Food and nutritional insecurity in Brazil and its correlation with vulnerability markers

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Abstract *This study aimed to analyze space-time distribution of the prevalence of food and nutritional insecurity (FNI) in the Brazilian Federative Units and their correlation with vulnerability markers. This is an ecological study, with data from the National Household Sample Survey (2004, 2009 and 2013) and Atlas Brazil (2010). A time analysis of the spatial distribution of FNI prevalence was performed. Moran's Index was used in bivariate spatial analysis. The prevalence of FNI have decreased along the years studied and showed a negative and moderate spatial correlation with the Human Development Index; a positive and moderate correlation with the percentage of the extremely poor, child mortality, social vulnerability index, human capital social vulnerability index; and positive and strong correlation with income and work social vulnerability index. We can conclude that there was a lower prevalence of FNI in the analyzed years and that the Brazilian territory showed two distinct patterns: territories with higher FNI prevalence and worse conditions as regards income, work and child health in the North and Northeast; and territories with lower FNI prevalence and lower vulnerability in the Midwest, Southeast and South.*

Key words *Food security, Social vulnerability, Social determinants of health, Spatial analysis*

Introduction

The concept of Food and Nutrition Security (FNS) was enshrined in the Organic Law on Food and Nutrition Security (LOSAN) defined as the realization of the right of all citizens to access to food regularly and healthily, so that the assurance of this right does not affect other essential needs, respecting cultural diversity, and that is environmentally, economically and socially sustainable[1]. So, Food and Nutrition Insecurity (FNI) in Brazil is understood as the lack of access to adequate food, predominantly conditional on income issues[2]. In the last survey, it was diagnosed that 22.6% of the Brazilian population lived in an FNI situation, and the prevalence rate was 38.1%, 36.1%, 18.2%, 14.9% and 14.5% in the Northeast, North, Midwest, South and Southeast, respectively[3].

In the early 2000s, 55 million Brazilians lived in poverty, with half a monthly minimum wage per capita, of which 24 million lived on less than a quarter of the minimum wage in conditions of extreme poverty[4]. This setting is a reality of the economic-social structure of the country, which is among the nations with the highest income inequality in the world[5]. This state of poverty, consequently of social vulnerability, hinders the adequate access to safe and nutritious foods, establishing a panorama of high FNI prevalence[6].

Social vulnerability understood conceptually in the process of construction represents multiple determinations that affect the idea of citizens living in fragile situations or lack of access to rights[7]. It is understood that the well-being of households depends on the ownership of some assets: income, adequate housing, water supply, basic sanitation, access to health services, schools and quality public transport, among others. However, it is recognized that individuals cannot achieve all these assets alone, and therefore, the State, through public policies, must act to ensure these rights. Thus, the definition of social vulnerability which underpins this study refers to the lack of or insufficient assets, a concept used by the Institute of Applied Economic Research (IPEA) to construct the Social Vulnerability Index (SVI) used as a variable in this research[8].

The Brazilian Food Insecurity Scale (EBIA) was created to measure FNI in Brazil, which is a direct marker of the magnitude of the problem in the population, gauged through a questionnaire applied to the family head, which allows classification into mild, moderate and severe. As part of the effort to combat FNI, and also aimed at

conducting a national diagnosis of the FNI situation, the Brazilian Institute of Geography and Statistics (IBGE) included it for the first time in the National Household Sample Survey (PNAD) in 2004[9,10].

FNI is a reality of Brazilian households, where these deprivations and instability of access to food from a qualitative and quantitative viewpoint, can have severe consequences for the well-being and health of individuals due to social exclusion. In a systematic review with meta-analysis of papers published from 2004 to 2013 on Food and Nutrition Security, it was verified that the prevalence of food insecurity among populations in social inequities was 87.2%, evidencing the social determination of food insecurity in Brazil[11].

Knowing the spatial behavior of FNI in the Brazilian territory provides a unique perspective for a better understanding of the processes that permeate the occurrence of this aggravation. The techniques of spatial data analysis allow the identification of possible patterns in this territory. Investigating the behavior of these food and nutritional patterns and their organization in geographical spaces over time provides an understanding of the contributing economic, social, political and cultural factors[12]. This allows the identification of more vulnerable groups, facilitating the direction of public policies[13]. Therefore, the knowledge of the most affected territories will allow the planning of public policies that affect the reduction of economic and social inequalities, aiming at ensuring FNS and the implementation of Human Right to Adequate Food (DHAA). This paper analyzes the space-time distribution of FNI prevalence in Brazil Federative Units (UF) and its correlation with vulnerability markers.

Methods

This is a cross-sectional, ecological study, whose area analysis units were the 27 Brazilian Federative Units (UF). IBGE population surveys were used, namely, the Food Security Supplement of the PNAD 2004, 2009 and 2013 Surveys to collect the dependent variable, which is the FNI situation. The collection of vulnerability markers, considered in this study as independent variables (Social Vulnerability Indexes and their realms, proportion of extremely poor, child mortality rate and the Municipal Human Development Index (MHDI)) required the use of the Atlas Bra-

zil of the United Nations Development Program (UNDP) and IPEA.

The IAN was identified through the EBIA, which classifies a household as food secure or insecure into mild, moderate or severe, according to the cutoff points of the score, which differs according to the presence of at least one resident under 18 years of age and households with only residents aged 18 years or over. The household was considered as in FNS situation when there was regular and permanent access to quality food in sufficient quantity. Mild FNI is when there is concern or uncertainty about access to food in the future and quality is inadequate. A moderate FNI refers to a quantitative reduction of food among adults and, lastly, severe FNI is characterized by a quantitative reduction of food among children and famine among adults or children in the household[3].

EBIA's structure was updated after a Technical Workshop held in August 2010, whose improvements consisted of excluding the association of weight loss with FNI and exclusion of a repetitive item. The survey questionnaire had 14 questions about the food situation experienced at home in the last 90 days before the interview, and PNAD brings these changes since its 2008-2009 edition[14].

As for the independent variables collected in the Atlas Brazil, the MHDI and SVI were shown by the respective arithmetic mean values referring to the three sub-indices/ realms. Extreme poverty was shown as a percentage, while child mortality was the number of deaths of children under one year of age per thousand live births. All variables were described by UF for 2010, data available from the last census. Thus, due to the approximation of the collection period, we decided to use 2009 FNI data, although more recent data (2013) was available.

The SVI has 16 markers to conduct a unique mapping of exclusion and social vulnerability, with the aim of signaling access, absence or insufficiency of some fundamental rights of all citizens in the Brazilian territory. Data from the Brazilian Institute of Geography and Statistics (IBGE) were chosen, precisely the demographic census data, since they allow a municipal selection[15].

The sub-index that includes urban infrastructure vulnerability seeks to reflect the conditions of access to urban mobility services and basic sanitation. The sub-index referring to human capital involves aspects that establish (current and future) perspectives of social inclusion of the individuals: health and education. On the other hand, the vulnerability of income and work gathers markers of current income insufficiency, as well as other factors that constitute a state of income insecurity[16].

The SVI was elaborated from the arithmetic mean of the sub-indices: SVI urban infrastructure, SVI human capital and SVI income and work, each with the same weight, in which each indicator had its value normalized in a scale that ranges from 0 to 1, in which 0 refers to the desirable situation, and 1 the worst situation, that is, greater social vulnerability[16]. A descriptive analysis of the variables was performed in the SPSS software to calculate the prevalence of FNI considering the sample weights and the effect of design.

We used spatial data analysis techniques from the Brazilian digital meshes by UF, using two geographic information systems (GIS) software. The included variables were continuous in all analyses. The descriptive spatial analysis of the prevalence of food insecurity was performed by Terra View 4.1.0 software (National Institute of Space Research, http://www.dpi.inpe.br/terraview). Time comparison of the spatial distribution of FNI prevalence in 2004, 2009 and 2013 required dividing the 2004 FNI into quartiles since 2004 was considered the first year of analysis and that with the highest FNI prevalence. These values were used as cut-off points for the distribution of prevalence in the three years.

The GeoDa software 0.9.9.10 (Spatial Analysis Laboratory, University of Illinois, Urbana-Champaign, USA) was used for the bivariate analysis between the dependent variable (Food and Nutritional Insecurity) and each of the independent variables (percentage of extremely poor, MHDI, child mortality, social vulnerability index and its sub-indices – SVI infrastructure, human capital and income and work).

The Local Moran Index (ranging from -1 to 1) was used to analyze the spatial distribution pattern and cluster intensity (cluster, random or scattered), with 99 permutations, both considering a statistical significance value of $p<0.05$. The occurrence of clusters and the statistical significance of these clusters were demonstrated by MoranMap and LisaMap[17].

In the bivariate spatial correlation, the interpretation of the spatial clusters can be of five types: not significant (territories that did not enter the formation of clusters, because their differences were not significant); high-high (areas formed by UFs with high frequencies of the

dependent variable, high frequencies of the independent variable); low-low (areas formed by UFs with low frequencies of the dependent variable, low frequencies of the independent variable), high-low (areas formed by UFs with high frequencies of the dependent variable, low frequencies of the independent variable), and low-high (areas formed by UFs with low frequencies of the dependent variable, high frequencies of the independent variable)[17].

Results

In the descriptive analysis, the highest FNI prevalence was found in the North and Northeast, and the highest was in the states of Maranhão (64.6%) and Piauí (58.6%), and the lowest in Rondônia (31.7%) and Amazonas (33.1%). In the Midwest, South and Southeast, the highest prevalence of FNI was found in Goiás (37.8%) and Mato Grosso do Sul (30.5%), and the lowest in Santa Catarina (14.8%) and Rio Grande do Sul (19.2%) (Table 1).

Concerning the MHDI, in the North and Northeast, the values ranged from 0.631 (Alagoas) to 0.708 (Amapá); while in the South, Southeast and Midwest, values ranged from 0.725 (Mato Grosso) to 0.824 (Federal District). Regarding the percentage of extremely poor, Maranhão had the highest percentage (22.47%), followed by Piauí (18.77%) in the North and Northeast; in the South, Southeast and Midwest, the highest prevalence levels were recorded in Mato Grosso (4.41%) and Mato Grosso do Sul (3.55%). The lowest proportion of extremely poor was found in Santa Catarina (1.01%) (Table 1).

In the North and Northeast, higher child mortality was found in Alagoas (28.04/1,000 live births) and Maranhão (28.03/1,000 live births) and lower in the states of Amapá (15.14 / 1,000 live births) and Roraima (16.11/1,000 live births). In the South, Southeast and Midwest, the highest prevalence was found in Mato Grosso do Sul (18.14 / 1,000 live births) and Mato Grosso (16.80 / 1,000 live births), while the lowest were recorded in Rio Grande do Sul (11.54 / 1,000 live births) and Santa Catarina (12.38 / 1,000 live births) (Table 1).

Regarding total SVI, the highest values ranged from 0.521 to 0.403, in the states of Maranhão, Amazonas, Pará, Alagoas, Acre, Pernambuco, Amapá, Piauí and Bahia, all located in the North and Northeast regions, in descending order. Meanwhile, the lowest SVI values ranged from 0.192 to 0.297, in the states of Santa Catarina, Rio Grande do Sul, Paraná, Espírito Santo, Mato Grosso, Minas Gerais, Mato Grosso do Sul, Federal District and São Paulo, in ascending order. (Table 1).

Concerning SVI fractions, infrastructure showed higher values in Maranhão (0.526) followed by Amazonas (0.515) in the North and Northeast regions, and in the states of Goiás (0,331) and Rio de Janeiro (0,323) in the South, Southeast and Midwest. In the states of Acre (0.564) and Alagoas (0.563), SVI human capital showed a higher value when compared to the other states of the North and Northeast. Regarding South, Southeast and Midwest, the highest values were recorded in the states of Mato Grosso do Sul (0.369) and Mato Grosso (0.359). Also, the income and work in the North and Northeast ranged from 0.325 (Rondônia) to 0.503 (Maranhão), and in the South, Southeast and Midwest, from 0.194 (Santa Catarina) and 0.295 (Minas Gerais) (Table 1).

In the bivariate spatial correlation analysis, it was possible to observe moderate and negative correlations between the prevalence of FNI and the MHDI (I_{ML} = 0.643), which means that the units with higher FNI prevalence had lower values of MHDI, and those with higher values of MHDI, lower prevalence of FNI. Also, it found moderate and positive correlations between FNI and the share of extremely poor (I_{ML} = 0.684) with high-high clusters formed by North and Northeastern states with high prevalence of FNI and extremely poor and low-low clusters with low prevalence of FNI and extremely poor in the states of Minas Gerais, Rio de Janeiro, São Paulo, Mato Grosso do Sul, Paraná and Rio Grande do Sul (Figure 1).

Child mortality and FNI in the bivariate spatial correlation formed clusters with moderate and positive correlations (I_{ML} = 0.572) of the high-high type in the states of Pernambuco, Alagoas and Piauí, that is, high child mortality and high prevalence of FNI. In contrast, low-low clusters were formed in the Mid-South states, with low prevalence of child mortality and FNI (Figure 1). Likewise, with social vulnerability and FNI, high-high clusters with moderate and positive correlation (I_{ML} = 0.654) were formed in the states of Piauí and Amapá, while in the states of the South, São Paulo and Mato Grosso do Sul, low-low clusters were formed, with low social vulnerability and low prevalence of FNI (Figure 2).

Correlation of SVI infrastructure with FNI was weak and positive (I_{ML} = 0.273) with a high-

Table 1. Prevalence of food and nutritional insecurity and vulnerability markers, by Federative Units, Brazil, 2009/2010.
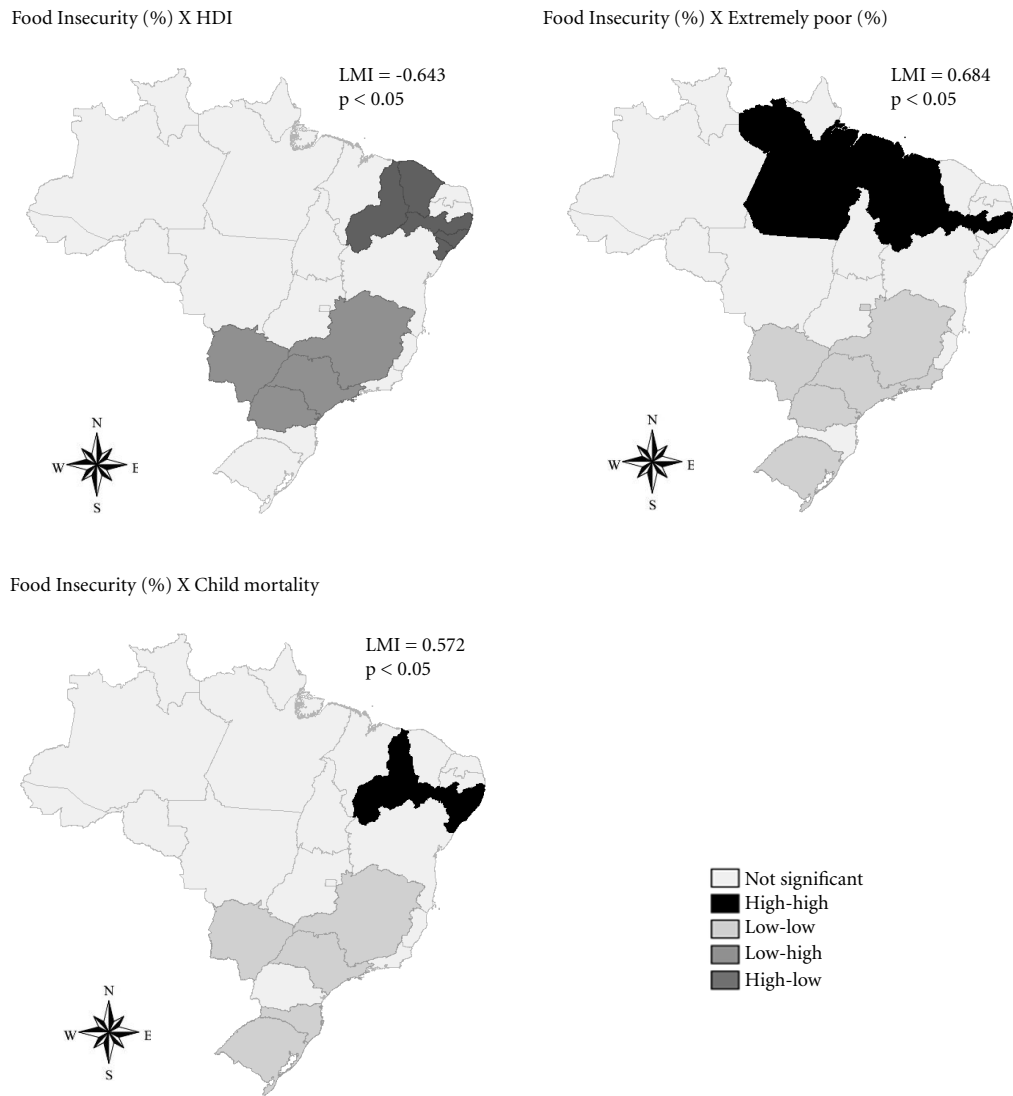
UF	Food Insecurity Prevalence * (%)	MHDI**	Extremely poor**	Child mortality **	SVI**	SVI Urban infrastructure**	SVI Human Capital**	SVI Income and Work**
Brazil	30.2	0.727	6.62	16.7	0.326	0.295	0.362	0.32
Northeast	46.1	0.659	14.90	22.72	0.412	0.299	0.475	0.461
Maranhão	64.6	0.639	22.47	28.03	0.521	0.526	0.534	0.503
Piauí	58.6	0.646	18.77	23.05	0.403	0.265	0.471	0.474
Ceará	48.3	0.682	14.69	19.29	0.378	0.263	0.438	0.434
Rio Grande do Norte	47.1	0.684	10.33	19.70	0.349	0.217	0.42	0.411
Pernambuco	42.1	0.673	12.32	20.43	0.414	0.318	0.46	0.463
Bahia	41.2	0.66	13.79	21.73	0.403	0.276	0.455	0.478
Paraíba	41.0	0.658	13.39	21.67	0.385	0.225	0.469	0.462
Sergipe	40.3	0.665	11.70	22.22	0.393	0.28	0.467	0.431
Alagoas	37.1	0.631	16.66	28.04	0.461	0.324	0.563	0.495
North	40.3	0.684	12.88	18.45	0.404	0.342	0.476	0.394
Roraima	47.6	0.707	15.66	16.11	0.366	0.245	0.483	0.37
Acre	47.5	0.663	15.59	23.01	0.443	0.36	0.564	0.405
Amapá	45.5	0.708	9.93	15.14	0.404	0.373	0.451	0.388
Tocantins	43.4	0.699	10.21	19.56	0.336	0.212	0.418	0.378
Pará	43.2	0.646	15.90	20.29	0.469	0.457	0.494	0.457
Amazonas	33.1	0.674	16.43	17.01	0.488	0.515	0.516	0.433
Rondônia	31.7	0.690	6.39	18.02	0.319	0.231	0.4	0.325
Midwest	30.1	0.753	2.87	15.72	0.298	0.302	0.332	0.260
Goiás	37.8	0.735	2.32	13.96	0.331	0.385	0.334	0.274
Mato Grosso do Sul	30.5	0.729	3.55	18.14	0.289	0.224	0.369	0.273
Mato Grosso	22.1	0.725	4.41	16.80	0.277	0.185	0.359	0.288
Distrito Federal	21.2	0.824	1.19	14.01	0.294	0.412	0.265	0.204
Southeast	23.3	0.754	2.33	14.31	0.294	0.319	0.299	0.263
Espírito Santo	27.8	0.74	2.67	14.15	0.274	0.217	0.319	0.285
Minas Gerais	25.5	0.731	3.49	15.08	0.282	0.228	0.323	0.295
São Paulo	22.4	0.783	1.16	13.86	0.297	0.407	0.263	0.222
Rio de Janeiro	21.9	0.761	1.98	14.15	0.323	0.427	0.292	0.251
South	18.7	0.756	1.65	12.33	0.226	0.172	0.284	0.222
Paraná	20.4	0.749	1.96	13.08	0.252	0.217	0.298	0.241
Rio Grande do Sul	19.2	0.746	1.98	11.54	0.234	0.17	0.3	0.231
Santa Catarina	14.8	0.774	1.01	12.38	0.192	0.128	0.253	0.194

Sources: * PNAD 2009; ** PNUD 2010.
MHDI: Municipal Human Development Index; SVI: Social Vulnerability Index.

high cluster in Roraima, which means high SVI infrastructure and high prevalence of FNI, and low-low type in Rio Grande do Sul and Santa Catarina. A moderate and positive correlation ($I_{ML} = 0.636$) was found with SVI human capital and the FNI variable, with high-high clusters in

Food Insecurity (%) X HDI

LMI = -0.643
p < 0.05

Food Insecurity (%) X Extremely poor (%)

LMI = 0.684
p < 0.05

Food Insecurity (%) X Child mortality

LMI = 0.572
p < 0.05

Not significant
High-high
Low-low
Low-high
High-low

Figure 1. Distribution of clusters of the bivariate spatial correlation LISA of the situation of food and nutritional insecurity with markers of vulnerability, in the Brazilian Federative Units, 2009-2010.
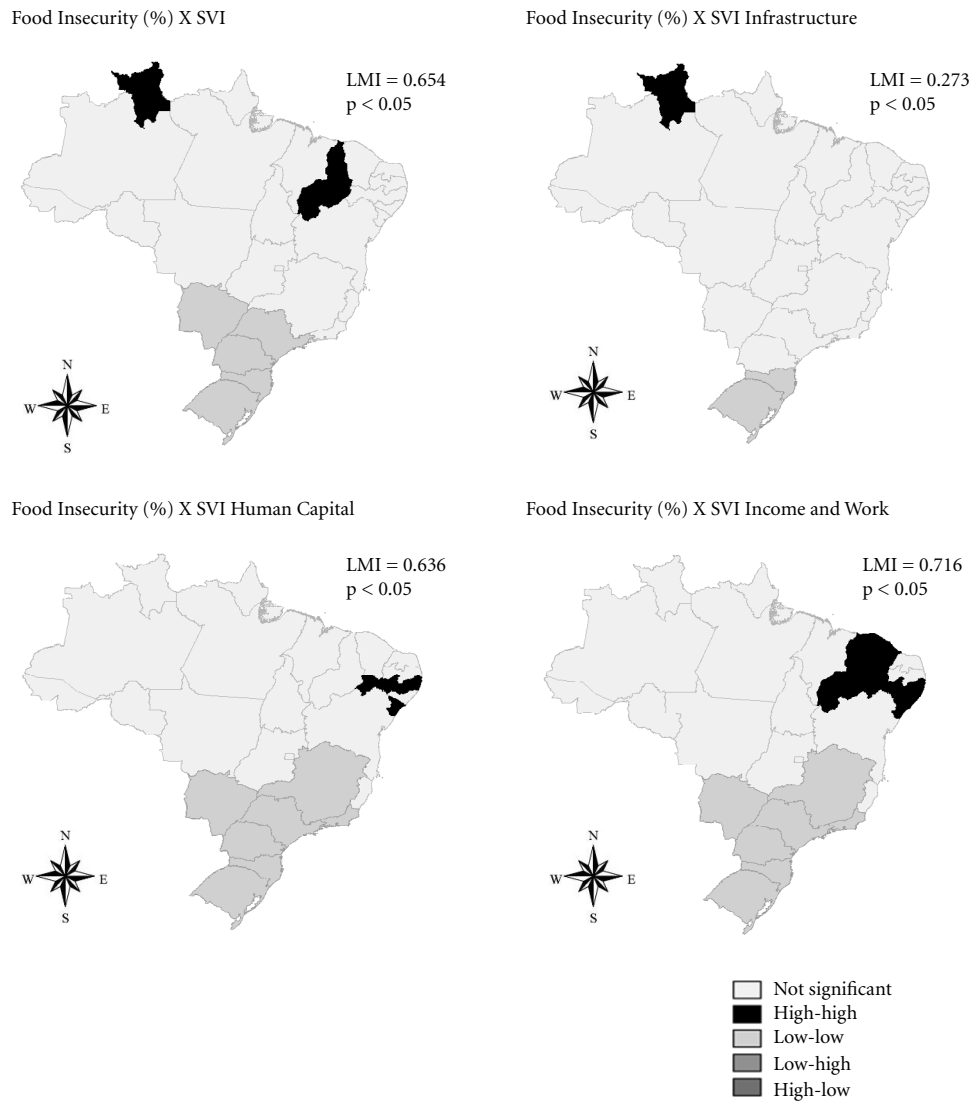
IML: Local Moran Index. HDI: Human Development Index.

Pernambuco and Sergipe, with high SVI human capital and high FNI prevalence, and with low-low type in states of the Mid-South of the Country (Figure 2).

In the (bivariate) spatial correlation of FNI with SVI income and work, clusters with strong and positive correlations ($I_{ML} = 0.716$) of the high-high type were found in Pernambuco, Alagoas, Sergipe, Ceará and Piauí, with high SVI income and work and high prevalence of FNI, while low-low clusters were observed in the Mid-South states, with lower values of SVI income and work and prevalence of FNI (Figure 2).

When comparing the prevalence of FNI, mild, moderate or severe in the three years evaluated, we observed a decline through the years, which was unequal, with the emergence of two patterns: one with higher prevalence of FNI in

Food Insecurity (%) X SVI

LMI = 0.654
p < 0.05

Food Insecurity (%) X SVI Infrastructure

LMI = 0.273
p < 0.05

Food Insecurity (%) X SVI Human Capital

LMI = 0.636
p < 0.05

Food Insecurity (%) X SVI Income and Work

LMI = 0.716
p < 0.05

Not significant
High-high
Low-low
Low-high
High-low

Figure 2. Distribution of clusters of the bivariate spatial correlation LISA of the situation of food and nutritional insecurity with markers of vulnerability, in the Brazilian Federative Units, 2009-2010.

LMI: Local Moran Index. SVI: Social Vulnerability Index.

UFs of the North and Northeast, and another one with lower prevalence of FNI in UFs of the South, Southeast and Midwest. It is noted that, in 2004, seven Brazilian states showed prevalence above 54% of some level of FNI, and in 2009 and 2013, only two states remained in this condition (Piauí and Maranhão). Again in 2004, seven states had a prevalence of less than 28%; they became eight states in 2009, and 13 states in 2013 (Figure 3).

Discussion

The establishment of the Organic Law on Food and Nutrition Security (LOSAN) in 2006 represents an advance in the assurance of social rights and explains the decreased prevalence observed. However, the creation of legal regulations alone does not guarantee FNS. According to Pinheiro[18], there is a long-term course to execute the

2004

2009

2013

< 28%
28.1 to 44.0%
44.01 to 54.0%
> 54%
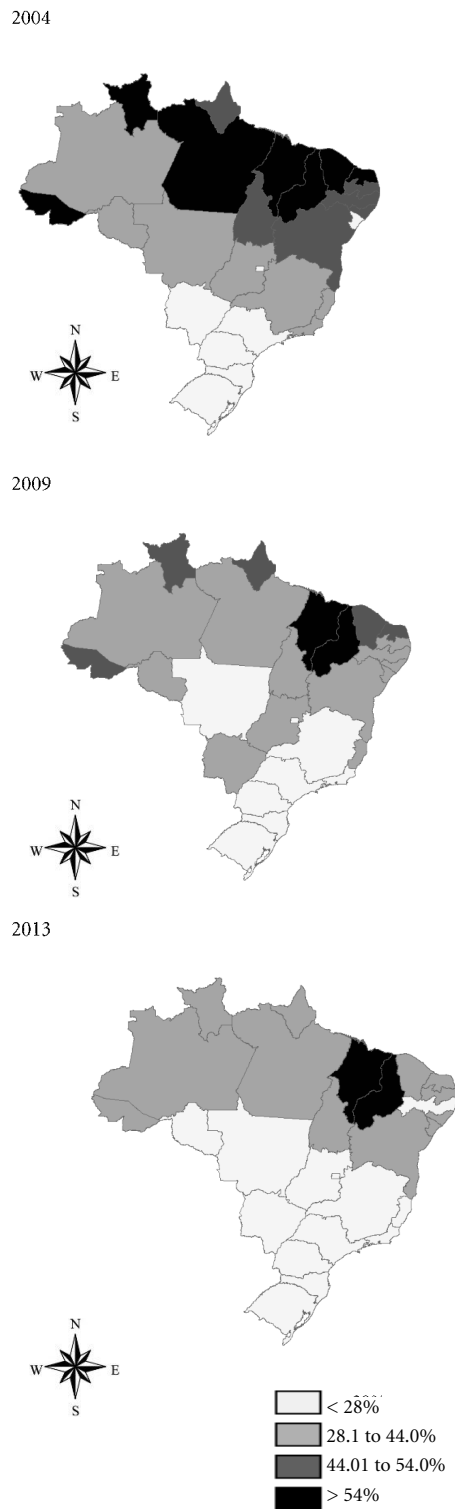
Figure 3. Spatial distribution of the food and nutritional insecurity situation, by Federative Unit, Brazil, 2004, 2009 and 2013.

principles of this law, aiming at significant impacts within the Brazilian territory, historically marked by inequalities and heterogeneity.

The FNS strengthening process at the national level begins with the *Fome Zero (*Zero Hunger) Program, the primary strategy of federal government actions between 2003 and 2004 consisting of several income transfer lines. Subsequently, the unification of the transfer programs and the program's reform to confer an organic character and alignment with the LOSAN culminated in the creation of the *Bolsa Família* (Family Grant) Program[19].

The involvement of the various sectors involved, such as Health, Agriculture, Social Welfare and Education, was one of the critical elements in the achievement of FNS advances. Programs such as those of Food Acquisition, Popular Restaurants, Food Bank, Cisterns Program, School Health, Family Agriculture and School Feeding were designed as structuring lines for access to food. This was important for the consolidation of Food Security policies as State policies and not for governments[20].

As Lawrence et al.[21] pointed out, the process of reforming and transforming food systems aiming at FNS should not only provide for the development of projects in individual sectors but the integration of these sectors into a holistic government approach. The authors also highlighted the vital role of social participation and good governance for significant advances in this field.

The results also showed a negative spatial correlation between the prevalence of FNI and the MHDI, which confirms the relationship between worse socioeconomic conditions with a higher probability of food insecurity (FI) at home, as well as in studies that show an association between FNI and lower level of schooling of the responsible/mother[21-25] and lower per capita household income[21-23,25-29].

In this study, the percentage of extremely poor had positive and moderate spatial autocorrelation with the prevalence of FNI, with the establishment of a spatial cluster in the states of Pernambuco, Maranhão and Piauí in the Northeast, and Pará in the North. The FNI scenario in this territory may occur due to the prominence that some of these states have been receiving as an agricultural border, responsible for a large part of Brazil's grain production[30]. This is what happens in the region known as Matopiba, which comprises the states of Maranhão, Piauí, Tocantins and Bahia, 337 municipalities and an area of

73,173,485 hectares. In recent years, this Brazilian territory, inhabited mainly by remnants of traditional peoples and communities, has been the scene of various political conflicts due to the process of territorialization of transnational capital in the region, mainly for the production of commodities such as cotton, sugar cane, corn and soybeans. There are currently 26 transnational corporations acting directly in the "foreignization" of the land of these Federative Units[31]. The lack of social control practices and consolidation of access to land reinforces the construction of the social injustice scenario and, thus, brings a greater possibility of moderate and severe FNI[32].

It is noted that the decreased availability, access or consumption of food ends up compromising the quality, quantity and regularity that underpin the basic food of households in an FNI situation. When this situation is associated with the child profile, it is possible to notice a compromise of the caloric and nutrient intake, reflecting deficits in the growth and development of these children, which contributes to a higher prevalence of child mortality in these populations[33]. Income transfer programs can also contribute significantly to reduce child mortality in general and, in particular, to deaths attributable to poverty-related causes, such as malnutrition and diarrhea, in a country with high income inequality, such as Brazil[34]. This is because, like the Bolsa Família Program (PBF), an enrolled household must fulfill specific education and health conditions, such as immunization and monitoring of growth and development, as well as school attendance depending on the age of the child. Pregnant and lactating women should participate in prenatal care and postnatal visits, health care follow-up and educational activities[35].

Regarding social vulnerability, evaluated in the three dimensions, namely, infrastructure, human capital and income and work, it was observed that the index of total social vulnerability was unevenly distributed in Brazilian territory, with the establishment of spatial clusters in the states of Roraima and Piauí. The situation of social vulnerability of the poor family is directly linked to the structural misery, aggravated by the economic crisis that throws the man or the woman into unemployment or underemployment. Also, a precarious socioeconomic situation contributes to fragile family conformations, directly affecting the most vulnerable. Poverty, misery and lack of perspective to improve living conditions impose on every household an unequal and inhumane struggle for survival[36,37].

Concerning SVI urban infrastructure, which evaluated markers related to water supply, sanitary sewage, garbage collection and low income, a positive and weak correlation was found with the prevalence of FNI, with a spatial cluster in the State of Roraima in the North. Garcia and Matos[38] also found municipalities with high urban vulnerability in the North; however, unlike this study, especially in the States of Pará and Tocantins. This is because it was evaluated through an index constructed with different markers.

Regarding the SVI human capital, which relates mainly to the schooling conditions of the household, this study evidenced spatial clusters in the States of Pernambuco and Sergipe. In a systematic review with meta-analysis, Bezerra et al.[39] found that six of the ten studies that aimed to associate the FNI with the schooling of the head of the household showed a significant association (60% of the studies). In a comparative study on socioeconomic conditions and FNI between the Northeast and South, it was found that, in both regions, the mean per capita income was twice lower if maternal schooling was up to four years, compared to nine years of maternal schooling or more[39].

In a systematic review of FNI's socioeconomic determinants, the variable that showed the most significant association with FNI was the worse household income[38]. Considering that income is a predictor of FNS, although not the only one, it is assumed that earnings in income may also contribute to reduced FNI and hunger[40]. Thus, the available household income has a significant influence on food consumption, where when there is a situation of lower income, the household's first attitude is to consume cheaper food so that the quantity is not compromised, regardless of the nutritional quality. Once there is a more drastic retraction of this income, the quantity and regularity of food consumed are reduced. This reality alerts us to the fact that hunger can be a reality even in the absence of specific clinical signs[41]. Data from *Vigitel Brasil 2016: surveillance of risk factors and protection for chronic diseases by telephone survey* indicate that obesity increased by 60% in the last 10 years in country[42]. The greater availability at the household level of ultra-processed food products is one of the causes associated with the higher prevalence of overweight and obesity in all age groups in the country, especially in lower income and schooling levels[43]. This study revealed a strong and positive spatial correlation of SVI income and work with the prevalence of FNI in Northeastern states.

This can be explained by the worse employment, income and schooling conditions of households in this territory.

Child mortality and prevalence of FNI had positive and moderate spatial correlations in less developed UFs, in the Northeast (Pernambuco, Alagoas, Sergipe and Piauí). Although poverty and social vulnerability are already known in the most historically underdeveloped regions of the country, such as the Northeast region, the prevalence of FNI has been spatially correlated with infant mortality in these territories, as corroborated by the findings of this research, show that besides social inequalities already known, inequalities are found in material, biological, psychosocial and behavioral health-producing factors that affect child health[44]. Studies show that the occurrence of FNI is associated with breastfeeding for less than 24 months[31], exclusive breastfeeding for less than six months[31], childhood asthma[45], child malnutrition[46], reduced energy, protein and iron consumption by the child[47] and the worst situations of child nutritional status, such as weight, height and weight-for-age deficits[30].

It is verified that the execution of FNS policies has addressed some isolated aspects, which hinder the realization of the Human Right to Adequate Food (DHAA). There is also a lack of articulation between levels of federation and weaknesses in the processes established for the eradication of hunger and misery in the country[48].

A change aimed at transforming the system ultimately depends on the creation of mechanisms to strengthen food democracy, a setting in which citizens are aware of and actively involved in the issues that permeate the food system of which they are part[49]. Democracy is the appropriate way and procedure to ensure that political decisions are an expression of the general will, as long as human rights are protected. The democratic regime identifies who decides, how it decides and what can be decided[50]. Decentralization as an FNS guideline, for example, considering local realities and social participation could be taken as guides to the process of strengthening food democracy, aiming at most significant impacts on the reduction of FNI[51].

As in this study, Gubert et al.[52] found a reduce prevalence of FNI in Brazilian UFs from 2004 to 2013, through municipal estimates. They found a more significant reduction in prevalence in the Northeast, although it increased during this period in some states, especially Amazonas, Sergipe and Santa Catarina.

Research that may continue this time study of the prevalence of FNI initiated in this paper can directly affect the FNI of the affected populations and prevent a process of transformation of the food system aiming at FNS. This is due to the current scenario of democratic weakness in the country, characterized by a regression in public policies, especially those aimed at strengthening family agriculture, income transfer, land redistribution, comprehensive health actions and vulnerable groups[21].

The limitations of the study are related to the methodology used, which results must be interpreted with caution due to a possible bias of aggregation or ecological fallacy. Because it is an ecological study, the observation of a relationship between two variables at the aggregate level does not necessarily imply that this relationship is employed at the individual level. The study evidenced good internal validity, since data derived from population surveys with a complex sample and were representative of the geographic strata analyzed.

One of the strong aspects of this study was the fact that it associated the territorial distribution of FNI with different social vulnerability conditions, and found two distinct patterns, one with territories with higher FNI prevalence and worse income, work and child health conditions in the North and Northeast, and another with lower prevalence of FNI and lower vulnerability according to the markers analyzed in UFs in the Midwest, Southeast and South regions.

Also, we highlight the methodological rigor in data processing and the relevance of the three-dimensional analysis that relate to the prevalence of FNI: infrastructure, human capital and income and work. The findings contributed to the knowledge of determinants of the FNI and its territorial distribution, which may help in the planning and implementation of policies and programs that are more effective, resolutive and specific to the priority geographic spaces, contributing to better living conditions and FNS at home.

Final considerations

We can conclude that the occurrence of FNI was reduced over the years analyzed (2004 to 2013) and was unevenly distributed in the Brazilian territory, with an inverse association with the MHDI. On the other hand, it showed a direct association with the percentage of extremely

poor, the higher occurrence of child mortality, and greater vulnerability associated with worse income and work conditions. We were managed to identify the UFs that still require priority actions for better working conditions and income and child health.

The findings confirmed the correlation between the FNI and the different structuring pillars of social vulnerability (infrastructure, human capital, income and work), which shows its establishment in territories with possible violation of fundamental rights, and this affects the lack of access to food, as was predominantly the case of UFs of the Northeast and North.

It is understood that the reduced prevalence of FNI in the analyzed years can be explained by the fact that the FNI has become a priority line in the government projects of the period, culminating with the food as a right in 2010. Also, the establishment of the policies, such as the expansion of programs such as the family grant, the strengthening of family agriculture, and social protection networks as measures of social inclusion in Brazil, may have contributed to some assurance of the realization of the human right to adequate food in all the Brazilian territory.

Collaborations

MS Bezerra contributed to the design, analysis and interpretation of data; Writing of the article or critical review relevant to the intellectual content; Final approval of the version to be published; D Vale in the analysis and interpretation of data; Critical review relevant to intellectual content; Final approval of the version to be published; MCM Jacob in the critical review relevant to intellectual content; Final approval of the version to be published. MAF Ferreira and IRB Mirabal in data analysis and interpretation; Critical review relevant to intellectual content; Final approval of the version to be published; CO Lyra in the design, analysis and interpretation of data; writing of the article or critical review relevant to the intellectual content; final approval of the version to be published.

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