Jornal de Pediatria xxxx;000(xxx): 1−7

Jornal de Pediatria
www.jped.com.br

ORIGINAL ARTICLE

The tendency of stunting among children under five in the Northern Region of Brazil, according to the food and nutrition surveillance system, 2008-2017

Ester Mourão Corrêa [a], Caroline de Oliveira Gallo [b,*], José Leopoldo Ferreira Antunes [c], Patrícia Constante Jaime [b]

[a] *Universidade de São Paulo (USP), Faculdade de Saúde Pública, Departamento de Nutrição, Programa de Pós-graduação Nutrição em Saúde Pública, São Paulo, SP, Brazil*
[b] *Universidade de São Paulo (USP), Faculdade de Saúde Pública, Departamento de Nutrição, São Paulo, SP, Brazil*
[c] *Universidade de São Paulo (USP), Faculdade de Saúde Pública, Departamento de Epidemiologia, São Paulo, SP, Brazil*

Received 7 April 2022; accepted 26 July 2022
Available online xxx

KEYWORDS
Stunting;
Primary Health Care;
Nutrition Policy;
Information Systems

Abstract
Objective: To analyze the temporal tendency of stunting prevalence among children under five years of age registered in the Food and Nutritional Surveillance System (SISVAN) in the Brazilian Northern Region, from 2008 to 2017.
Methods: Ecological time-series study with data from SISVAN. The annual variation rate for the prevalence of undernutrition, measured by the presence of stunting (low height-for-age index), was estimated for the Northern Region and for each of its states using the Prais-Winsten regression model with and without variable adjustment for SISVAN coverage to explore the relationship between these variables.
Results: The Northern Region showed a tendency toward the reduction of chronic child stunting, with an annual variation of -5.30% (95%CI -9.64; -0.77) in the period studied. The states of Acre (-7.19%; 95%CI -12.31; -1.77), Pará (-4.86%; 95%CI -9.44; -0.03), and Tocantins (-6.22%; 95%CI -9.88; -2.41) showed a tendency to reduce the prevalence of stunting, while the other four states showed stability during the period. A strong negative correlation was found between SISVAN coverage and the prevalence of stunting in the states of Acre (beta: -0.725), Amazonas (beta: -0.874), Pará (beta: -0.841), and Tocantins (beta: -0.871), indicating that the increase in system coverage is associated with a reduction of stunting.
Conclusions: There is a tendency toward a reduction in the prevalence of stunting particularly in three states and in the North Region as a whole, from 2008 to 2017. The coverage by the system was associated with a reduction in the prevalence of child stunting in four states.

Study conducted at the Faculdade de Saúde Pública da Universidade de São Paulo (FSP/USP), Programa de Pós-graduação Nutrição em Saúde Pública, São Paulo, SP, Brazil.

* Corresponding author.
E-mail: caroline.gallo@alumni.usp.br (C.O. Gallo).

https://doi.org/10.1016/j.jped.2022.07.006
0021-7557/

Introduction

Chronic undernutrition in childhood, which is defined by a low height-for-age index (stunting), is an indicator of poor environmental conditions or long-term restrictions on the child growth potential and is the most prevalent form of child undernutrition. Linear growth delay is a constant health problem in developing countries, and a risk factor for several health issues and for short- and long-term developmental delay, causing both physical and cognitive impairments to the individual.[1–3] According to national surveys, the prevalence of chronic undernutrition among children under five years of age reduced from 36.8% to 7.1% between 1974-75 and 2006-07.[4]

Nonetheless, it remains a public health problem in some regions of the country and in certain social segments, particularly in the Northern Region, of which the estimated prevalence is 14.8%, well above the national average (7.0%).[5,6] Some particularities of this region may explain the difficulty in achieving the decline observed in other regions of the country, such as the great distances between the capitals and other cities and towns; the lack of transport and communication infrastructure across the Amazonian territory; and the large proportion of population devoid of material and educational resources.[7]

The determinants of stunting are multifactorial and interrelated. They go through household determinants related to child health, care and nutrition, maternal factors, lack of access to basic sanitation and potable water, low socioeconomic status, low caregiver education, and food and nutritional insecurity. Underlying these determinants are the different social, economic, and political contexts.[8] In addition to the already established conceptual model of determinants, the role of environmental enteric dysfunction in linear growth delay has been explored in the literature. This condition is present in regions with unfavorable socio-environmental conditions and has been considered one of the determinants of stunting. It is characterized by a series of acquired and reversible morphological and functional intestinal alterations, the result of repeated or chronic exposures of the gastrointestinal tract to pathogenic agents, in turn, related to the maternal, environmental, and contextual factors, mediated by poor hygiene conditions.[9–11]

The search for strategies to address chronic child undernutrition stems from its relationship with high mortality rates in early childhood and its negative impact on growth development.[1] In this perspective, the Food and Nutritional Surveillance (VAN) – defined by the Health Organic Law as a field within the Unified Health System (SUS)[12] and established as one of the guidelines of the National Policy for Food and Nutrition (PNAN) since 1999 – aims to monitor the health and nutrition situation of the Brazilian population, as well as its determining factors, providing essential information for the planning and articulation of interventions directed to the production of health care and organization of nutritional care within the scope of the SUS.[13] Among the VAN strategies, the Food and Nutritional Surveillance System (SISVAN) emerges as a health information system to enable the continuous generation of data on the nutritional status and food consumption of the population assisted by the Primary Health Care network of the SUS.[14,15]

Since 2008, the insertion of anthropometric data in SISVAN has increased due to the computerization of this system, which has brought advantages by facilitating and optimizing the collection, consolidation, analysis, and interpretation of information. Considering the cost and time required for periodic field research – another instrument used by VAN – the computerized system is a good tool for rapid, accurate, and low-cost identification of children and other groups at nutritional risk.[16]

Therefore, the present study aims to describe and analyze the temporal tendency of the prevalence of stunting among children under five years of age, registered with SISVAN, in the Northern Region of the country, from 2008 to 2017.

Methods

This is an ecological time-series study for epidemiological characterization of stunting (low height-for-age index) in residents of the municipalities in the Brazilian North Region, using secondary data from the Food and Nutritional Surveillance System (SISVAN) for the years 2008 to 2017.

The beginning of the time series was defined as 2008 – the year of SISVAN data computerization – considering the incorporation of growth curves recommended by the World Health Organization,[17] and the expressive increase of records on nutritional status.[16]

Data on the nutritional status of children from SISVAN's public reports were obtained, and are available, at the following website <http://sisaps.saude.gov.br/sisvan/relatoriopublico/index>. Annual reports were generated considering all months of each year and all types of recorded monitoring: SISVAN-Web, *Bolsa Família* Management System (SIGPBF – *Sistema de Gestão do Programa Bolsa Família*), and Primary Health Care Information System (e-SUS AB). The data were not stratified according to the types of records.

The stunting prevalence was obtained by summing up the percentage of children under five years of age with low stature for age (z-score of the height-for-age index lower than -2 standard deviations) and very low stature for age (z-score of the height-for-age index less than -3 standard deviations).[18]

Prevalence was estimated by the sum of the total number of children with records of stunting over the sum of the total number of children registered in SISVAN, multiplied by 100. This indicator was described for the Northern Region, for each of its Federal Unit, and for each year of the time-series.

An indicator of SISVAN coverage was established for inclusion in the analyses, since the variation in the percentage of children covered by the system may be associated with the prevalence of stunting found, influencing the results. The variable of coverage of the system was obtained by dividing the number of individuals with nutritional status recorded in SISVAN by the total population of children under five years of age residents in the municipality, multiplied by 100. The total population of each municipality was obtained from the population estimates of the Interagency Network of Information for Health and the Brazilian Institute of Geography and Statistics, available at the address <http://www2.datasus.gov.br>.

The units of analysis correspond to the municipalities of the Northern Region (n=450). The municipalities that presented inconsistent values for the system coverage index − coverage sums greater than 100% − were excluded from the analyses, excluding a total of 27 municipalities, of which three were from the state of Amazonas, four from Pará, 19 from Tocantins, and one from Acre. All exclusions occurred due to inconsistency in the coverage index and none of the capitals was excluded, resulting in a final sample of 423 municipalities.

Prais-Winsten regression[19] was used for temporal tendency analysis, considering the serial autocorrelation between values during the period, i.e., dependence on a serial measure with its own values at different times. The mean annual variation in the prevalence of stunting and their respective confidence intervals were estimated according to the formula:

$$\text{APV}(\text{average annual percentage variation}) = \left[-1 + \left(10^{b1}\right)\right] \times 100\%$$

Where b1 is the Prais-Winsten regression coefficient for the time-series of the variable of interest, transformed to decimal base logarithm.

A significance level of 5% was adopted. Thus, non-significant p-values ($p \geq 0.05$) indicated a tendency of stability, and significant p-values ($p < 0.05$) indicated an increasing or decreasing tendency when the annual variation was positive or negative, respectively.

Since the variable for SISVAN coverage could explain the variation in the prevalence of child stunting, both by increasing the notification of cases (increased prevalence) and by better monitoring individuals (reduction of prevalence), two Prais-Winsten regression models were created to evaluate the temporal tendency toward stunting: with and without adjustment for system coverage, in order to explore the relationship between these variables.

Moreover, to broaden the understanding of the effect of the system coverage variable on the observed prevalence trends, simple linear regression models were created, with the prevalence of stunting and SISVAN coverage as an explanatory variable. The standardized regression coefficients indicate the association between the variables "SISVAN coverage" and "prevalence of child stunting". To conduct this analysis, it would be important, strictly, to assess the normality of both variables. However, the number of points used in the time series − ten years − is reduced to confer discriminatory statistical power for the evaluation of normality in the distribution of regression residuals.

Stata version 13.0 software for Windows was used for statistical analysis.

To illustrate the evolution of the prevalence of stunting during the period studied, maps were drawn up considering the current definition of population classification for the prevalence of growth deficit: very low (<2.5%), low (2.5<10.0%), average (10.0<20.0%), high (20.0<30.0%), and very high (>30.0%).[20] The maps were elaborated in the QGIS software version 3.6.3, generated in the SIRGAS 2000 geographic projection system. These are quantitative maps, determined by class intervals referring to the average estimates of the prevalence of growth deficits for the years 2008, 2012, and 2017.

This study was approved by the Research Ethics Committee of the Faculty of Public Health of the University of São Paulo (opinion no. 2,301,602), in compliance with the Publishing Policy of the Ministry of Health of Brazil, approved by Ordinance No. 884/2011,[21] which regulates the assignment of data contained in the national databases of Health Information Systems (SIS) managed by the Secretariat of Primary Health Care.

Results

Northern region

The total number of children under five years of age registered with SISVAN, considering the entire Northern Region, was 222,002 in 2008 and 621,690 in 2017. The sample included in the analyses was composed of 215,553 (2008) and 603,657 (2017) children, among which 51,595 were classified as chronically malnourished (stunting) in 2008 and 116,169 in 2017.

Throughout the historical series, the estimated prevalence of stunting decreased from 23.3% in 2008 to 18.6% in 2017, with a minimum and maximum prevalence of 17.9% (2015) and 23.8% (2009), respectively (Table 1).

The temporal analysis, obtained from the regression models, shows a tendency toward a reduction in the prevalence considering both models of regression adjustment for the SISVAN coverage variable: with (APV: 3,13; $CI_{95\%}$ -4.14; -2.10) and without (APV: -5.30; $CI_{95\%}$ -9.64; -0.77). There is a significant increase in the tendency of decreasing prevalence associated with the inclusion of the coverage variable in the model (Table 2). Table 3 indicates a strong negative association between these two variables (-0.813), reinforcing the results.

Federative units

The prevalence of stunting reduced from 2008 to 2017 in all states. When analyzing the first and last years of the series it can be verified that Acre, Amapá, Amazonas, and Pará had the highest prevalence of stunting. The largest reductions in the prevalence of stunting, in percentage points (p.p.), occurred in Pará (6.7 p.p.), Amazonas (5.5 p.p.), Acre (5.2 p.p.), and Tocantins (3.0 p.p.); while the other states (Roraima, Rondônia, and Amapá) recorded a slight decline, considering that the variation in prevalence was small (Table 1).

Regarding the temporal tendency obtained from the regression models (Table 2), considering the model without adjustment for system coverage, there is a tendency

Table 1 Temporal tendency of the prevalence of stunting among children under five years of age according to SISVAN, the Northern Region of Brazil and its states, 2008-2017.

States	Estimation of the prevalence of stunting (%)[a]										Annual Percentage Variation (95%CI)[b]	p-value[c]	Tendency
	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017			
Northern Region/FU	**23.3**	**23.8**	**22.3**	**21.7**	**19.3**	**21.8**	**20.6**	**17.9**	**18.1**	**18.6**	**−3.13 (−4.14; −2.10)**	**< 0.001**	**Reduction**
Acre	22.2	21.4	22.5	21.9	21.3	20.5	22.2	18.0	19.0	17.0	−2.56 (−3.79; −1.31)	< 0.001	Reduction
Amapá	23.1	23.1	22.3	21.9	20.1	22.2	25.2	21.3	22.3	22.7	−0.05 (−1.54; 1.46)	> 0.05	Stability
Amazonas	26.5	27.4	26.1	25.6	22.6	23.5	22.6	19.7	19.9	21.0	−3.79 (−4.71; −2.87)	< 0.001	Reduction
Pará	25.9	26.6	23.6	22.7	20.5	23.3	20.9	18.2	18.7	19.2	−4.02 (−5.21; −2.82)	< 0.001	Reduction
Rondônia	10.8	11.4	11.3	11.1	10.6	11.3	11.2	12.1	9.5	10.3	−0.79 (−2.18; 0.62)	> 0.05	Stability
Roraima	19.0	20.1	19.5	19.7	16.8	27.5	27.0	16.9	16.5	17.7	−0.77 (−6.02; 4.7−)	> 0.05	Stability
Tocantins	16.2	16.6	16.4	15.6	14.3	14.4	14.9	14.0	14.0	13.2	−2.37 (−3.16; −1.57)	< 0.001	Reduction

[a] Prevalence of stunting (%) = (sum of the total number of children in municipalities with stunting/sum of the total number of children from the municipalities registered in SISVAN)*100.
[b] Values of annual percentage variation (APV) and their respective confidence intervals (95%CI) were obtained by Prais-Winsten regression, without adjusting the model for the SISVAN's coverage variable, and were estimated by the formula: APV = (-1+ [10^β]) × 100.
[c] p-value of Prais-Winsten regression.

towards a reduction of the prevalence of child stunting only in the states of Acre (APV: -2,56; $CI_{95\%}$ -3.79; -1.31), Amazonas (APV: -3.79; $CI_{95\%}$ -4.71; -2.87), Pará (APV: -4.02; $CI_{95\%}$ -5.21; -2.82), and Tocantins (APV: -2.37; $CI_{95\%}$ -3.16; -1.57), whereas the other states showed a trend of stability.

When the regression model was adjusted for the system coverage variable, only the state of Amazonas began to present stability (APV: -4.01; $CI_{95\%}$ -7.99; 0.15), indicating that the reduction in the prevalence of stunting previously observed can be explained by the coverage variable. Regarding the other states, the temporal tendency remained the same in either of the regression models tested. However, there was an increase in the decline in prevalence associated with the inclusion of the coverage variable in the model, which was significant in Acre (APV: -7.19; $CI_{95\%}$ -12.31; -1.77) and Tocantins (APV: -6.22; $CI_{95\%}$ -9.88; -2.41), indicating that part of the reduction in the prevalence of child stunting can be explained by the increased coverage of SISVAN (Table 2).

The authors observed a strong negative association between the system's coverage and the prevalence of stunting in the states of Amazonas (-0.874), Pará (-0.841), Tocantins (-0.871), and Acre (-0.725) (Table 3).

Figure. 1 illustrates the behavior of the series in 2008, 2012, and 2017. The prevalence of child stunting was classified as medium and high in all states analyzed, during the three years represented in the figure. The states of Amazonas and Pará presented the highest prevalence of stunting at the beginning of the studied period, showing a reduction until the last year evaluated, but remaining in the categories of high and medium prevalence, respectively. Amapá, Rondônia, and Roraima, which had shown a tendency toward stability in the regression models, remained in the same categories throughout the period.

Discussion

The choice of SISVAN as an analysis tool allowed us to observe the epidemiological profile of primary health care users. The deficit of the linear growth in children under five years of age remains a relevant public health problem in the Brazilian Northern Region, with wide distinction among states. The prevalence observed in this study was classified between medium and high throughout the period studied, both for the overall Northern region and for its respective states. The authors observed that regional differences persist in the reduction in the prevalence of stunting observed in the period; only the states of Acre, Pará, and Tocantins showed a temporal tendency toward the decrease in stunting prevalence, pointing to the need for differentiated planning to combat chronic undernutrition according to the local epidemiological situation.

Analysis of the global situation of childhood in 2018 indicates a prevalence of 21.9% of stunting.[22] The data found in this study throughout the series, when compared with those from other regions of the world, place the Brazilian Northern Region in the same position as less developed countries, such as countries in Africa (14.7% to 33.6%) and Asia (34.4%), as well as above Latin America (16.5%),[22] indicating the existence of a great challenge in coping with chronic undernutrition in this region of the country.

Table 2 Temporal tendency of the prevalence of stunting among children under five years of age adjusted or not to coverage of SISVAN according to SISVAN, by state, Northern Region, Brazil, 2008-2017.

States	Without adjustment for SISVAN coverage			With adjustment for SISVAN coverage		
	Annual Percentage Variation % (95%CI)[a]	p-value[b]	Tendency	Annual Percentage Variation % (95%CI)[a]	p-value[b]	Tendency
Region North	**−3.13 (−4.14; −2.10)**	**< 0.001**	**Reduction**	**−5.30 (−9.64; −0.77)**	**0.028**	**Reduction**
Acre	−2.56 (−3.79; −1.31)	< 0.001	Reduction	−7.19 (−12.31; -1.77)	0.017	Reduction
Amapá	−0.05 (−1.54; 1.46)	> 0.05	Stability	−3.68 (−7.38; 0.17)	0.058	Stability
Amazonas	−3.79 (−4.71; −2.87)	< 0.001	Reduction	−4.01 (−7.99; 0.15)	0.056	Stability
Pará	−4.02 (−5.21; −2.82)	< 0.001	Reduction	−4.86 (−9.44; −0.03)	0.049	Reduction
Rondônia	−0.79 (−2.18; 0.62)	> 0.05	Stability	−1.18 (−7.53; 5.61)	0.685	Stability
Roraima	−0.77 (−6.02; 4.77)	> 0.05	Stability	0.51 (−11.05; 13.56)	0.925	Stability
Tocantins	−2.37 (−3.16; −1.57)	< 0.001	Reduction	−6.22 (−9.88; −2.41)	0.007	Reduction

[a] Values of annual percentage variation (APV) and their respective confidence intervals (95%CI) were obtained by Prais-Winsten regression, with and without the adjustment of the model for the SISVAN's coverage variable, and were estimated by the formula: APV = (-1+ [10^β]) × 100.
[b] p-value of the Prais-Winsten regression.

National surveys and other studies have already shown the precariousness of the nutritional situation in the Northern Region. Despite the significant decrease in stunting rates in other Brazilian regions since the 1980s, this region experienced the smallest decrease, with rates of 39% (1974/75), 23% (1989), and 16.6% (1996).[23] In the late 1990s and early 2000s, high rates of stunting were found among Amazon preschoolers living in rural areas such as in the Rio Negro River gutter (35.2%) and in ecosystems that are influenced by the Solimões (24.4%), Amazon (20.5%), Purus (20.9%), and Madeira (15.6%) rivers.[24] In 2006-2007, the estimated rate was 14.7% in this region, compared to 6.6% and 6.1% in the Northeast and Central-South regions, respectively, putting municipalities in this region at medium to high risk for the occurrence of chronic undernutrition.[25] In the same year, high rates were found in the northern states: 6.3% in Rondônia, 12.2% in Tocantins, 21.6% in Roraima, 25.1% in Amazonas, and about 30% in Acre, Amapá, and Pará.[6] Additionally, the indigenous population stands out with about 30% of children affected by chronic undernutrition and reaching 80% among the Yanomami people.[26,27]

Table 3 Standardized coefficient of the linear regression model between the variables: prevalence of chronic child undernutrition and coverage of SISVAN by states, Northern Region, Brazil, 2008-2017.

States	Standardized regression coefficient[a]	p-value[b]
Northern Region	−0.813	0.004
Acre	−0.725	0.018
Amapá	0.141	0.697
Amazonas	−0.874	0.001
Pará	−0.841	0.002
Rondônia	−0.330	0.352
Roraima	−0.173	0.632
Tocantins	−0.871	0.001

[a] Value of the standardized coefficient obtained from the simple linear regression model.
[b] p-value of simple linear regression.

In the Brazilian scenario, however, evidence points to a significant reduction in chronic undernutrition among children under five years of age, especially in the Northeast region of the country. These results are due to the increase in the purchasing power of families with lower social classes, increased maternal education, greater access to health care, and increased coverage of sanitation services; all of which are structural determinants related to child undernutrition.[28,29] In any case, we emphasize that the decline in the prevalence of child stunting was not enough to reclassify states considered with low or very low prevalence at the end of this time-series.

One of the factors that may be related to the precarious nutritional health of children in the Northern Region is the iniquity of access to health services, especially in rural areas.[30] Data on the structuring of primary care point to the North Region as a critical area.[31] Factors such as difficulty in regionalizing primary care, centralization of service provision at the headquarters of municipalities, and long distances between users and services - caused by the low population density of this region, especially the Amazon - explain the worse structuring of health care networks.[31] Geographical characteristics, such as the rivers and forests, become great challenges to be overcome; the low availability of transportation, among other difficulties, contribute to the concentration of health care centers in the urban areas and make it difficult for many communities to access health care.[30]

The expansion of Food and Nutrition Surveillance (VAN), within health surveillance, is expected to favor the organization of nutritional care aimed at children and groups that are vulnerable and at nutritional risk, by allowing the monitoring, diagnosis, and planning of interventions at the individual and collective level aimed at improving nutritional status.

The implementation of the VAN has increased since 2008, evidenced by the coverage of SISVAN.[32,33] In Northern Region, the SISVAN coverage increased from 12.2% in 2008 to

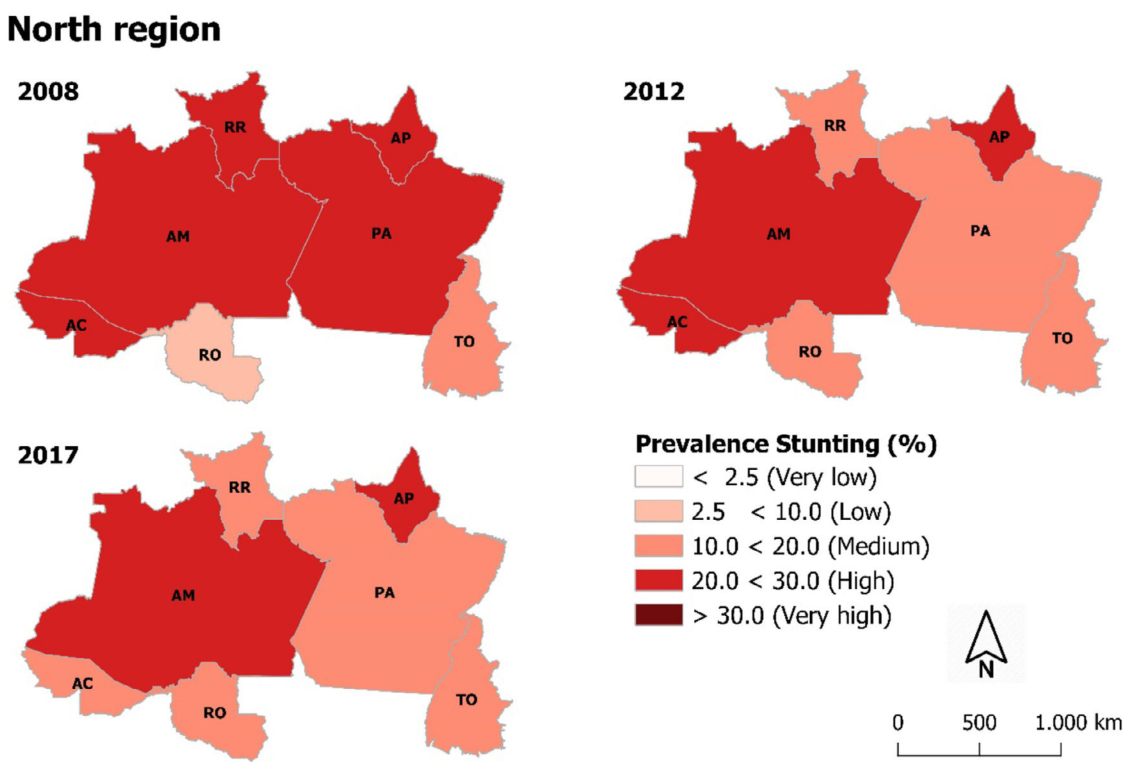

Figure. 1 Prevalence of stunting[a] among children under five years of age, according to SISVAN, categorized into four ranges, by state of the Northern Region, Brazil, 2008, 2012 and 2017. Classification of chronic child undernutrition based on de Onis et al.[20]
[a]Stunting was defined by low stature for age (z-score of the height-for-age index lower than -2 standard deviations) and very low stature for age (z-score of the height-for-age index less than -3 standard deviations).[20]

38% in 2017, which represented an annual increase of 14.2%. This annual increase in coverage ranged from around 9% in the states of Rondônia and Roraima to around 17% in the states of Acre, Amazonas, and Amapá; this past year, coverage rates ranged from 23.9% in the state of Rondônia to 46.1% in Tocantins, evidencing better monitoring of the nutritional situation in children under five years of age in this region.[33]

This increase in VAN suggests that the decreased tendency found here can be explained, at least in part, by the increase in SISVAN coverage between 2008 and 2017, considering that the insertion of the system coverage variable altered the results initially found in the regression model and showed a strong negative association with the prevalence of stunting. The expansion of VAN due to their computerized system can provide better care to children who use the service, being a cheap and adequate way for early identification of nutritional risks, for the prevention and intervention of diseases related to stunting, and finally, for the promotion of nutritional health in the first years of life. Given this potential positive impact, the authors recommend for the actions of VAN to be intensified throughout the Northern Region, especially in states that showed a stationary tendency. Moreover, understanding other variables that may explain or be associated with the scenario observed in this region is essential to support actions aimed at combating this form of undernutrition.

The results presented here may not reflect the reality considering that the source is secondary data, informed by the municipalities through the Municipal Health Departments. Anthropometric measurements may have been performed by professionals who were not qualified or properly trained and/or with equipment that is inadequate or without maintenance. Despite the limitations, however, the authors can clearly see the dimension of stunting in children under five years of age living in this region. This time-series study hopes to have contributed to scientific evidence on this form of child undernutrition; it may serve as a basis for the elaboration or adequacy of nutritional protocols promoting health and nutrition in childhood, specifically in the Brazilian Northern Region. Population surveys developed after the period defined in the present study, as well as future studies that will use nutritional data from health information systems, may benefit from the analysis presented here.

Conflicts of interest

The authors declare no conflicts of interest.

Acknowledgments

To the National Council for Scientific and Technological Development/CNPq, for the Research Productivity Grant - PCJ PQ (process 312148/2018-6). To Dr. Susy Cristina Pedroza da Silva for her technical support in editing the maps presented in this study.

References

1. Victora CG, Adair L, Fall C, Hallal PC, Martorell R, Richter L, et al. Maternal and child undernutrition: consequences for adult health and human capital. Lancet. 2008;371:340–57. Erratum in: Lancet. 2008;371:302.
2. United Nations Children's Fund (UNICEF). The State of the World's Children 2021: On My Mind – Promoting, protecting and caring for children's mental health. New York: UNICEF; 2021.
3. World Health Organization (WHO). Nutrition Landscape Information System (NLIS) country profile indicators: interpretation guide. Geneve: WHO; 2010.
4. Conde WL, Monteiro CA. Nutrition transition and double burden of undernutrition and excess of weight in Brazil. Am J Clin Nutr. 2014;100:1617S–22S.
5. Brasil. Ministério da Saúde. Centro brasileiro de análise e planejamento. Pesquisa Nacional de Demografia e Saúde da Criança e da Mulher (PNDS) 2006: dimensões do processo reprodutivo e da saúde da criança. Brasília: Ministério da Saúde; 2009.
6. Brasil. Ministério da Saúd. Secretaria de Atenção à Saúde. Departamento de Atenção Básica. Coordenação-Geral da Política Nacional de Alimentação e Nutrição. Chamada Nutricional da Região Norte - 2007. Brasília: eMinistério da Saúde; 2009.
7. Sathler D, Monte-Mór RL, Carvalho JAM. As redes para além dos rios: urbanização e desequilíbrios na Amazônia brasileira. Nova Econ. 2009;19:11–39.
8. World Health Organization (WHO) [internet]. 2017 [Cited 2022 Jul 09]. Available from: https://www.who.int/publications/m/item/childhood-stunting-context-causes-and-consequences-framework.
9. Budge S, Parker AH, Hutchings PT, Garbutt C. Environmental enteric dysfunction and child stunting. Nutr Rev. 2019;77:240–53.
10. Keusch GT, Rosenberg IH, Denno DM, Duggan C, Guerrant RL, Lavery JV, et al. Implications of acquired environmental enteric dysfunction for growth and stunting in infants and children living in low- and middle-income countries. Food Nutr Bull. 2013;34:357–64.
11. Morais MB, Silva GA. Environmental enteric dysfunction and growth. J Pediatr (Rio J). 2019;95:85–94.
12. Brasil. Dispõe sobre as condições para a promoção, proteção e recuperação da saúde, a organização e o funcionamento dos serviços correspondentes e dá outras providências. Diário Oficial da União. 20 set. 1990. Seção 1:018055.
13. Brasil. Ministério da Saúde. Secretaria de Atenção à Saúde. Departamento de Atenção Básica. Política Nacional de Alimentação e Nutrição. Brasília: Ministério da Saúde; 2013.
14. Brasil. Ministério da Saúde. Secretaria de Atenção à Saúde. Departamento de Atenção Básica. Marco de Referência da Vigilância Alimentar e Nutricional na Atenção Básica. Brasília: Ministério da Saúde; 2015.
15. Jaime PC, Santos LM. Transição nutricional e a organização do cuidado em alimentação e nutrição na atenção básica. Revista Divulgação em Saúde para Debate. 2014;51:72–85.
16. Coutinho JG, Cardoso AJ, Toral N, Silva AC, Ubarana JÁ, Aquino KK. A organização da Vigilância Alimentar e Nutricional no Sistema Único de Saúde: histórico e desafios atuais. Rev Bras Epidemiol. 2009;12:688–99.
17. World Health Organization (WHO). WHO Multicentre Growth Reference Study Group. WHO child growth standards: length/height-for-age, weight-for-age, weight-for-length and body mass index-for-age: methods and development. Geneva: WHO; 2006.
18. Brasil. Ministério da Saúde. Secretaria de Atenção à Saúde. Departamento de Atenção Básica. Orientações para coleta e análise de dados antropométricos em serviços de saúde; Norma Técnica do Sistema de Vigilância Alimentar e Nutricional (SISVAN). Brasília: Ministério da Saúde; 2011.
19. Antunes JL, Cardoso MR. Uso da análise de séries temporais em estudos epidemiológicos. Epidemiol Serv Saúde. 2015;24:565–76.
20. de Onis M, Borghi E, Arimond M, Webb P, Croft T, Saha K, et al. Prevalence thresholds for wasting, overweight and stunting in children under 5 years. Public Health Nutr. 2019;22:175–9.
21. Brasil. Ministério da Saúde. Portaria n° 884, de 13 de dezembro de 2011. Estabelece o fluxo para solicitação de cessão de dados dos bancos nacionais dos Sistemas de Informação. Diário Oficial da União. 14 dez 2011.
22. United Nations Children's Fund (UNICEF). The State of the World's Children 2019: Children, Food and Nutrition: Growing well in a changing world. New York: UNICEF; 2019.
23. Monteiro CA. A dimensão da pobreza, da desnutrição e da fome no Brasil. Estudos Avançados. 2003;17:7–20.
24. Alencar FH, Yuyama LK, Varejão MD, Marinho HA. Determinantes e conseqüências da insegurança alimentar no Amazonas: a influência dos ecossistemas. Acta Amaz. 2007;37:413–8.
25. Benício MH, Martins AP, Venancio SI, Barros AJ. Estimativas da prevalência de desnutrição infantil nos municípios brasileiros em 2006 [Estimates of the prevalence of child malnutrition in Brazilian municipalities in 2006]. Rev Saude Publica. 2013;47:560–70.
26. Mourão E, Vessoni AT, Jaime PC. Magnitude da Desnutrição Infantil na Região Norte Brasileira: uma Revisão de Escopo. Rev Bras Crescimento Desenvolv Hum. 2020;8:107129.
27. United Nations Children's Fund (UNICEF) [Internet]. Brazil; 2019 [Cited 2021 Oct 10]. Available from: https://www.unicef.org/brazil/comunicados-de-imprensa/unicef-alerta-sobre-desnutricao-cronica-de-criancas-ianomamis.
28. Monteiro CA, Benicio MH, Konno SC, Silva AC, Lima AL, Conde WL. Causes for the decline in child under-nutrition in Brazil, 1996-2007. Rev Saude Publica. 2009;43:35–43.
29. Lima AL, Silva AC, Konno SC, Conde WL, Benicio MH, Monteiro CA. Causes of the accelerated decline in child undernutrition in Northeastern Brazil (1986-1996-2006). Rev Saude Publica. 2010;44:17–27.
30. Garnelo L, Lima JG, Rocha ESC, Herkrath FJ. Acesso e cobertura da Atenção Primária à Saúde para populações rurais e urbanas na região norte do Brasil. Saúde Debate. 2018;42:81–99.
31. Soares Filho AM, Vasconcelos CH, Dias AC, Souza AC, Merchan-Hamann E, Silva MR. Primary Health Care in Northern and Northeastern Brazil: mapping team distribution disparities. Cien Saude Colet. 2022;27:377–86.
32. Nascimento FA, Silva SA, Jaime PC. Coverage of assessment of nutritional status in the Brazilian Food and Nutritional Surveillance System, 2008-2013. Cad Saude Publica. 2017;33:e00161516.
33. Mourão E, Gallo CO, Nascimento FAD, Jaime PC. Temporal trend of Food and Nutrition Surveillance System coverage among children under 5 in the Northern Region of Brazil, 2008-2017. Epidemiol Serv Saude. 2020;29:e2019377.