Journal of Biosocial Science (2024), 56: 3, 493–503
doi:10.1017/S0021932024000087

CAMBRIDGE UNIVERSITY PRESS

RESEARCH ARTICLE

Social inequities in food deserts and food swamps in a northeastern Brazilian capital

Jennyffer Mayara Lima da Silva[1], Juliana Souza Oliveira[1], Daniely Casagrande Borges[2], Olívia Souza Honório[3], Larissa Loures Mendes[4] and Raquel Canuto[1,2]

[1]Program in Nutrition, Universidade Federal de Pernambuco, Brazil, [2]Program in Food, Nutrition and Health, Universidade Federal do Rio Grande do Sul, Brazil, [3]Program in Health and Nutrition, Universidade Federal de Ouro Preto, Brazil and [4]Program in Nutrition and Health, Universidade Federal de Minas Gerais, Brazil
Corresponding author: Raquel Canuto; Email: raquel.canuto@ufrgs.br

(Received 1 September 2023; revised 2 January 2024; accepted 30 January 2024; first published online 28 February 2024)

Abstract

This study identified food deserts and swamps, investigating their associations with socioeconomic and demographic conditions. This ecological study was conducted using data from urban census tracts in the city of Recife, which were considered the unit of analysis. Information on food retail was obtained from government sources in 2019. Census tracts below the 25th percentile in the density of healthy food retail (i.e., those that predominantly sell natural or minimally processed foods, mixed businesses, and super- and hypermarkets) were classified as food deserts. Census tracts above the 25th percentile in the density of unhealthy food retail (i.e., those selling primarily ultra-processed foods) were considered food swamps. The socioeconomic and demographic conditions of the census tracts were evaluated using variables from the 2010 census (per capita income, average income, race, literacy of the head of household, and the availability of essential services) and the Health Vulnerability Index. Census tracts considered food deserts (28.5%) were more vulnerable, characterized by lower income and access to essential services, more illiterate residents and more minorities (Black/Indigenous/mixed race). Food swamps (73.47%) were more prevalent in less vulnerable neighbourhoods characterized by higher percentages of literate residents and Whites, greater purchasing power, and better basic sanitation. The characteristics of Recife's food deserts and swamps demonstrate social inequalities in the food environment. Public facilities could play a vital role in promoting healthy eating within food deserts. Additionally, future implementation of taxes on ultra-processed foods and the provision of tax subsidies to natural or minimally processed food sellers might contribute to fostering healthier dietary choices.

Keywords: Food desert; food swamp; food environment; food systems; social determinants on health

Introduction

Access to food is influenced by the characteristics of the food environment, such as the quantity, type, and location of food outlets (Health Canadá, 2013). Studies show that the distribution of these retailers is uneven and varies according to the socioeconomic and demographic aspects of neighbourhoods, which can influence the eating patterns of residents and produce or aggravate social health inequalities (Black *et al.*, 2014; Pessoa *et al.*, 2015; Matozinhos *et al.*, 2015; Llavero-Valero *et al.*, 2021; Almeida *et al.*, 2023). According to Espinoza's model (2017), food environments can be considered an intermediate social determinant of health.

Specific metrics for food deserts and swamps have been proposed to better understand access to healthy food and its relationship with neighbourhood characteristics (Cummis and Mancintyre, 2002; Rose *et al.*, 2009). Food deserts are socially vulnerable areas with limited or no access to

healthy foods (Cummis and Mancintyre, 2002), while food swamps are areas where ultra-processed food sales predominate (Rose *et al.*, 2009). In Brazil, food deserts are defined as areas with limited or no access to healthy foods independently of social vulnerability (CAISAN, 2018).

Food deserts have been more investigated in high-income countries, such as the USA, where they have been widely identified in poor and minority neighbourhoods through lower access to supermarkets, which are considered healthy food retailers (Walker *et al.*, 2010; Black *et al.*, 2014). In the USA, purchasing healthy foods is also more difficult for populations living in food deserts due to higher prices (Powell *et al.*, 2007). Food swamps are more common in Canada than in the USA and are considered better predictors of obesity and other chronic diseases than food deserts (Rose *et al.*, 2009; Cooksey-Stowers *et al.*, 2017).

Although food deserts and swamps have been studied in some high-income countries, these food environments may not reflect the characteristics of low- and middle-income countries, such as Brazil (Turner *et al.*, 2018). In Brazil, the Interministerial Chamber of Food and Nutrition Security (CAISAN) pioneered research into food deserts mapping the presence of food deserts in Brazilian state capitals. More recently, Honorório *et al.* conducted a study comparing the socioeconomic conditions of food deserts and swamps in Belo Horizonte, Brazil (Honório *et al.*, 2021).

Although this theme is advancing in Brazilian research, the northeast region of the country has been little investigated regarding social inequalities in food deserts and swamps. Therefore, the present study aimed to identify food deserts and swamps and their association with the socioeconomic and demographic conditions of census tracts of a metropolis in northeastern Brazil. We hypothesize that the presence of food deserts is associated with worse socioeconomic and demographic conditions in the area. Conversely, the presence of swamps is associated with better socioeconomic and demographic conditions.

Methods

Study design and unit of analysis

This ecological observational study was conducted in the city of Recife, the capital of the state of Pernambuco, Brazil, whose estimated 2021 population was 1,661,017 (IBGE, 2021), with a population density of 7,039.64 inhabitants per square kilometre (IBGE, 2010). According to social indicators for 2020 (IBGE, 2020), the city's Gini coefficient is 0.612, making it the state capital with the greatest intra-urban social inequality in Brazil. Recife's census tracts were considered the unit of analysis. Of its 1845 census tracts, 17 (0.9%) were excluded due to incomplete data. A census tract is a geographic region defined to take a census. Sometimes it coincides with the limits of cities, towns, or other administrative areas. The Brazilian Institute of Geography and Statistics uses the term census sector. As of the 2010 Census, there were approximately 314,000 sectors in Brazil (IBGE, 2010).

Food retail information

The following information was collected about food retail to survey the food environment in Recife: name, address, and code from the National Classification of Economic Activities (CNAE), a system for standardizing economic activity that is used by Brazilian tax agencies to identify economic activities (IBGE, 2016). A previous study carried out in Recife described the types of foods most frequently sold by each food retailer (Menezes *et al.*, 2022; Oliveira *et al.*, 2022). We utilized this information to categorize food retailers as follows: (I) food retailers that predominantly sell natural or minimally processed foods (50% or more); (II) mixed food retailers (those selling natural or minimally processed and ultra-processed foods); (III) food retailers selling predominantly ultra-processed foods (50% or more); and (IV) supermarkets and

https://doi.org/10.1017/S0021932024000087 Published online by Cambridge University Press

hypermarkets (Supplementary Table 1). Information from all 20.199 registered food retailers in Recife was analysed.

Following previous Brazilian studies (Leite *et al.*, 2021; Menezes *et al.*, 2022; Oliveira *et al.*, 2022; Borges *et al.*, 2023), supermarkets and hypermarkets were categorized separately due to the wide variety of foods they sell and the lack of consensus in the literature about their real influence on the purchasing profile of the population (Larson *et al.* 2009; Machado *et al.*, 2017).

Food deserts and swamps

Food deserts were identified using the methodology of the Technical Mapping Study of Food Deserts in Brazil (CAISAN, 2018), in which census tracts below the 25th percentile in the density of healthy food retail (i.e., those selling predominantly fresh or minimally processed foods, mixed businesses, supermarkets and hypermarkets) per 10,000 inhabitants are considered food deserts. Following Honório *et al.* (2021), food swamps were classified according to sales of a list of ultra-processed foods proposed by CAISAN (2018). This method considers food swamps to be census tracts above the 25th percentile in the density of unhealthy food retail (i.e., those selling mainly ultra-processed foods) per 10,000 inhabitants (Honório *et al.*, 2021).

The following data were collected on food retail: address, National Classification of Economic Activities registration, and geographic coordinates (latitude and longitude) (Find Latitude and Longitude, 2022). The businesses were then georeferenced through the Geographic Information System and QGIS 2.14.9 software.

Socioeconomic and demographic variables

The following variables were extracted from the 2010 Census database for each tract: total and per capita family income, total number of households, and total population. Data for each household included the literacy of the head of household, the residents' race, and household characteristics (IBGE, 2010). The per capita family income of the census tract was calculated using the ratio between the total income and number of residents in the tract, categorized into quartiles: 1st quartile: BRL 78.20–264.88; 2nd quartile: BRL 264.89–417.91; 3rd quartile: BRL 417.92–939.96; 4th quartile: > BRL 939.96, based on 2010 exchange rates.

Literacy was categorized as literate (those who can read and write a simple note) or illiterate (those who can only write their own name) (IBGE, 2010); race was categorized as White, Black, Indigenous, or mixed race according to self-report (IBGE, 2010); and households were evaluated regarding basic services: water supply, garbage collection, and sewage system (IBGE, 2010).

The Health Vulnerability Index (HVI) was also used to assess the degree of vulnerability in census tracts. The HVI is used as a proxy for socioeconomic vulnerability (Honório *et al.*, 2021; Leite *et al.*, 2021). This is a composite indicator that combines socioeconomic dimension (residents per household, percentage of illiterate people, percentage of private households with a per capita income of up to half a minimum wage, average nominal income of those responsible, percentage of people of brown, black and indigenous) and environmental dimension (sanitary sewage, water supply, and disposal of solid waste). All indicators were standardized to values between zero and one to facilitate comparison and aggregation of indicators measured on different scales.

The final composite indicator assigns distinct weights to each variable and dimension, determined through discussions involving 16 experts in the field. For the socioeconomic dimension, the weights are as follows: residents per household (0.073), percentage of illiterate people (0.289), percentage of private households with a per capita income below half a minimum wage (0.288), average nominal income of household heads (0.173), and percentage of people identifying as brown, black, and indigenous (0.185). Similarly, for the environmental dimension, the weights are sanitary sewage (0.424), water supply (0.375), and disposal of solid waste (0.201).

https://doi.org/10.1017/S0021932024000087 Published online by Cambridge University Press

The composite indicator also incorporates a weighted sum of both dimensions, with a weight of 0.604 assigned to socioeconomic variables and 0.396 to environmental variables.

The resulting HVI ranges from 0 to 1, where values closer to 1 indicate high social vulnerability and values closer to zero indicate low or negligible social vulnerability. Census tracts are subsequently categorized based on their HVI scores into medium risk (mean ± 0.5 SD), low risk (<−0.5 SD), high risk (+0.5 to +1.5 SD), and very high risk (>+1.5 SD). Notably, the high-risk and very high-risk categories were combined due to the limited number of high-risk tracts.

Data analysis

The absolute and relative frequency of food deserts and swamps were described according to census tract HVI, and the association was tested using Pearson's chi-square test. Data normality was determined using the Kolmogorov-Smirnov test. Using Student's *t*-test, the association between tracts considered food deserts/food swamps and their socioeconomic conditions was determined. The significance level was set at $p < 0.05$. All analyses were performed in QGIS 2.14.9 and SPSS version 20.

Results

Of the total of 20,199 identified food retail, most predominantly sold ultra-processed foods (77.3%, $n = 15{,}607$), followed by mixed items (14.6%, $n = 2952$), natural or minimally processed foods (7.4%, $n = 1488$), and supermarkets and hypermarkets (0.75%, $n = 152$). Regarding the classification of census sectors according to the HVI, 34% ($n = 623$) were classified as low health vulnerability, 35.3% ($n = 645$) as medium, and 30.6% ($n = 560$) as high or very high. In total, 28.5% ($n = 521$) of Recife's census tracts were classified as food deserts and 73.47% ($n = 1343$) were classified as food swamps. The frequency of food deserts varied according to vulnerability, being more prevalent in areas with high HVI (12.47%). In contrast, food swamps were more frequent in tracts with a low or medium HVI (Table 1). There was a dose-response association in both associations.

As shown in Table 2, census tracts classified as food deserts had a higher mean number of households whose per capita income was ≤0.5 the federal minimum salary (35% [SD, 21%] vs. 27% [SD, 19%]; $p < 0.001$), as well as a lower mean monthly nominal income (BRL 1730.66 [SD, 1941.88] vs. BRL 1812.39 [SD, 1921.9]; $p = 0.004$), than in tracts considered non-food deserts. Food deserts also had more residents per household, more illiterate people, and a higher percentage of Black, Indigenous, and mixed-race residents than non-food deserts. Food deserts also had a higher mean number of households with inadequate water supply, sewage, and garbage collection than non-food deserts.

As also shown in Table 2, census tracts classified as food swamps had a lower mean number of households whose per capita income was ≤0.5 the federal minimum salary (28% [SD, 19%] vs. 35% [SD, 21%]; $p < 0.001$) and a higher mean nominal income than tracts classified as non-food swamps (BRL 1829.64 [SD, 1963.9] vs BRL 1456.67 [SD, 1854.10]; $p < 0.001$). In addition, food swamps had fewer illiterate people, fewer non-Whites, and a lower mean number of residents per household than non-swamps. The mean number of households with adequate essential services (water supply, sewage, and garbage collection) was higher in food swamps than in non-food swamps.

Regarding geographical distribution, food deserts predominated in highly vulnerable regions, especially the northern outskirts of the city, with scattered points in areas of low and medium HVI, as shown in Fig. 1. Food swamps were widely distributed among the 3 HVI categories, except for tracts of low vulnerability in the extreme north of the city, as shown in Fig. 2.

https://doi.org/10.1017/S0021932024000087 Published online by Cambridge University Press

Table 1. Food deserts and swamps according to census tract (n = 1828) Health Vulnerability Index. Recife, 2019

	Food Deserts		Food Swamps	
Health Vulnerability Index	521 (28.5%)	p-value*	1343 (73.47%)	p-value*
Low risk (n = 623)	124 (6.78%)	<0.001	501 (27.41%)	<0.001
Medium risk (n = 645)	169 (9.24%)		495 (27.1%)	
High and very high risk (n = 560)	228 (12.47%)		347 (18.98%)	

*Pearson's chi-square test.

Discussion

Notably, there were few food deserts, but they predominated in highly vulnerable areas on the outskirts of the city. The socioeconomic conditions and essential services were worse than in areas not classified as deserts. In contrast, food swamps were many and widely distributed, predominating in areas of medium and low vulnerability, mainly downtown and in upscale neighbourhoods. Such areas also have a better income profile and access to essential services.

Fewer food deserts were found in Recife than in other large cities in southern (48.3%) and southeastern (38%) Brazil (Honório *et al.*, 2021; Borges *et al.*, 2023). However, the characteristics of food deserts (i.e., income, demographic profile, and access to basic services) were similar in all 3 cities. The CAISAN study (2018) identified food deserts in several Brazilian capitals but did not find a fixed distribution pattern in income. These differences may be linked to urban characteristics. For example, Recife's low-income neighbourhoods are contiguous with high-income neighbourhoods, where food swamps are highly prevalent. In contrast, high-income and low-income neighbourhoods are separated in the cities investigated in southern and southeastern Brazil (Belo Horizonte, 2021; Borges *et al.*, 2023).

North American studies have also found more food deserts in low-income regions with a higher prevalence of Black and Latino residents (Walker *et al.*, 2010; Black *et al.*, 2014). The lower income of minority populations and racial segregation are considered important factors in the occurrence of food deserts (Walker *et al.*, 2010; Black *et al.*, 2014). However, due to the different methodologies of Brazilian studies, caution should be exercised when comparing the findings in the food deserts and swamps analyses. Indeed, the present study evaluated a wide variety of food retail, as in previous Brazilian studies (CAISAN, 2018; Honório *et al.*, 2021; Borges *et al.*, 2023), while studies in other countries have focused on proximity to supermarkets (Walker *et al.*, 2010; Black *et al.*, 2014); in these countries, the presence of supermarkets is a marker of access of foods considered to be healthy (Walker *et al.*, 2010; Black *et al.*, 2014). North American studies also used different measures of socioeconomic position limiting comparison.

A North American study adopted the measure of income ≤200% of the poverty line and distance greater than 1.6 km in an urban area or greater than 16 km in a rural area to classify a neighbourhood as a food desert (Cooksey-Stowers *et al.*, 2017). Food swamps are also assessed by different measures. The Center for Disease Control and Prevention (CDC), the USA, proposed a widely adopted measure: the modified retail food environment index (mRFEI) (CDC, 2011). This index evaluates the proportion of healthy food retail stores in relation to the total available in each census sector and classifies neighbourhoods that have a small value, but greater than zero, as a food swamp (CDC, 2011). Despite the different measurement methods, the Brazilian methodology is the most appropriate to study the topic in Brazil as it considers the most frequent food retailers present in Brazil (Honório *et al.*, 2021).

Regarding the income and racial profile of food deserts, the lower access to healthy foods among Black, Indigenous, and mixed-race residents reflects historical racial inequalities in

https://doi.org/10.1017/S0021932024000087 Published online by Cambridge University Press

Table 2. Socioeconomic conditions of census tracts in considered food deserts and swamps in Recife, Brazil, 2019

	Total (n = 1828)		Food Deserts					Food Swamps				
			Yes (n = 521)		No (n = 1307)			Yes (n = 1343)		No (n = 485)		
Variables	Mean	SD	Mean	SD	Mean	SD	p-value*	Mean	SD	Mean	SD	p-value*
% of households with inadequate or no water supply	13	0.2	15	0.23	13	0.19	0.056	13	0.18	15	0.24	0.014
% of households with inadequate or no sewage	29	0.15	36	0.37	27	0.32	<0.001	27	0.33	35	0.37	<0.001
% of households with inadequate or no garbage collection	5	0.15	8	0.18	4	0.13	<0.001	5	0.14	7	0.17	0.008
% of Black, Indigenous, and mixed-race people	56	0.17	60	0.17	54	0.17	<0.001	55	0.17	60	0.17	<0.001
number of residents per household	3.25	0.33	3.3	0.33	3.23	0.33	<0.001	3.24	0.33	3.28	0.34	<0.010
% of households with per capita income $\leq$0.5 $\times$ the federal minimum salary	29	0.19	35	0.21	27	0.19	<0.001	28	0.19	35	0.21	<0.001
Mean nominal monthly income	1730.66	1941.88	1525.63	1978.17	1812.39	1921.9	0.004	1829.64	1963.9	1456.57	1854.10	<0.001
% of illiterate People	10	0.06	12	0.07	9	0.05	<0.001	9	0.05	12	0.07	<0.001

*Student's t-test.

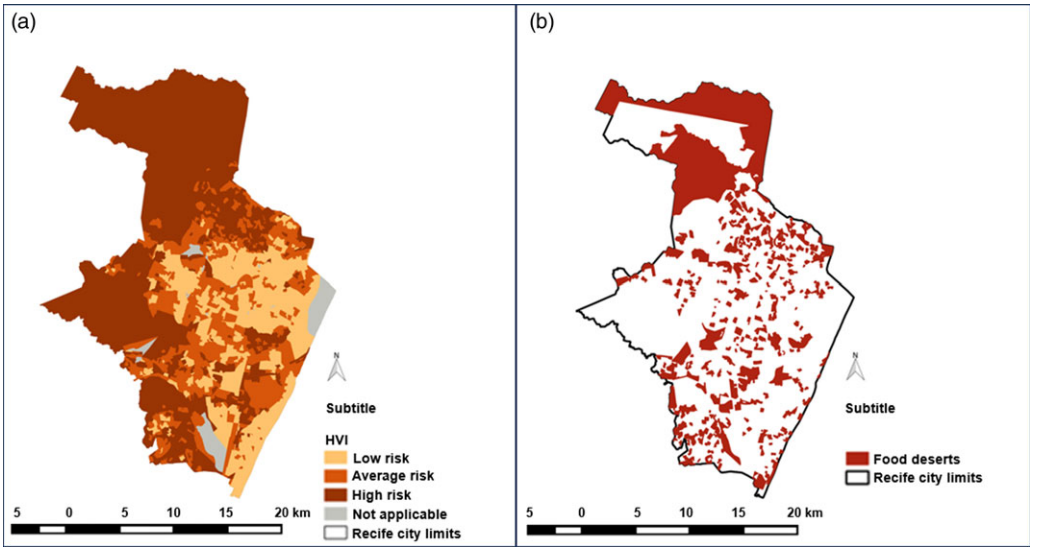

Figure 1. Census tracts ($n = 1828$) mapped according to the Health Vulnerability Index (HVI) (a) and food deserts (b). Recife. Brazil, 2019.

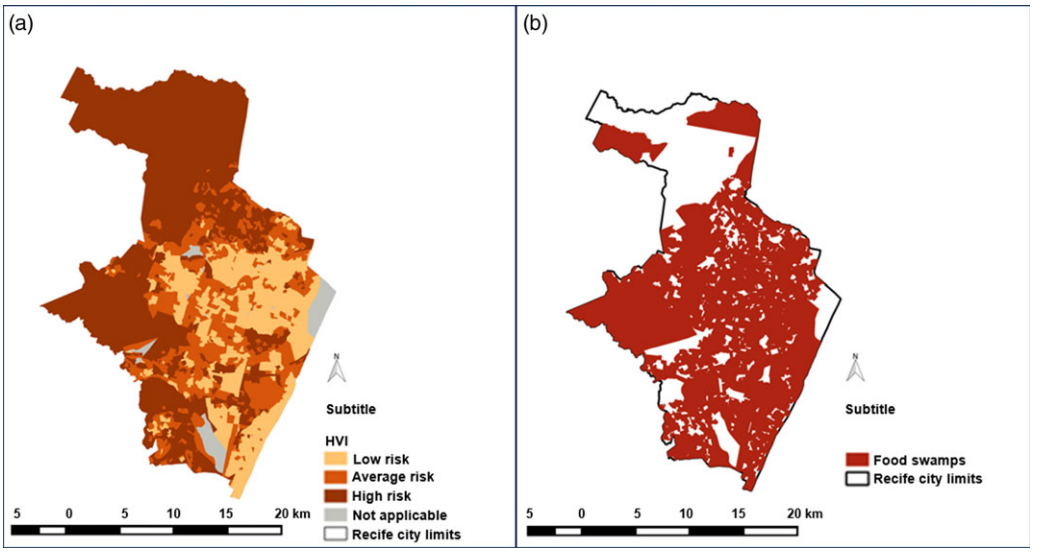

Figure 2. Census tracts ($n = 1828$) mapped according to the Health Vulnerability Index (HVI) (a) and food swamps (b), Recife, Brazil, 2019.

Brazilian society. According to a 2021 survey by the Brazilian Institute of Geography and Statistics (IBGE), the average income of White workers was almost double that of Black and mixed-race workers in Brazil. Accordingly, in these populations, the poverty rate is twice that of Whites. Unemployment also disproportionately affects Blacks (16.5%) and people of mixed race (16.25%) compared to Whites (11.3%) (IBGE, 2022).

This study is the first to associate food environment characteristics with basic service provision in a city in northeastern Brazil. The lower socioeconomic condition of residents and inadequate

https://doi.org/10.1017/S0021932024000087 Published online by Cambridge University Press

access to essential services prevalent in Recife's food deserts shows that vulnerable groups may face additional barriers to maintaining a healthy diet. This could be due to the ability of unfavourable environmental conditions to increase individual socioeconomic disadvantage (Macintyre, 2007; Ford and Dzewaltowski, 2008). Thus, individuals from a historically lower socioeconomic position (non-White race, lower education and income, and rural vs urban residence) are less likely to have a nutritionally balanced diet (Canuto *et al.*, 2019), and a healthy diet is even more inaccessible for residents of food deserts (Macintyre, 2007; Ford and Dzewaltowski, 2008).

The city's numerous food swamps, characterized by an excessive supply of ultra-processed foods (Rose *et al.*, 2009), especially in less vulnerable areas, reflect the findings of other studies in southeastern Brazil (Honório *et al.*, 2021; Grilo *et al.*, 2022). The higher percentage of White residents, higher income, and better access to basic services in the food swamps of Recife were similar to food swamps in Belo Horizonte, where 58.8% of the census tracts were classified as food swamps (Honório *et al.*, 2021).

The predominance of food swamps in the most affluent areas of Recife follows a trend toward a greater density of food retail, including those that sell ultra-processed foods, as a neighbourhood's socioeconomic level increases, resulting in high exposure to unhealthy foods in Brazilian urban areas (Almeida *et al.* al., 2021; Honório *et al.*, 2021). However, Canadian (Luan *et al.*, 2015) and North American studies (Hager *et al.*, 2017) have found that food swamps exist independently of the neighbourhood's socioeconomic status.

One explanation for the predominance of food swamps in these census tracts in Recife could be the purchasing power of the population and the characteristics of the foods. The high presence of food swamps may also be a reflection of the non-random distribution of food retail. These businesses generally appear in wealthier areas of the city, where there are more potential consumers. The precarious infrastructure and higher crime rates in the most vulnerable areas can discourage the development of food retail (Walker *et al.*, 2010).

The abundant supply of ultra-processed foods in food swamps can discourage healthy eating and negatively affect the health of the population. Evidence suggests that individuals living in areas with more healthy food retail eat more fruits and vegetables (Jaime *et al.*, 2011; Pessoa *et al.*, 2015) and are less likely to become obese (Matozinhos *et al.*, 2015; Oliveira *et al.*, 2022). However, living in areas with more fast food restaurants and less fresh and whole foods is associated with a higher prevalence of overweight and chronic disease (Mendonça *et al.*, 2010; Chen *et al.*, 2019; Gómez-Donoso *et al.*, 2020; Llavero-Valero *et al.*, 2021).

The concepts of food swamp and food desert complement each other as they demonstrate the effects of competition in the food environment between a high supply of ultra-processed foods and a scarcity of natural or minimally processed foods. Evidence suggests that food swamps are stronger predictors of obesity and other chronic non-communicable diseases than food deserts (Rose *et al.*, 2009; Cooksey-Stowers *et al.*, 2017). A study carried out in the USA identified a higher prevalence of obesity in adults living in swamps than those living in food deserts, and this situation was worsened by socioeconomic factors, such as the lack of public transport in the neighbourhood (Cooksey-Stowers *et al.*, 2017). Another study demonstrated that living in a food swamp was associated with increased hospitalization rates for diabetes complications in the USA (Phillips and Rodriguez, 2020). Moreover, in Canada, proximity to fast-food restaurants has been associated with an elevated likelihood of developing diabetes mellitus among young adults (Polsky *et al.*, 2016).

Limitations and strengths

This study has some limitations. The first involves the age of the data, since the sociodemographic data are from the 2010 Census, while the food retail data are from 2019. Due to COVID-19 and a political crisis, Brazil did not have a Census in 2020. The second limitation is the use of a HVI not adapted for the context of Recife. However, similar Brazilian studies have used the same HVI

https://doi.org/10.1017/S0021932024000087 Published online by Cambridge University Press

(Honório *et al.*, 2021; Leite *et al.*, 2021; Borges *et al.*, 2023). The third limitation refers to the non-inclusion of outdoor farmer's markets in the study, which may have led to an underestimation of the number of retailers that predominantly sell natural or minimally processed foods. Finally, the utilization of secondary data for food establishments can be a limitation, as it does not encompass informal market establishments.

However, this study's strengths include its pioneering investigation into the association between food deserts/swamps and social inequality (especially regarding essential services) in a city in northeastern Brazil. The study's second strong point is its inclusion of a wide variety of food retailers, including street vendors, rather than simply supermarket retailers.

Conclusions

In Recife, a metropolis in the northeast region of Brazil, the food environment includes few food deserts, which are predominantly in vulnerable areas with worse socioeconomic conditions and access to essential services and mainly affect non-White and illiterate residents. On the other hand, food swamps predominate in more affluent areas with better basic services. The characteristics of Recife's food deserts and swamps point to socioeconomic and racial inequalities in the food environment that can limit access to healthy foods and facilitate the consumption of ultra-processed foods. Thus, this investigation identified priority regions for increasing exposure and access to healthy foods and discouraging the sale of ultra-processed foods, especially in more vulnerable areas. For example, public facilities could be created to support healthy eating in food deserts and swamps, taxes could be added to ultra-processed foods and tax subsidies could be provided to natural or minimally processed food sellers. Furthermore, the social inequalities in food deserts and swamps, especially regarding access to basic services, indicate that public managers must consider new structural policies to mitigate social inequality.

Supplementary material. The supplementary material for this article can be found at https://doi.org/10.1017/S0021932024000087

Acknowledgements. This study was supported by the Brazilian Ministry of Education (CAPES: Code 001).

Funding statement. Larissa Loures Mendes – The National Council for Scientific and Technological Development (CNPq) *n.* 4/2021 – Research Productivity Scholarship – PQ – Process *n.* 312979/2021-5. Raquel Canuto – The National Council for Scientific and Technological Development (CNPq) *n.* 9/2022 – Research Productivity Scholarship – PQ – Process *n.* 306656/2022-1.

Competing interests. The authors declare no conflicts of interest.

Ethics standard. Since this was an ecological study, no human beings were recruited, and institutional ethics committee approval was not required.

References

Almeida IJ, Garcez VB, Cunha CML, Schuch I and Canuto R (2023) Association between the community food environment and dietary patterns in residents of areas of different socio-economic levels of a southern capital city in Brazil. *British Journal of Nutrition* **129** (6), 1066–1074. https://doi.org/10.1017/S0007114522001969

Almeida LFF, Novaes TG, Pessoa MC, do Carmo AS, Mendes LL and Ribeiro AQ (2021) Socioeconomic disparities in the community food environment of a medium-sized city of Brazil. *Journal of the American College of Nutrition* **40**(3), 253–260. https://doi.org/10.1080/07315724.2020.1755911

Belo Horizonte (2021) *Mapa das desigualdades*. Belo Horizonte. URL: https://nossabh.org.br/uploads/2021/06/Mapa-das-desigualdades-da-RMBH-2021.pdf

Black C, Moon G and Baird J (2014) Dietary inequalities: what is the evidence for the effect of the neighbourhood food environment? *Health Place* **27**, 229–242. https://doi.org/10.1016/j.healthplace.2013.09.015

Borges DC, Vargas JCB, Honório OS, Mendes LL and Canuto R (2023) Social and etnic-racial inequities in the occurrence of food deserts in a Brazilian capital. PREPRINT (Version 1) available at Research Square. https://doi.org/10.21203/rs.3.rs-3117295/v1

CAISAN (2018) *Estudo Técnico Mapeamento dos Desertos Alimentares no Brasil*: Secretaria-Executiva da Câmara Interministerial de Segurança Alimentar e Nutricional Ministério do Desenvolvimento Social. URL: https://aplicacoes.mds.gov.br/sagirmps/noticias/arquivos/files/Estudo_tecnico_mapeamento_desertos_alimentares.pdf

Canuto R, Fanton M and Lira PIC (2019) Social inequities in food consumption in Brazil: a critical review of the national surveys. *Ciências Saúde Coletiva* **24**(9), 3193–3212. https://doi.org/10.1590/1413-81232018249.26202017

Centers for Diseases Control and Prevention (CDC) (2011) Children's Food Environment State Indicator Report. URL: https://www.cdc.gov/obesity/downloads/ChildrensFoodEnvironment.pdf

Chen M, Creger T, Howard V, Judd SE, Harrington KF and Fointaine KR (2019) Association of community food environment and obesity among US adults: a geographical information system analysis *Journal of Epidemiology & Community Health* **73**(2), 148–155. https://doi.org/10.1136/jech-2018-210838

Cooksey-Stowers K, Schwartz MB and Brownell KD (2017) Food swamps predict obesity rates better than food deserts in the United States. *International Journal of Environmental Research and Public Health* **14**(11), 1366. https://doi.org/10.3390/ijerph14111366

Cummins S and Macintyre S (2002) "Food deserts"—evidence and assumption in health policy making. *British Medical Journal* **325**(7361), 436–4388. https://doi.org/10.1136/bmj.325.7361.436

Espinoza PG, Egaña D, Masferrer D and Cerda R (2017) Propuesta de un modelo conceptual para el estudio de los ambientes alimentarios en Chile. *Revista Panamericana de Salud Pública* **41**, e169. https://doi.org/10.26633/RPSP.2017.169

Find Latitude and Longitude (2022) URL: https://www.findlatitudeandlongitude.com/

Ford PB and Dzewaltowski DA (2008) Disparities in obesity prevalence due to variation in the retail food environment: three testable hypotheses. *Nutrition Reviews* **66**(4), 216–228. https://doi.org/10.1111/j.1753-4887.2008.00026.x

Gómez-Donoso C, Sánchez-Villegas A, Martínez-González MA, Gea A, Mendonça RD, Lahortiga-Ramos F and Bes-Rastrollo M (2020). Ultra-processed food consumption and the incidence of depression in a Mediterranean cohort: the SUN Project. *European Journal of Nutrition* **59**(3), 1093–1103. https://doi.org/10.1007/s00394-019-01970-1

Grilo MF, Menezes C and Duran AC (2022) Food swamps in Campinas, Brazil. *Ciência e Saúde Coletiva* **27**(7), 2717–2728. https://doi.org/10.1590/1413-81232022277.17772021

Hager ER, Cockerham A, O'Reilly N, Harrington D, Harding J, Hurley KM and Black MM (2017) Food swamps and food deserts in Baltimore City, MD, USA: associations with dietary behaviours among urban adolescent girls. *Public Health Nutrition* **20**(14), 2598–2607. https://doi.org/10.1017/S1368980016002123

Health Canadá (2013) Measuring the food environment in Canada. URL: https://www.canada.ca/en/health-canada/services/food-nutrition/healthy-eating/nutrition-policy-reports/measuring-food-environment-canada.html

Honório OS, Pessoa MC, Gratão LHA, Rocha LL, Castro IRR, Canella DS, Horta PM and Mendes LL (2021) Social inequalities in the surrounding areas of food deserts and food swamps in a Brazilian metropolis. *International Journal for Equity in Health* **20**(168). https://doi.org/10.1186/s12939-021-01501-7

Instituto Brasileiro de Geografia e Estatística – IBGE (2010). Censo 2010. URL: https://censo2010.ibge.gov.br/materiais/guia-do-censo/operacao-censitaria.html

Instituto Brasileiro de Geografia e Estatística – IBGE (2010). Censo 2010. URL: https://cidades.ibge.gov.br/brasil

Instituto Brasileiro de Geografia e Estatística – IBGE (2016) Classificação Nacional de Atividades Econômicas: Comissão Nac Classif Rio Janeiro. URL: https://concla.ibge.gov.br/classificacoes/por-tema/atividades-economicas/classificacaonacional-de-atividades-economicas

Instituto Brasileiro de Geografia e Estatística – IBGE (2020) Síntese de Indicadores Sociais. URL https://biblioteca.ibge.gov.br/visualizacao/livros/liv101760.pdf

Instituto Brasileiro de Geografia e Estatística – IBGE (2021) Diretoria de Pesquisas – DPE – Coordenação de População e Indicadores Sociais – COPIS. URL: https://ibge.gov.br/estatisticas/sociais/populacao/9103-estimativas-de-populacao.html?edicao = 17283&t = downloads

Instituto Brasileiro de Geografia e Estatística – IBGE (2022). IBGE – Desigualdades por raça e cor no Brasil – 2ª edição. URL: https://biblioteca.ibge.gov.br/index.php/biblioteca-catalogo?view = detalhes&id = 2101972

Jaime PC, Duran AC, Sarti FM and Locket K (2011) Investigating environmental determinants of diet, physical activity, and overweight among adults in Sao Paulo, Brazil. *Journal of Urban Health* **88**(3), 567–581. https://doi.org/10.1007/s11524-010-9537-2

Larson NI, Story MT and Nelson MC (2009) Neighborhood environments: disparities in access to healthy foods in the U.S. *American Journal of Preventive Medicine* **36**(1), 74–81. https://doi.org/10.1016/j.amepre.2008.09.025

Leite MA, de Assis MM, do Carmo AS, Nogueira MC, Netto MP and Mendes LL (2021) Inequities in the urban food environment of a Brazilian city. *Food Security* **13**, 539–549. https://doi.org/10.1007/s12571-020-01116-w

Llavero-Valero M, Escalada-San Martín J, Martínez-González MA, Basterra-Gortari FJ, de la Fuente-Arrillaga C and Bes-Rastrollo M (2021) Ultra-processed foods and type-2 diabetes risk in the SUN project: a prospective cohort study. *Clinical Nutrition* **40**(5), 2817–2824. https://doi.org/10.1016/j.clnu.2021.03.039

Luan H, Law J and Quick M (2015) Identifying food deserts and swamps based on relative healthy food access: a spatio-temporal Bayesian approach. *International Journal of Health Geographics* **14**(37). https://doi.org/10.1186/s12942-015-0030-8

Machado PP, Claro RM, Canella DS, Sarti FM and Levy RB (2017) Price and convenience: the influence of supermarkets on consumption of ultra-processed foods and beverages in Brazil. *Appetite* **116**, 381–388. https://doi.org/10.1016/j.appet.2017.05.027

Macintyre S (2007) Deprivation amplification revisited; or, is it always true that poorer places have poorer access to resources for healthy diets and physical activity? International Journal of Behavioral. *Nutrition and Physical activity* **4**(32). https://doi.org/10.1186/1479-5868-4-32

Matozinhos FP, Gomes CS, Andrade AC, Mendes LL, Pessoa MC, Friche AA and Velasquez-Melendez G (2015) Neighbourhood environments and obesity among adults: a multilevel analysis of an urban Brazilian context. *Preventive Medicine Reports* **2**, 337–341. https://doi.org/10.1016/j.pmedr.2015.04.019

Mendonça RD, Lopes AC, Pimenta AM, Gea A, Martinez-Gonzalez MA and Bes-Rastrollo M (2017) Ultra-processed food consumption and the incidence of hypertension in a Mediterranean cohort: the Seguimiento Universidad de Navarra project. *American Journal of Hypertension* **30**(4), 358–366. https://doi.org/10.1093/ajh/hpw137

Menezes RCE, Oliveira JS, Almendra R, Lira PIC, Costa EC, Leal VS and Santana P (2022) Influence of food environment on ultra-processed drinks consumption among an economically vulnerable population in a metropolitan area in Brazil: a multilevel analysis. *Health Place* **77**, 102869. https://doi.org/10.1016/j.healthplace.2022.102869

Oliveira JS, Menezes RCE, Almendra R, Lira PIC, Aquino NB, Souza NP and Santana P (2022) Unhealthy food environments that promote overweight and food insecurity in a Brazilian metropolitan area: a case of a syndemic? *Food Policy* **112**, 102375. https://doi.org/10.1016/j.foodpol.2022.102375

Pessoa MC, Mendes LL, Gomes CS, Martins PA and Velasquez-Melendez G (2015) Food environment and fruit and vegetable intake in a urban population: a multilevel analysis. *BMC Public Health* **15**, 1012. https://doi.org/10.1186/s12889-015-2277-1

Phillips AZ and Rodriguez HP (2020) U.S. county "food swamp" severity and hospitalization rates among adults with diabetes: a nonlinear relationship. *Social Science & Medicine*, [s. l.], **249**, 112858. https://doi.org/10.1016/j.socscimed.2020.112858

Polsky JY, Moineddin R, Dunn JR, Vidraceiro RH and Boot GL (2016) Relative and absolute availability of fast-food restaurants in relation to the development of diabetes: a population-based cohort study. *Canadian Journal of Public Health = Revue Canadienne De Sante Publique*, [s. l.], **107**(Suppl 1), 5312. https://doi.org/10.17269/cjph.107.5312

Powell LM, Slater S, Mirtcheva D, Bao Y and Chaloupka FJ (2007) Food store availability and neighborhood characteristics in the United States. *Preventive Medicine* **44**(3), 189–195. https://doi.org/10.1016/j.ypmed.2006.08.008

Rose D, Bodor J, Swalm C, Rice J, Farley and Hutchinson P (2009) Deserts in New Orleans? illustrations of Urban food access and implications for policy. *University of Michigan National Poverty Centre*. https://api.semanticscholar.org/CorpusID:15277497

Turner C, Aggarwal A, Paredes H, Herforth A, Nowski AD, Coates J, Kalamatianou S and Kadiyala S (2018) Concepts and critical perspectives for food environment research: a global framework with implications for action in low- and middle-income countries. *Global Food Security* **18**, 93–101. https://doi.org/10.1016/j.gfs.2018.08.003

Walker RE, Keane CR and Burke JG (2010). Disparities and access to healthy food in the United States: a review of food deserts literature. *Health Place* **16**(5), 876–884. https://doi.org/10.1016/j.healthplace.2010.04.013

Cite this article: Lima da Silva JM, Oliveira JS, Casagrande Borges D, Honório OS, Mendes LL, and Canuto R (2024). Social inequities in food deserts and food swamps in a northeastern Brazilian capital. *Journal of Biosocial Science* **56**, 493–503. https://doi.org/10.1017/S0021932024000087