# Fruit and vegetable consumption among older adults: influence of urban food environment in a medium-sized Brazilian city

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## Abstract

*Objective:* To examine the association between urban food environment and regular consumption of fruits and vegetables (FV) by older adults from a medium-sized Brazilian city.
*Design:* Cross-sectional study based on data related to (1) objective assessment of establishments with predominant sale of unprocessed/minimally processed foods, mixed establishments and establishments with predominant sale of ultra-processed foods; (2) regular consumption of FV ($\geq 5$ times/week), health and socio-demographic variables of community-dwelling older adults. Tertiles of proximity between food establishments and older adults' residence were calculated. Poisson generalised estimating equations with robust variance, adjusted for individual and contextual variables, were used to estimate the independent association between the proximity of establishments and regular consumption of FV.
*Setting:* Medium-sized Brazilian city.
*Subjects:* Representative sample of community-dwelling older adults (*n* 549).
*Results:* Older adults travelled the longest distances to establishments with predominant sale of unprocessed/minimally processed foods. The longer the distance to establishments with predominant sale of unprocessed/minimally processed foods, the lower the prevalence of regular consumption of FV (tertile 2: prevalence ratio (PR) = 0·86; 95 % CI = 0·74, 0·99; tertile 3: PR = 0·84; 95 % CI = 0·72, 0·97). Older adults living larger distance tertiles from establishments with predominant sale of ultra-processed foods, mixed establishments or all categories of establishments had 16 % (PR = 0·84; 95 % CI = 0·73, 0·96), 19 % (PR = 0·81; 95 % CI = 0·71, 0·93) and 19 % (PR = 0·81; 95 % CI = 0·70, 0·94) lower prevalence of regular consumption of FV, respectively.
*Conclusion:* The food environment is associated with regular consumption of FV among older adults. Longer distances from the residence of older adults to food establishments are independently associated with lower prevalence of regular consumption of FV.

Population ageing is a predominant phenomenon worldwide. In 2019, 9·1 % of the world's population was over 65 years old. In 2050, older adults will be 15·9 % of the world population. The speed of population ageing in countries in Latin America and the Caribbean will be even greater, going from 8·7 % in 2019 to 19·0 % in 2050[1]. In addition, there is the urbanisation process, in which 57 % of the older people live in urbanised regions[2]. This phenomenon has implications for the development of public health policies for the promotion of healthy ageing, defined as 'the process of developing and maintaining the functional ability that enables well-being in old age'[3].

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The Age-Friendly Cities and Communities programme, proposed by the WHO, supports the development of urban policies, systems, services, products and technologies that promote health and physical and mental ability throughout life, as well as the development of activities for those with disabilities in the environment where they live[2]. Age-Friendly Cities and Communities 'adapt their structures and services to be accessible to and inclusive of older people with varying needs and capacities'[4]. In this programme, improving access to adequate and healthy food is a fundamental strategy to promote health and prevent disease among the older adults[2,3,5].

Among the markers of healthy eating, the consumption of fruits and vegetables (FV) stands out[6]. According to NOVA food classification, FV are unprocessed or minimally processed foods, which have been associated with better health outcomes in older people, such as decreased risk of death, prevention of chronic non-communicable diseases, maintenance of good cognitive performance and mental health[5–8]. On the other hand, the consumption of ultra-processed foods, which are formulations obtained from industrial processes using substances derived from foods and food additives, has been associated with risk factors for chronic non-communicable diseases such as obesity and dyslipidaemias[8].

The food consumption among the older adults, especially FV consumption, is determined by individual and contextual factors, including the food environment[7]. The food environment is the space where food acquisition occurs influenced by market opportunities and restrictions[9]. It can be divided into community food environment, consumer food environment and organisational food environment. The community food environment covers the type, quantity, density, location and proximity to places that provide food. The consumer food environment includes information about price, availability, promotion and nutritional information of foods offered within these establishments. The organisational food environment, on the other hand, covers other sources of food such as cafeterias in schools, workplaces, churches and health facilities that serve specific groups[10].

Although the literature indicates a considerable number of studies on the relationship between the food environment and the diet[11], those studies that assess the association between the food environment and the food consumption of older people are still scarce, and most have been conducted in large cities in developed countries[12–15]. Therefore, studies on this theme in older adults living in small- and medium-sized cities are essential, considering that these places represent the majority, since close to half of the world urban population resides in cities with up to 500 000 inhabitants[16].

In addition, there is a need to develop studies on this topic, since older adults may depend on the resources of their neighbourhood with the changes associated with ageing, limiting their access to the food sold beyond their local surroundings[17–19], especially older adults who live in places of socio-economic vulnerability, structural problems that hinder their displacement, from poor public transport system, public insecurity to the decrepit quality of streets and sidewalks.

In Brazil, no studies have assessed the relationship between the food environment and outcomes specifically in the elderly population. Brazilian studies have assessed this subject for children[20], adolescents[21,22], adults[23,24] or adults together with the older adults[25–28]. The present study seeks to fill this gap by investigating how the current scenario of food availability is related to the food consumption of people aged 60 years or older, thus to promote actions for the development of urban structures and equipment appropriate to the specificities of the elderly population.

This study aimed to estimate the association between the proximity of food establishments and the regular consumption of FV by older people in a medium-sized Brazilian city. Our hypothesis is that older adults who live next to establishments that possibly sell FV have a higher consumption of these foods and, consequently, a healthier diet. Furthermore, we hypothesise that this association is independent of relevant individual and contextual characteristics.

## Methods

### Study design

This is a cross-sectional study in which two sources of data were used: (1) the data from food establishments in the urban area of a Brazilian medium-sized city (Viçosa, Minas Gerais) operating in 2009, collected by objective assessment and (2) individual data on food consumption, health conditions and socio-demographic variables of older adults living in the community, collected in 2009 in the urban area Viçosa.

The city of Viçosa is located in the Zona da Mata region in the state of Minas Gerais, southeastern Brazil. Its population of 72 220 inhabitants include 7976 older people (11·04 %). Viçosa has a territory of 299·42 km², demographic density of 241·20 inhabitants/km² with ninety-nine urban and eleven rural census tracts[29,30].

The target population of this study was older adults from the community, age 60 or over, living in the municipality of Viçosa (Minas Gerais), including urban and rural areas. In 2008, a survey of 7980 records of the older people was carried out using information from the census of the National Vaccination Campaign for the Elderly Population; enrollments in the Family Health Program and enrollment of servers at the Federal University of Viçosa. The sample calculation was defined considering a confidence level of 95 %, estimated prevalence of outcomes of interest of 50 %, tolerated error of 4 % and an increase of 20 % to cover possible losses, totaling 670 older adults to be selected by

simple random sampling. The loss of information due to refusal was 3·6 % and for unavoidable reasons in conducting the interviews was 3·7 %. Thus, 621 older adults were effectively interviewed. The effective sample is statistically equal to the sample drawn in relation to the distribution by sex and by age group. For the present study, the 549 older adults residing in addresses located in urban census tracts were evaluated according to the 2010 demographic census classification[30].

### Food environment

The coverage area for data collection of food establishments was all urban census tracts (*n* 99) in the city. Among these, only one census tract (0·28 % of the total urban area) was not evaluated for reasons of safety to the team of evaluators.

Before the data collection, a pilot study was conducted in the central region of the city to assess the dynamics of obtaining data and the feasibility of applying the used questionnaires. Data collection was conducted in 2016, and details can be found elsewhere[31]. Formal and informal establishments were identified, and information of the complete address and type of establishment was collected through objective assessment. The question 'How long has it been at this current address?' was asked to the person in charge of each establishment for comparability with the older adults database and to enable the survey of establishments that were functioning in 2009.

The typology of the establishments was based on the adaptation of an assessment tool for the food environment developed for the Brazilian reality[32]. The types of food establishments were grouped into the following categories: establishments with predominant sale of unprocessed or minimally processed food (where the purchase of unprocessed or minimally processed food represents more than 50 % of the total purchase); establishments with predominant sale of ultra-processed foods (where the purchase 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 with neither a predominance of acquisition of unprocessed/minimally processed foods nor ultra-processed foods). The specification of the types of establishments in each of the three categories mentioned is listed in Table S1. The categorisation followed a methodology developed for the mapping of food deserts in Brazil[33], with adaptations to suit the reality of the studied city. According to this methodology, the categories of establishments were created based on data from the Household Budget Survey (2008/2009), in which respondents provide information on the type of establishment used to buy food[33].

All questionnaires related to the objective assessment instrument of the food establishments were checked by field supervisors. Independent data entry was performed twice, followed by consistency analysis.

Georeferencing was conducted through the geocoding process, in which the geographical coordinates of the food establishments were obtained from their addresses using the online search service Google Maps (https://www.google.com.ma/maps?hl=pt-BR). Such coordinates were collected in Geographic Coordinate System, datum WGS 84 and later transformed into the Projected Coordinate System, Universal Transverse Mercator System (UTM), spindle 23S, datum WGS 84.

### Socio-demographic variables, health conditions and food consumption

The information was obtained through a face-to-face home interview conducted by properly trained evaluators during data collection. The semi-structured questionnaire was applied directly to the older adults, and in case of difficulty, a person close to them provided assistance. The following data were obtained: sex; age (60–69 years old; 70–79 years old; 80 years old or more); individual monthly income, in quartiles (US\$ 0–US\$ 198·96; US\$ 198·97–US\$ 223·57; US\$ 223·56–US\$ 631·38; ≥ US\$ 631·39); educational level (none; ≤ 5 years; ≥ 6 years) and cohabitation (not alone; alone). Self-reported diseases related with the ageing process (diabetes; arthritis, osteoarthritis or rheumatism; heart attack; asthma or bronchitis; depression; hearing loss; hypertension; angina; stroke; eye disorders; osteoporosis; dyslipidaemia; kidney disease or cancer) were registered and further categorised as < 5 or ≥ 5. Functional ability was measured through the ability to perform fourteen types of activities of daily living and instrumental activities of daily living, which were categorised as inadequate (some difficulty in performing six or more activities, or unable to perform at least three activities) or adequate[34].

To obtain data on food consumption, a qualitative FFQ was applied for the 12 months prior to the interview, developed for the elderly population in the studied city[35]. This consisted of a list of ninety-five foods with the options of frequency of consumption: never or rarely; monthly; biweekly; once a week; five to six times a week; two to four times a week; daily (1 time/day) or daily (≥ 2 times/day). The foods listed were grouped in the FFQ into cereals; beans; vegetables; fruits; meats, fish and sausages; eggs; milk and dairy products; sweets; drinks and infusions and oil and fat. Only the consumption variables of thirteen types of fruit and twenty-two types of vegetables were used in this study. In the vegetable group, all those foods consumed in raw or cooked form were considered. In the fruit group, consumption of fresh food was considered.

The regular consumption of FV was defined as the intake of at least one fruit and one vegetable at a frequency greater than or equal to five times a week, according to the adaptation of the methodology used by the Brazilian

Surveillance of Risk and Protective Factors for Chronic Diseases by Telephone Survey (VIGITEL)[36].

The georeferencing of the home location of each of the 549 elderly people was carried out after the home interview, using a portable Global Positioning System from Garmin® eTrex H®.

### Neighbourhood socio-economic status

Data were obtained about the geographical limits of urban census tracts according to the 2010 Brazilian Demographic Census[37]. Census tracts are the smallest territorial unit formed by a continuous area with an adequate dimension for the collection of information in the Brazilian Demographic Census. Income (total monthly nominal income of permanent households) and population (residents in permanent households or population living in permanent private households) were used to calculate the *per capita* household income by census tracts[30].

### Spatial and statistical analysis

The Kernel estimator was used to analyse the density of points of the establishments, by category. This interpolation technique permitted estimation of the intensity of points in a territorial unit of analysis, identifying regions of greater aggregation[38]. The length of the influence radius was 500 m, considering an area of immediate influence[13,14]. The intervals of the five categories referring to the results of the analysis were established by the method of natural breaks. The resolution of the maps was defined with a pixel size of 5 m.

The analysis of the randomness of the punctual patterns of the food establishments was performed using the univariate Ripley's K function. Based on this function, it was assessed whether the distribution of food establishments, by categories, occurred randomly, clustered or dispersed in space[38]. Monte Carlo simulations, with a 99 % confidence level, were conducted to assess the statistical significance of the analyses. For conducting the calculation, the radius value was 150 m, with a maximum distance or area of influence of 1500 m, which was the average radius of the neighbourhoods of the city under study, calculated based on the area of the urban census tracts and the number of urban neighbourhoods raised by the research team.

A thematic map was prepared with the spatial distribution of the older adults in the urban area of the municipality.

Proximity was calculated as the shortest Euclidean distance, in meters, between the older adults' residence and the food establishment, by categories, using the Near tool, from the ArcGis software. This variable was later categorised into tertiles.

For the descriptive analysis of individual socio-demographic variables, health conditions and neighbourhood socio-economic status, the values of absolute and relative frequencies were presented. Pearson's $\chi^2$ was used to verify differences of regular and non-regular consumption of FV

according to individual socio-demographic characteristics, health conditions and neighbourhood socio-economic status. The descriptive analysis of the proximity variable was performed using median and interquartile range according to the regular and non-regular consumption of FV.

Poisson generalised estimating equations with robust variance and exchangeable correlation matrix were used to consider the correlation between individuals in the same census tract. Regular consumption of FV was considered a dependent variable. The main independent variables were the tertiles of the proximity of (i) establishments with predominant sale of unprocessed or minimally processed foods; (ii) establishments with predominant sale of ultra-processed foods; (iii) mixed establishments and (iv) all establishments. According to the literature[7], all analyses were adjusted for potential confounding variables: age group, sex, individual monthly income, educational level, functional ability, cohabitation, number of self-reported diseases and neighbourhood socio-economic status.

All analyses were performed considering a significance level of 5 %. For spatial analysis, ArcGIS 10.7 software was used. For the other analyses, the software STATA version 14.0 was used.

## Results

During the study period, Viçosa had 320 food establishments in the urban area. The majority (48·13 %; *n* 154) were mixed establishments, and only 14·38 % (*n* 46) were establishments which predominantly sold unprocessed or minimally processed foods.

The formation of medium- to high-density clusters occurred only in census tracts of the central region of city (Fig. 1). According to the graphs of the univariate Ripley's K function for each category of establishments (Fig. 2), the curves referring to the observed values were located outside and above the confidence envelope for all evaluated distances, indicating 99 % confidence for a clustered pattern for all categories of food establishments. According to the visual analysis, most older adults also lived in census tracts of the central region and its surroundings (Fig. 3).

Most of the older adults were women, between 60 and 69 years old, who had studied for 5 years or less, with individual monthly income between US$ 198·97 and US$ 223·57 (minimum wage was US$ 198·97 in 2009) and living with a partner and/or a relative. Most of the older adults had a maximum of four diseases and did not have functional disabilities.

The prevalence of regular consumption of FV was 69·22 % (95 % CI = 65·21 %, 72·95 %). The regular consumption of FV increased proportionally to the level of education. It was higher among those with higher individual monthly income (Q4) than the older adults with income between US$ 198·97 and US$ 223·57 and among the older adults with five or more diseases. The higher the *per capita*
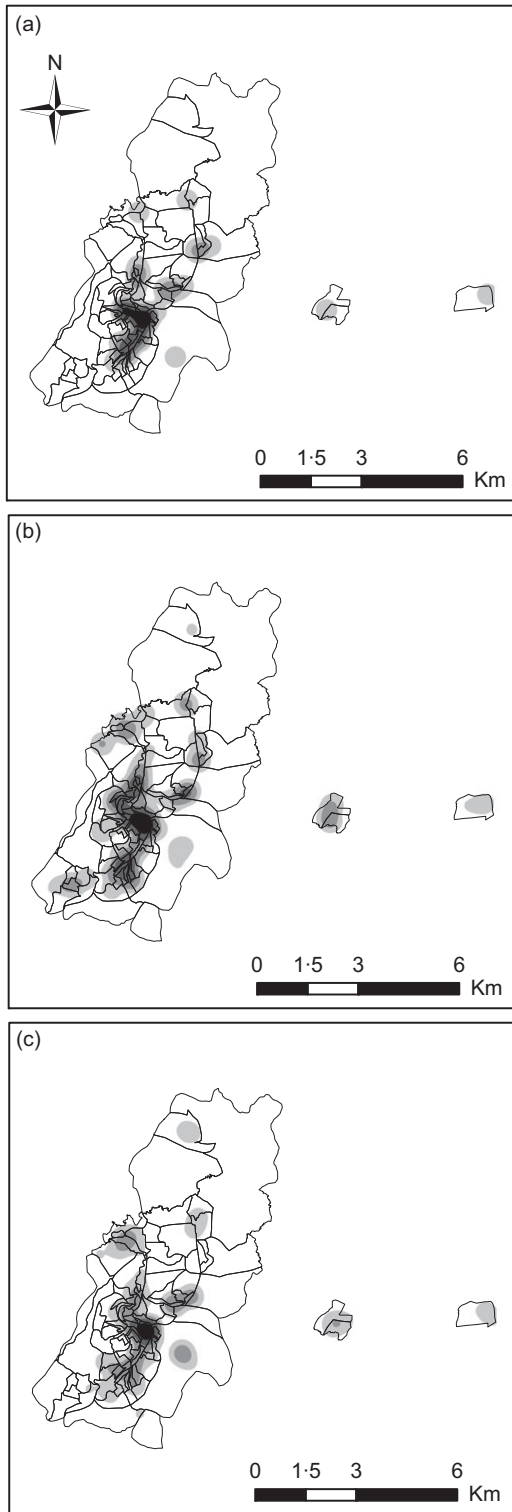
**Fig. 1** Kernel density estimation for (a) establishments with predominant sale of unprocessed or minimally processed foods; (b) mixed establishments; (c) establishments with predominant sale of ultra-processed foods. ☐, Census tracts; kernel density: ☐, low; ▨, low to medium; ▨, medium; ▨, medium to high; ▨, high
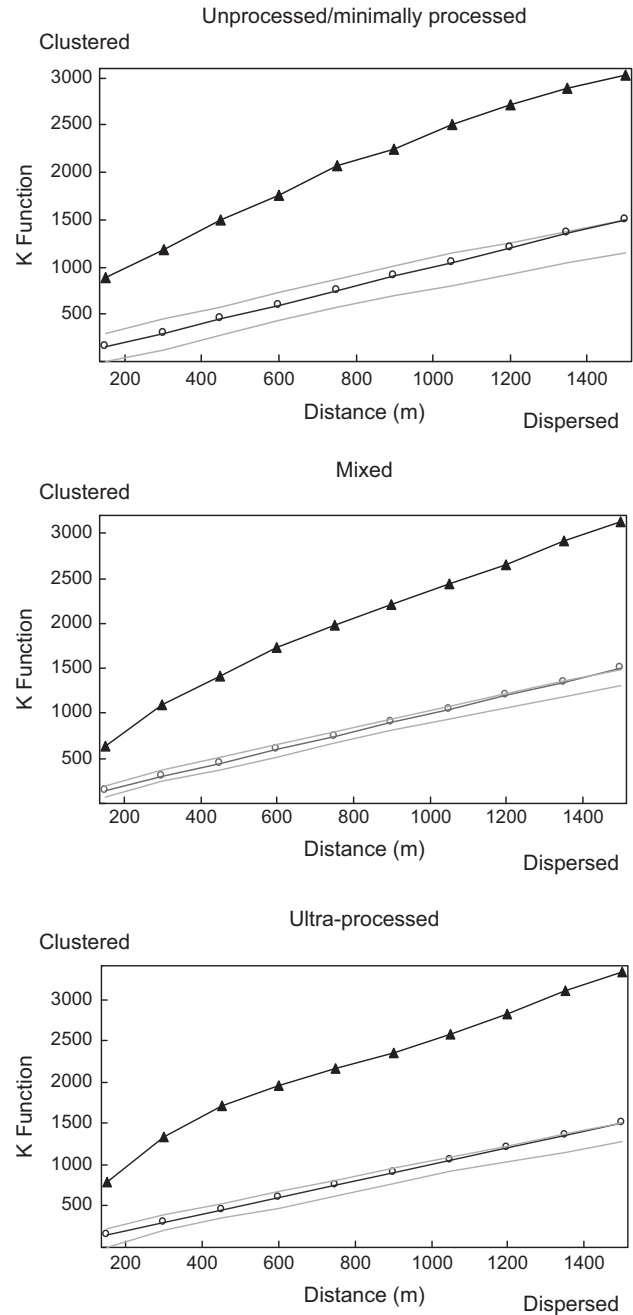


**Fig. 2** Univariate Ripley's K function for establishments with predominant sale of unprocessed or minimally processed foods; mixed establishments; establishments with predominant sale of ultra-processed foods. K Function: —▲—, observed value, —○—, expected value, ——, confidence envelope

household income of the census tract of older adults' residence, the greater the regular food consumption of fruits and vegetables (Table 1). In addition, older adults who regularly consumed FV needed to travel shorter distances to any category of establishment than older adults who consumed FV less than five times a week (Table 2).
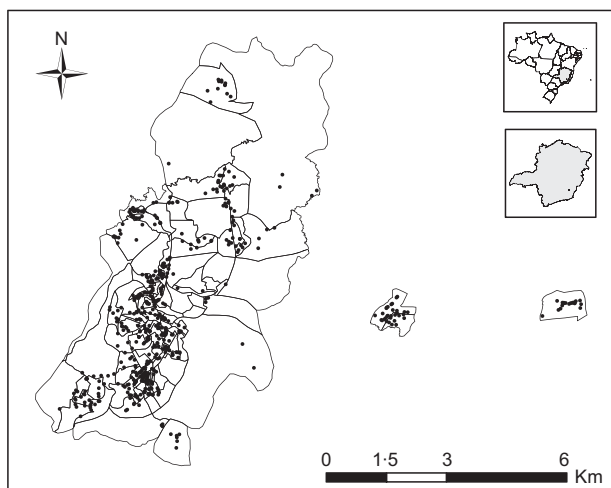
**Fig. 3** Geographic distribution of older adults. ●, Older adults; ▭, census tracts

**Table 2** Distance (m) from older adults' residence to the closest food establishments, by category, according to consumption of fruits and vegetables (n 549)

| | Consumption of fruits and vegetables | | | |
| | Non-Regular | | Regular | |
| Establishment category | Median | IQR | Median | IQR |
|---|---|---|---|---|
| Unprocessed/minimally processed | 409·44 | 549·50 | 254·51 | 360·68 |
| Ultra-processed | 189·12 | 281·04 | 149·82 | 180·72 |
| Mixed | 161·85 | 158·07 | 109·95 | 135·19 |
| All categories | 120·37 | 133·70 | 85·56 | 106·95 |

IQR, interquartile range, that is, P75–P25.

**Table 1** Prevalence of regular and non-regular consumption of fruits and vegetables by socio-demographic characteristics, health conditions and neighbourhood socio-economic status of older adults (n 549)

| | | | Consumption of fruits and vegetables | | |
| Characteristics | n* | % | Non-regular % | Regular % | P value |
|---|---|---|---|---|---|
| **Individual variables** | | | | | |
| Sex | | | | | |
| Male | 253 | 46·08 | 32·81 | 67·19 | 0·342† |
| Female | 296 | 53·92 | 29·05 | 70·95 | |
| Age group (years) | | | | | |
| 60–69 | 281 | 51·18 | 32·03 | 67·97 | 0·786† |
| 70–79 | 187 | 34·06 | 29·95 | 70·05 | |
| ≥ 80 | 81 | 14·76 | 28·40 | 71·60 | |
| Educational level | | | | | |
| None | 80 | 14·57 | 51·25 | 48·75 | < 0·001‡ |
| ≤ 5 years | 344 | 62·66 | 31·69 | 68·31 | |
| ≥ 6 years | 125 | 22·77 | 15·20 | 84·80 | |
| Monthly individual income§ | | | | | |
| Q1–US$ 0–198·96 | 63 | 11·67 | 36·51 | 63·49 | < 0·001† |
| Q2–US$ 198·97–223·57 | 191 | 35·37 | 40·31 | 59·69 | |
| Q3–US$ 223·56–631·38 | 137 | 25·37 | 28·47 | 71·53 | |
| Q4–≥ US$ 631·39 | 149 | 27·59 | 19·46 | 80·54 | |
| Cohabitation | | | | | |
| Not alone | 490 | 89·25 | 30·41 | 69·59 | 0·583† |
| Alone | 59 | 10·75 | 33·90 | 66·10 | |
| Number of diseases | | | | | |
| < 5 | 325 | 59·20 | 34·15 | 65·85 | 0·039† |
| ≥ 5 | 224 | 40·80 | 25·89 | 74·11 | |
| Functional ability | | | | | |
| Adequate | 460 | 84·10 | 30·00 | 70·00 | 0·297† |
| Inadequate | 87 | 15·90 | 35·63 | 64·37 | |
| **Contextual variable** | | | | | |
| *Per capita* household income | | | | | |
| Tertile 1-US$93·90–US$186·26 | 185 | 33·70 | 48·11 | 51·89 | < 0·001‡ |
| Tertile 2-US$198·21–US$336·69 | 181 | 32·97 | 27·07 | 72·93 | |
| Tertile 3-US$344·32–US$1421·96 | 183 | 33·33 | 16·94 | 83·06 | |

*There may be divergent values due to missing values.
†Pearson's $\chi^2$ test.
‡$\chi^2$ test for linear trend.
§Brazilian Real (BRL) converted to United States Dollar (USD). Quote USD/BRL on 01-01-2009: 2·34.

The greater the distance to establishments with predominant sale of unprocessed or minimally processed foods, the lower the prevalence of regular consumption of FV (adjusted analysis). Older adults, who lived greater distance tertiles from establishments with predominant sale of ultra-processed foods, mixed establishments, or all categories of establishments, had 16 % (prevalence ratio = 0·84; 95 % CI = 0·73, 0·96), 19 % (prevalence ratio = 0·81;

**Table 3** Association between food establishments' proximity, in tertiles, and regular consumption of fruits and vegetables of older adults (n 549)

| | Regular consumption of fruits and vegetables | | | |
| --- | --- | --- | --- | --- |
| | Crude analysis | | Adjusted analysis* | |
| | PR | 95 % CI | PR | 95 % CI |
| **Unprocessed/minimally processed** | | | | |
| 4·56–192·66 m | 1·00 | – | 1·00 | – |
| 192·84–448·11 m | 0·80 | 0·69–0·93 | 0·86 | 0·74–0·99 |
| 448·47–2722·52 m | 0·75 | 0·64–0·88 | 0·84 | 0·72–0·97 |
| **Ultra-processed** | | | | |
| 5·76–115·31 m | 1·00 | – | 1·00 | – |
| 115·33–230·65 m | 0·91 | 0·78–1·06 | 0·92 | 0·80–1·06 |
| 231·28–2083·67 m | 0·82 | 0·69–0·96 | 0·84 | 0·73–0·96 |
| **Mixed** | | | | |
| 4·54–83·70 m | 1·00 | – | 1·00 | – |
| 84·07–183·82 m | 0·89 | 0·77–1·02 | 0·91 | 0·80–1·04 |
| 184·75–2228·50 m | 0·79 | 0·68–0·92 | 0·81 | 0·71–0·93 |
| **All categories** | | | | |
| 4·54–63·87 m | 1·00 | – | 1·00 | – |
| 63·98–138·08 m | 0·87 | 0·77–0·99 | 0·89 | 0·78–1·00 |
| 138·41–2083·67 m | 0·78 | 0·73–0·85 | 0·81 | 0·70–0·94 |

PR, prevalence ratio.
*Adjusted for sex; age group; educational level; monthly individual income; number of diseases, cohabitation, functional ability and neighbourhood *per capita* household income.

95 % CI = 0·71, 0·93) and 19 % (prevalence ratio = 0·81; 95 % CI = 0·70, 0·94) lower prevalence of regular consumption of FV, respectively (Table 3).

## Discussion

Our findings indicate that the majority of older adults consume FV on five or more days a week and, on average, they live closer to mixed establishments and more distant from establishments that predominantly sell unprocessed or minimally processed foods. Accessibility to establishments was associated with the consumption of FV, independently of individual socio-demographic characteristics, health conditions and neighbourhood socio-economic status. The greater the distance from their residence to establishments which predominantly sell unprocessed or minimally processed foods, the lower the prevalence of regular consumption of FV. In addition, those who lived in the tertiles at greatest distance from establishments with predominant sale of ultra-processed foods, mixed establishments or all categories of establishments had a lower prevalence of consumption of FV.

The prevalence of regular consumption of FV among older adults living in the medium-sized city was higher than the national prevalence[39]. According to data from the VIGITEL, 43·40 % (95 % CI: 41·10 %, 45·80 %) of people, 65 and older who lived in Brazilian capitals consumed FV five or more times a week in 2009[39]. In a city in the interior of the state of Minas Gerais, a lower prevalence of regular consumption of FV (48·5 %) was also found among older adults with a profile similar to our sample[40].

This difference can be attributed to the specificities of eating behaviour that occur due to regional differences in food production, socio-economic and cultural conditions[36]. In addition, the studies mentioned asked objective questions to investigate the regular consumption of FV[41,42], while the present study investigated the frequency of consumption in the last year of thirty-five FV through the use of FFQ, which may have contributed to the difference in the prevalence of food consumption between studies.

The WHO recommends the consumption of five daily servings or 400 g of FV for the prevention of non-communicable diseases, such as diabetes, cardiovascular diseases and cancer, as well as for the prevention of micronutrient deficiencies[6]. In Brazil, the VIGITEL system does not investigate the daily consumption of FV due to the difficulties in transmitting the concept of portions to the interviewees, and therefore, it is assumed that the consumption of these foods on five or more days of the week is required to achieve daily consumption of FV[36].

Few studies have focused on the relationship between availability[12–14,43] and accessibility[15,44] of food establishments and the food consumption of older adults. As in our study, an association was found between healthier diets and better quality of the food environment around the residence of older adults in cities in the United Kingdom[12], Canada[13,14] and the USA[15]. Among older adults without a car living in twenty British cities, the greater diversity of food outlets in the neighbourhood was associated with greater consumption of FV[12]. In a study carried out with older adults in rural areas of the state of Texas (USA), an association was found between the increase in the distance from the residence to supermarkets or even stores selling fruit and vegetables and the lower daily consumption of FV[15]. Older adults from the cities of Laval and Montreal (Canada) who lived in neighbourhoods with a higher density of fast-food restaurants had lower scores for a diet pattern considered healthy[13].

On the other hand, other studies have found no association between the food environment and the food consumption of the older adults[43,44]. The distance between the main fruit and vegetable purchase establishment was not associated with the daily intake of portions of these foods by older adults living in a community centre in New York City (USA)[44]. According to the authors, the older adults were independent, and the distance factor did not seem to generate barriers for the acquisition of food[44]. There was also no association between density of food outlets and inadequate consumption of proteins or total fats in the neighbourhood of older adults living in a suburb of Tokyo (Japan)[43]. However, the authors found an association between the perception of low quality of the food environment and inadequate protein consumption, indicating that, in this case, the measures of the

perceived food environment proved to be superior to the assessment of the food environment from secondary data.

It is recognised that the consumption of FVs among older adults is associated with individual factors[7]. Despite adjustments using important individual factors associated with the food consumption of the older adults, the contextual factor, that is, the proximity to food establishments, remained associated with regular consumption of FV. Thus, we evidence that the contextual factors related to the food environment may be important to explain the food consumption of community-dwelling older adults. Studies indicate that older adults have specific characteristics that make them more dependent on the neighbourhood close to their residence, such as increased time at home[45], probably due to retirement; difficulty carrying purchases; not having a car[17–19]; lack of financial condition to pay for public transport and difficulty to travel long distances on foot[18]. Thus, older adults may be likely to have poorer quality of diet if the environment does not provide them with access to healthy food. This is corroborated by our findings, in which older adults who live far from establishments with healthy foods available, such as establishments with predominant sale of unprocessed or minimally processed foods, mixed establishments or any category of establishments consumed less FV.

Our results also evidence that the association between the urban food environment and the consumption of FV is independent of the neighbourhood socio-economic status. According to Diez-Roux[46], the neighbourhood socio-economic status acts as a proxy for physical and social characteristics of the environment related to health, such as safety and quality of physical structures in the neighbourhood. In addition, this measure has been associated both with the distribution of food establishments[31] and with the consumption of FV by Brazilians[47]. In this context, we believe that the difficulty in accessing food establishments is preponderant in relation to the food consumption of older adults, even in the face of physical and social barriers, indirectly measured in this study, and which potentially influence access to food for older people, for example, quality of sidewalks and streets, inefficiency of public transport, social disorder and crime.

On the other hand, our findings indicated that older adults who live more distant from establishments that predominantly sell ultra-processed foods had a lower prevalence of regular consumption of FV. This result can be partially explained by the fact that those, who live in places far from establishments with predominant sale of ultra-processed foods, also live in a greater distance from establishments with predominant sale of unprocessed or minimally processed foods, as indicated in the Kernel density maps (Fig. 1).

This study has some limitations. The cross-sectional design does not allow causal inference and the self-selection bias may have occurred, that is, older adults who eat better may have chosen to live in places with better quality of the food environment. We used data from 2009, for the urban food environment and for the socio-demographic and health characteristics of the older adults. However, the distribution of the categories of establishments is similar to the year 2016[31]. On the other hand, the population of this city had a higher proportion of older adults 60–69 years old and 80 years or more in 2019, but the same proportion of males and females as our sample (data not shown).

Our study did not investigate characteristics related to the consumer food environment, such as variety, availability, price and quality of food sold inside, and therefore, investigations of data about this theme are important to better understand what factors influence the diet of the older adults in the city. Assessing the perception of the older adults about the environment in which they live is essential to understand the barriers or facilitators for the acquisition of food and, consequently, the eating behaviour of older adults. Thus, this is a limiting factor in this work, and future research should include subjective methods of assessing the food environment.

The food survey used to assess the regular consumption of FV by the older adults may also have been a limitation of this study. The qualitative FFQ did not allow the assessment of food portions, thus contributing to a possible overestimation of the consumption of FV. However, the investigation of the quantity of portions consumed is not always superior to the use of a qualitative FFQ, as it can decrease accuracy measurement of food consumption[48]. Although the use of FFQ for the past 12 months is important to consider seasonal differences in eating habits, its use may have introduced memory bias in the study. In cases in which the older adult had cognitive impairment, the FFQ was answered by the closest respondent, usually relatives or caregivers, helping to minimise this bias. In addition, we believe that the use of qualitative FFQ may introduce less chance of memory bias when compared with instruments that also investigate the amount of food consumed.

Despite these limitations, this study is a pioneer in evaluating the relationship between the urban food environment and food consumption among older adults in a middle-income country, to the best of our knowledge. The assessment of the food environment has been minimally explored in developing countries and in small- and medium-sized cities. The results obtained suggest similarities with results of other studies in relation to the characteristics of the food environment as well as its association with the population's eating behaviour. Moreover, the representative sample of the older adults, together with high coverage of the evaluated food environment, guarantees the external validity of our estimates, and our results can be generalised to populations with characteristics similar to ours.

In addition, the high cost of data collection through objective assessment of the environment has contributed to studies on the urban food environment using the

territory sampling process or the use of secondary data, such as registration of formal establishments. In this sense, our study is relevant for carrying out the objective assessment of all formal and informal establishments with day-time operation throughout the urban territory of the city surveyed.

In this context, our results suggest that older adults living in small- or medium-sized cities in middle-income countries may have their food consumption altered due to access to food establishments. The access to food is included in the requirements that are necessary to establish an Age-Friendly City[4]. This aspect is also emphasised by the Age-Friendly Brazil Strategy, an initiative created in 2018 for encouraging opportunities for communities and cities to implement actions that promote active, healthy, civil and sustainable ageing of the Brazilian elderly population, to cope with vulnerabilities present in the older population's social life[49]. Among the aspects considered for evaluating how friendly a city is to the elderly is the evaluation of structures for open spaces and buildings. In this regard, there is a need to maintain or create small neighbourhood establishments to facilitate access to food for the older adults. Access to low-cost meals is also identified as one of the demands for health-related services[4].

Thus, our findings show the need for urban (re)planning of medium-sized cities in a scenario similar to that studied, with the hope of meeting the needs of the elderly population to access and promote healthy eating, to become friendly to older adults and contribute to the healthy ageing of this population[3].

## Conclusion

Our findings indicate that older adults needed to travel greater distances to access establishments selling fresh food. In addition, older adults, who lived closer to any type of food establishment, had a higher prevalence of regular consumption of FVs. Therefore, our results point to the relevance of the food environment close to the older adults' residence as a determinant of the quality of their diet.

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## Supplementary material

For supplementary material accompanying this paper visit https://doi.org/10.1017/S136898002000467X

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