DOI: 10.1590/1413-81232022271.24122020

Time-trend analysis (2008-2018) of overweight prevalence among low-income infant and preschool children

Laís Gomes Lessa Vasconcelos (https://orcid.org/0000-0002-9445-1966) [1]
Nykholle Bezerra Almeida (https://orcid.org/0000-0002-8536-3972) [1]
Mayara Oliveira de Alencar Santos (https://orcid.org/0000-0001-9223-0177) [1]
Jonas Augusto Cardoso da Silveira (http://orcid.org/0000-0003-3838-6212) [1]

Abstract *This study aimed to analyze the overweight (OW) prevalence trends from 2008 to 2018 among under-five-year-old children assisted by the conditional cash transfer program entitled Programa Bolsa Família (PBF). The panel was based on the Food and Nutritional Surveillance System (SISVAN) (n=30,574,118) nutritional status reports. Age- (infants and preschoolers) and region-specific joinpoint regression models were used to analyze OW's prevalence temporal changes. Besides, the coverage of SISVAN for PBF and national representativity were calculated according to census projection. In the decade analyzed, OW in infants decreased from 11.9% (11.8; 12.0 95%CI) to 8.5% (8.4; 8.6 95%CI) (-3.6%/year [-5.1; -2.0 95%CI]); for preschool children, the prevalence of OW increased by 3.1%/year (2.0; 4.2 95%CI) until 2015, followed by a decrease until 2018 (-6.4%/year [-10.1; -2.6 95%CI]). In both age groups, the North region had the lowest prevalence in all time-series, and the Northeast had the worst performance in managing childhood obesity. The SISVAN's coverage in the PBF was high, and the data representativity varied between 13.9% (South) and 42.2% (Northeast). Although the prevalence was higher than expected, after 2014, it was detected a linear reduction in OW in infants and a deceleration in the growth rate in preschoolers.*

Key words *Child, Obesity, Food and Nutritional Surveillance*

[1] Núcleo de Estudos e Pesquisas sobre o Ambiente Alimentar, Laboratório de Nutrição em Saúde Pública, Faculdade de Nutrição, Universidade Federal de Alagoas. Av. Lourival Melo Mota s/n, Tabuleiro dos Martins. 57072-900 Maceió AL Brasil. jonas.silveira@fanut.ufal.br

Introduction

In recent decades, the prevalence of obesity in children and adolescents has dramatically increased worldwide. From 1975 to 2006, it increased from 0.7% to 5.6% for females, and from 0.9% to 7.8% for males[1]. In Brazil, time-trend analyses using data from the latest national maternal and child health surveys found that the prevalence of overweight (OW) in infants decreased 2.5 p.p. between 1989 and 2006[2]. However, concerning preschool children, there was an increasing trend from 3% to 7.8% between 1989 and 2006, with the Northeast region showing the greatest increase, from 1.6% to 7.2%[3].

Among these surveys, 2006/2007 National Demographic and Health Survey of Children and Women (DHSCW 2006/07) was the last nationally representative survey on child health in Brazil with anthropometric data. Therefore, there is a significant gap in knowledge about the current status of childhood obesity, especially in groups characterized by a high degree of social vulnerability, within a society that has experienced intense processes of change in dietary patterns[4].

Thus, health information systems constantly updated and with expanded coverage play a key role in monitoring the nutritional status of communities. In addition, these data serve as a tool to support decision-making, especially when they allow us to trace temporal trends and monitor populations in vulnerable conditions/participants of social support programs.

For this purpose, Brazil has the Food and Nutrition Surveillance System (In Portuguese, *Sistema de Vigilância Alimentar e Nutricional* - SISVAN). It is a surveillance system focused on collecting data from the population assisted by primary care of the Unified Health System (SUS). The information generated by SISVAN ranges from anthropometric data and food consumption markers to the generation of reports on the health and nutrition status of certain locations[5,6].

Given the background of lack of information and significant changes in the children's nutrition status profile, the SISVAN is a strategic tool for monitoring overweight in children under five years of age, mainly because it allows stratification by age groups (infants and preschool children). Another advantage of this surveillance system is the availability of information about the children who are beneficiaries of the *Bolsa Família* Program (PBF), characterized by high social vulnerability.

The PBF is a conditional cash transfer program of Brazil to reduce poverty and increase access to health, education, and social assistance services. It has three central pillars: cash transfer, conditionalities, and complementary programs. The health conditionalities include basic actions, such as immunization, prenatal care, and monitoring the growth and development of socially vulnerable children[7,8]. Thus, the data on children's nutritional status have high regional and national coverage[5,6].

In order to better understand the transformations in the nutritional profile of children under five, it may be interesting to stratify the groups according to developmental stages. Such an approach may provide new insights regarding the childhood obesity transition since infants and preschoolers represent stages with specific nutritional recommendations and different levels of autonomy and influence on food choices[9].

Therefore, this study aimed to evaluate the OW time-trend and the coverage of the nutritional status of infants (0-23 months) and preschoolers (24-59 months) assisted by the PBF in Brazil and its macro-regions between the years 2008 and 2018.

Methods

We conducted a time series analysis (2008-2018) of the OW prevalence in Brazil based on data from infants and preschoolers in a situation of high socioeconomic vulnerability assisted by the *Bolsa Família* Program, the most extensive conditional cash transfer program in the world[10]. Since the monitoring of the nutritional status in primary health care facilities is one of the conditionalities of the program, these data have a census feature regarding this population. For PBF, the woman is the reference for the transfer of the financial resource if all the conditions are met.

The data were extracted and aggregated by age group (0-23 months and 24-59 months), sex (male and female), and region of residence (North, Northeast, Midwest, Southeast, and South). We obtained these information from the annual reports on the nutritional status of children registered in the PBF Management System, generated from the public domain database SISVAN Web[11]. Since the prevalence estimates of OW were not different by sex, this stratification was not considered in our analyses.

The SISVAN platform does not produce consolidated reports with estimates for all the population sets of interest. Thus, to ensure the quality of the final database, the extraction and merging of the twelve microdata were done by two independent researchers.

The outcome variable used in this study was the OW prevalence, defined as the weight-for-age Z-score index (zPI)>+2DP and using the WHO Child Growth Standards[12] as reference. The zPI was used to the detriment of the other indexes since it only considers the child's weight, anthropometric data that is simpler, more practical, and cheaper to obtain; because it does not require an infantometer or stadiometer to measure height, this indicator has an increased coverage in the SISVAN. From a technical point of view, the professional's inability to measure height in children could be an additional source of error in the estimate.

Prevalence rates and their respective 95% confidence intervals (95%CI) were calculated using the *prop.test* function of the R software (R Foundation for Statistical Computing, Vienna, Austria) since the data were extracted as counts (number of overweight children and the total number of children).

Age- and region-specific OW prevalence trends were analyzed using *joinpoint regression* (Joinpoint Regression Program 4.8.0.1, The National Cancer Institute, MD, USA). This technique aims to identify *k*-inflection points on a straight line given by a linear equation (null hypothesis), where statistically significant changes in trend direction occur[13,14]. The criterion for selecting the final models with autocorrelated errors was based on the weighted (*data-driven*) Bayesian Information Criterion. Since the data were obtained as counts, the estimates were calculated by log-linear Poisson models. The results were presented as 1) annual percentage change (APC), which represents the annual change in OW rates at each *k*-model *jointpoint*; 2) average annual percentage change ($_{A}$APC), which represents a weighted average of the annual change in OW rates for the total time series period (2008-2018). All estimates have been presented with their respective 95% confidence intervals (95%CI).

The weight-for-age indicator coverage in SISVAN for the total number of children enrolled in the PBF was calculated from the consolidated reports of the Department of Primary Health Care of the Ministry of Health[15]. However, since the age range of child coverage by SISVAN is 0-5 years of age and the PBF reports stratify information for the 0-2 years and 0-7 years sets, the calculation of preschool coverage was performed by subtracting the number of children aged 0-7 years by the number of children aged 0-2 years. Thus, the coverage for preschool children is underestimated.

The national representativeness of the data in 2018 was estimated from the proportion of children registered in the PBF and with data available in SISVAN regarding the 2010 Census and the 2018 Population Projection, conducted by the Brazilian Institute of Geography and Statistics (IBGE)[16]. We used both as a reference to evaluate the national representativeness of the data since the 2018 Population Projection does not present estimations stratified by infants and preschoolers.

Since this was a study that used aggregated data from the public domain, there was no need for Ethics in Human Research Committee review.

Results

This study analyzed anthropometric data of under five years old children assisted by PBF available in SISVAN, representing an annual average of 574,993 and 2,204,471 infants and preschoolers evaluated, respectively, totaling 30,574,118 observations in the period from 2008 to 2018.

Table 1 presents SISVAN coverage in relation to the total number of infants and preschool children assisted by the PBF from all macro-regions in Brazil between 2008 and 2017. In the decade, it is observed that about ¾ of the infants had their weight monitored. As for preschoolers, although the observed coverage was close to 60%, it should be noted that this data is underestimated since the information is only available for those under seven years of age. The only year with a significant reduction in coverage for both age groups and macro-regions was 2012. This result was due to the migration between platforms for supplying data to the surveillance system (information obtained directly with national platform managers).

Table 2 presents the proportion of children accompanied in the PBF with weight-for-age data in SISVAN in relation to the 2010 Census and the 2018 Population Projection. The North and Northeast regions were the territories with the largest population contingent of children assisted by the PBF, representing, respectively, 22.3% and 27.9% for infants and 45.6% and 49.4% for preschoolers. Regarding the 2018 Population Projection, it was observed that children assisted by PBF and who had their nutritional status monitored in SISVAN represented ¼ of the Brazilian population under five years old.

Over the ten-year period, OW prevalence among socially vulnerable Brazilian under five

Table 1. Coverage of the Food and Nutrition Surveillance System (SISVAN) for infants and preschoolers assisted by the *Bolsa Família* Program in the five Brazilian regions between 2008 and 2017*.

Year	Age group (months)	Regions					Brazil (%)
		MW (%)	N (%)	NE (%)	S (%)	SE (%)	
2017	0-23	86.0	77.0	86.0	80.0	76.0	75.0
	24-59	67.4	58.7	55.0	62.4	56.4	57.0
2016	0-23	84.0	77.0	74.0	80.0	73.0	75.0
	24-59	65.3	60.0	55.5	61.8	53.3	56.6
2015	0-23	83.0	81.0	76.0	80.0	72.0	76.0
	24-59	61.6	59.8	55.5	61.2	54.2	56.5
2014	0-23	81.0	79.0	77.0	80.0	75.0	77.0
	24-59	61.0	58.4	55.5	60.9	55.5	56.6
2013	0-23	85.0	79.0	80.0	81.0	76.0	79.0
	24-59	60.9	58.1	56.7	59.0	55.3	57.0
2012	0-23	44.0	39.0	37.0	36.0	36.0	37.0
	24-59	44.9	40.0	42.7	40.5	39.4	41.5
2011	0-23	72.0	60.0	63.0	69.0	60.0	63.0
	24-59	62.0	54.5	56.0	62.8	55.8	56.6
2010	0-23	78.0	75.0	69.0	76.0	73.0	72.0
	24-59	60.8	61.5	55.3	58.8	58.8	57.5
2009	0-23	80.0	73.0	67.0	74.0	77.0	71.0
	24-59	62.9	59.6	54.3	58.5	61.2	57.2
2008	0-23	77.0	73.0	65.0	71.0	77.0	70.0
	24-59	51.9	50.7	45.5	47.6	52.0	48.1

MW: Midwest; NE: Northeast; N: North; SE: Southeast; S: South. *Until completion of the analysis, stratified data on 2018 coverage was not available.

Source: Authors.

years old children showed distinct temporal processes. Until 2015, trends that were stationary among infants (APC: -0.5%/year [-2.0; 1.0 95%CI]) and upward among preschoolers (APC: 3.1%/year [2.0; 4.2 95%CI]), became decreasing for both groups after that period ($APC_{infants}$: -10.3%/year [-15.1; -5.1 95%CI] / $APC_{preschoolers}$: -6.4%/year [-10.1; -2.6 95%CI]) (Table 3 and Figure 1). The $_{A}$APC for infants and preschoolers was -3.6%/year (-5.1; -2.0 95%CI) and 0.2%/year (-1.0; 1.3 95%CI), respectively.

When disaggregated by region, the joinpoint models identified statistically significant inflection points in the years 2013 (South and Southeast) and 2016 (Midwest, North, and Northeast) for both age groups studied (Figure 2 and Table 3).

Despite identifying these points, in relation to infants, it was observed that only the Midwest region showed a statistically significant trend in reducing OW prevalence in the first period (2008-2016 APC: -2.8%/year [-5.1; -0.5 95%CI]). As for the second period, in the South and Southeast regions (2013-2018), we identified that the decreasing OW trends were -7.5%/year (-11.3; -3.5 95%CI) and -8.3%/year (-1.9; -4.6 95%CI), respectively (Figure 2). Regarding $_{A}$APC, only the North and Northeast regions did not show a statistically significant prevalence reduction trend. Throughout the time series, the North region remained to show the lowest OW prevalence, and the Northeast region, the highest (Table 3).

Regarding the preschool children, we observed an increasing trend in the OW prevalence during the first period in the North (2008-2016 APC: 2.4%/year [0.9; 4.0 95%CI]), Northeast (2008-2016 APC: 3.9%/year [2.2; 5.5 95%CI]), and South (2008-2013 APC: 5.6%/year [2.8; 8.6 95%CI]) regions (Figure 2). In the second period, statistically significant negative variations were observed only in the South (APC: -3.6%/year [-5.8; -1.4 95%CI]) and Southeast (APC: -4.0%/year [-7.4; -0.4 95%CI]) regions, which makes the prevalence in 2018 practically the same as that observed in 2008 (Figure 2 and Table 3). Thus, based on the $_{A}$APC between 2008 and 2018, it is considered that the OW trend in preschoolers was stationary. As observed in infants, pre-

Table 2. National representativeness of the data from under five years old children assisted by *Bolsa Família* Program in the Food and Nutrition Surveillance System (SISVAN) based on the 2010 Census and the 2018 Population Projection*.

	2010 Census (0-23m)	2018 SISVAN (0-23m)		2010 Census (24-59m)	2018 SISVAN (24-59m)		2018 Projection (0-59m)**	2018 SISVAN (0-59m)**	
Brazil	5,408,153	973,442	18.0%	8,388,005	2,740,445	32.7%	14,787,557	3,713,887	25.1%
MW	420.146	57.612	13.7%	642.517	164.212	25.6%	1.221.426	221.824	18.2%
N	606,237	135,047	22.3%	947,311	431,767	45.6%	1,616,417	566,814	35.1%
NE	1,647,377	460,341	27.9%	2,584,532	1,276,150	49.4%	4,155,569	1,736,491	41.8%
S	696,141	77,010	11.1%	1,067,603	196,805	18.4%	1,985,078	273,815	13.8%
SE	2,038,252	243,432	11.9%	3,146,042	671,511	21.3%	5,809,067	914,943	15.8%

MW: Midwest; NE: Northeast; N: North; SE: Southeast; S: South. *Includes only children assisted by the Bolsa Família Program. **In the 2018 Population Projection, there are no estimates stratified by age groups (0-23 months and 24-59 months).

Source: Authors.

schoolers in the North region had the lowest OW prevalence in the entire time series (2008: 4.4% [4.3-4.5 95%CI]; 2018: 3.9% [3.8-4.0 95%CI]). On the other hand, in 2018, children assisted by PBF residing in the South and Northeast regions had the highest OW prevalence in Brazil.

Discussion

Our study evaluated the temporal trend of OW prevalence in children aged 0-59 months who are beneficiaries of the PBF, the largest conditional cash transfer program globally in terms of funding and coverage[10,17]. From the stratification into infants (0-23 months) and preschoolers (24-59 months), it was possible to observe two different OW trends in the decade from 2008 to 2018. In addition, we also identified critical regional differences from the disaggregation of the analyses, especially regarding the North region.

Previous studies[2,3] have already indicated that the OW prevalence since the early 1990s showed distinct behaviors. In 2006, the OW prevalence for the Brazilian infant and preschool population was 6.5% and 7.6%, respectively, which represented a decrease in children under two years of age and an increase in children between two and five years of age, based on 1989 prevalence estimates. Compared to the 2008 SISVAN estimates, the OW prevalence increased among infants but was similar among preschool children from deprived settings.

Despite the difference between the target populations, the consistency between the results indicates that the nutritional scenario presented in our study represents the continuity of the phenomenon that began in the 1970s, worsened in the early 2000s, and is apparently entering a new phase of the obesity transition process[2,3,18,19].

As the authors of the conceptual model of the obesity transition argue[20], Brazil presents a unique characteristic among the analyzed countries. In the Brazilian context, the prevalence of obesity among poorer women has continued to increase despite the reduction in prevalence among wealthier women; moreover, the prevalence of obesity among men has increased in all economic groups. When considering the parameters adopted by the authors to define the stage the country is at in the obesity transition process (prevalence of obesity, according to sex, age group, and economic level), Brazil could be classified in the initial stages of stage three. Brazil is assumed to be in the early stages of the process since the prevalence's magnitude among adults is lower than the proposed range proposed by Jaacks *et al.*[20]. On the other hand, it may be that Brazil has such peculiar characteristics that this conceptual model is not sufficient to explain the

Table 3. Overweight prevalence among infants and preschoolers assisted by the *Bolsa Família* Program with data on the Food and Nutrition Surveillance System (SISVAN) in the five Brazilian regions between 2008 and 2017.

Infants (0-23 months)												
Year	Regions										Brazil	
	MW		N		NE		S		SE			
	%	95% CI	%	95% CI	%	95% CI	%	95% CI	%	95% CI	%	95% CI
2008	12.6	12.0; 13.2	9.4	9.1; 9.8	12.7	12.5; 12.9	10.4	10.0; 10.8	11.6	11.4; 11.9	11.9	11.8; 12.0
2009	11.8	11.3; 12.3	9.9	9.6; 10.3	12.8	12.6; 12.9	11.0	10.6; 11.3	11.4	11.2; 11.7	12.0	11.9; 12.1
2010	11.4	11.0; 11.8	9.1	8.8; 9.3	13.0	12.9; 13.2	11.1	10.9; 11.4	11.5	11.3; 11.7	11.9	11.8; 12.0
2011	12.5	12.1; 13.0	10.0	9.7; 10.3	14.5	14.3; 14.7	11.9	11.5; 12.2	12.7	12.4; 12.9	13.3	13.2; 13.4
2012	10.4	10.0; 10.9	9.2	8.9; 9.5	13.2	13.0; 13.3	11.1	10.7; 11.5	12.0	11.8; 12.3	12.1	12.0; 12.2
2013	10.9	10.5; 11.2	9.7	9.5; 9.9	13.5	13.3; 13.6	11.5*	11.2; 11.8	11.9*	11.7; 12.1	12.3	12.2; 12.4
2014	11.6	11.3; 11.9	10.0	9.8; 10.2	14.0	13.9; 14.1	11.1	10.8; 11.3	11.5	11.3; 11.6	12.4	12.3; 12.5
2015	8.6	8.3; 8.9	8.3	8.1; 8.5	11.1	11.0; 11.2	9.0	8.8; 9.2	9.3	9.2; 9.4	10.0*	9.9; 10.1
2016	11.0*	10.7; 11.3	10.4*	10.2; 10.6	13.9*	13.7; 14.0	10.9	10.7; 11.2	11.0	10.9; 11.2	12.3	12.2; 12.4
2017	7.1	6.9; 7.3	7.4	7.3; 7.6	10.6	10.5; 10.7	8.1	7.9; 8.3	8.2	8.1; 8.4	9.2	9.1; 9.3
2018	6.6	6.4; 6.8	6.9	6.8; 7.0	9.8	9.7; 9.9	7.6	7.4; 7.8	7.6	7.5; 7.7	8.5	8.4; 8.6
$_{A}$APC	-6.8	-13.0; -0.1	-3.6	-8.1; 1.0	-3.3	-8.5; 2.1	-3.0	-5.9; -0.1	-3.6	-6.3; -0.8	-3.6	-5.1; -2.0
Preschoolers (24-59 months)												
Year	Regions										Brazil	
	MW		N		NE		S		SE			
	%	95% CI	%	95% CI	%	95% CI	%	95% CI	%	95% CI	%	95% CI
2008	7.8	7.6; 8.0	4.4	4.3; 4.5	7.1	7.0; 7.2	7.8	7.6; 7.9	7.9	7.8; 8.0	7.1	7.0; 7.2
2009	8.4	8.2; 8.6	5.0	4.9; 5.1	7.5	7.4; 7.6	8.4	8.3; 8.6	8.2	8.1; 8.3	7.5	7.4; 7.6
2010	8.0	7.9; 8.2	4.7	4.6; 4.8	7.9	7.8; 8.0	8.7	8.5; 8.8	8.3	8.2; 8.4	7.6	7.5; 7.7
2011	8.7	8.6; 8.9	4.9	4.8; 5.0	8.6	8.5; 8.7	9.5	9.3; 9.6	9.4	9.3; 9.5	8.4	8.3; 8.5
2012	8.0	7.9; 8.2	4.4	4.3; 4.5	8.7	8.6; 8.8	9.8	9.6; 9.9	9.2	9.1; 9.3	8.3	8.2; 8.4
2013	8.2	8.1; 8.4	4.9	4.8; 5.0	9.0	8.9; 9.1	10.1*	10.0; 10.3	9.5*	9.4; 9.6	8.6	8.5; 8.7
2014	9.1	8.9; 9.2	5.1	5.0; 5.2	9.7	9.6; 9.8	10.1	9.9; 10.2	9.2	9.1; 9.3	8.9	8.8; 9.0
2015	8.3	8.2; 8.4	4.7	4.6; 4.8	8.8	8.7; 8.9	9.4	9.3; 9.6	8.7	8.6; 8.8	8.2*	8.1; 8.3
2016	8.9*	8.7; 9.0	6.2*	6.1; 6.3	10.3*	10.2; 10.4	10.0	9.9; 10.2	9.6	9.5; 9.7	9.4	9.3; 9.5
2017	7.2	7.1; 7.3	4.6	4.5; 4.7	8.7	8.6; 8.8	8.8	8.7; 8.9	8.1	8.0; 8.2	7.8	7.7; 7.9
2018	7.0	6.9; 7.1	3.9	3.8; 4.0	8.0	7.9; 8.1	8.3	8.1; 8.4	7.5	7.4; 7.6	7.2	7.1; 7.3
$_{A}$APC	-2.0	-4.6; 0.8	-1.2	-3.9; 1.5	0.7	-2.4; 3.9	0.9	-0.6; 2.4	0.1	-2.2; 2.4	0.2	-1.0; 1.3

MW: Midwest; NE: Northeast; N: North; SE: Southeast; S: South. AAPC: average annual percentage change between 2008 and 2018. *Inflection point on overweight trend (joinpoint).

Source: Authors.

changes in the nutritional profile of the population. Another potential argument would be that, in Brazil, the final phase of the obesity transition process (reduction in prevalence) would start with the decline in the prevalence of obesity in children, which would subsequently, through the cohort effect, result in a reduction in the prevalence among adults.

Comparing with other contexts, based on national surveys conducted in the United States (USA), it was observed that the prevalence of obesity in children aged 2-5 years increased from 7.2% (5.8-8.8 95%CI) to 13.9% (10.7-17.7 95%CI) from 1988-1994 to 2003-2004; however, it is interesting to note that, as we observed in our population, after this peak, the trend also showed retraction (2013-2014: 9.4% [6.8-12.6 95%CI]). On the other hand, the overlap between confidence intervals of the central estimates suggests that the difference may have been due to sampling variation[21]. Worldwide, in 2019, it was estimated that 38.3 million (5.6% [4.9; 6.4 95% CI]) of children under five years of age were overweight[22]. Thus, although the national estimates are not at the same level as the USA (primarily because the USA's reference curve was used in the

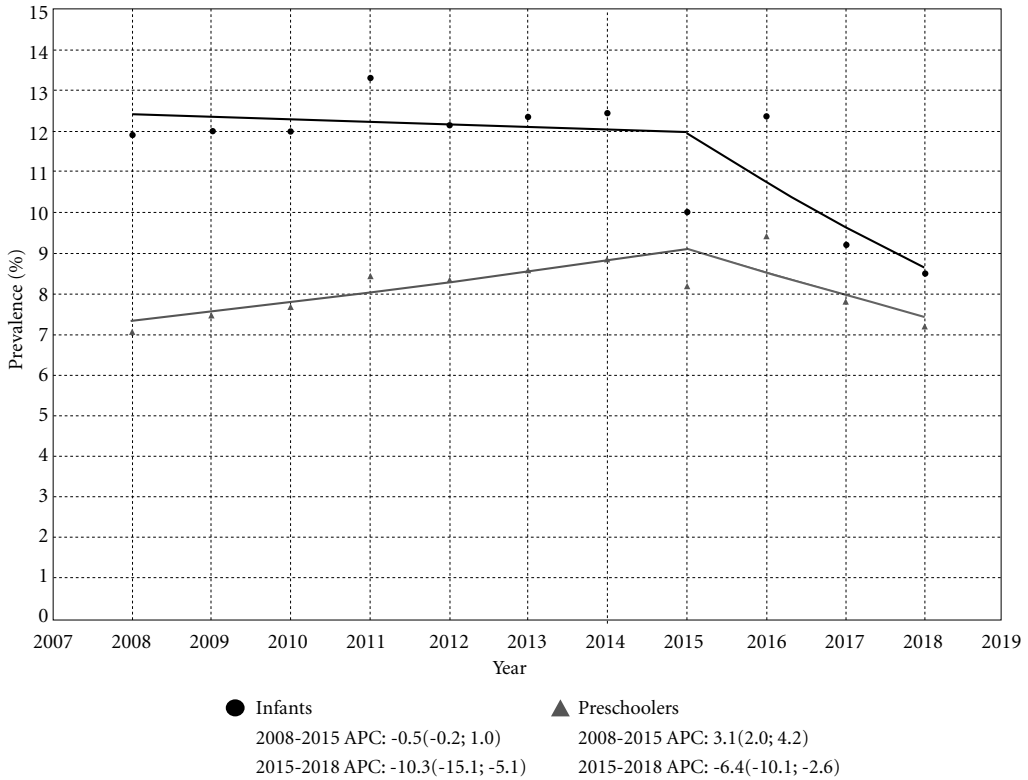


Figure 1. Trends in the overweight prevalence among infants and preschoolers assisted by the *Bolsa Família* Program. Brazil, 2008-2018.

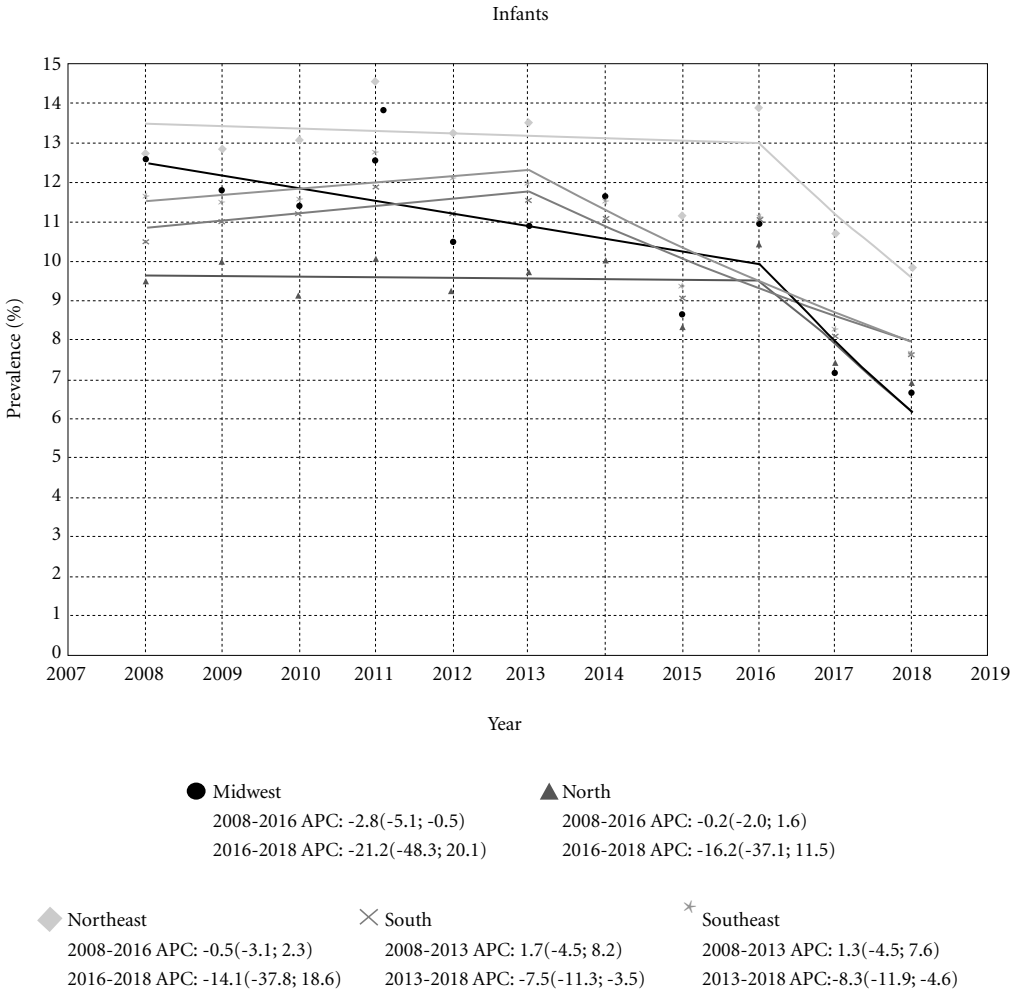
APC: annual percent change (the values in parentheses represent the APC's 95% confidence intervals).

Source: Authors.

analysis, which underestimates the OW prevalence compared to the WHO standards), our data indicate that the OW prevalence among PBF-assisted children is above the world prevalence, demonstrating the need to adopt a vulnerability approach to address childhood obesity.

Within a perspective of changes in Brazilian society and considering that breastfeeding in the first year of life significantly decreases the risk of childhood overweight[23], a possible hypothesis to partially justify the prevalence reduction in infants would be the increase in exclusive and total breastfeeding rates between 1996 and 2013[24]. On the other hand, despite this increase in breastfeeding indicators over the decades (since 1986), the prevalence rates in 2013 were still very low (exclusive BF in children under six months: 36.6%; BF in children under two years: 52.1%). Moreover, the authors show a significant reduction in breastfeeding during the first two years of life.

An important landmark for this interpretation may be the regional differences in prevalence and median duration of exclusive and total breastfeeding in 2008, observed in the II Brazilian Survey on Breastfeeding Prevalence in the Capitals and Federal District[25]. Except for the Midwest region, there is an apparent inverse association between OW prevalence and breastfeeding indicators, i.e., the regions where the breastfeeding duration is longer, the OW prevalence was lower in 2008; we highlight the North region, where the median breastfeeding duration was ~90 days higher than the median for Brazil. In the case of the Midwest, the hypothesis that justifies its exceptionality would be the fact that, although the median and prevalence of exclusive breastfeeding are comparable to those of the



it continues

Figure 2. Trends by region in the overweight prevalence among infants and preschoolers assisted by the *Bolsa Família* Program. Brazil, 2008-2018.

APC: annual percent change (the values in parentheses represent the APC's 95% confidence intervals).

Source: Authors.

North region, when we observe the estimates of total EBF during the first year of life, the region's indicators are similar to those of the Northeast.

Besides the low duration of exclusive breastfeeding, it is also necessary to examine the role of infant feeding. From an individual perspective, unhealthy feeding practices may be the product of the interrelationship between the insufficient knowledge about complementary feeding of mothers and family members[26] and the frequent exposure to unhealthy feeding practices by other families[27,28] (vicarious experience). Moreover, from a macro-social perspective, we can mention the implementation of fiscal and regulatory measures that encourage the consumption of unhealthy products[29] and the pernicious effect of the food industry's marketing practices through abusive advertising and sales strategies, such as cross promotion[30]. In relation to products aimed at children's consumption, food companies use the same visual identity of infant formula labeling for dairy compounds to intentionally mislead consumers in the acquisition of products with entirely different nutritional compositions.

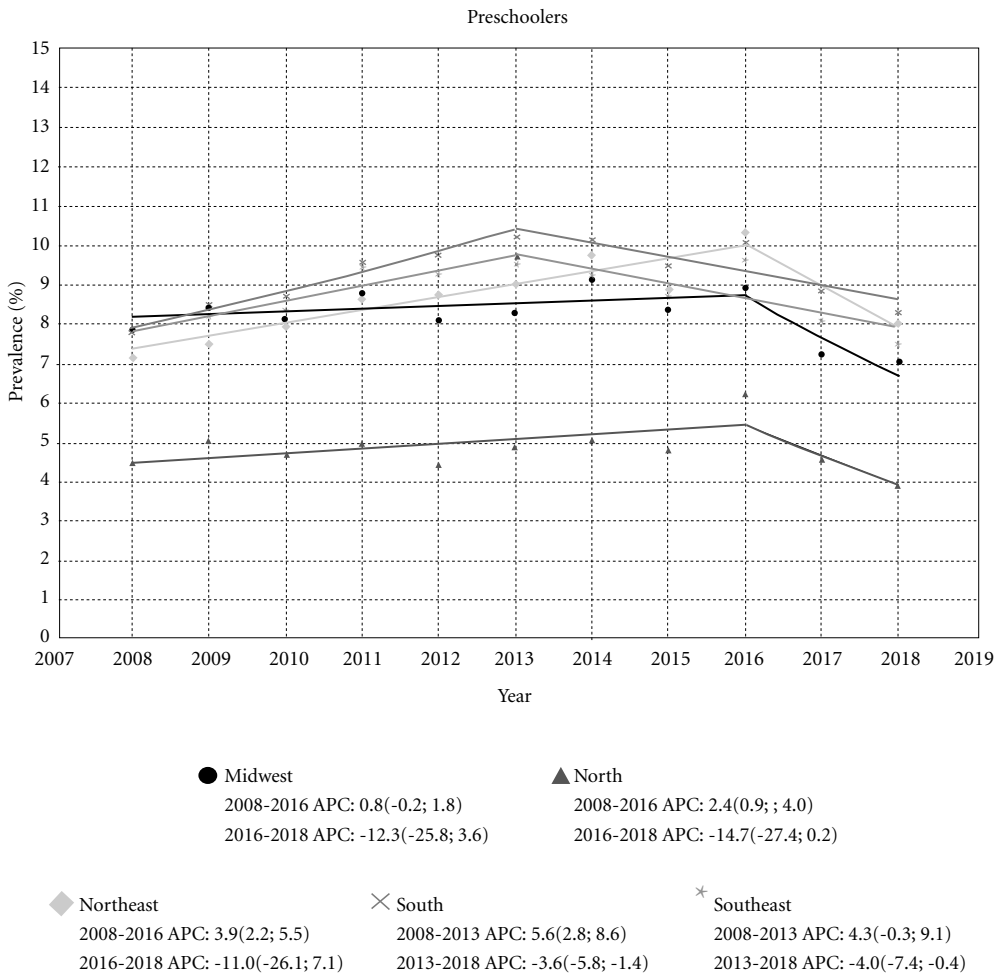


Figure 2. Trends by region in the overweight prevalence among infants and preschoolers assisted by the *Bolsa Família* Program. Brazil, 2008-2018.

APC: annual percent change (the values in parentheses represent the APC's 95% confidence intervals).

Source: Authors.

Within the analyzed decade, the main findings with national representativeness about infant feeding and overweight come from the DHSCW 2006/07, limiting the ability to hypothesize about the mechanisms that may have influenced the variation in prevalence in preschool children.

Except in the North region, until mid-2014, even if with different magnitudes, the OW trend in preschool children increased in all Brazilian regions. When considering consumption data from the DHSCW 2006/07 as a baseline, we observed that the consumption of soft drinks and artificial juices (≥4x/day) was twice as frequent among preschool children in the South, Southeast, and Midwest regions compared to the North and Northeast regions[28]. Still considering the data from 2006/07, another study identified a positive association between the intensity of consumption of sugary drinks and artificial juices and excessive weight gain in preschool children[31].

As for the OW trend among preschoolers in the North region, the geographical distance may have introduced limitations to disseminating ultra-processed foods in the states. However, despite the ultra-processed foods' presence, it is scarce, especially in the interior, since the fre-

quent consumption of sweets, cookies, packaged snacks, and soft drinks, and artificial juices is less frequent than in more economically developed regions[27]. Furthermore, the greater presence of traditional communities (indigenous, *quilombolas*, and river dwellers) may be an important factor in maintaining health-protective eating behaviors and practices.

However, it is essential to consider that the trends analyzed refer to populations in poverty. This apparent paradox between socioeconomic vulnerability and overweight can be understood from the perspective of food insecurity, a phenomenon in more than 60% of families below the poverty line in 2013[32]. Considering households with children, mild and moderate food insecurity describe a process of substitution in the acquisition of food by the families, where there is a reduction in the quality of the food to favor quantity[33,34]; while in mild insecurity, the children are not necessarily affected by this process, in moderate insecurity, there is a reduction in the quality of the children's diet. Despite studies reporting the association with overweight[35], inconsistencies in the findings may stem from the predominance of cross-sectional studies (limiting the ability to establish causal relationships). They may also derive from the OW prevalence and the degree of social deprivation in the study population.

Finally, based on the analyses carried out by Rasella *et al.*[36], we consider that a potential explanation for the observed phenomena may lie in the effects of the worsening economic and political crises that began in 2014 and the fiscal austerity measures taken in 2016. Thus, reductions in the OW prevalence would not be due to improved food and nutrition conditions but instead to violations of the Human Right to Adequate Food and Nutrition, promoting the growth of child malnutrition in groups facing situations of socioeconomic vulnerability[37,38]. In this sense, it is urgent that researchers carry on state-level investigations, disaggregating data by specific populations (e.g., traditional populations), to explore this hypothesis; analyses based on SISVAN data are currently underway.

This study has some limitations. First, since we used secondary data, the spectrum of variation in the accuracy of anthropometric measurements may be large, given that the evaluations were performed by professionals with different levels of proficiency in anthropometry; moreover, there is no guarantee regarding the quality and calibration of the equipment used. One way to minimize these problems was to use an indicator that requires only the child's weight to be calculated, which is a simpler measure to obtain and also appropriate for assessing under five years old children's nutritional status[12].

Despite the limitations, our analyses reliably reproduce the temporal dynamics of OW prevalence in Brazilian children under five years of age assisted by the PBF; moreover, given the territorial representativeness, we consider it relatively safe to generalize our data to other groups of low-income children, especially to those living in the North and Northeast regions. The conclusion of the National Child Nutrition Study[39] will fill the massive gap on the health and nutrition status of children under five years old, dated 2006/07, corroborating or not the external validity of SISVAN for child populations.

Conclusion

In the analyzed decade, we identified two distinct patterns in the OW temporal trend among Brazilian children under five years old who were assisted by the PBF. First, there was a steady reduction in the OW prevalence among infants, and despite differences in 2008, the rates of decrease were similar across regions, except in the Midwest, where the reduction was more intense. Second, as for preschool children, we observed that until 2013/2016, the OW trend showed an upward trajectory in all Brazilian regions, with subsequent reduction in prevalence rates to values close to the initial ones.

Therefore, the data show that the prevalence of childhood obesity among children assisted by the PBF and potentially other low-income groups in Brazil is entering a period that will be characterized by reduction or stabilization. It is recommended that future studies seek to understand the trends from a systemic perspective, involving economic, political, and national food system scenarios.

Finally, we reinforce the importance of SISVAN as a fundamental instrument for managing the National Food and Nutrition Policy in Brazil. Challenges for the System are expanding the coverage of nutritional status for children followed in primary health care and, especially, the markers of food consumption, whose coverage in 2018 for children under five years old was 3.2%[40].

Collaborations

LGL Vasconcelos contributed to the study's conceptualization and methodology, data curation, and writing the original draft. NB Almeida contributed to the study's conceptualization and methodology, data curation, and writing the original draft. MOA Santos contributed to the study's methodology, data curation, and writing the original draft. JAC Silveira contributed to the study's conceptualization and methodology, formal data analysis, supervision, and revising the original draft.

References

1. NCD Risk Factor Collaboration (NCD-RisC). Worldwide trends in body-mass index, underweight, overweight, and obesity from 1975 to 2016: a pooled analysis of 2416 population-based measurement studies in 128,9 million children, adolescents, and adults. *Lancet* 2017; 390(10113):2627-2642.
2. Cocetti M, Taddei JAAC, Konstantyner T, Konstantyner TCRO, Barros Filho AA. Prevalence and factors associated with overweight among Brazilian children younger than 2 years. *J Pediatr (Rio J)* 2012; 88(6):503-508.
3. Silveira JAC, Colugnati FAB, Cocetti M, Taddei JAA. Secular trends and factors associated with overweight among Brazilian preschool children: PNSN-1989, PNDS-1996, and 2006/07. *J Pediatr (Rio J)* 2014; 90(3):258-266.
4. Brasil. Ministério da Saúde (MS). *Pesquisa Nacional de Demografia e Saúde da Criança e da Mulher – PNDS 2006*. Brasília: MS; 2008.
5. Brasil. Ministério da Saúde (MS). *Orientações para a coleta e análise de dados antropométricos em serviços de saúde: Norma Técnica do Sistema Vigilância Alimentar e Nutricional – SISVAN*. Brasília: MS; 2011.
6. Brasil. Ministério da Saúde (MS). *Marco de referência da vigilância alimentar e nutricional na atenção básica*. Brasília: MS; 2015.
7. Moraes VD, Machado CVO. Programa Bolsa Família e as condicionalidades de saúde: desafios da coordenação intergovernamental e intersetorial. *Saude Debate* 2017; 41:129-143.
8. De Bem Lignani J, Sichieri R, Burlandy L, Salles-Costa R. Changes in food consumption among the Programa Bolsa Família participant families in Brazil. *Public Health Nutr* 2011; 14(5):785-792.
9. Silventoinen K, Rokholm B, Kaprio J, Sørensen TI. The genetic and environmental influences on childhood obesity: a systematic review of twin and adoption studies. *Int J Obes (Lond)* 2010; 34(1):29-40.
10. Shei A, Costa F, Reis MG, Ko AI. The impact of Brazil's Bolsa Família conditional cash transfer program on children's health care utilization and health outcomes. *BMC Int Health Hum Rights* 2014; 14(1):10.
11. Brasil. Ministério da Saúde (MS). Secretaria de Atenção Primária à Saúde. Sistema de Vigilância Alimentar e Nutricional. *Relatórios de acesso público – Estado nutricional* [Internet]. [acessado 2020 ago 23]. Disponível em: http://sisaps.saude.gov.br/ sisvan/relatorio-publico/index.
12. World Health Organization (WHO). *WHO child growth standards: length/height-for-age,weight-for-age, weight-for-length, weight-for-height and body mass index-for-age: Methods and development*. Geneva: WHO; 2006.
13. Kim H-J, Fay MP, Feuer EJ, Midthune DN. Permutation Tests for Joinpoint Regression with Applications to Cancer Rates. *Stat Med* 2000; 19(3):335-351.
14. Kim J, Kim H-J. Consistent model selection in segmented line regression. *J Stat Plan Infer* 2016; 170:106-116.
15. Brasil. Ministério da Saúde (MS). Departamento de Atenção Básica. Coordenação Geral de Alimentação e Nutrição. *Portal do Bolsa Família - Relatórios consolidados* [Internet]. [acessado 2020 ago 23]. Disponível em: http://bolsafamilia.datasus.gov.br/w3c/bfa_relconsol.asp.
16. Instituto Brasileiro de Geografia e Estatística (IBGE). *Projeções da População 2018* [Internet]. [acessado 2020 ago 23]. Disponível em: https://www.ibge.gov.br/estatisticas/sociais/populacao/9109-projecao-da-populacao.html?=&t=downloads.
17. Pase HL, Melo CC. Políticas públicas de transferência de renda na América Latina. *Ver Adm Publica* 2017; 51(2):312-329.
18. Monteiro CA, Conde WL, Popkin BM. Income-specific trends in obesity in Brazil: 1975-2003. *Am J Public Health* 2007; 97(10):1808-1812.
19. Brasil. Ministério da Saúde (MS). *Vigitel Brasil 2018: vigilância de fatores de risco e proteção para doenças crônicas por inquérito telefônico: estimativas sobre frequência e distribuição sociodemográfica de fatores de risco e proteção para doenças crônicas nas capitais dos 26 estados brasileiros e no Distrito Federal em 2018*. Brasília: MS; 2019.
20. Jaacks LM, Vandevijvere S, Pan A, McGowan CJ, Wallace C, Imamura F, Mozaffarian D, Swinburn B, Ezzati M. The obesity transition: stages of the global epidemic. *Lancet Diabetes Endocrinol* 2019; 7(3):231-240.
21. Ogden CL, Carroll MD, Lawman HG, Fryar CD, Kruszon-Moran D, Kit BK, Flegal KM. Trends in obesity prevalence among children and adolescents in the United States, 1988-1994 through 2013-2014. *JAMA* 2016; 315(21):2292-2299.
22. World Health Organization (WHO). Global Health Observatory. *Joint child malnutrition estimates 2020 edition* [Internet]. [cited 2020 ago 23]. Available from: http://apps.who.int/gho/tableau-public/tpc-frame.jsp?id=402.
23. Weng SF, Redsell SA, Swift JA, Yang M, Glazebrook CP. Systematic review and meta-analyses of risk factors for childhood overweight identifiable during infancy. *Arch Dis Child* 2012; 97(12):1019-1026.
24. Boccolini CS, Boccolini PDMM, Monteiro FR, Venâncio SI, Giugliani ERJ. Tendência de indicadores do aleitamento materno no Brasil em três décadas. *Rev Saude Publica* 2017; 51(1):108.
25. Brasil. Ministério da Saúde (MS). Secretaria de Atenção à Saúde. Departamento de Ações Programáticas e Estratégicas. *II Pesquisa de Prevalência de Aleitamento Materno nas Capitais Brasileiras e Distrito Federal*. Brasília: MS; 2009.
26. Pizzatto P, Dalabona CC, Correa ML, Neumann NA, Cesar JA. Maternal knowledge on infant feeding in São Luís, Maranhão, Brazil. *Rev Bras Saude Mater Infant* 2020; 20(1):169-179.
27. Alves MN, Muniz LC, Vieira MFA. Consumo alimentar entre crianças brasileiras de dois a cinco anos de idade: Pesquisa Nacional de Demografia e Saúde (PNDS), 2006. *Cien Saude Colet* 2013; 18(11):3369-3377.

28. Vega JB, Poblacion AP, Taddei JAAC. Fatores associados ao consumo de bebidas açucaradas entre pré-escolares brasileiros: inquérito nacional de 2006. *Cien Saude Colet* 2015; 20(8):2371-2380.
29. Moodie R, Stuckler D, Monteiro C, Sheron N, Neal B, Thamarangsi T, Lincoln P, Casswell S, Lancet NCD Action Group. Profits and pandemics: prevention of harmful effects of tobacco, alcohol, and ultra -processed food and drink industries. *Lancet* 2013; 381(9867):670-679.
30. Prado ISCF, Rinaldi AEM. Compliance of infant formula promotion on websites of Brazilian manufacturers and drugstores. *Rev Saude Publica* 2020; 54:12.
31. Silveira JAC, Colugnati FAB, Poblacion AP, Taddei JAAC. The role of exclusive breastfeeding and sugar-sweetened beverage consumption on preschool children's weight gain. *Pediatr Obes* 2015; 10(2):91-97.
32. Instituto Brasileiro de Geografia e Estatística (IBGE). *Pesquisa Nacional por Amostra de Domicílios: segurança alimentar 2013*. Rio de Janeiro: IBGE; 2014.
33. Segall-Corrêa AM, Marin-León L, Melgar-Quiñonez H, Pérez-Escamilla R. Aprimoramento da Escala Brasileira de Medida Domiciliar de Insegurança Alimentar: recomendação de EBIA com 14 itens. *Rev Nutr* 2014; 27(2):241-251.
34. Uchimura KY, Bosi MLM, Lima FELD, Dobrykopf VF. Qualidade da alimentação: percepções de participantes do programa bolsa família. *Cien Saude Colet* 2012; 17(3):687-694.
35. Monteiro F, Schmidt ST, Costa IBD, Almeida CCB, Matuda NDS. Bolsa Família: insegurança alimentar e nutricional de crianças menores de cinco anos. *Cien Saude Colet* 2014; 19(5):1347-1358.
36. Rasella D, Basu S, Hone T, Paes-Sousa R, Ocké-Reis CO, Millett C. Child morbidity and mortality associated with alternative policy responses to the economic crisis in Brazil: A nationwide microsimulation study. *PLoS Med* 2018; 15(5):e1002570.
37. Souza LEPF, Barros RD, Barreto ML, Katikireddi SV, Hone TV, Sousa RP, Leyland A, Rasella D, Millett CJ, Pescarini J. The potential impact of austerity on attainment of the Sustainable Development Goals in Brazil. *BMJ Glob Health* 2019; 4(5):e001661.
38. Paes-Sousa R, Rasella D, Carepa-Sousa J. Política econômica e saúde pública: equilíbrio fiscal e bem-estar da população. *Saude Debate* 2018; 42:172-182.
39. Estudo Nacional de Alimentação e Nutrição Infantil (ENANI) [Internet]. [acessado 2020 ago 23]. Disponível em: https://enani.nutricao.ufrj.br.
40. Brasil. Ministério da Saúde (MS). Secretaria de Atenção Primária à Saúde. Sistema de Vigilância Alimentar e Nutricional. *Relatórios de acesso público – Consumo alimentar* [Internet]. [acessado 2020 ago 23]. Disponível em: http://sisaps.saude.gov.br/sisvan/relatoriopublico/index.

Article submitted 11/06/2020
Approved 20/11/2020
Final version submitted 22/11/2020

Chief editors: Romeu Gomes, Antônio Augusto Moura da Silva