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Original Research

Neighborhood food environment and consumption of fruit and leafy vegetables: Pro-Saude Study, Brazil

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ABSTRACT

Objective: To explore the relationship between availability of different types of retail food stores and consumption of fruit and leafy vegetables.
Study design: This study is a cross-sectional study.
Methods: Data were derived from 2032 adults living in the city of Rio de Janeiro, Brazil, participating in the longitudinal Pro-Saude Study. Exposure to street markets, fruit and vegetable stores, groceries and markets, unhealthy food outlets, restaurants, and supermarkets within 1600 m buffers was obtained by georeferencing residential addresses. Consumption of fruit and leafy vegetables was assessed via two single questions, categorized as 'yes' (≥4 days/week) and 'no' (<3 days/week). Multiple logistic regression models were used to assess relationships of interest adjusted for surrounding average monthly income, sex, age, education, and family income per capita.
Results: Except for supermarkets, the presence of a greater number of retail food stores – irrespective of the type – was associated with higher odds of consumption of fruit and leafy vegetables than with areas with a lower number (e.g. odds ratio = 1.47; 95% confidence interval = 1.13–1.91).
Conclusions: The greater availability of several types of retail food stores close to participants' residences was associated with higher consumption of fruit and leafy vegetables in Rio de Janeiro.

Introduction

Fruits and vegetables present low energy density and high fiber contents, being an important component of a healthy diet.[1,2] Adequate consumption of these types of food reduces the risk of many chronic conditions, including obesity, diabetes, cardiovascular diseases, and several types of cancer.[3–6] However, globally, consumption of fruits and vegetables falls below the levels recommended by the World Health Organization of a daily intake of 400 g.[7] Therefore, promoting greater consumption of fruits and vegetables has become a public health priority in many countries in the past decade, supported by the Global Strategy on Diet and Physical Activity and Health.[1,6,8]

Food choices are determined by a variety of complex factors, including physiological, psychological, and cultural and social aspects.[9] There is a well-established direct association between individual attributes, such as income and education, and consumption of fruits and vegetables.[10] In addition, mounting research has investigated the influence of contextual characteristics, such as place of residence, work, and study,[11–13] on determining individual food choices, suggesting a direct relationship between greater availability of retail food stores offering healthy foods and better quality diets with consumption of fruits and vegetables in urban environments.[14]

Some studies, most of which were carried out in high-income countries, such as the United States, the United Kingdom, and Australia,[15] showed that food intake is influenced by types of food available in the area surrounding people's residences. In a systematic review investigating the environmental determinants of the intake of fruits and vegetables among adults, Kamphuis et al.[16]

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highlighted that the local availability of healthy foods appears to exert a positive influence. More recently, a review on the same topic found that the association between intake of fruits and vegetables and environmental markers was inconsistent.[17] Some studies have found that greater availability of healthy products was associated with higher consumption of fruits and vegetables, whereas others have failed to observe this association.[17] Another systematic review indicated that greater access to supermarkets was not associated with consumption of fruits and vegetables. In addition, no consistent association was found between availability of fruits and vegetables and their consumption.[18] These inconsistencies might be attributed to methodological challenges imposed by the complexity of studying the food environment, including differences in definition of neighborhood and food stores and in approaches used for measuring the environmental characteristics. Moreover, environmental determinants can differ across regions, according to social, cultural, and economic differences that influence the dynamic of food purchase and consumption.

Few studies have been conducted among Brazilian adults investigating the relationship between local food environment and consumption of fruits and vegetables.[19–21] To our knowledge, no such investigation has been conducted in Rio de Janeiro, Brazil's second largest and populous city (Instituto Brasileiro de Geografia e Estatística (IBGE), 2010). Historical, socio-economic, and political processes in combination with its unique geographical features resulted in a large proportion of people living in informal settlements (22% in Rio vs. 6% nationwide),[22] mostly slums. Large disparities exist among the city's neighborhoods, some of which have a Social Development Index (SDI) greater than 0.8, while others have an SDI of less than 0.4.[23] Differently from the territorial distribution of poorer neighborhoods in other cities, in Rio those areas are scattered across the city.[24] Besides its great natural beauty, Rio de Janeiro is also recognized for high violence rates, with 'quality of life' ranging from levels comparable with that of Belgium to those comparable with Vietnam, according to the Human Development Index.[25] Investigating the experiences of a population exposed to such heterogeneous environment may contribute to improve the understanding of the role of contextual determinants of food consumption.

The objective of the present study was to explore the relationship between the availability of different types of retail food stores and the consumption of fruits and leafy vegetables among civil servants of a university in the city of Rio de Janeiro.

Methods

Study design, setting, and population

A cross-sectional study comprising part of a larger prospective investigation (Pró-Saúde Study - PPS),[26] whose main goal is to investigate the role of socio-economic and sociocultural determinants in health and morbidity patterns among civil servants of a university in the state of Rio de Janeiro, Brazil, was carried out.

For the present study, data from participants in wave 4 (2012–13) of the PPS living in the city of Rio de Janeiro were used.

The present study included individuals with full georeferenced address for whom data on consumption of fruits and vegetables were available ($n = 2032$, 93.1% of total study population).

Individual data

Individual data were collected in 2012–13 using self-report questionnaires. Methods were used to ensure quality control during data collection and processing, such as regular monitoring of the data collected involving analysis of missing data concomitant with data collection and double entry.[26]

The study outcome was the self-reported intake of fruits and leafy vegetables, assessed by the following questions: 'How often do you eat fresh fruits?' and 'How often do you eat leafy vegetables?' with the following response options: never or less than once per month, 1–3 times per month, 1–3 times per week, 4–6 times per week, and daily. In this study, to express regular consumption, responses were dichotomized into 'yes' (consumes fruits and leafy vegetables 4–6 times per week and daily) and 'no' (other categories).

In a pilot study involving 89 temporary civil servants at the same university, reliability estimated by kappa statistic with 95% confidence intervals (95% CIs) calculated using the kapci routine, developed for Stata software,[27] was 0.78 (95% CI = 0.66–0.87) for fruits and 0.60 (95% CI = 0.47–0.74) for vegetables.

The other individual variables assessed were sex (male, female), age in years (categorized into <45, 45–54, ≥55 years), family income per capita in monthly minimum wages (MWs) (categorized into < 3 MW, 3–6 MW, > 6 MW; where 1 MW = R$ 622.00 or US$ 319.00 in 2012), education (elementary or lower, high school, college, or higher), marital status (never married, stable union or married, separated or divorced, or widowed) and skin color/race (black, mixed-race, white, yellow, or indigenous).

Context data

Participants' residential addresses were obtained by applying a self-report questionnaire. Addresses of retail food stores (hereinafter called 'stores') were obtained from the Subsecretariat for Surveillance, Health Inspection and Disease Control of the city of Rio de Janeiro for 2012.

The variables related to the food environment surrounding participants' residences were obtained by georeferencing the residential addresses. Georeferencing was performed using Google Maps,[28] accessed by the R software,[29] in which addresses of residences were compared against the Google Maps addresses database to yield the geographic coordinates of latitude and longitude. Coordinates were obtained by hand in cases where the address was not located or located incorrectly.

Stores were grouped according to an adapted version of the classification used by Pessoa et al:[21] (1) street markets, (2) fruit and vegetable specialized stores, (3) grocers and markets, (4) 'unhealthy' food stores (bakery, confectionery, coffee shop, candy store, sweet store, ice cream parlor, convenience store, department store, diners, pastry shop, cantina, pizzeria, bar), (5) restaurants, (6) supermarkets.

Exposure to the food environment in the neighborhood was assessed by the availability of each of the categories of the aforementioned stores, based on the absolute number of stores contained within a circular buffer centered in each participant's residence, categorized into quartiles. A circular buffer with 1600 m radius was used, considering this was a reasonable distance to travel to purchase food. This same distance was also used in other studies.[19,30]

To adjust for contextual socio-economic status, the surrounding average monthly income was used. It was calculated based on the spatial moving average among adjacent tracts, so as to smooth random fluctuations. The average income of each census tract was obtained from the Demographic Census 2010.

Data analysis

Initially, consumption of fruits and leafy vegetables was described according to individual-level variables. The chi-squared test was used to determine the influence of those variables on the consumption of these foods. Statistical summaries of retail food

stores in the buffer zones and surrounding average monthly income were described (mean, standard deviation, minimum and maximum values).

The effect of availability of retail food stores in each category on the consumption of fruits and leafy vegetables was estimated using multiple logistic regression models. The measure of effect obtained was the odds ratio (OR) along their respective 95% CIs. Variables showing statistically significant ($P < 0.05$) associations with the study outcome were retained in the final model. All statistical analyses were performed using the Stata 13 software program.[31]

Ethical aspects

The study was approved by the Research Ethics Committee of the Institute of Social Medicine of the University of the state of Rio de Janeiro (Permit no. CAAE 0041.0.259.000-11). All participants signed the free and informed consent form.

Results

Of the total of 2032 individuals included in this study, 60% were women and 46% were aged 45–54 years. Most participants had higher education (56%), 61% were married or in a stable union, 51% were self-designated as white, and 54% had an income per person of ≤3 MWs (equivalent to 957 USD in 2012), and 44% participants consumed fruits and leafy vegetables at least 4 times per week. In the latter group, around 70% were female, 61% had higher education, and 48% had a family income per capita of >3 MWs (Table 1). Statistical summaries of retail food stores within a 1600 m buffer around participants' residences and surrounding average monthly income are given in Table 2.

Crude analyses revealed higher OR of the consumption of fruits and leafy vegetables among participants residing in locations with a greater number of retail food stores in the surrounding neighborhood (upper quartile), irrespective of the store type. With the exception of supermarkets, this result persisted in the model adjusted for the individual variables and for neighborhood average monthly income, showing that the greater presence (upper quartile) of stores analyzed was associated with (the last OR for fruit and leafy vegetable specialized stores) higher odds (1.35–1.47) of consuming fruits and leafy vegetables than those observed in areas with a lower number (lower quartile) of these stores (Table 3).

Discussion

To the best of our knowledge, this is the first study to investigate the relationship between the availability of different types of retail food stores and consumption of fruit and leafy vegetables in Rio de Janeiro, Brazil's second largest city. Our findings showed that the higher number of retail food stores in the area surrounding participants' residences was associated with greater consumption of the fruits and leafy vegetables, irrespective of the type of store, except for supermarkets. The different types of stores analyzed were located proximally, corroborating the results of other studies,[32,33] including several conducted in Brazil.[21,34] Thus, locations with a higher number of different types of food stores can be a proxy for availability of fruit and vegetable stores.

Some studies showed that the concentration of stores is determined mainly by the level of income of the region; in general, high-income neighborhoods have a higher number of stores, particularly those with a greater availability of healthier foods.[19,35] The city of Rio de Janeiro, similar to most Brazilian cities, has major socioeconomic disparities in SDI,[36] likely influencing the availability of all types of services, including those related to food.

One study explored the association of density of different sources of food in the residential environment with dietary

Table 1
Consumption of fruits and leafy vegetables according to individual characteristics of participants in the Pro-Saude Study. Brazil, 2012–13.

Variables	Number of participants [*N* (%)]	Consumption fruit and leafy vegetables[a]		p[b]
		Yes [*N* (%)]	No [*N* (%)]	
Number of participants	2032 (100.0)	887 (43.65)	1145 (56.35)	–
Sex				
Male	812 (40.0)	270 (30.4)	542 (47.3)	0.000
Female	1220 (60.0)	617 (69.6)	603 (52.7)	
Age				
<40 years	155 (7.63)	51 (32.90)	104 (67.10)	0.000
40–50 years	712 (35.04)	287 (40.31)	425 (59.69)	
50–60 years	803 (39.52)	362 (45.08)	441 (54.92)	
>60 years	362 (17.81)	187 (51.66)	175 (48.34)	
Education				
Elementary or less	225 (11.07)	91 (10.26)	134 (11.70)	0.001
High school	663 (32.63)	255 (28.75)	408 (35.63)	
College or above	1144 (56.30)	541 (60.99)	603 (52.66)	
Marital status				
Married or stable union	1242 (61.12)	517 (58.29)	725 (63.32)	0.008
Separated or divorced	365 (17.96)	183 (20.63)	182 (15.90)	
Widowed	117 (5.76)	60 (6.76)	57 (4.98)	
Never married	308 (15.16)	127 (14.32)	181 (15.81)	
Skin color/race				
White	1037 (51.03)	473 (53.33)	564 (49.26)	0.025
Mixed-race	639 (31.45)	248 (27.96)	391 (34.15)	
Black	329 (16.19)	152 (17.14)	177 (15.46)	
Yellow/indigenous	27 (1.33)	14 (1.58)	13 (1.14)	
Income				
<3 MW	1110 (54.63)	423 (47.69)	687 (60.00)	0.000
3–6 MW	692 (34.05)	331 (37.32)	361 (31.53)	
>6 MW	230 (11.32)	133 (14.99)	97 (8.47)	

MW, minimum wage.
[a] Consumption of fruit and vegetables on four or more days per week.
[b] Chi-squared test.

Table 2
Statistical summaries of retail food stores and neighborhood average monthly income of participants in the Pro-Saude Study. Brazil, 2012–13.

Characteristics	Mean (SD)	Minimum	Maximum
Stores[a]			
Street markets	4.47 (2.90)	0.00	13.00
Fruit and vegetable specialized stores	3.91 (2.96)	0.00	13.00
Grocers and markets	14.73 (7.79)	0.00	40.00
'Unhealthy' food stores[b]	130.57 (121.73)	0.00	674.00
Restaurants	38.94 (45.50)	0.00	383.00
Supermarkets	6.35 (4.45)	0.13	24.00
Neighborhood average monthly income[c]	1345.91 (856.36)	264.81	6652.56

SD, standard deviation.
[a] Distributed in circular buffers within a 1600 m buffer of participants' residences.
[b] Includes bakery, confectionery, cafés, coffee shops, candy store, sweet store, ice cream parlor, convenience store, department store, diner, pastry shop, cantina, pizzeria, and bar.
[c] Neighborhood average monthly income in US dollar. Calculated as average including the census tract and its first order neighbors.

Table 3
Association between retail food stores availability and consumption of fruits and leafy vegetables[a]. Pró-Saúde Study, Brazil, 2012–13.

Stores[b]	Crude model OR (95% CI)	Adjusted model[c] OR (95% CI)
Street markets		
<2	1,00	1,00
2-4	0.94 (0.74–1.21)	0.90 (0.71–1.23)
5-7	**1.44 (1.15–1.81)**	1.26 (0.98–1.61)
8-13	**1.62 (1.24–2.12)**	1.25 (0.93–1.68)
Fruit and vegetable specialized stores		
0	1.00	1.00
1-2	0.96 (0.74–1.25)	0.99 (0.76–1.30)
3-6	1.22 (0.97–1.53)	1.14 (0.90–1.45)
7-13	**1.75 (1.38–2.22)**	**1.47 (1.13–1.91)**
Groceries and markets		
≤9	1.00	1.00
10-14	0.88 (0.69–1.13)	0.87 (0.68–1.11)
15-20	1.15 (0.90–1.49)	1.12 (0.86–1.45)
21-40	**1.61 (1.26–2.06)**	**1.35 (1.03–1.77)**
Unhealthy food stores[d]		
≤39	1.00	1.00
40-80	0.87 (0.68–1.12)	0.79 (0.60–1.03)
81-210	1.09 (0.86–1.41)	0.93 (0.72–1.22)
210-675	**1.84 (1.43–2.36)**	**1.36 (1.01–1.83)**
Restaurants		
≤7	1.00	1.00
8-20	0.94 (0.73–1.21)	0.84 (0.64–1.10)
21-62	**1.32 (1.04–1.70)**	1.10 (0.84–1.44)
63-383	**1.98 (1.54–2.53)**	**1.43 (1.04–1.96)**
Supermarkets		
≤3	1.00	1.00
4-6	0.82 (0.65–1.05)	**0.78 (0.60–0.99)**
7-9	1.21 (0.94–1.56)	0.99 (0.76–1.31)
10-24	**1.38 (1.08–1.76)**	0,86 (0.91–1.47)

OR, odds ratio; CI, confidence interval.
Bold font indicates statistical significance.
[a] Consumption of fruit and leafy vegetables on four or more days per week.
[b] Absolute number of outlets categorized into quartiles of distribution.
[c] Analyses adjusted by surrounding average monthly income and by individual variables: sex, age, education, and family income per person.
[d] Includes bakery, confectionery, cafés, coffee shops, candy store, sweet store, ice cream parlor, convenience store, department store, diner, pastry shop, cantina, pizzeria, and bar.

consumption among African-American adults in Houston, Texas, and found an unexpected positive association between fast food, pizzerias, limited-service facilities, availability of bakeries, and consumption of fruits and vegetables.[13] In the same direction, another study in a large sample of African-American adults from central Mississippi found a positive association between fast food restaurant availability and fiber ingestion.[37] It is well known that fast food restaurants were more prevalent in low-income areas than in developed countries,[38] and it could be suggested that individuals are making healthier food choices at this type of restaurants, which might be contributing to this positive association.[13] On the other hand, the spatial effects resulting from the agglomeration of food retailers, especially in the most populated areas, could be a confounder of this relationship.

In Brazil, few studies assessing the availability of retail food stores and consumption of fruits and vegetables have been conducted. In a study carried out in Belo Horizonte, higher consumption of fruits and vegetables was observed in neighborhoods with higher density of healthy food stores and higher income. Conversely, lower consumption was found in neighborhoods that had a higher density of unhealthy foods. In São Paulo city, Duran et al.[19] found that the availability of fruits and vegetables in the surrounding area of the residence was associated with higher intake of these foods. However, the intake was lower among residents of low-income neighborhoods with fewer supermarkets and outlets selling fresh produce. Menezes et al.[20] also conducted a study in Belo Horizonte and found similar results to those of the present study, showing greater average consumption of fruits and vegetables in the surrounding area of the residence with higher concentration of retail food stores.

Although some studies showed that greater access to supermarkets was associated with a healthy diet, particularly with greater consumption of fruits and vegetables,[14,33,39] in the present study, consumption of fruits and leafy vegetables was inversely associated with the availability of supermarkets for the second quartile, in line with the results of Michimi et al.[40] It is important to note that supermarkets offer a range of different foods, including healthy foods and ultraprocessed food products. Machado et al.[41] showed a remarkable contribution of supermarkets to Brazilian food intake, with emphasis on ultraprocessed products. Probably, the great availability of ultraprocessed products on supermarkets can facilitate the acquisition of these items and thus discouraging the purchase of perishable foods, such as fresh fruits and vegetables. It should be also highlighted that food choices are influenced by many factors such as quality, price, and advertising, among others.[42,43]

It is noteworthy that most participants of the present study reported low regular consumption of fruits and leafy vegetables compared with participants of other Brazilian studies.[44] Notably, although the two types of stores that sell mainly fruits and vegetables (street markets and fruit and vegetable specialized stores) were far fewer in number than the other types, their influence on consumption of fruits and vegetable was evident. Greater exposure of individuals to these stores may contribute to higher consumption of fruits and vegetables.

Limitations

The present study has some limitations. The first one concerns the cross-sectional design of the study, with exposure of

participants to contextual aspects at the time of the survey, independently of their time residing at the address. Similarly, it is not possible to assess changes in this dietary pattern promoted by living in different areas throughout life.

In addition, secondary data on retail food stores were used, which may have underestimated or overestimated the number of stores compared with use of primary data because informal outlets or outlets which had closed down or had a change in profile were not included.[45] Moreover, classification food stores classification does not guarantee the types of foods sold which would result in inappropriate grouping. However, the database used was obtained from the local government body responsible for the registration and inspection of these establishments, and thus based on supposedly updated data. Environmental data from local government, referred to 2012, were obtained in 2014, being impossible to conduct a field validation of the food store database, because the operation of this type of establishment is dynamic, and in two years, a number of stores could open, close, or change their products. Another limitation is that, because of the format of the questionnaire, predefined for all phases of the PPS, the outcome variable of consumption of fruits and leafy vegetables did not include other vegetables, such as, carrots and zucchini, and information on quantity consumed was not available. Finally, reverse causation cannot be completely ruled out, namely that a favorable food environment might be a response to individuals' preferences.

Despite the limitations outlined, studies reporting the availability of food stores help further understanding of the complex interaction between the food environment and dietary patterns.

Conclusions

The present study in Rio de Janeiro found that greater availability of several types of retail food stores located in the area surrounding residences was associated with higher consumption of fruits and leafy vegetables. Future studies might use mixed-methods research to integrate qualitative and quantitative approaches (with enhanced food environment methods and metrics) to improve the understanding of interactions of individuals with their food environment that determine dietary patterns. Thereby, this may cast light on how the consumption of fruits and vegetables can be encouraged in these areas, if retail food stores favor healthier food choices. In this respect, the strengthening of public policies aimed at guaranteeing access to healthy foods is paramount to achieving healthier populations.

Future studies should aim to improve the methodology of assessing retail food by involving different methods to advance understanding of the food environment in Rio de Janeiro or in metropolitan areas sharing similar characteristics.

Author statements

Ethical approval

The study was approved by the Research Ethics Committee of the Institute of Social Medicine of the University of the State of Rio de Janeiro (Permit no. CAAE 0041.0.259.000-11). All participants signed the free and informed consent form.

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Competing interests

The authors declare no competing interest.

Author contributions

C.C.C., K.L.S.B., I.H.S., and E.F. designed the analysis plan; C.C.C. performed statistical analysis, wrote the manuscript, and had primary responsibility for the final content; K.L.S.B. supervised data collection; W.J. and I.H.S. contributed to acquisition of georeferenced data; K.L.S.B., I.H.S., D.S.C., I.R.R.C., F.F.B., W.J., and E.F. contributed to the interpretation of results and critical review of the manuscript. All authors read and approved the final manuscript.

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