It was not possible to collect data on gestational age at birth and determine which children were born with low weight. Moreover, due to recalling bias, it

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was also not possible to collect data on the duration of breastfeeding and, therefore, the effect of pregnancy, childbirth and peripartum variables was not adequately tested. Since the majority of children were cared for by their biological mothers, the ability of this study to evaluate the effect of caregivers on undernutrition occurrence was also limited. Finally, the relationship between attending a daycare center or a school and stunting also introduced a selection bias, since children can only attend such services after they are two years old.

Finally, it is concluded that, although Brazil is going through a process of nutritional transition with consequent reduction in undernutrition, the prevalence of stunting in Assis Brasil can be regarded as an important public health problem. Socioeconomic conditions and maternal characteristics were shown to be closely related to the occurrence of stunting in this population, and some intervention is possible in the short term, while others depend on greater social and economic transformation in the Amazon region. A few interventions are already being executed by the Brazilian government, such as the inclusion of all children in school and kindergarten, where balanced food is offered everyday, and the social program of monthly wealth distribution for the poor, which is targeting those children at major risk for stunting, as seen in this study. Hopefully, these interventions will be able to eliminate stunting in the Amazon in near future.

Collaborations

SAS Mantovani, AA Ramalho, TM Pereira, FLCC Branco, H Oliart-Guzmán, BM Delfino, AM Braña, AC Martins, JA Filgueira-Júnior, AP Santos, RG Campos, AS Guimarães, TS Araújo, CSM Oliveira, CT Codeço and M da Silva-Nunes participated in the conception, design and analysis of data and read the final version of the manuscript.

Ethical approval

The study was approved by the Ethics Committee for Human Research of our Institution (Process n. 23107.09782/2009-04). We obtained informed consent from the parents or legal guardian of each participant after the nature and possible consequences of the studies had been fully explained.

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