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Spatial correlation between excess weight, purchase of ultra-processed foods, and human development in Brazil

Diôgo Vale [1]
Célia Márcia Medeiros de Morais [2]
Lucia de Fátima Campos Pedrosa [2]
Maria Ângela Fernandes Ferreira [3]
Ângelo Giuseppe Roncalli da Costa Oliveira [3]
Clélia de Oliveira Lyra [2]

Abstract *The aim of this study was to analyze the spatial distribution of excess weight in Brazil and its correlation with household food insecurity, purchase of foods by type of processing, and Human Development Index (HDI). An ecological study was undertaken using data from three surveys conducted by the Brazilian Institute of Geography and Statistics. Spatial analysis techniques were used to perform univariate and bivariate analysis. The prevalence of excess weight was 34.2% (CI 95% 33.8-34.6%). Excess weight showed a moderate and significant spatial autocorrelation (0.581; p = 0.01), with higher prevalence in states in the South, Southeast and Center-West regions. A positive moderate spatial correlation was shown between the prevalence of excess weight and HDI (0.605; p < 0.05) and purchase of ultra-processed foods (0.559; p < 0.05), while a negative moderate spatial correlation was observed between prevalence of excess weight and household food insecurity (-0.561; p < 0.05). It can be concluded that there is an unequal distribution of excess weight across Brazil. The highest prevalence rates were found in states in the Southeast, South, and Center-West regions, associated with higher HDI values and higher ultra-processed food purchases as a proportion of overall household food purchases.*

Key words *Nutritional epidemiology, Nutritional status, Medical geography, Industrialized foods*

[1] Programa de Pós-Graduação em Nutrição, Universidade Federal do Rio Grande do Norte (UFRN). Av. Senador Salgado Filho 3000, Lagoa Nova. 59078-970 Natal RN Brasil. diogovaleufrn@gmail.com
[2] Departamento de Nutrição, UFRN. Natal RN Brasil.
[3] Departamento de Odontologia, UFRN. Natal RN Brasil.

Introduction

Excess weight is a nutritional problem with multidimensional determinants. Individual aspects of this problem, such as the nutritional quality of food consumed and energy expenditure, are strongly influenced by household factors like food insecurity and the type of food available for consumption[1]. In this respect, the social situation of households varies between neighborhoods, municipalities, states, and countries[2].

To understand the increase in prevalence of excess weight it is necessary to investigate a range of determining or conditioning factors that influence the health and nutritional status of a population group[3]. To this end, the use of the concepts of space and territory developed by Milton Santos[4] allows researchers to widen the focus when exploring social determinants of health care and nutritional status. It is understood that the social appropriation of space produces territories and territorialities that are conducive to a rise in the prevalence of certain diseases, including those linked to nutritional status such as excess weight. Therefore, the prevalence of excess weight across territories, each with their own social dynamics, may vary and should be investigated to ensure the successful implementation of more specific and resolutive food and nutrition policies and actions. In this respect, the spatial analysis of health data[5] is an important technique for understanding the dynamics of the prevalence of excess weight across territories.

In his work *Geografia da Fome* (The Geography of Hunger), Josué de Castro described different realities in relation to diet and nutrition in Brazil, whose territory he divided into five regions: two where hunger was classified as endemic (*Amazônica* and *Nordeste Açucareiro* or Amazon and Northeast Sugarcane regions), one where hunger was classified as epidemic (*Sertão Nordestino* or "Northeast Outback"), and two defined as areas of malnutrition (Center-West and Extreme South)[6]. His description made a significant contribution to thinking about the factors that influence eating habits practices across Brazil, such as the social realities in each territory, their models of production and income generation, and social inequality.

However, this territorial analysis was conducted at a time when Brazil's main nutritional problems were protein-calorie malnutrition and hunger. Since then, few researchers have analyzed the overall spatial pattern of nutritional problems in Brazil, with the majority focusing on the spatial distribution of nutritional deficiencies in specific age groups[7-11].

The nutrition transition in Brazil is characterized by a significant drop in the prevalence of malnutrition and a rise in excess weight and obesity across different age and income groups[12]. These changes are associated with consumption or availability of food products with a poorer nutrient profile and high energy density[13]. It is also important to highlight the high prevalence of household food insecurity[14]. Despite this paradox, there is a relationship between excess weight and food insecurity[15].

In Brazil, food in securityis assessed using the Brazilian Food Insecurity Scale (BFIS), an adapted version of the US Department of Agriculture's Core Food Security Module[16], the most widely used screening tool for food insecurity. The BFIS is a psychometric scale that assesses household access to food. It directly measures the phenomenon based on the food insecurity experience as perceived by the affected individuals, capturing difficulty in accessing food and the psychosocial dimensions of food insecurity[17].

Food processing is an important aspect that should be taken into consideration when investigating the high prevalence of excess weight and food insecurity. Food can be classified by the type of processing it undergoes: unprocessed or minimally processed foods, which do not undergo any change after being extracted from nature - apart from washing, grinding, drying, and other processes that do not involve the addition of salt, sugar, oils, fats, or other substances -such as rice, beans, meat, fruit, and milk; processed culinary ingredients, which are extracted from foods and are used for seasoning, cooking, and creating culinary preparations, such as oils, butter, sugar and salt; processed foods, which are manufactured and involve the addition of processed culinary ingredients, such as vegetables in brine, fruits in syrup, and canned fish; and ultra-processed foods, which are industrial formulations made principally of substances derived from foods or nonfoods, such as sodas, sausages, and cereal bars[18].

Recent studies have raised concerns over the link between increased consumption of ultra-processed foods and the rise in nutritional disorders[19] and increased risk of noncommunicable diseases[20]. These types of food also affect the social, cultural, economic, and environmental development of a territory, especially when they account for an increasingly large part of food supply[21,22].

These trends in dietary patterns and nutritional status are accompanied by population aging and increased prevalence of noncommunicable diseases. However, these demographic and epidemiological transitions occur in different ways across Brazil, normally influenced by the level of social development of each territory[22,23].

It is believed that there is a spatial correlation between excess weight, food insecurity, the quality of food consumed, and social development across Brazil. The aim of this study was therefore to analyze the spatial distribution of the prevalence of excess weight and its correlation with household food insecurity, household food purchases by type of processing, and the Human Development Index (HDI) across the states of Brazil.

Methods

An exploratory ecological study was conducted using Brazil's 27 states as the units of analysis. Data from the following population surveys conducted by the Brazilian Institute of Geography and Statistics (IBGE, acronym in Portuguese) was used: the 2008-2009 Household Budget Survey (POF, acronym in Portuguese)[24,25] and the food security complement of the 2008-2009National Household Sample Survey (PNAD, acronym in Portuguese)[14]. Information on social development was collected from the Human Development Atlas in Brazil2010, systematized by the United Nations Development Program (UNDP)[26].

The sampling plans of the POF and PNAD used complex sampling procedures involving the geographical and statistical stratification of the country's census tracts, random sampling of tract clusters within strata, and random sampling of households within the tracts[24,25]. Although sampling plans adopted by the surveys differ, each household represents a given number of permanent private households of the population (universe) from which the study sample was selected. With specific regard to the POF, each household in the sample is assigned a sampling weight or adjusted expansion factor, from which it was possible to obtain the estimates of prevalence of excess weight for the study sample universe.

Prevalence of the dependent variable excess weight was determined using weight and height-based nutritional status indicators. Data imputation and critical processing was performed by the IBGE to correct the data for response errors related to the values rejected in the critical and missing values stage. The imputed weight and height data was used for the purposes of the present study. The study population comprised 190,159 people. The anthropometric data of 1,698 pregnant women was excluded, resulting in a final sample of 188,461 individuals[24].

Weight and height-based nutritional status was categorized into the following age groups: 0 to 4 years, 11 months and 29 days; 5 to 9 years, 11 months and 29 days; 10 to 19 years, 11 months and 29 days; 20 to 59 years, 11 months and 29 days; and over 60 years. For all age groups, Body Mass Index (BMI) was calculated using the formula [weight (kg)/height^2 (m)]. For children and adolescents, excess weight was assessed based on the variables weight, height, age, and sex. These variables were processed using the software packages WHO Anthro[27] and WHO AnthroPlus[28], respectively, to calculate the BMI-for-age (BMI-A) z-score for each child and adolescent according to the WHO Child Growth Standards[29]. For the age groups 0 to 9 years, 11 months and 29 days and 10 to 19 years, 11 months and 29 days, excess weight was defined according to the respective cut-off point for each group (BMI-A $\geq$ +2SD and BMI-A $\geq$ +1SD, respectively)[30]. For adults (20 to 59 years,11 months and 29 days) and older adults ($\geq$ 60 years) BMI equal to or greater than 25kg/m^2 and 27 kg/m^2, respectively, was considered excess weight[30].

Four independent variables were used to represent the factors of interest: household food insecurity, quality of food available for consumption in the household, and social development. Household food insecurity was measured based on the prevalence of household food insecurity (%) reported by the PNAD 2008-2009[14], defined as the sum of households in the food security categories mild, moderate, and severe assessed using the BFIS[14]. Quality of food available for consumption in the household was measured based on the purchase per capita of unprocessed or minimally processed foods (%) and ultra-processed foods (%) as a proportion of total household food purchases, using the classification proposed by the Dietary Guidelines for the Brazilian Population[18]. The food purchase data comprised aggregate measures of annual per capita household food purchases[21] in kilograms of 312 items listed in the POF 2008-2009[25] collected from the IBGE's Automatic Recovery System (SIDRA, acronym in Portuguese). The variable social development was based on the HDI for each state taken from the Human Development Atlas in

Brazil2010[26]. The HDI is an arithmetic average of three subindices: life expectancy, education, and income.

Descriptive data analysis was performed using the software package Statistical Package for the Social Sciences(SPSS) using frequencies, a 95% confidence interval, and design effect for the prevalence of excess weight. For the variables household food insecurity and quality of food available in the household, which were aggregated, frequencies were described as percentages. The variables were described for each state and Brazil as a whole.

Spatial analysis was performed based on the digital grid of each state using two geographic information system (GIS) software packages. The analysis used continuous variables. Spatial analysis was conducted using the software Terra View 4.1.0 (National Institute for Space Research; http://www.dpi.inpe.br/terraview). Spatial autocorrelation was measured using Global Moran's I (I_G), which varies between -1 and +1and computes the p-value indicating whether differences are statistically significant or not. Subsequently, the data was analyzed to detect spatial clusters according to Local Indicators of Spatial Association (LISA). To this end, a box map was elaborated for the dependent variable and each independent variable. The cartograms show four types of spatial clusters: high-high (regions made up of states with a high frequency of the variable, surrounded by regions with high frequencies); low-low (regions made up of states with a low frequency of the variable, surrounded by regions with lower frequencies), high-low (regions made up of states with a high frequency of the variable, surrounded by regions with low frequencies), and low-high (regions made up of states with low frequencies of the variable, surrounded by regions with high frequency). In addition, a Moran map was elaborated for the dependent variable showing statistically significant univariate spatial clusters ($p < 0.05$)[31].

The software package GeoDa 0.9.9.10 (Spatial Analysis Laboratory, University of Illinois, Urbana-Champaign, United States) was used for the bivariate LISA analysis to measure the spatial correlation between the dependent variable (prevalence of excess weight) and each independent variable, thus showing the linear relationship between a variable *xk* at the local it y *i*, *xk i* and the corresponding spatial lag for the other variable *WyiI* (*lkl* = *xk* '*Wyi/n*). This analysis generates the Local Moran's I (I_L) spatial correlation maps (LISA)[31]. In the case of bivariate spatial correlation, five types of interpretation of spatial clusters were possible: not statistically significant (territories that are not part of the clusters because the differences were not statistically significant); high-high (regions made up of states with high frequencies of the dependent variable and high frequencies of the independent variable); low-low (regions made up of states with low frequencies of the dependent variable and low frequencies of the independent variable), high-low (regions made up of states with high frequencies of the dependent variable and low frequencies of the independent variable), and low-high (regions made up of states with low frequencies of the dependent variable and high frequencies of the independent variable). The correlation values generated by the I_G and I_L were classified as positive/negative and weak (< 0.3), moderate (0.3-0.7), or strong (> 0.7), as in Pearson correlation.

This study did not require research ethics committee approval because all data was secondary, publically available, and did not disclose the participants' identities.

Results

The overall prevalence of excess weight in Brazil was 34.2%. In the North and Northeast regions the highest prevalence rates were found in Rio Grande do Norte (34.1%) and Pernambuco (34%) and the lowest rates were observed in Maranhão (23.9%) and Acre (24.4%). The highest prevalence rates in the South, Southeast, and Center-West regions were in Rio Grande do Sul (43.2%) and São Paulo (39.3%) and the lowest rates were in Espírito Santo (30.9%) and Goiás (31.2%) (Table 1). The prevalence of excess weight according to state showed a significant moderate spatial autocorrelation ($I_G = 0.581$), with low-low spatial clustering across the majority of states in the North and Northeast regions and high-high spatial clustering across the majority of states in the South, Southeast and Center-West regions (Figure 1a). The Moran map, which displays statistically significant spatial clusters, shows two clusters: a low-low cluster made up of Piauí, Maranhão, Tocantins, and Pará; and a high-high cluster formed by Minas Gerais, São Paulo, Santa Catarina, Paraná, and Mato Grosso do Sul (Figure 1b).

HDI values range between 0.631 (Alagoas) and 0.708 (Amapá) in the North and Northeast regions and between 0.725 (Mato Grosso) and 0.824 (Federal District) in the South, Southeast

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Table 1. Prevalence *(%) of excess weight by state, Brazil, 2008-2009.

State	Prevalence of Excess weight (%)	CI (95%)	Design effect
Brazil	34.2	33.8-34.6	2.61
Rio Grande do Norte	34.1	32.6-35.6	0.86
Pernambuco	34	32.8-35.3	1.49
Paraíba	31.9	30.5-33.4	0.92
Rondônia	31.5	29.7-33.4	0.67
Amapá	30.3	28.4-32.4	0.34
Ceará	29.9	28.5-31.3	1.85
Pará	29.7	28.5-31.0	1.21
Amazonas	29.3	28.0-30.7	0.82
Sergipe	28.6	27.2-30.1	0.56
Bahia	28.5	27.4-29.6	1.87
Alagoas	27.9	26.8-29.0	0.53
Tocantins	27.2	25.8-28.7	0.38
Roraima	26.9	25.0-28.9	0.23
Piauí	25.2	24.1-26.3	0.57
Acre	24.4	22.9-26.0	0.26
Maranhão	23.9	22.8-25.0	1.01
Rio Grande do Sul	43.2	41.7-44.7	2.19
São Paulo	39.3	38.0-40.5	6.06
Paraná	38.3	36.9-39.7	2.06
Rio de Janeiro	37.6	36.0-39.3	4.14
Santa Catarina	37.3	35.9-38.7	1.26
Mato Grosso do Sul	36.1	34.8-37.4	0.47
Federal District	33.3	31.2-35.4	1.28
Minas Gerais	33.2	32.3-34.1	1.73
Mato Grosso	32.3	31.1-33.5	0.57
Goiás	31.2	30.0-32.4	1.02
Espírito Santo	30.9	29.9-31.9	0.43

Source: POF 2008-2009.
* Weighted percentages from the geographic and socioeconomic stratification of the POF 2008-2009 sample.

and Center-West regions (Table 2). Spatial autocorrelation of HDI was moderate and significant (I_G 0.596). Low-low spatial clustering was found across the majority of states in the North and Northeast regions, while high-high spatial clustering was observed across the majority of states in the South, Center-West, and South regions (Figure 2a). Bivariate spatial correlation showed a moderate positive association between the prevalence of excess weight and HDI ($I_L = 0.605$), demonstrating that states with higher HDI values have a higher prevalence of excess weight, while those with lower HDI values have a lower prevalence (Figure 3a).

With respect to prevalence of household food insecurity, the highest rates were found in Maranhão (64.6%) and Piauí (58.6%) in the North and Northeast regions and in Goiás (37.8%) and Mato Grosso do Sul (30.5%) in the South, Southeast, and Center-West regions, while the lowest rate was found in Santa Catarina (14.8%) (Table 2). Spatial autocorrelation of the prevalence of household food insecurity was moderate and significant (I_G 0.624, $p = 0.01$). High-high spatial clustering was found across the majority of states in the North and Northeast (Figure 2b). The bivariate spatial correlation showed a moderate positive association (I_L = -0,561) between excess weight and prevalence of household food insecurity. Spatial clustering was observed in states in the Southeast, Center-West, and South regions, with a high prevalence of excess weight and low prevalence of household food insecurity, and in Ceará, Piauí, Maranhão, and Tocantins, with low prevalence of excess weight and high prevalence of household food insecurity (Figure 3b).

With regard to household food purchases by type of processing, the purchase of unprocessed

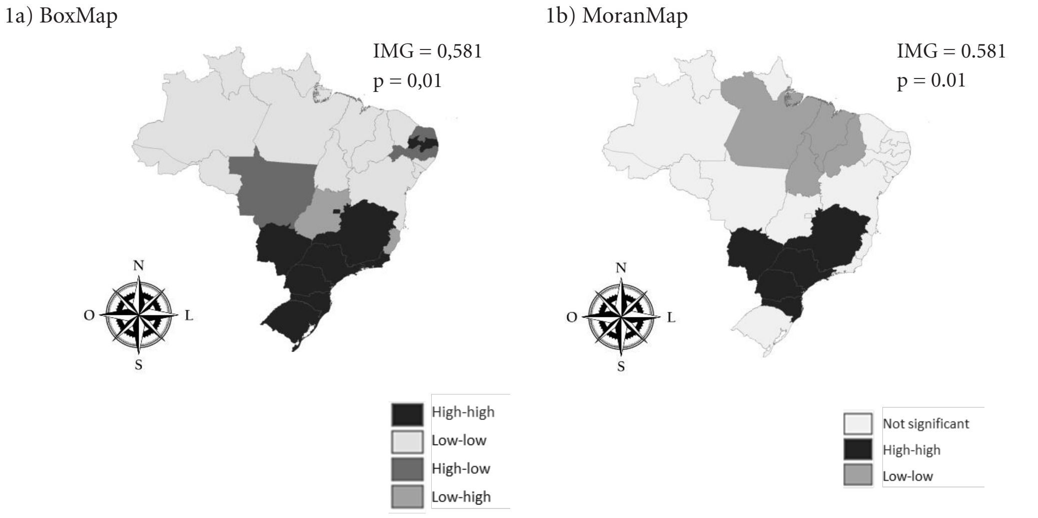

Figure 1. Spatial distribution of nonsignificant (Boxmap) and significant (Moranmap) clusters of prevalence of excess weight by state, Brazil, 2008-2009.

I_G: Global Moran'sI.

or minimally processed foods as a proportion of total food purchases was highest in Maranhão (78.7%). This state also showed the lowest purchase of ultra-processed foods as a proportion of total food purchases (4.6%). In the South, Southeast, and Center-West regions, the purchase of unprocessed or minimally processed foods as a proportion of total food purchases was lowest in Rio de Janeiro (59.4%), while the purchase of ultra-processed foods as a proportion of total food purchases was highest in São Paulo (15.8%) (Table 2). The spatial autocorrelation of household purchases of unprocessed or minimally processed foods was weak and not significant (I_G = 0.218, p = 0.09). The lack of statistical significance of this autocorrelation may be due to the fact that frequencies across states were very similar, meaning that well defined spatial clusters were not formed (Figure 2c). The spatial autocorrelation of household purchases of ultra-processed foods was moderate and significant (I_G 0.621, p = 0.01). Furthermore, low-low spatial clustering was observed for these food types across the majority of states in the North and Northeast regions, while high-high spatial clustering was observed across the majority of states in the Southeast, Center-West and South regions (Figure 2d). The results of the bivariate analysis showed a moderate correlation between the prevalence of excess weight and purchase of ultra-processed foods (I_L = 0.559, p = 0.01). Spatial clustering was observed across states in the Southeast, Center-West, and South regions showing a high prevalence of excess weight and a high proportion of ultra-processed food purchases, while clustering in Piauí, Maranhão, and Tocantins showed a low prevalence of excess weight and low proportions of ultra-processed food purchases (Figure 3).

Discussion

The spatial distribution of prevalence of excess weight in Brazil points to inequality in the occurrence of this nutritional disorder, showing that prevalence is greater in states in the Southeast, South, and Center-West regions in comparison to those of the North and Northeast. The findings also show positive spatial correlations between excess weight, HDI, and household purchases of ultra-processed foods and a negative correlation between excess weight and prevalence of household food insecurity.

Given that excess weight is a national and global public health problem, understanding its spatial distribution is crucial. In Brazil, between 1974 and 1975 and 2008 and 2009, adult excess weight increased almost three-fold among males

Table 2. Prevalence de household food insecurity*, Human Development Index**, and purchase of unprocessed or minimally processed foods*** and ultra-processed foods*** as a proportion of overall household food purchases by state, Brazil, 2008-2009.

State	HDI	Household food insecurity	Household purchase of unprocessed or minimally processed foods	Household purchase of ultra-processed foods
		(%)	(%)	(%)
Brazil	0.727	36.1	65.6	9.3
Rondônia	0.69	31.7	65.3	10.6
Acre	0.663	47.5	64.1	6.1
Amazonas	0.674	33.1	65.3	9.1
Roraima	0.707	47.6	72.4	7.2
Pará	0.646	43.2	65.3	7.6
Amapá	0.708	45.5	60.7	10.1
Tocantins	0.699	43.4	75	7.8
Maranhão	0.639	64.6	78.7	4.6
Piauí	0.646	58.6	76.5	5.8
Ceará	0.682	48.3	64.5	6.8
Rio Grande do Norte	0.684	47.1	54	6.7
Paraíba	0.658	41	65.8	6.8
Pernambuco	0.673	42.1	55.4	8.7
Alagoas	0.631	37.1	64.1	7.8
Sergipe	0.665	40.3	68.5	7.1
Bahia	0.66	41.2	68.4	6.2
Minas Gerais	0.731	25.5	64.8	11
Espírito Santo	0.74	27.8	62.8	10.2
Rio de Janeiro	0.761	21.9	59.4	14
São Paulo	0.783	22.4	59.7	15.8
Paraná	0.749	20.4	66.4	12.4
Santa Catarina	0.774	14.8	62.8	12.7
Rio Grande do Sul	0.746	19.2	65.5	14.9
Mato Grosso do Sul	0.729	30.5	68.8	10.9
Mato Grosso	0.725	22.1	66.4	8.3
Goiás	0.735	37.8	66.1	11.5
Federal District	0.824	21.2	64.4	11.8

Sources: * PNAD 2009; ** UNDP 2010; *** POF 2008-2009.

(from 18.5% to 50.1%) and almost two-fold in women (from 28.7% to 48%)[24]. Globally, it is estimated that 44% of the diabetes burden, 23% of the ischemic heart disease burden, and 7–41% of certain cancer burdens are attributable to this problem[32].

The spatial correlation found by this study between prevalence of excess weight and HDI corroborate the findings of previous studies describing excess weight and obesity in Brazil. The prevalence of excess weight increases with age, reaching its highest level between the ages of 50 and 60 years[33]. A stratified analysis of socioeconomic status and schooling using data from the POF 2008-2009 reported similar findings[24], while a cohort study conducted in Pelotas in the State of Rio Grande do Sul showed that excess weight increased with age and was associated with maternal socioeconomic status and schooling[34]. Furthermore, research conducted with older adults in states in the South and Southeastregions found that prevalence of excess weightwas greater among individuals with a higher level of social development[35].

In Brazil, the purchase of unprocessed or minimally processed foods as a proportion of

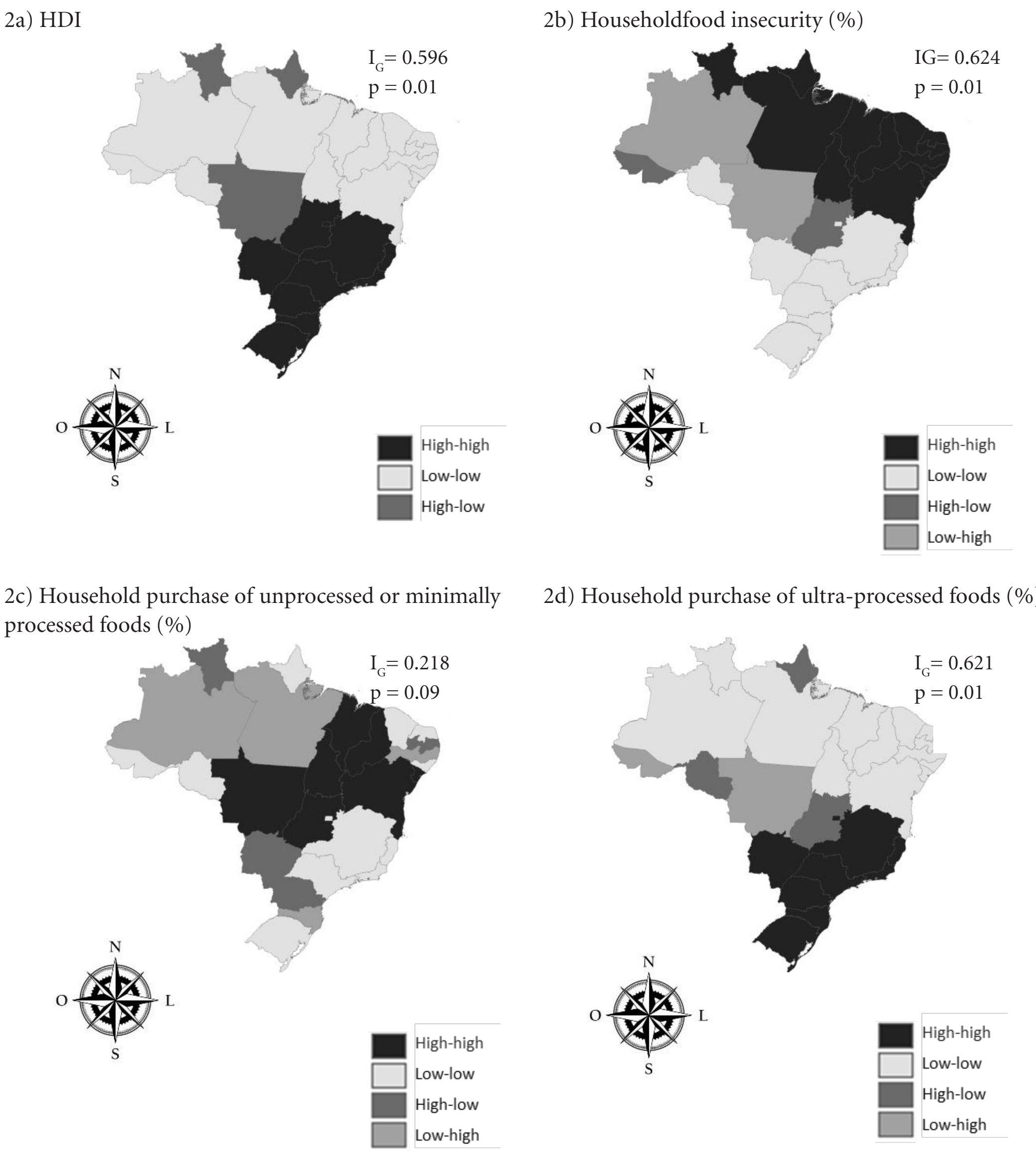

Figure 2. Spatial distribution of clusters (Box map) of Human Development Index (HDI) (2a), prevalence of household food insecurity (2b), purchase of unprocessed or minimally processed foods (2c) and ultra-processed foods (2d) as a proportion of overall household food purchases by state, Brazil, 2008-2010.

I_G: GlobalMoran'sI.

overall household food purchases currently exceeds 60%, which compares favorably to the food consumption patterns of other countries[36]. This percentage is in line with the findings of a previous study, which showed that the prevalence of consumption of these types of food in Brazil was 69.5%[37]. The present study found that the spatial autocorrelation of household purchases of unprocessed or minimally processed foods was weak and negative; however, bivariate spatial clustering occurred with the prevalence of excess weight in states in the North and Northeast regions (Piauí, Maranhão, Tocantins, and Pará). The high proportions of unprocessed or minimally processed food purchases in this territory may be due to high levels of household food insecurity in these states and the fact that the majority of the population have low purchasing

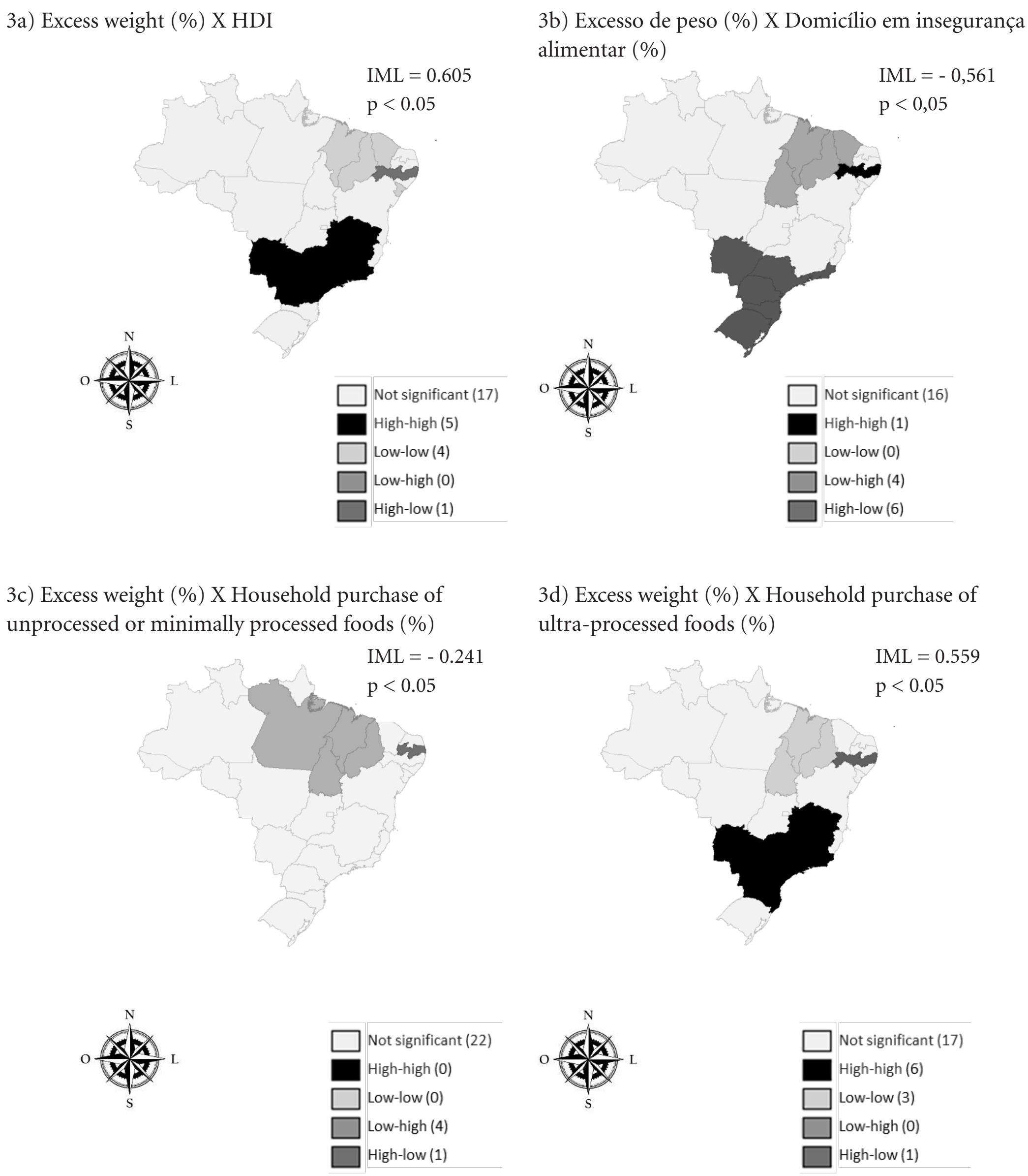

Figure 3. Distribution of clusters of spatial correlation (bivariate LISA analysis) of the prevalence of excess weight with the prevalence of household food insecurity (3a), Human Development Index (HDI) (3b), and purchase of unprocessed or minimally processed foods (3c) and ultra-processed foods (3d) as a proportion of overall household food purchases by state Brazil, 2008-2010.

I_L: LocalMoran's I.

power. A study that evaluated the price of food groups consumed in Brazil considering the nature, degree, and purpose of the processing of the food found that minimally processed foods, such as dry grains (rice and beans), are more affordable[38]. However, it is necessary to investigate the quality of the food items that make up this category, since they can be monotonous, posing a risk to the nutritional status of people living in these states.

The purchase of ultra-processed foods as a proportion of overall household food purchases was 9.3%, which differs from the prevalence of consumption of these food types, which has been shown to be as high as 21.5%[37]. This difference may be explained by the fact that the present study investigated foods available for consumption in the household, whereas the analysis of food consumption considered foods consumed at home and outside the home. It is important to highlight that, although to a lesser extent, there are concerns about the prevalence of the consumption of ultra-processed foods by Brazilians. In this respect, a study showed that the nutritional profile of the fraction of the diet made up of ultra-processed foods showed higher energy density, higher levels of overall fat and saturated and trans fat, higher amounts of free sugar and salt, and less fiber, protein, sodium and potassium, when compared to the fraction related to unprocessed or minimally processed foods[37]. Furthermore, average levels of micronutrients were lower in the fraction of the diet made up of ultra-processed foods than in the fraction made up of unprocessed or minimally processed foods for 16 of the 17 micronutrients analyzed. Studies have also shown that an increase in the proportion of ultra-processed foods in the diet is inversely and significantly associated with lower levels of vitamins B12, D, and E, niacin, pyridoxine, copper, iron, phosphorus, magnesium, selenium, and zinc[20] and that deficiencies in these substances may be related to excess weight and the consequent development of noncommunicable diseases[39].

The findings of the present study show a positive moderate spatial correlation between the proportion of ultra-processed food purchases and prevalence of excess weight in more developed states (Southeast, South and Center-West). The Pan American Health Organization[21] highlights that more developed and urbanized regions are more attractive markets for ultra-processed foods because they are fully industrialized and have a higher income. At the global level, for example, in countries in the global north (North America, Western Europe, and developed regions of East Asia),sales of ultra-processed foods are greater and the prevalence of excess weight and obesity is higher[21].

A study that investigated sales of ultra-processed foods in different countries showed that, although overall sales between 2000 and 2013 were greater in high-income countries, the sales growth rate was greater in low-income countries. In addition, the findings showed that there was a link between the increase in sales of ultra-processed foods and increased prevalence of excess weight and obesity in Latin America[21].

The findings suggest that states in the Southeast, South, and Center-West regions and the North and Northeast regions may be experiencing different stages of the nutrition transition and dietary change. This may be explained by the fact that the sociodemographic effects of liberal capitalism are more pronounced in more economically developed regions, which are concentrated in the Southeast, South, and Center-West regions in Brazil[40]. The Southeast, South and Center-West regions have experienced strong economic growth marked by rapid industrialization, consolidating themselves as regions that have drawn major economic and commercial interest throughout the history of Brazil[41], resulting in a higher level of human development. The findings show that the states in these regions are at a more advanced stage of the nutrition transition and dietary change corresponding to the stage of the epidemiological transition characterized by an increased prevalence of noncommunicable diseases[42].

In contrast, the historical-geographical construction of the majority of states in the North and Northeast regions has been marked by commercial exploitation and extractivism, of Pernambuco wood and sugarcane at the beginning of colonization and later rubber, and a lack of commercial interest and investment in industrialization, meaning that they lag behind the other regions in terms of human development[41]. The high prevalence of household food insecurity, high proportion of unprocessed or minimally processed food purchases compared to ultra-processed foods, and low prevalence of excess weight shows that these states are at a less advanced stage of the nutrition transition and dietary change in comparison to the Southeast, South, and Center-West regions, accentuating epidemiological polarization[42].

These socioeconomic and demographic factors directly influence the dynamics of access to food, nutritional status, and population health[40]. Batista Filho[12] make us reflect upon the concept of nutrition transition and dietary change, drawing attention to the commodification of food and eating, triggering the "denaturation of food, the denaturation of human life and biomes as a whole, and the confrontation with nature, like an undeclared war: technology gains at the service of markets"[12]. These authors raise alarm over the growth in consumption of ultra-processed foods, highlighting that "80% to 90% of food goes through the mouths of machines before it enters our mouths"[12].

The findings of the present study also point to an unequal distribution of prevalence of household food insecurity across Brazil and a negative correlation with the spatial distribution of the prevalence of excess weight. In this respect, it is important to bear in mind that food insecurity is related to changes in the nutritional status and health of individuals and population groups. Food insecurity may lead to clinical and subclinical malnutrition, particularly in more vulnerable age groups (children, adolescents, and older adults), and can trigger subsequent manifestations related to the risk of noncommunicable disease in adult life[15].

This study has as number of limitations related to the methodology and its results should be interpreted with caution due to the possibility of aggregation bias or ecological fallacy. With respect to ecological studies, the observation of a relationship between two variables at the aggregate level does not necessarily means that this relationship is maintained at the individual level. However, the results showed good internal validity due to the fact that the data sources were population surveys that used complex sampling designs and whose samples are representative of the geographical strata of interest.

Furthermore, similar national-level studies using spatial analysis to investigate the prevalence of excess weight among the Brazilian population were not found in the literature, thus limiting the comparability of results. However, the results of the study are valid and reveal important aspects regarding innovation in relation to the type of processing categories used for the analysis of household food purchases. It is also important to mention the methodological rigor of data processing and the three factors that influence prevalence of excess weight: food quality, household food insecurity, and social development. The findings provide important insights into the social determinants of dietary intake and nutritional status of the Brazilian population.

The periodical analysis of these and other aspects of diet and nutrition in Brazil would help in the implementation of relevant policies, such as the National Food and Nutrition Security and Policy[43] and National Food and Nutrition Policy[44], and in the development of more specific food, nutrition, and health actions across different geographic spaces in Brazil. The practice of recognizing a territory and its problems and potentialities enables for the effective planning of coherent and resolutive actions to tackle the problems that negatively affect the health-disease process experienced by the population. It can be concluded that there is an unequal distribution of excess weight across Brazil associated with HDI and the purchase of ultra-processed foods. In addition, there is an inverse association between the prevalence of excess weight and the prevalence of household food insecurity.

Collaborations

D Vale and CO Lyra participated in study conception, data analysis and interpretation, drafting the article, and in the critical review of intellectual content. CMM Morais and LFC Pedrosa collaborated in the critical review of intellectual content. MAF Ferreira and AGRC Oliveira collaborated in data analysis and interpretation and the critical review of intellectual content.

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References

1. Brasil. Ministério da Saúde (MS). *Estratégias para o cuidado da pessoa com doença crônica: Obesidade*. Brasília: MS; 2014.
2. Ng M, Fleming T, Robinson M, Thomson B, Graetz N, Margono C, Mullany EC, Biryukov S, Abbafati C, Abera SF, Abraham JP, Abu-Rmeileh NM, Achoki T, AlBuhairan FS, Alemu ZA, Alfonso R, Ali MK, Ali R, Guzman NA, Ammar W13, Anwari P1 Banerjee A, Barquera S, Basu S, Bennett DA, Bhutta Z, Blore J, Cabral N, Nonato IC, Chang JC, Chowdhury R, Courville KJ, Criqui MH, Cundiff DK, Dabhadkar KC, Dandona L, Davis A, Dayama A, Dharmaratne SD, Ding EL, Durrani AM, Esteghamati A, Farzadfar F, Fay DF, Feigin VL, Flaxman A, Forouzanfar MH, Goto A, Green MA, Gupta R, Hafezi-Nejad N, Hankey GJ, Harewood HC, Havmoeller R, Hay S, Hernandez L, Husseini A, Idrisov BT, Ikeda N, Islami F, Jahangir E, Jassal SK, Jee SH, Jeffreys M, Jonas JB, Kabagambe EK, Khalifa SE, Kengne AP, Khader YS, Khang YH, Kim D, Kimokoti RW, Kinge JM, Kokubo Y, Kosen S, Kwan G, Lai T, Leinsalu M, Li Y, Liang X, Liu S, Logroscino G, Lotufo PA, Lu Y, Ma J, Mainoo NK, Mensah GA, Merriman TR, Mokdad AH, Moschandreas J, Naghavi M, Naheed A, Nand D, Narayan KM, Nelson EL, Neuhouser ML, Nisar MI, Ohkubo T, Oti SO, Pedroza A, Prabhakaran D, Roy N, Sampson U, Seo H, Sepanlou SG, Shibuya K, Shiri R, Shiue I, Singh GM, Singh JA, Skirbekk V, Stapelberg NJ, Sturua L, Sykes BL, Tobias M, Tran BX, Trasande L, Toyoshima H, van de Vijver S, Vasankari TJ, Veerman JL, Velasquez-Melendez G, Vlassov VV, Vollset SE, Vos T, Wang C, Wang X, Weiderpass E, Werdecker A, Wright JL, Yang YC, Yatsuya H, Yoon J, Yoon SJ, Zhao Y, Zhou M, Zhu S, Lopez AD, Murray CJ, Gakidou E. Global, regional, and national prevalence of overweight and obesity in children and adults during 1980-2013: a systematic analysis for the Global Burden of Disease Study 2013. *Lancet* 2014; 384(9945):766-781.
3. Barros DC deEngstrom E, Bagni UV, Balão MR. Determinantes de saúde e nutrição da população brasileira. In: *Alimentação e nutrição: contexto político, determinantes e informação em saúde*. Rio de Janeiro: EAD/ENSP; 2013. p.10-137.
4. Santos M. *O Espaço do Cidadão*. São Paulo: Editora Universidade de São Paulo; 2012.
5. Brasil. Ministério da Saúde (MS). Secretaria de Vigilância em Saúde. Fundação Oswaldo Cruz. *Introdução à Estatística Espacial para Saúde Pública*. Brasília: MS; 2007.
6. Castro J. *Geografia da fome: o dilema brasileiro: pão ou aço*. 11ª ed. Rio de Janeiro: Civilização Brasileira; 2011.
7. Gurgel RQ, Dias IMO, França VLA, Neyra Castañeda DF. Distribuição espacial do baixo peso ao nascer em Sergipe, Brasil, 1995/1998. *Cad Saude Publica* 2005; 21(5):1329-1337.
8. Lima MCBM, Oliveira GS, Lyra CO, Roncalli AG, Ferreira MAF. A desigualdade espacial do Baixo Peso ao Nascer no Brasil. *Cien Saude Colet* 2013; 18(8):2443-2452.

9. Rocha Neves K, Teixeira RA, Bodevan EC, Dias JVL, Pinto PAF, Souza Morais RL. Representação espacial na saúde: análise do déficit de crescimento e desenvolvimento infantil em um município do Jequitinhonha-MG. *Hygeia* 2016; 12(22):139-154.
10. Benício MHD'A, Martins APB, Venâncio SI, Barros AJD. Estimativas da prevalência de desnutrição infantil nos municípios brasileiros em 2006. *Rev Saude Publica* 2013; 47(3):560-570.
11. Matozinhos FP, Meléndez GV, Pessoa MC, Mendes L, Gomes CS, Costa MA. Distribuição espacial da obesidade em área urbana no Brasil. *Cien Saude Colet* 2015; 20(9):2779-2786.
12. Batista Filho M, Batista LV. Transição alimentar/nutricional ou mutação antropológica? *Ciência Cult* 2010; (3):26-30.
13. Canella DS, Levy RB, Martins APB, Claro RM, Moubarac JC, Baraldi LG, Cannon G4, Monteiro CA. Ultra-processed food products and obesity in Brazilian households (2008-2009). *PLoS One* 2014; 9(3):1-6.
14. Instituto Brasileiro de Geografia e Estatística (IBGE). *Segurança Alimentar 2004/2009*. Rio de Janeiro: 2010.
15. Amuna P, Zotor, FB. Epidemiological and nutrition transition in developing countries: impact on human health and development. *Proceedings of the Nutrition Society* 2008; 67(01):82-90.
16. Pérez-Escamilla R, Segall-Corrêa AM, Maranha LK, Sampaio MDFA, Marín-León L, Panigassi G. An adapted version of the US Department of Agriculture Food Insecurity module is a valid tool for assessing household food insecurity in Campinas, Brazil. *The Journal of nutrition* 2004; 134(8):1923-1928.
17. Pérez-Escamilla R, Segall-Corrêa AM. Food insecurity measurement and indicators. *Rev Nutr* 2008; 21(Supl.):15s-26s.
18. Brasil. Ministério da Saúde (MS). *Guia alimentar para a população brasileira*. 2ª ed. Brasília: MS; 2014.
19. Monteiro CA, Cannon G. The impact of transnational "big food" companies on the South: a view from Brazil. *PLoS Med* 2012; 9(7):e1001252.
20. Louzada MLDC, Martins APB, Canella DS, Baraldi LG, Levy RB, Claro RM, Moubarac JC, Cannon G, Monteiro CA. Impact of ultra-processed foods on micronutrient content in the Brazilian diet. *Rev Saude Publica* 2015; 49:1-8.
21. Organización Panamericana de la Salud (OPAS). *Alimentos y bebidas ultraprocesados en América Latina: tendencias, efecto sobre la obesidad e implicaciones para las políticas públicas*. Washington: OPAS; 2015.
22. Ludwig DS. Technology, Diet, and the Burden of Chronic Disease. *JAMA* 2011; 305(13):1352-1353.
23. Di Cesare M, Khang Y-H, Asaria P, Blakely T, Cowan MJ, Farzadfar F, Guerrero R, Ikeda N, Kyobutungi C, Msyamboza KP, Oum S, Lynch JW, Marmot MG, Ezzati M; Lancet NCD Action Group. Inequalities in non-communicable diseases and effective responses. *Lancet* 2013; 381(9866):585-597.
24. Instituto Brasileiro de Geografia e Estatística (IBGE). *Pesquisa de Orçamentos Familiares 2008-2009: Antropometria e Estado Nutricional de Crianças, Adolescentes e Adultos no Brasil*. Rio de Janeiro: IBGE; 2010.
25. Instituto Brasileiro de Geografia e Estatística (IBGE). *Pesquisa de orçamentos familiares 2008-2009: aquisição alimentar domiciliar per capita: Brasil e grandes regiões/ IBGE*. Rio de Janeiro: IBGE; 2010.
26. Programa das Nações Unidas para o Desenvolvimento. Atlas Brasil [Internet]. [acessado 2016 Fev 23]. Disponível em: http://www.atlasbrasil.org.br/2013/pt/o_atlas/o_atlas_/
27. World Health Organization (WHO). *WHO Anthro*. [computer program]. Version 3.2.2, January 2016.
28. World Health Organization (WHO). *WHO AnthroPlus*. [computer program]. Version 1.0.4, January 2016.
29. 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. WHO (nonserial publication).
30. Brasil. Ministério da Saúde (MS). *Orientações para a coleta e análise de dados antropométricos em serviços de saúde: Norma Técnica do Sistema de Vigilância Alimentar e Nutricional - SISVAN*. Brasília: MS; 2011.
31. Brasil. Ministério da Saúde (MS). Secretaria de Vigilância em Saúde. Fundação Oswaldo Cruz. *Sistemas de Informações Geográficas e Análise Espacial na Saúde Pública*. Brasília: MS; 2007.
32. World Health Organization (WHO). *Global health risks: mortality and burden of disease attributable to selected major risks*. Geneva: WHO; 2009.
33. Low S, Chin MC, Deurenberg-Yap M. Review on epidemic of obesity. *Ann Acad Med Singapore* 2009; 38(1):57-59.
34. Lima NP, Horta BL, Motta JVS, Valença MS, Oliveira V, Santos TV, Gigante DP, Barros FC. Evolução do excesso de peso e obesidade até a idade adulta, Pelotas, Rio Grande do Sul, Brasil, 1982-2012. *Cad Saude Publica* 2015; 31(9):2017-2025.
35. Pereira IFDS, Spyrides MHC, Andrade, LDMB. Estado nutricional de idosos no Brasil: uma abordagem multinível. *Cad Saude Publica* 2016; 32(5):e00178814.
36. Imamura F, Micha R, Khatibzadeh S, Fahimi S, Shi P, Powles J, Mozaffarian D; Global Burden of Diseases Nutrition and Chronic Diseases Expert Group (NutriCoDE). Dietary quality among men and women in 187 countries in 1990 and 2010: a systematic assessment. *Lancet Glob Heal* 2015; 3(3):e132-142.
37. Louzada MLDC, Martins APB, Canella DS, Baraldi LG, Levy RB, Claro RM, Moubarac JC, Cannon G, Monteiro CA. Ultra-processed foods and the nutritional dietary profile in Brazil. *Rev Saude Publica* 2015; 49:38.
38. Claro RM, Maia EG, Costa BVDL, Diniz DP. Preço dos alimentos no Brasil: prefira preparações culinárias a alimentos ultraprocessados. *Cad Saude Publica* 2016; 32(8):e00104715.

39. Leão ALM, Santos LC. Consumo de micronutrientes e excesso de peso: existe relação? *Rev Bras Epidemiol* 2012; 15(1):85-95.
40. Garnelo L, Welch JR. Transição alimentar e diversidade cultural: desafios à política. *Cad Saude Publica* 2009; 25(9):1872-1873.
41. Vasentini JW. Geografia: o mundo em transição. v. 3. São Paulo: Ática; 2010.
42. Araújo JD de. Polarização epidemiológica no Brasil. *Epidemiol e serviços Saúde*. 2012; 1(2):533-538.
43. Brasil. Ministério da Saúde (MS). *Política Nacional de Alimentação e Nutrição*. Brasília: MS; 2013.
44. Brasil. Decreto no 7.272, de 25 de agosto de 2010. Regulamenta a Lei no 11.346, de 15 de setembro de 2006, que cria o Sistema Nacional de Segurança Alimentar e Nutricional - SISAN com vistas a assegurar o direito humano à alimentação adequada, institui a Política Nacional de Segurança Alimentar e Nutricional - PNSAN, estabelece os parâmetros para a elaboração do Plano Nacional de Segurança Alimentar e Nutricional, e dá outras providências. *Diário Oficial da União* 2010; 26 ago.

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