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## Socioeconomic Disparities in the Community Food Environment of a Medium-Sized City of Brazil

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### ABSTRACT

**Objective:** The purpose of this ecological study was to characterize the community food environment according to the socioeconomic condition of census tracts (CTs) in the urban area of a medium-sized city of southeastern Brazil in 2016.

**Method:** Food establishments were identified on the streets covered by raters and information about type was collected through objective assessment. Geocoding was carried out from address observed by raters. Food establishments were categorized into establishments with predominant sale of natural or minimally processed foods, mixed establishments, and establishments with predominant sale of ultra-processed foods. The distribution of the number of establishments, by category, was evaluated according to tertiles of per capita income of the CT. The kernel estimation was used to analyze the density of establishments by category. The spatial pattern of the categories of establishments was investigated using the univariate Ripley's K-function.

**Results:** A total of 656 establishments were evaluated. In all, 11.1% had predominant sale of natural or minimally processed foods, 44.5% were mixed, and 44.4% had predominant sale of ultra-processed foods. The average of establishments with predominant sale of natural or minimally processed foods, of ultra-processed foods, and all categories increased according to the income of the CT. There was a clustering of all categories of establishments in high-income CTs downtown. However, peripheral and low-income CTs were composed of a higher number of mixed establishments or those with predominant sale of ultra-processed foods than establishments with predominant sale of natural or minimally processed foods.

**Conclusions:** On average, the number of all categories of establishments increased according to the per capita income of the CT and were clustered in central and higher-income regions of the city. These findings may have practical implications for the development of public policies to increase the availability of healthy foods and to reduce the sale of unhealthy foods.

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socioeconomic factors;  
disparities; neighborhood;  
food stores

## Introduction

Over the last four decades, the prevalence of obesity has increased in all regions of the world and is currently considered a pandemic (1). In 2016, the worldwide prevalence of overweight and obesity between adults were 38% and 13%, respectively (2). Brazil presents a worse scenario, as it is estimated a prevalence of 54% of overweight and 18.9% of obesity among adults from Brazilian capitals in 2017 (3).

There is evidence that increased consumption or acquisition of ultra-processed foods is associated with a greater chance or risk of obesity developing (4). In turn, studies indicate that food consumption and obesity have been associated with the characteristics of the food environment (5–7). In Brazil, a larger variety of sugar-sweetened beverages in food stores around the adults' residence was associated with the higher consumption of this product (8). Furthermore, a higher intake of ready-to-consume foods,

such as ultra-processed ones, was associated with greater availability of establishments with predominant sale of these foods around children's residences (9). In addition, there is some evidence that the availability of supermarkets, which are hypothesized to increase the consumption of fruits and vegetables, is inversely associated with obesity, while fast food restaurants are directly associated with this outcome (7). These findings corroborate the role of the food environment as a component of the obesogenic environment, which is defined as "the sum of influences that the surroundings, opportunities, or conditions of life have on promoting obesity in individuals or populations" (10).

The food environment is defined as the "collective physical, economic, policy and sociocultural surroundings, opportunities and conditions that influence people's food and beverage choices and nutritional status" (11). It can be divided into community food environment, consumer food

**Table 1.** Categories of food establishments according to predominantly commercialized foods. Viçosa, Minas Gerais, Brazil, 2016.

Categories	Types of establishments
Establishments with predominant sale of natural or minimally processed foods	Farmers' market; butchery and fish market; retail store of powder coffee or honey; street vendors of fruits and vegetables; and open-air markets
Mixed establishments	Grocery store; supermarkets; bakery; delicatessen (dairy and cold cuts); natural food store; and restaurants
Establishments with predominant sale of ultra-processed foods	Convenience store; department store; bar; bonbon store; beverage distributors; snack bar; coffee shop; fast food restaurant; ice cream shop; and street vendors of fast food

environment, and organizational food environment. The community food environment covers the type, quantity, density, location, and access to food establishments. The consumer food environment includes information about price, availability, discounts, and nutritional information of foods offered within these establishments. The organizational food environment encompasses other food sources such as cafeterias in schools, workplaces, churches, and health facilities that serve specific groups (12).

There is evidence of socioeconomic disparities in the community and consumer food environment in high-income countries (13). In general, residents of low-income or ethnic minority neighborhoods have less access to healthy food when compared to residents of less deprived neighborhoods (13). These disparities in the food environment, with individual socioeconomic restriction, may contribute to the greater risk of obesity in populations of ethnic minorities and worse socioeconomic status (14).

However, studies about the food environment involving the analysis of socioeconomic disparities in low- and middle-income countries are scarce (15). In Latin America, the evaluation of the availability of food stores according to the socioeconomic condition of the neighborhood has been conducted mainly in large cities (15), not showing a well-established pattern between the spatial distribution of food stores according to the socioeconomic status of the neighborhood.

In Brazil, there are few studies about food environment and socioeconomic disparities. In the largest city in the country, São Paulo (SP), a better quality of consumer food environment was found in census tracts (CTs) with higher education levels (16). On the other hand, it was not possible to verify a spatial distribution pattern between the low availability of health food stores and the extreme poverty rate in the metropolitan region of Manaus (AM) and in four small cities around this region (17). Therefore, there is a lack of evidence about the socioeconomic disparities in the food environment in Brazilian cities. Thus, the objective of this study was to analyze the community food environment according to socioeconomic status of CTs of a medium-sized city of Brazil. We hypothesized that neighborhoods with better socioeconomic status are suggested to have greater availability of establishments that provide healthy food when compared to CT with poorer socioeconomic status.

## Methods

### Study setting

This was an ecological study of the community food environment conducted in 2016 in the city of Viçosa, located in

the Zona da Mata region of the state of Minas Gerais (MG) (Brazil).

The urban CT was considered as the territorial unit of analysis. The study coverage area was all urban CT of the city of Viçosa. In 2016, Viçosa had an estimated population of 77,863 inhabitants (18) and Municipal Human Development Index of 0.775 (19). According to the last Brazilian Census, Viçosa had 99 CTs in the urban area, 11 in the rural area (20), a territory of 299 km<sup>2</sup>, and a population density of approximately 241 inhabitants/km<sup>2</sup> (19).

### Food environment assessment

A pilot study was conducted in the central region of Viçosa (MG) to evaluate the dynamics of data collection and the feasibility of applying the instruments. Data collection was performed in all food stores in the urban area between 8 AM and 6 PM.

The team of raters (11 undergraduate and graduate students) was properly trained prior to data collection, and all them carried street maps with urban CT and guidance manuals for data collection.

The raters walked, in pairs, on all the streets of each CT. During this path, all food establishments with daytime operation were identified and information of complete address and type of establishment was collected through observation. When the raters found a closed establishment at the time of their passage, information about the opening hours was raised with local residents. In case of a store with daytime operation, raters came back to this location a few days later to check the operation and to obtain accurate information about the establishment. Formal and informal establishments were assessed. Also, information about street vendors with a same fixed place on street were assessed. Due to staff safety reasons, the survey of food establishments was not conducted in one of the CTs (0.28% of the total urban area), and 98 CTs were effectively studied.

The typology of the food establishments was based on the adaptation of a food environment assessment instrument developed to the Brazilian reality (21). As described in Table 1, the types of food establishments were categorized into establishments with predominant sale of natural or minimally processed foods (where the acquisition of natural or minimally processed food represents more than 50% of the total purchase); establishments with predominant sale of ultra-processed food (where the acquisition of ultra-processed foods represents more than 50% of the total purchase); and mixed establishments (where there is a predominance of acquisition of culinary preparations or processed foods or

where there is predominance of acquisition of neither natural/minimally processed foods nor ultra-processed foods). This grouping followed the methodology developed for the mapping of food deserts in Brazil (22), with adaptations to suit the reality of the studied city. According to this methodology, the categories of the establishments were created based on data from the Household Budget Survey (2008/2009), in which respondents provide information about the type of establishment used to purchase food (22).

All objective assessment questionnaires of food establishments were checked by field supervisors (graduate students). Independent double data entry was performed, followed by consistency analysis.

Georeferencing was performed through the geocoding process, where the geographic coordinates of food establishments were obtained from addresses using the Google Maps online search service (<https://www.google.com/maps?hl=en>). These coordinates were collected in WGS 84 Geographic Coordinate System and later transformed to the Projected Coordinate System, Universal Transverse Mercator System, 23S spindle, SIRGAS 2000, using ArcGIS 10.7 software.

### Social environment

Information from the 2010 Brazilian census was used to characterize the social environment of Viçosa. Data were obtained about the geographical limits of urban CTs in Viçosa (23), income (total monthly nominal income of permanent households), and population (residents in permanent households or population living in permanent private households) by CT (20).

### Analyses

The average per capita income of each CT was obtained by dividing the total nominal monthly income of permanent private households by the resident population of permanent private households and then categorized into tertiles.

Measures of central tendency and dispersion were presented for all variables. Mean and standard deviation values of the number of establishments were also presented according to tertile of average per capita income of the CT. Since we did not work with sample data, it was not necessary and appropriate to perform hypothesis tests to verify the existence of differences in the number of establishments according to the tertile of average per capita income of the CT (24).

For the spatial analyses, choropleth maps were elaborated to visualize the spatial distribution of the absolute number of establishments with predominantly natural or minimally processed foods, mixed establishments, and establishments with predominant sale of ultra-processed foods according to tertiles of average per capita income of the CT.

The kernel density estimation was used for the point density analysis of establishments by category. This interpolation technique estimates the intensity of points in a territorial unit of analysis, identifying regions of greater aggregation (25). The length of the influence radius was 500

meters, and this distance is walkable, as well as providing access to services and infrastructure (26). Five categories were established (low; medium to low; medium; medium to high; and high) to express the results, and the intervals of each category were defined by the natural break method. The map resolution was set to a pixel size of 5 meters.

The randomness of the point patterns of food establishments was assessed using univariate Ripley's K-function (25). Monte Carlo simulations, with a significance level of 99%, were conducted to assess the statistical significance of the analyses. The radius value was 150 meters, with a maximum distance or area of influence of 1500 meters, which is the average radius of the neighborhoods of the city of Viçosa, calculated based on the area of urban census tracts and the number of urban neighborhoods surveyed by the research team.

ArcGIS 10.7 software was used for spatial analyses and Stata 14.0 for other statistical analyses.

### Ethical aspects

The research was approved by the Research Ethics Committee of the Federal University of Viçosa (Number: 61511216.4.0000.5153).

### Results

In 2016, 656 formal and informal food establishments were evaluated. Of these, only 11.1% ( $n = 73$ ) were establishments with predominant sale of natural or minimally processed foods. Mixed establishments (44.5%;  $n = 292$ ) and establishments with predominant sale of ultra-processed foods had similar quantities (44.4%;  $n = 291$ ). This distribution was similar among the CTs, where there were, on average, fewer establishments with predominant sale of natural or minimally processed foods and similar quantities of mixed establishments and establishments with predominant sale of ultra-processed foods. In addition, there were no establishments with predominant sale of natural or minimally processed foods or mixed establishments in at least half of the CTs (Table 2).

The mean of the number of establishments was associated with the average per capita income of the CT. The average of establishments with predominant sale of natural or minimally processed foods or ultra-processed foods and all groups increased according to the average per capita income of the CT. In contrast, on average, there were more mixed establishments in the CTs within the first and second tertiles of per capita income (Table 3).

Regardless of the category, there was a higher number of establishments downtown, which was also characterized by the highest income tertile. Establishments with predominant sale of natural or minimally processed foods were absent or in small number in peripheral CTs within the lower per capita income tertile. However, mixed establishments and establishments with predominant sale of ultra-processed foods were present in a greater number of CTs (Figure 1).

**Table 2.** Description of environmental variables according to urban census tracts (n = 98). Viçosa, Minas Gerais, Brazil, 2016.

Variables	Mean (SD)	Median	Minimum	Maximum	Total of establishments
<b>Per capita income (US\$)</b>	256.04 (189.10)	188.63	63.14	965.14	Not applicable
<b>Number of food establishments by category</b>					
Natural or minimally processed	0.74 (1.31)	0.00	0.00	6.00	73.00
Mixed	2.94 (2.59)	0.00	0.00	12.00	292.00
Ultra-processed	2.94 (3.69)	2.00	0.00	24.00	291.00
<b>Number of all categories of establishments</b>	6.62 (6.47)	5.00	0.00	40.00	656.00

SD: Standard-Deviation; US\$1 = R\$3.48 in 2016.

**Table 3.** Mean and standard deviation of food establishments according to tertiles of per capita income of the census tract. Viçosa, Minas Gerais, Brazil, 2016.

	Tertile 1 US\$63.14–US\$96.94 Mean (SD)	Tertile 2 US\$96.95–US\$231.52 Mean (SD)	Tertile 3 US\$231.53–US\$956.14 Mean (SD)
<b>Number of food establishments by category</b>			
Natural or minimally processed	0.27 (0.57)	0.70 (1.26)	1.24 (1.68)
Mixed	2.79 (2.13)	3.27 (2.34)	2.76 (3.21)
Ultra-processed	2.24 (2.50)	2.58 (2.21)	4.00 (5.37)
<b>Number of all categories of establishments</b>	5.30 (4.45)	6.55 (4.56)	8.00 (9.16)

SD: Standard-Deviation; 1US\$ = R\$3.48 in 2016.

According to the kernel estimation, high-density clustering was formed only in the central region of the municipality, regardless of the category of establishments (establishments with predominant sale of natural or minimally processed foods, mixed establishments, and those with predominant sale of ultra-processed foods). Mixed establishments formed medium or medium to low density agglomerations in larger areas of the municipality when compared to other categories of establishments (Figure 2).

According to univariate Ripley's K-function (Figure 3), for each category of establishments, the expected values were outside and above the confidence envelope for all evaluated distances, indicating that there was a pattern of aggregation of all categories of food establishments with a confidence level of 99%.

## Discussion

The results of the present study show that the distribution of establishments with predominant sale of natural or minimally processed foods and ultra-processed foods is associated with the socioeconomic condition of the neighborhood. To the best of our knowledge, this is the first study to conduct an objective assessment of the entire food environment in a medium-sized Brazilian city. On average, the number of these establishments increased according to the per capita income of the CT. All the categories of food establishments had significant clustering in central and higher-income regions of the city. Peripheral regions were characterized by lower income and fewer establishments, especially those with predominant sale of natural or minimally processed food. In addition, the poor quality of the community food environment is confirmed by the lack of establishments with predominant or partial sale of natural foods in at least half of the CTs.

The concomitant increase in establishments with predominant sale of natural or minimally processed (healthy) foods or ultra-processed (unhealthy) foods as socioeconomic status increases is also reported in other Brazilian studies. In

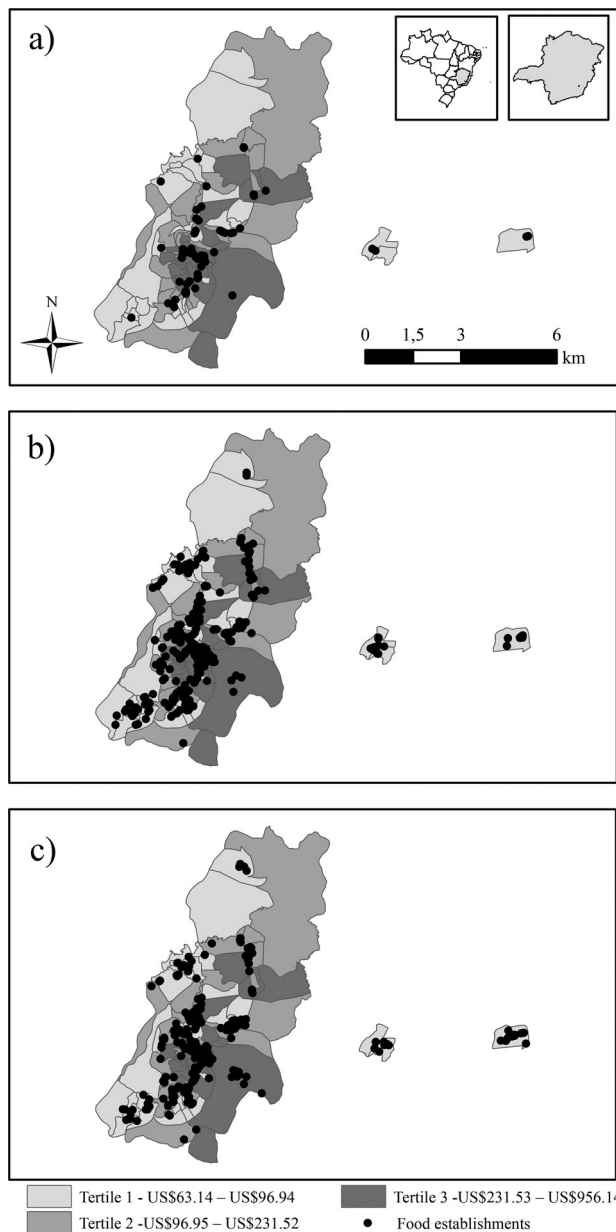
another medium-sized city of southeastern Brazil, less vulnerable urban regions had a higher density of healthy, unhealthy, or mixed establishments, compared to regions with greater vulnerability (27). Similar results were also found in large Brazilian cities, where the presence of all types of evaluated establishments increased as the socioeconomic indicators of the cities improved (28, 29).

On the other hand, studies indicate that better socioeconomic condition of the neighborhood or community was associated with fewer establishments selling healthy foods (30, 31), less availability of unhealthy food establishments, like bars and fast food restaurants (16), or even no association between distribution of establishments and the socioeconomic condition of the neighborhood (17). This variability is probably influenced by the historical, regional, and cultural context of each location. Also, the methodological differences of the studies in relation to the classification criteria of the food establishments; the variables that compose the socioeconomic status of the neighborhood; the indicator that characterizes the availability of establishments (density, number, or proportion), and the choice of territorial unit of analysis may contribute to the variability of results.

The distribution of establishments with predominant sale of natural or minimally processed or ultra-processed foods can be explained by the characteristics of these foods as well as the Brazilian food consumption profile. Reduced shelf life; the higher calorie price of natural foods such as fruits, vegetables, and fresh meats; and the decreased participation of these foods in the Brazilian diet may be associated with lower consumer demand and possibly explain the lower availability of establishments with predominant sale of natural or minimally processed foods throughout the municipality, especially in the peripheral and lower-income CTs (32, 33).

The large availability of establishments with predominant or partial sale of ultra-processed products observed in this study may be related to the increased presence of these products in Brazilians' diet (33). In addition, CTs located in the center of the city and, coincidentally, with higher

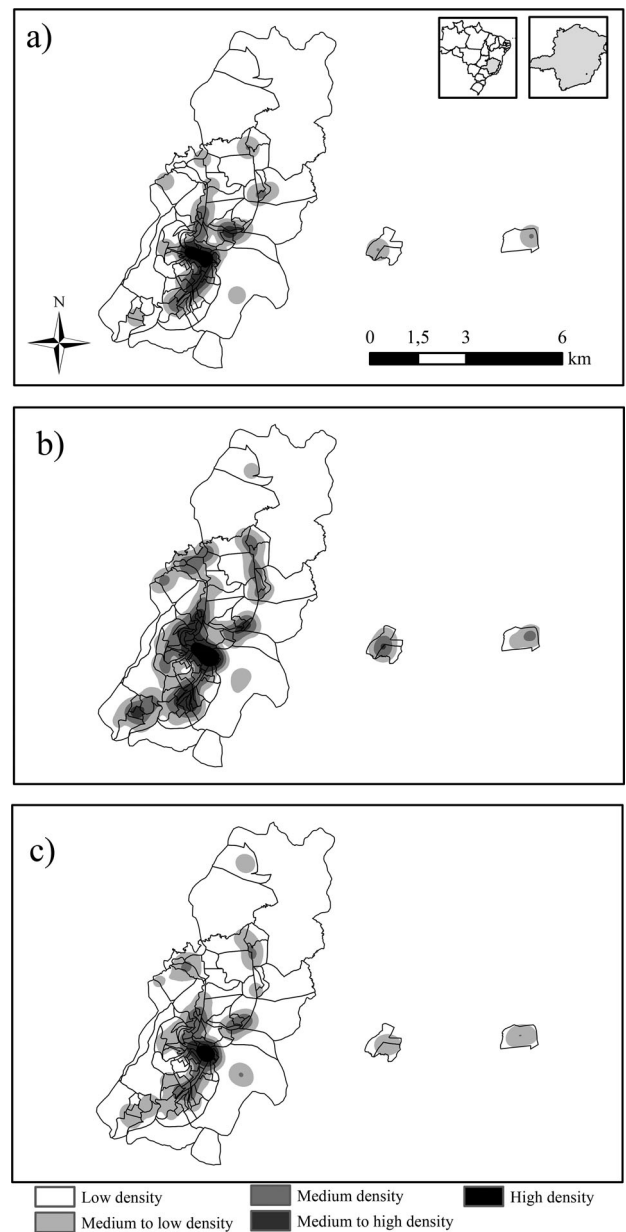




**Figure 1.** Distribution of (a) establishments with predominant sale of natural or minimally processed foods, (b) mixed establishments, and (c) establishments with predominant sale of ultra-processed foods according to tertiles of per capita income of the urban census tracts. Viçosa, Minas Gerais, Brazil, 2016.

income, represent the commercial center, with the largest flow of people moving to study and work, who are potential consumers of ready-to-consume foods and food with a longer shelf life, possibly explaining the greater number of establishments with predominant sale of ultra-processed foods in this region.

The low availability of establishments with predominant sale of natural or minimally processed foods, associated with the greater availability of establishments with predominant sale of ultra-processed foods throughout the city, shows the characterization of this place as an obesogenic environment. This scenario contributes to the increased availability of cheap, palatable, and high-calorie-density foods, which are considered to be one of the factors associated with obesity (34).



**Figure 2.** Kernel density estimation of (a) establishments with predominant sale of natural or minimally processed foods, (b) mixed establishments, and (c) establishments with predominant sale of ultra-processed foods in urban census tracts. Viçosa, Minas Gerais, Brazil, 2016.

The largest number of mixed establishments in the tertiles 1 and 2 of the CTs may have been due to food sale strategies by Viçosa business owners. In low- and middle-income CTs (tertiles 1 and 2), there is a predominance of small establishments designed to quickly serve their nearest neighborhood and, thus, there is a considerable diversity of food within them. On the other hand, there are large supermarkets and farmers' markets, restaurants, and especially small and large fast food establishments to serve the public who eat out in higher-income central CTs.

This study presents some limitations. First, the collection of data related to the community food environment was important to verify the distribution of categories of food establishments in the city. However, variables related to the consumer food environment, such as variety, availability, price, and quality of food sold inside establishments are also

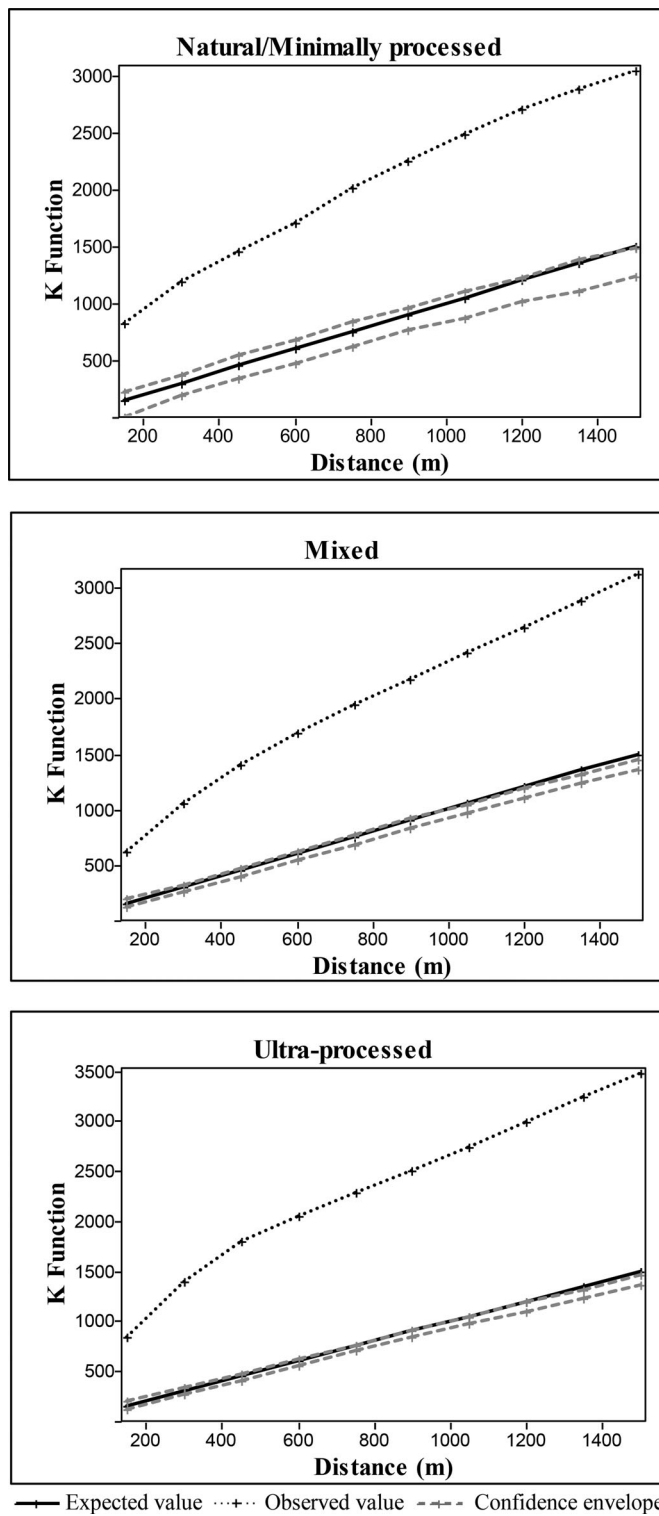


Figure 3. Univariate Ripley's K-function.

important to understand the relationship of the environment with different outcomes, such as food consumption and nutritional status of individuals. Thus, further data investigations regarding this theme in the city are necessary (6).

Second, *a priori* classification of the establishments was realized, without an audit to investigate the consumer food environment, which can result in misclassification. On the other hand, the classification of the establishments was based in a methodology that considers information of the

Household Budget Survey, in which respondents provide information about the establishment used to purchase food (22).

Third, we choose to use the number and not the density of establishments because Viçosa has a floating population of 20,000 students and these people are not counted in the CTs of the city. Hence, this indicator was our best choice to study the distribution of establishments in this specific scenario. Besides that, many studies use the absolute number indicator in their analyses, and the literature indicates that it is not yet possible to conclude which is the best indicator for the assessment of the community food environment (6, 35). In addition, we prove the quality of these results since they are corroborated by the results found using the kernel density estimation, a type of gravity metric that reflects the availability and accessibility of establishments in a previously determined area (zone of influence) (35).

Despite these limitations, this study contributes to the evaluation of a common scenario in Brazil, that is, a country composed mostly of small or medium-sized cities (22). In addition, it is a pioneer in conducting objective assessment of the entire food environment in a medium-sized Brazilian city, including the survey of formal and informal food establishments. It is innovative also in using a robust methodology for classifying food outlets according to the predominance of food classified in line with the extent of processing (22).

## Conclusion

In Viçosa, a medium-sized city, there is evidence of the presence of a food environment with a greater supply of healthy foods restricted to higher-income central areas, in addition to the high availability of establishments with supply of unhealthy foods across all CTs, especially the central and higher-income ones.

These results point to the necessity of developing public policies that stimulate the increase of healthy food availability as well as the reduction of unhealthy food supplies. Among these policies, we highlight the importance of including actions that favor the opening and maintenance of establishments/spaces that provide healthy food (such as the creation of government subsidies for companies), as well as the incentive to regional farmers, encouragement to carry out open-air markets in more parts of the city, and food and nutrition education initiatives to make the population aware of the importance of consuming fewer processed and ultra-processed foods.

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## Disclosure statement

The authors declare that they have no conflict of interest.

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