

Food swamps in Campinas, Brazil

Mariana Fagundes Grilo (<https://orcid.org/0000-0002-0864-2169>)¹

Caroline de Menezes (<https://orcid.org/0000-0002-0146-3707>)²

Ana Clara Duran (<https://orcid.org/0000-0001-7317-5790>)^{1,2,3}

Abstract *The characteristics of the food environment can interfere with physical access to healthy foods and accentuate health inequalities. The presence of food swamps, i.e., the greater availability of ultra-processed food and commercial establishments compared to those that sell healthier options, are associated with the consumption of unhealthy foods. This study identified the spatial distribution of these establishments in Campinas, São Paulo. Fast-food restaurants, open-air organic/agroecological food markets and supermarkets were geocoded. Regional administrations (RAs) with greater social vulnerability according to the 2010 Census and with a greater availability of fast-food restaurants in relation to open-air food markets and supermarkets were considered food swamps. The less vulnerable neighborhoods had a higher concentration of all types of commercial food establishments compared to the most vulnerable regions. In Campinas, of eighteen RAs, five were considered food swamps. The findings reinforce the need for actions to improve exposure to healthy foods in more vulnerable neighborhoods.*

Key words *Inequalities, Food, Socioeconomic factors*

¹ Programa de Pós-Graduação em Saúde Coletiva, Faculdade de Ciências Médicas, Universidade Estadual de Campinas (Unicamp). R. Tessália Vieira de Camargo 126, Cidade Universitária. 13083-887 Campinas SP Brasil. m147256@dac.unicamp.br

² Núcleo de Estudos e Pesquisas em Alimentação, Unicamp. Campinas SP Brasil.

³ Núcleo de Pesquisas Epidemiológicas em Nutrição e Saúde, Faculdade de Saúde Pública, Universidade de São Paulo. São Paulo SP Brasil.

Introduction

The physical, economic, political and sociocultural contexts that constitute the food environment have the ability to influence the population's acquisition, preparation and consumption of food. They are inserted in contexts, such as race, income, education, and the location, number and type of commercial food establishments^{1,2}.

The inequity in the location of commercial food establishments, combined with social, economic and residential segregation, contributes to health inequalities in several countries, including Brazil³⁻⁷. The unequal availability of locations that sell fresh and minimally processed foods is potentially one of the mechanisms that explains the higher prevalence of obesity and type 2 diabetes in more vulnerable population groups⁸⁻¹⁰.

Regions with difficult access to fresh foods and minimally processed foods at affordable prices are known as "food deserts"¹¹, while socio-economically vulnerable regions with a preponderance of establishments selling ultra-processed foods in relation to the number of establishments selling fresh and minimally processed foods can be considered "food swamps"^{12,13}. The presence of food swamps has been associated with higher rates of obesity than the so-called food deserts¹³. These concepts seek to quantify the access to fresh and minimally processed foods in urban centers and help in the planning and formulation of measures aimed at combating the inequalities of access to these foods¹⁴.

The use of the term "food apartheid" highlights inequalities in access to healthy foods as a symptom of the presence of social injustices such as poverty, racism and other forms of discrimination that lead to unequal allocation of resources¹⁵. The lack of availability of fresh and minimally processed foods and greater exposure to ultra-processed foods affect individuals of all colors and races, but black and brown populations are disproportionately affected¹⁵. Communities with predominantly white individuals are more likely to have greater availability of fresh and minimally processed foods with affordable prices compared to communities with predominantly black and brown populations¹².

In Brazil, where ethnic minorities have a lower average income than whites¹⁶, supermarkets¹⁷ and establishments that sell a greater amount of fresh and minimally processed foods¹⁸ are more frequently found in the richest regions. Residents living in regions with a higher concentration of establishments that sell fresh and minimally pro-

cessed foods have a more frequent consumption of these foods compared to those who live farther away^{17,19,20}.

Healthy eating environments contribute to the maintenance of eating habits consistent with the recommendations of the Food Guide for the Brazilian Population²¹. As the most recent data from the 2017/2018 Family Budget Survey show, there has been an increase in the consumption of food from outside the home in the poorest regions of the country, such as Northeast²², which may represent a greater demand for ready meals, and consequently, an increase in the number of eating establishments, such as fast-food restaurants²³.

The mapping of the distribution of commercial food establishments and the identification of regions of the city that can be considered food swamps allow us to better characterize the food environment, describe the presence of a potential food apartheid, and inform interventions and public policies that help to correct possible inequalities. The objective of the present study was to map the distribution of commercial food establishments and to determine if and where food swamps are located in the municipality of Campinas, São Paulo, Brazil.

Methods

An ecological study was conducted in the municipality of Campinas, São Paulo, Brazil, which is the headquarters of the metropolitan region of Campinas, one of the ten largest regions in the country with a population of 3.2 million inhabitants²⁴. The Gross Domestic Product of Campinas is the 3rd largest in the state and the 14th largest in the country, showing the economic importance of the region at the state and federal levels²⁵.

Identification of commercial food establishments

To evaluate the geographic distribution of establishments that sell food in the municipality of Campinas, three types of establishments were identified according to the products mostly sold: i) fast-food restaurants, where the sale of ultra-processed foods predominates²⁶, ii) open-air organic/agroecological food markets, characterized by the sale of fresh and minimally processed products^{27,28}, and iii) supermarkets, considered mixed establishments because they offer both

fresh and minimally processed and ultra-processed foods²⁹.

The study included the largest fast-food restaurant chains classified by *Entrepreneur*³⁰ magazine and Brazilian restaurant chains: McDonalds, Bob's, Giraffas, Burger King, Pizza Hut, Subway, Habib's, Domino's, Taco Bell and KFC. Store addresses were found on the official website of each company. In addition to fast-food restaurants, stores from the four supermarket chains responsible for the highest sales volumes in the country were incorporated, according to information provided by the Euromonitor of 2017³¹, Grupo Cassino (including the Sugarloaf and Extra Stores), Carrefour, Walmart and Dia. The regional supermarket chains Dalben, Pay Less, Covabra and Paulistan were included. Data on the location of open-air organic/agroecological food markets existing in the municipality were collected through the Campinas municipality website³² and through the platform "Map of Organic Fairs" of the Brazilian Institute of Consumer Protection (*Instituto Brasileiro de Defesa do Consumidor* - IDEC)³³ and confirmed by the General Technical Services of Campinas (Setec), the municipality responsible for the management of open markets and municipal markets in the city. These three types of commercial food establishments were selected due to the lack of consistent secondary data on neighborhood markets and other smaller food retailers.

After identification of the establishments, the programming interface of the Google geocoding application was used to establish the geographic coordinates of each establishment. Spatial validation, i.e., the process of confirming the accuracy of geographic codes, was performed to ensure data reliability. Points identified outside the geographical boundaries of the municipality of Campinas were removed from the analysis. The data were organized between March and June 2018 and updated in January 2019.

Neighborhood socioeconomic variables

To analyze the distribution of commercial food establishments according to the socioeconomic characteristics of the neighborhoods, we used the average income of the head of the household and the proportion of black and brown minorities in the census tracts of Campinas provided by the 2010 National Demographic Census³⁴ because the cost of food is a barrier to adequate and healthy eating³⁵ and minorities face barriers that hinder their mobility³⁶. The average

income of the head of household (R\$) was categorized into five groups according to the minimum wage of R\$ 510 established on June 15th, 2010³⁷. The proportion of minorities was divided into quartiles.

Distribution of commercial food establishments and mapping of food swamps

The socioeconomic information of the neighborhoods and the geographic coordinates of the commercial food establishments were imported into ArcGis 10.6.1 software; using the digital mesh of the Regional Administration (RAs) of Campinas provided by Brazilian Institute of Geography and Statistics (*Instituto Brasileiro de Geografia e Estatística*)³⁸, choropleth maps were developed to analyze the distribution of commercial food establishments according to the socioeconomic variables of the RAs. The RAs are submunicipalities divided according to the geographical position and the history of occupation of the regions to facilitate the administration of the municipality and divide the territory of Campinas into 18 regions: RA 01, 02, 03, 04, 05, 06, 07, 08, 09, 10, 11, 12 (or Ouro Verde), 13 (or Campo Grande), 14, Barão Geraldo, Joaquim Egidio, Nova Aparecida and Souza³⁹.

Densities of each type of commercial food establishment were identified and two indicators were developed. Indicator 1 refers to the density of fresh and minimally processed food establishments per 10,000 inhabitants in each RA. In this indicator, open-air organic/agroecological food markets and supermarkets were considered. The open-air food markets were included because they mostly sell fresh food^{27,28} and the supermarkets because they also offer fresh and minimally processed foods. Moreover, in the southeast of the country, the profile of food acquisition in supermarkets is mixed²⁹. The index, also used by CAISAN to identify food deserts²⁹, was calculated using the following formula:

Indicator 1:

$$\frac{\text{open-air organic/agroecological food markets + supermarkets}}{\text{RA population}} \times 10.000$$

Based on classifications used in Brazil and other countries that take into account the existence of regions with low physical access to establishments that sell fresh and minimally processed foods and the abundance of establishments

that sell ultra-processed foods^{29,40-43}, indicator 2 was created and adapted to identify the RAs of Campinas considered food swamps.

Using the formula below, we created a dichotomous variable in which the SWs had greater availability of fast-food restaurants in relation to open-air organic/agroecological food markets and supermarkets (value of the ratio greater than the median, (p50=0.332) in addition to the average income of the head of the household below the median income distribution in the municipality of Campinas (p50=R\$ 2,275) and/or the mean proportion of minorities above the median income distribution (p50=26.9%).

Indicator 2:

$$\frac{\text{absolute number of fast-foods restaurants}}{(\text{absolute number of open-air organic/ agroecological food markets and supermarkets}) > \text{median of the municipality}}$$

+ *average income of the head of household <median of the municipality and/or % of minorities > median of the municipality*

Choropleth maps with the results of indicators 1 and 2 were made using ArcGis 10.6.1 software.

Results

Among the commercial food establishments analyzed in Campinas, 30.3% (n=79) were fast-food, 31.4% (n=82) supermarkets, and 38.3% (n=100) open-air food markets. Of the latter, 85.0% were free fairs and 15.0% were organic/agroecological fairs. The free fairs and organic/agroecological fairs were not fixed but were held on specific days and times and at planned locations.

To evaluate the density of commercial food establishments in Campinas and map the regions of the municipality considered food swamps, municipal division of RAs were used. The RAs with the highest incomes were those with the lowest percentages of minorities (Table 1). In addition, all the establishments analyzed coexisted predominantly in the census tracts in which the head of household had a higher average income (>R\$ 1,021) and a lower proportion of minorities (<27.4%).

The highest densities of free markets, organic/agroecological markets and supermarkets were found in the central region of the municipality of Campinas and in the Souza's RA (Figure 1, Table 2).

In addition, in nine RAs, the ratio between the absolute number of fast-food restaurants and the absolute number of open-air organic/agroecological food markets and supermarkets was higher than the median ratio in the municipality (Table 2). Among these RAs, five were classified as food swamps considering the average income of the head of the household less than R\$ 2,275 and the proportion of minorities less than 26.9% (Table 2, Figure 2). The regions considered food swamps accounted for one third (32.0%) of open-air organic/agroecological food markets and 26.5% of supermarkets in the municipality.

Discussion

When evaluating the distribution of commercial food establishments in the municipality of Campinas, we found evidence of inequalities in this distribution, and regions with higher income and lower percentage of minorities showed a higher concentration of all types of commercial food establishments analyzed – restaurants of fast-food, free markets and organic/agroecological and supermarkets – compared to the most vulnerable regions.

Five of a total of eighteen RAs in the municipality were considered food swamps. These RAs, which are located in the central and southern regions of the municipality of Campinas, showed indicators of social vulnerability; the ratio between the absolute number of establishments selling unhealthy foods and the absolute number of establishments with healthy options was greater than the median of ratio of the municipality.

Our results were similar to those of municipalities such as São Paulo¹⁷, Jundiaí⁴⁴, Belo Horizonte¹⁸, and Juiz de Fora⁴⁵, which showed that, in general, wealthier neighborhoods have a higher density of *in natura* and minimal commercial food establishments. We also found that less vulnerable regions have a higher proportion of all types of establishments⁴⁵⁻⁴⁷.

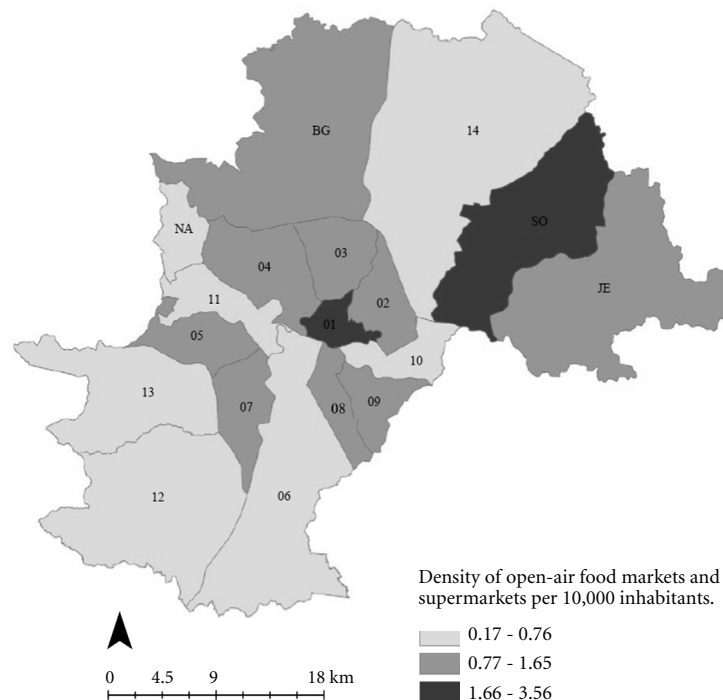
The food swamps identified in Campinas, consisting of regions of low socioeconomic status that have higher availability of ultra-processed food establishments compared to establishments selling fresh and minimally processed foods, indicate high exposure to unhealthy foods. The concept of food swamp complements the concept of food desert in that it highlights the deleterious role of competition established by the presence of establishments that sell a higher proportion of ultra-processed foods compared

Table 1. Characteristics of Regional Governments, Campinas, 2019.

RA	Total population (inhabitants)	Income of the head of household (R\$)		Minorities (%)	
		Median	IQR	Median	IQR
14	64,269	3742.9	1425.7	9349.9	13.7
1	89,813	3549.6	2545.9	4881.5	8.4
2	72,325	3236.4	1788.8	6238.1	11.3
3	132,669	2933.2	1770.2	4811.1	11.6
Sousas	38,384	2590.8	1320.0	3758.8	26.5
Barão Geraldo	94,230	2240.4	1089.5	3915.9	19.3
8	79,197	2153.5	1661.0	3062.3	13.2
4	84,460	2117.4	896.3	3212.8	17.6
Joaquim Egídio	6,764	1880.0	1800.7	2442.7	17.5
9	80,036	1621.3	1115.5	2034.1	21.6
11	111,132	1504.5	1086.5	2188.0	27.0
10	80,710	1450.5	1026.7	3084.9	24.9
5	42,413	1264.9	867.6	1471.8	33.1
7	148,625	1177.1	856.6	1550.2	33.0
6	247,706	1119.0	810.5	1676.0	38.5
Nova Aparecida	58,571	892.0	752.5	1088.1	47.1
12/Ouro Verde	227,191	873.9	699.0	1135.3	48.5
13/Campo Grande	171,760	828.6	697.7	1010.6	50.4

RA: Regional administration; IQR: interquartile range.

Source: Authors, through data provided by the Brazilian Institute of Geography and Statistics, 2010 Census. 2010.

**Figure 1.** Density of open-air food markets and supermarkets per 10,000 inhabitants.

Source: Authors, through the choropleth maps provided by the Brazilian Institute of Geography and Statistics and by the location information of the commercial food establishments: public information from supermarkets and information available on the Campinas city hall website and the platform "Map of Organic Fairs" of the Brazilian Institute of Consumer Protection for open-air organic/agroecological food markets.

Table 2. Density of commercial food establishments, Campinas, 2019.

RA	Density of open-air organic/agroecological food markets and supermarkets/10,000 inhabitants	Density of fast-food restaurants/10,000 inhabitants	Number of fast-food restaurants/Number of open-air organic/agroecological food markets + supermarkets
1	3.56	1.45	0.41
2	1.11	1.24	1.13
3	1.43	1.06	0.74
4	1.65	0.59	0.36
5	1.18	1.18	1.00
6	0.75	0.44	0.58
7	1.08	0.20	0.19
8	1.52	0.38	0.25
9	1.00	0.37	0.38
10	0.37	0.00	0.00
11	0.72	0.18	0.25
12/Ouro Verde	0.35	0.22	0.63
13/Campo Grande	0.17	0.00	0.00
14	0.31	0.31	1.00
Barão Geraldo	1.38	0.42	0.31
Joaquim Egídio	1.48	0.00	0.00
Nova Aparecida	0.51	0.00	0.00
Sousas	2.34	0.00	0.00

RA: Regional administration.

Source: Authors, through the choropleth maps provided by the Brazilian Institute of Geography and Statistics and by the location information of the food commercial establishments: public information on fast-food restaurants and supermarkets, and information available through the website of the city of Campinas and the platform “Map of Organic Fairs” of the Brazilian Institute of Consumer Protection for the open-air organic/agroecological food markets.

to mixed establishments and that sell primarily fresh and minimally processed foods⁴⁸. Evidence suggests that food swamps may play an even more relevant role than food deserts in contributing to the prevalence of obesity, diabetes and health inequities^{13,42,49}.

Individuals living in regions with limited access to fresh and minimally processed foods, such as food swamps, also have worse access to health services, transportation, parks and leisure facilities⁵⁰ and higher rates of food and nutritional insecurity⁵¹. In Brazil, in households with low income, food and nutritional insecurity is even more aggravated among households headed by women and with black residents⁵².

Despite the classification of supermarkets as establishments that offer fresh and minimally processed foods²⁹, it is important to note that currently, most of these establishments are not restricted to selling only one type of product, i.e., ultra-processed foods occupy the largest portion of supermarket offerings⁵³. Advertising strategies

and high exposure to ultra-processed foods can influence the choice of these foods at the time of purchase⁵⁴⁻⁵⁶. Due to convenience and affordable prices, in addition to structural changes in food supply chains, supermarkets supply an increasing share of fresh and minimally processed foods purchased in Brazil and other Latin American countries^{56,57}.

Considering the differences in the food environment between countries^{57,58}, it is possible to observe similarities and differences when comparing the food environment of large Brazilian metropolises and other countries. In the United States, for example, fewer supermarkets and more fast-food restaurants and convenience stores are located in neighborhoods with higher proportions of low-income residents compared to wealthier neighborhoods⁵⁹. In addition, in the regions with the highest proportion of blacks, the availability of supermarkets corresponds to half of that found in the regions with the highest proportion of whites^{3,60}. On the other hand,

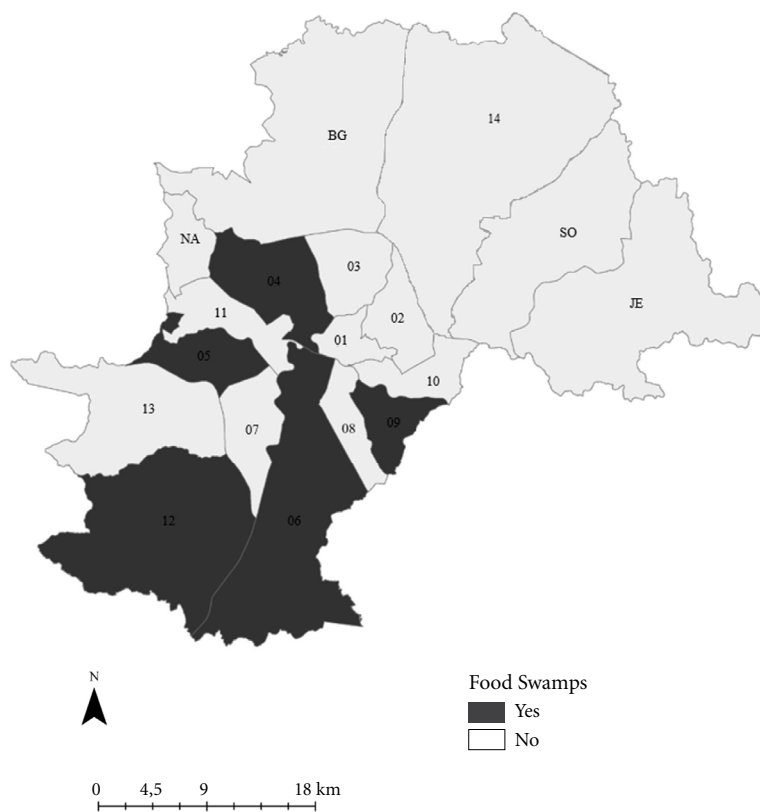


Figure 2. Food swamps.

Source: Authors, through the choropleth maps provided by the Brazilian Institute of Geography and Statistics and by the location information of the commercial food establishments: public information of fast-food restaurants and supermarkets and information available on the city hall website of the city of Campinas and through the “Map of Organic Fairs” platform of the Brazilian Institute of Consumer Protection for open-air organic/agroecological food markets.

in New Zealand and Canada, there is a higher density of different types of establishments, such as supermarkets and fast-food restaurants, in more vulnerable regions than in less vulnerable regions⁶¹⁻⁶⁵. The term “food apartheid” therefore arises to reinforce that food environments are the result of social and racial policies and injustices¹⁴, highlighting the discriminatory political structures of the past and present that affect food access¹⁴.

Many factors influence the location of commercial establishments, including the income of residents, proximity to potential consumers, traffic and access facilities, location of competitors, and characteristics of the property⁶⁶. Urban planning tools can assist in food equity¹².

Promoting healthy eating habits, therefore, requires a combination of multilevel strategies⁶⁷,

including improving the local food environment, which can be achieved by restricting establishments that essentially sell ultraprocessed foods in areas close to schools^{68,69}, increasing the number of open-air food markets, and extending their opening hours to meet residents’ needs and providing incentive programs and/or subsidies to encourage the purchase of food in these locations^{70,71}. Our results may contribute to the design of local policies by identifying priority regions.

The present study is not without limitations. The geographical division of municipalities, widely used in the literature^{17,72}, is important for the characterization of the food environment but does not necessarily reflect the eating experiences of individuals⁴⁵. In addition, we used a restricted spectrum of types of commercial food establish-

ments due to the lack of reliable secondary data on the location of bars, small cafeterias, grocery stores, neighborhood markets, and candy stores. However, the identification of potential priority areas for the implementation of public policies allows assisting the government and civil society in directing local actions. We did not collect data on the supply and price of food sold in each of the establishments individually to better characterize them. However, the growing literature in the area allows us to classify the commercial food establishments studied as more or less healthy according to the proportion of ultra-processed foods vs. natural and minimally processed foods they offered their consumers^{17,29,73}.

In addition, the cross-sectional design of the study does not allow us to infer the causes of the inequalities found, but it corroborates the findings of several other studies in the country^{17,18}. Studies with experimental and quasi-experimental designs, which allow conclusions about the effects of the local retail environment on food purchasing and consumption behaviors, have found that the opening of a new supermarket in an area previously considered a food desert was associated with an improvement in food and nutritional security and decreased consumption of sugary

foods among beneficiaries of a food aid program in the United States⁷⁴ and a lower prevalence of diabetes when compared to a counterfactual⁷⁵.

These findings demonstrate the potential effect of changes in the food environment and diet of populations living in more vulnerable areas and with less access to fresh and minimally processed foods among beneficiaries of income transfer programs. The combination of measures that affect both the supply and demand for fresh and minimally processed foods should therefore be stimulated to enhance their effectiveness. Finally, evaluations of food marshes, especially in low- and middle-income countries, should be refined to support new studies on the association between the distribution of commercial food establishments, food consumption, and health outcomes⁷⁶.

In Campinas, the most vulnerable regions had a lower concentration of all types of commercial food establishments compared to the less vulnerable regions. Approximately one-third of the RAs of Campinas were considered food swamps and should be prioritized in public policies and local interventions aimed at promoting the equitable distribution of fresh and minimally processed foods.

Collaborations

MF Grilo, C Menezes and AC Duran worked on the study design, data analysis and interpretation. MF Grilo and C Menezes worked on the literature review and writing of the article. AC Duran worked on the final revision of the text. All authors approved the final version.

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