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Neighborhood socioeconomic characteristics and differences in the availability of healthy food stores and restaurants in Sao Paulo, Brazil

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Abstract

Differential access to healthy foods has been hypothesized to contribute to health disparities, but evidence from low and middle-income countries is still scarce. This study examines whether the access of healthy foods varies across store types and neighborhoods of different socioeconomic statuses (SES) in a large Brazilian city. A cross-sectional study was conducted in 2010–2011 across 52 census tracts. Healthy food access was measured by a comprehensive in-store data collection, summarized into two indexes developed for retail food stores (HFSI) and restaurants (HMRI). Descriptive analyses and multilevel models were used to examine associations of store type and neighborhood SES with healthy food access. Fast food restaurants were more likely to be located in low SES neighborhoods whereas supermarkets and full service restaurants were more likely to be found in higher SES neighborhoods. Multilevel analyses showed that both store type and neighborhood SES were independently associated with in-store food measures. We found differences in the availability of healthy food stores and restaurants in Sao Paulo city favoring middle and high SES neighborhoods.

Keywords

Neighborhood; Food environment; Socioeconomic factors; Disparities; Food stores

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Introduction

The rising prevalence of overweight and obesity is currently a major public health concern (WHO, 2003) and occurs in both developed and developing countries (Jones-Smith et al., 2012; Popkin et al., 2012). Such increase is likely related to society-wide changes in diet and physical activity, which in turn, are associated with economic growth, trade, mass agricultural production, and urbanization (Thom & Hawkes, 2009; Ruel et al., 2010). In Brazil, overweight (body mass index ≥ 25 kg/m²) prevalence in adult men increased from 18% to 50% and from 29% to 49% in women in the past 30 years (IBGE, 2010); no longer only affecting the more affluent sectors of the Brazilian society (Monteiro et al., 2007). Additionally, obesity- and overweight-related diseases already account for approximately 10% of the public health sector costs in the country (Bahia et al., 2012).

Several observational studies have shown that rates of physical activity (McCormack & Shiell, 2011), diet patterns (Diez-Roux et al., 1999; Shohaimi et al., 2004), and obesity (Smith et al., 1998; Sundquist et al., 1999; Lovassi et al., 2009) vary across neighborhoods.

The most consistent evidence on associations of obesity and dietary patterns and food availability primarily comes from the United States, and suggests that greater availability of healthy foods (e.g., fruits and vegetables) and healthier food outlets are associated with greater consumption of such foods (Auchincloss et al., 2011; Moore et al., 2008; Franco et al., 2009) and lower obesity rates (Inagami et al., 2006; Morland et al., 2006; 2009). Moreover, low-income neighborhoods have significantly fewer grocery stores and supermarkets, and more fast food restaurants than high-income neighborhoods (Morland et al., 2006; Franco et al., 2008; Moore & Diez Roux, 2006).

Whether these results are generalizable to other countries is not clear, as studies elsewhere reported mixed results (Ball et al., 2009; Cummins et al., 2010). Contradictory findings on the availability and accessibility of healthy foods across neighborhoods of different socioeconomic status may reflect real cultural and geographical differences (Cumming & Macintyre, 2006).

Studies exploring the food environment have used a wide variety of methodologies to measure food access. These measures are divided into the macro-level or community food environment, such as the density and location of stores and proximity to the nearest food store (Glanz et al., 2005; Charreire et al., 2010); and the micro-level or consumer food environment that include in-store measures of healthy and unhealthy food availability, variety, pricing, quality, promotion, and placement (Glanz et al., 2005; Gustafson et al., 2012). Much of the existing literature, however, employs store types as proxies for healthy foods (Moore & Diez Roux, 2006; Morland et al., 2006; Powell et al., 2007; Jaime et al., 2011), but evidence shows that the same type of store can carry different foods depending on the type of neighborhood it is located in (Franco et al., 2008) and stores often carry both healthy and unhealthy foods (Caspi et al., 2012). Therefore, combining macro and micro-level food environment measures allows a more comprehensive analysis of food environment–diet relationships (Glanz et al., 2005; Gustafson et al., 2012).

Despite the importance of assessing macro and micro-level food environments, studies that combined both measures have mostly been conducted in high-income countries (Franco et al., 2008; Hickson et al., 2011; Ball et al., 2009; Gustafson et al., 2011). Lack of evidence from countries from other parts of the world, especially those undergoing rapid nutrition and socioeconomic transitions, may lead to erroneous interventions and policy-making.

This study investigates whether access to healthy foods, measured by in-store measures of healthy and unhealthy foods, varies across different store types and neighborhoods in a large

Brazilian city. We also investigated whether differences across neighborhoods of various socioeconomic statuses are present after controlling for the types of stores.

Methods

Geographic coverage and census tract sampling

As part of the “Obesogenic” Environment Study in Sao Paulo, Brazil (ESAO-SP), we conducted a cross-sectional survey in the city of Sao Paulo, Brazil from November 2010 to February 2011 in which we directly measured the local food environment.

Located in the Southeast region of Brazil and with a population of over 11 million (IBGE, 2011), the city of Sao Paulo is the largest city in the country, and one of the most populous urban agglomerations in the world. Despite being the richest city in Brazil, with a Gross Domestic Product (US\$ 267 million) (Fundação SEADE, 2010) larger than some entire nations (The World Bank, 2012), Sao Paulo has an unequal distribution of wealth, with a GINI coefficient of 0.642, higher than the figure for the country as a whole (0.536) (IBGE, 2011).

The city is divided into 96 districts, defined by the Sao Paulo city council based on geographic and administrative matters. These districts are further divided into census tracts (CT), with a median of 177 tracts per district. According to the 2010 Brazilian Census, the average area of a district is 15.86 km², have a mean population of 10,247 residents, and a mean density of 9,920 residents/km² (IBGE, 2011).

For the present study, CT were selected utilizing a strategy that ensured representation of socioeconomic and food environment diversity in the sample. Previous studies have employed similar methods to ensure socioeconomic diversity when studied urban food environments (Glanz et al., 2007; Ball et al., 2009).

Figure 1 shows a diagram of the sampling methodology. We first ranked all 96 districts of the city and divided them into tertiles of the Human Development Index modified for use in Sao Paulo city (HDI-M). This index includes information regarding life expectancy, per capita household income, and education – illiteracy rate in the population over 15 years of age (weighted 1/3) and mean schooling years of the person with the highest income in the household (weighted 2/3) – using data from the 2000 Brazilian Census (PMSP, 2007). Our selection (based on tertiles of HDI-M) included districts in the five quintiles of HDI-M in the city, thus providing us enough socioeconomic variation in the sample.

Within each tertile of the HDI-M, districts were classified into low or high food environment density (per 1,000 district residents) based on whether they were below or above the median on all of three selected food environment indicators: a) local grocery stores and supermarkets, b) specialized fruit and vegetable (FV) stores/markets and open-air food markets and c) fast food restaurants. These indicators have been previously associated with obesity and/or a healthy food intake (Moore et al., 2008; Ball et al., 2009; Morland et al., 2009).

We collected data to construct those indicators from the most recently available secondary datasets and aggregated them to the district level. The first two indicators utilized data available from the City Council in 2010, and the third indicator utilized data from commercial lists of five large fast food restaurants chains in the city of Sao Paulo (Bob’s, Burger King, Habib’s, McDonald’s, and Pizza Hut) as well as the location of all shopping malls in the city. Shopping malls were used as proxies for fast food restaurant locations as they usually hold at least one fast food court with fast food restaurants on their premises.

We then randomly selected two districts from each of the six combined strata of HDI-M and food density. An extra district, which was adjacent to one of the selected districts within the highest tertile of HDI-M, was selected in order to offset potential data loss. We selected this stratum for over-sampling because it was expected to have a high food store density. No data were lost but the 13th district was retained in the analyses to maximize sample size.

Eight CT were randomly selected in each district. The field coordinator visited each of these tracts in order to check whether they would have a sufficiently large number of food stores and/or restaurants in accordance with its food environment density strata. If a selected census tract located in a district originally selected for a high density of fast food restaurants, retail food stores and specialized FV stores/markets did not have at least one store within its boundaries, it was discarded.

Out of the 104 tracts initially selected, 18 were excluded, yielding 86 eligible tracts. The excluded tracts did not differ from the totality of the selected tracts in terms of mean income and education levels. Of the remaining 86 tracts, 4 were randomly sampled in each of the 13 selected districts, resulting in a final count of 52 CT.

The final area included in this study was 5.09 km², comprised by 52 tracts. These tracts have a total population of 31,353 residents (IBGE, 2011) and are located in all of the five large geographic regions in the city: 8 in the North, 12 in the South, 12 in the East, 16 in the West, and 4 in the downtown area. The Brazilian Census establishes CT areas that in Sao Paulo city have an average of 0.08 km² and 195 households (IBGE, 2011).

Exposures

Socioeconomic measures—Two neighborhood socioeconomic characteristics were investigated: mean education of the sampled CT and mean education of the neighboring CT (both measured by the mean years of education of adults over 25 years of age). Data were extracted from the 2000 Brazilian Census, as no more recent data at the tract level were available for neighborhood education level when we carried out the analyses (IBGE, 2002).

We investigated socioeconomic status (SES) characteristics of both the index CT and the surrounding CT in order to determine whether the food environment in more and less segregated areas differ (holding local characteristics constant). We hypothesized that highly segregated areas (i.e., areas surrounded by other deprived areas) are more likely to lack resources, which has been reported for three diverse American cities (Smiley et al., 2010).

Mean years of education of the neighboring CT was derived from the mean years of education in all census tracts that fell within a 1,000 m buffer zone from the sampled census tracts centroid. Geographic Information System (ArcGIS 10.0, ESRI, Redlands, 2011) was used to create this variable. Both neighborhood education variables were then categorized into tertiles.

Store measures—After undertaking extensive training on the application of standardized tools, research assistants visited all food stores they found within the selected CT and systematically classified them into the following categories for retail food stores, adapted from Glanz et al. (2007): 1) convenience stores, 2) public-owned specialized FV markets, 3) privately-owned specialized FV markets/stores, 4) open-air food markets, 5) corner stores, 6) local grocery stores, 7) large chain grocery stores, 8) large chain supermarkets, and 9) delis. They were then collapsed into four categories, so we could compare the food access index across store types. The categories are: a) large chain supermarkets and grocery stores, b) specialized FV markets/stores and open-air food markets, c) local grocery stores, and d) delis and convenience stores.

In the case of restaurants, research assistants categorized business into the following categories adapted from Saelens et al. (2007): 1) A la carte full service restaurants, 2) All-you-eat buffet restaurants, 3) Full service restaurants where foods were sold by weight, 4) Large chain fast food restaurants, 5) Chainless fast food restaurants, 6) Bars and establishments where alcohol was sold in large quantities, 6) Bakeries, 7) Coffee shops, and 7) Ice cream shops. These restaurant categories were then collapsed into four categories, so we could compare the food access index across various types of restaurants: a) Full service restaurants, b) Fast food restaurants, c) Bars, d) Bakeries and Coffee shops.

Analyses were adjusted for the density of stores per 10,000 residents in each census tract. We hypothesized that this could confound the associations between CT education and food environment if density is associated with CT education and if more competition created by a larger concentration of stores is associated with the items available in stores. Gustafson et al., (2012) posited a similar hypothesis when they assessed the micro-level food environment.

Outcome: Food environment

The two healthy food access scores were the outcome variables, which were estimated based on the store and restaurant audits: a healthy food store index (HFSI) and a healthy restaurant index (HMRI).

The HFSI ranges from 1 to 15 and measures the availability, variety, and signage/advertising (counts of different signs that promoted food purchase) of healthy and unhealthy foods. We rated healthy foods with a positive score and unhealthy foods with a negative score. Availability and variety of the ten most commonly purchased fruits and vegetables (FV) in the metropolitan area of Sao Paulo city (IBGE, 2010b) were included in the score. It also incorporates data on signage/promotion of FV, as well as the availability and signage/advertising of selected snack items (sugar-sweetened beverages, chocolate sandwich cookies, and processed corn chips), which are among the most commonly consumed processed snack items in Brazil (IBGE, 2010b) (Appendix 1).

The HMRI ranges from 0 to 8 points and combines information on FV availability and signage/promotion with highly processed foods availability and signage/advertising. It also incorporates data on the presence of nutrition information and barriers to healthy eating, such as the presence of all-you-can-eat-buffets. As in the case of the HFSI, items referring to unhealthy items and barriers to healthy eating, were negatively coded (Appendix 2).

The HFSI and HMRI were derived from data collected using two tools developed to assess healthy and unhealthy foods availability, quality, variety, price, and signage/ advertising or promotion in retail food stores such as supermarkets and grocery stores; in all types of restaurants; and in specialized FV markets/stores and open-air food markets. They were based on existing consumer food environment comprehensive assessment tools tested and validated in the United States (NEMS-S and NEMS-R) (Glanz et al., 2007; Saelens et al., 2007; Franco et al., 2008) and in other countries (EPOCH) (Chow et al., 2010). We pilot tested the tools in four CT in both high and low SES neighborhoods of the city, and finally used modified final versions. Inter-rater reliability and test-retest reliability of tool items were generally high as Kappa statistics ranged from 0.50 to 0.95.

Statistical analyses

The primary goal of the analysis was to estimate the associations of neighborhood education levels with healthy food access as assessed by HMRI and HFSI for retail food stores and restaurants within the CT. The distribution of store types was compared across tertiles of neighborhood education using chi-square tests. We then compared mean HMRI and HFSI

scores for different store type and for a given store type located in neighborhoods of varying levels of education using ANOVA. In a second set of analyses, two-level multilevel models, with stores as the level-1 units and CT as the level-2 units, were used to quantify the associations of store type and neighborhood socioeconomic status (CT mean education level and neighboring CT education level) with store HMRI and HFSI, before and after adjustment for each other. Adjustment by store density (n/10,000 residents in each census tract) was further tested.

By including both store types and neighborhood education level variables in the models we were able to investigate whether differences across neighborhoods held after controlling for the type of store. Intraclass correlation coefficients (ICC) were calculated using variance estimates from intercept-only multilevel models. All analyses were performed on Stata 11.2 (StataCorp LP, College Station).

Results

Of the 52 sampled CT, data on restaurants (n=472) were available in 50 tracts, and data on retail food stores (n=305) and open-air food markets (n=8) were available in 48 CT. Research assistants were able to access all available food stores and restaurants in sampled tracts with the exception of one large supermarket, two small grocery stores, and two fast food restaurants.

Table 1 shows the characteristics of the sample tracts, which had similar median number of residents when all CT in the city were considered (583), but had slightly higher education levels. Mean years of education for all CT in the city is 7.78 years (IBGE, 2002).

Retail food store densities ranged from 0.0 to 466.7/10,000 residents, with a median of 82.1 (interquartile range 36.4; 141.0). The majority (80.8%) were classified as local grocery stores, and 15 (4.8%) were classified as specialized FV markets/stores (including open-air food markets). Restaurant densities ranged from 0.0 to 871.2/10,000 residents per CT. One-third of restaurants were fast food restaurants, but only 4.9% of them belonged to large chain fast food companies. Another third of the restaurant-like places was classified as bars (Table 1).

Census tracts within the lowest tertile of education had the largest number of food stores (136.5/10,000 residents) when compared with those CT in the upper tertile of education (58.7/10,000 residents) ($p=0.027$). CT in the first tertile of education had proportionately more local grocery stores and proportionately less supermarkets than CT in the upper tertile, and deli and convenience store proportions increased as CT education increased. The proportion of restaurants that were full service restaurants was higher in the upper tertile than in the lower tertile of education (46.5% vs. 18.4% for higher and lower tertile; $p<0.001$) whereas the opposite was true for fast food restaurants (32.2% vs. 41.3% for higher and lower tertile; $p<0.001$). The proportion of stores that were bars also decreased from the lowest to the highest education tertile whereas the proportion of stores that were bakeries or cafes increased.

Overall, mean HFSI and HMRI (averaged across all stores) increased as neighborhood education increased and were the highest in the upper tertile of education ($p=0.027$ and $p<0.001$ respectively). Within store types, these patterns were especially clear for local grocery stores and supermarkets (although differences for supermarkets were not statistically significant) and for fast food restaurants and bars (differences for bars were also not significant) (Table 2).

Retail food stores

Table 3 shows mean differences in store HFSI by store type and neighborhood education level of the store location, before and after adjustments for each other. Local grocery stores, delis and convenience stores scored lower than supermarkets before and after adjustments for neighborhood education level. Supermarkets scored slightly lower than FV markets but scored substantially higher than local grocery stores and delis (Table 3; Models 1–4). Adjusted by store type, access to healthy foods was better in CT with a higher education level, (Table 3; Models 2 and 3). Associations of local CT mean education with store HFSI persisted after adjustment for store type and neighboring CT education, with stores in higher education areas showing higher scores in a graded fashion across tertiles (Table 4; Model 4).

Stores density was not associated with HFSI scores, nor did it change above results when included in the models, therefore we decided not to include it in the final model. HFSI scores for stores located within the same tract were correlated (ICC for null model=0.27). This correlation was only slightly reduced after adjustments for neighborhood education level and store type (ICC=0.25).

Restaurants

Full service restaurants scored higher than all the other three types of establishments before and after adjustments for neighborhood education level (Table 4; Models 1–4). Restaurants located in low education CT had lower HMRI than those located in high education CT, even when adjusted by store type (Table 4; Model 2). Being surrounded by tracts with higher education was also associated with higher scores (Table 4; Model 3). Associations of neighboring CT education with store scores persisted after adjustment for store type and local mean education, with stores in higher education areas showing higher scores also in a graded fashion across tertiles (Table 4; Model 4). HMRI scores for stores located within the same census tract were correlated (ICC for null model=0.27) and the correlation was reduced after adjustment for neighborhood education and store types (ICC=0.18).

Though stores density was positively associated with HMRI (a 0.007 points increase in the HMRI for every store/1,000 residents in the census tract), adjustments for store density did not significantly change the results.

Discussion

The present study explored differences in the types of stores and restaurants available by neighborhood education level in a large Brazilian city. We also investigated the extent to which in-store measures in retail stores and restaurants were patterned by neighborhood education level of education and by store type. Overall, we found evidence of systematic differences in the location of stores and in the healthy food offerings of stores by neighborhood characteristics. Low education neighborhoods tended to have more local grocery stores and fewer supermarkets than higher education neighborhoods. They also had more bars, fast food restaurants, and less full service restaurants. When stores were compared, supermarkets, specialized FV markets/stores, and open-air food markets carried more healthy items than local grocery stores and convenience stores. Full service restaurants scored higher, in terms of access to healthy foods, than fast food restaurants and bars.

The healthy food access scores of retail stores and restaurants within a neighborhood were correlated, even after accounting for the type of store and both local-area and surrounding CT education level. Hence, a given type of food store located in low education neighborhoods had lower healthy food availability than those located in higher education neighborhoods. Restaurants located in areas surrounded by higher education neighborhoods also had higher scores than those surrounded by lower education neighborhoods.

Despite the increasing interest in the study of the food environment in recent years (Lytle et al., 2009; Walker et al., 2010; Gustafson et al., 2012; Caspi et al., 2012), little data on the food environment are available for low- or middle-income countries. Our study contributes to the existing literature because it investigates these issues in a middle-income country in Latin America—a region that has recently experienced fast and complex epidemiological changes (Barreto et al., 2012). Our results are consistent with those reported in various cities in the United States (Zenk et al., 2005; Moore et al., 2006; Glanz et al., 2007; Saelens et al., 2007; Franco et al., 2009), Australia (Ball et al., 2009), and Paraguay (Gartin 2012), showing that healthier food stores and full service restaurants are less likely to be found in more deprived neighborhoods, while fast food restaurants are more likely to be found in these same neighborhoods.

The still scarce evidence on urban food environments in Latin America suggests that open-air food markets may play a role in increasing the access to fresh produce to low-income groups in these contexts. Consistent with previous findings (Jaime et al., 2011; Gartin, 2012), open-air food markets in our sample were more likely to be found in middle and low education neighborhoods than supermarkets, and scored higher than all the other types of food retail venues. In Canada, bringing a farmer's market to an area underserved by supermarkets decreased grocery prices by 12% in three years and increased the available variety of fruits and vegetables in the neighborhood (Larsen & Gilliland, 2009). Future studies on Latin American urban food environments should, thus, consider evaluating the impact of open-air food markets on FV consumption, availability, and pricing.

With respect to restaurant availability, our results are consistent with studies conducted in the United States (Block et al., 2004; Lewis et al., 2005); Canada (Hemphill et al., 2008; Smoyer-Tomic et al., 2008), United Kingdom (Cummins et al., 2005) and Australia (Burns & Inglis, 2007). We found more full service restaurants in higher education neighborhoods and more fast food restaurants in neighborhoods with lower education levels. A previous study undertaken in Sao Paulo showed that major fast food chain outlets were more likely to be located in neighborhoods with medium and high socioeconomic status (Jaime et al., 2011). In our sample, 95.1% of the fast food outlets were not part of major national or international fast food chains and were indeed more likely to be found in neighborhoods with lower education levels. Results suggest that differences in the location of fast food outlets may be highly context dependent and vary according to the type of fast food store investigated.

We found that a grocery store located in a higher education neighborhood provided more healthy items than one located in low-education areas, which is comparable with previous studies on disparities in other cities (Glanz et al., 2007; Franco et al., 2009; Bodor et al., 2010). Taken together, differences in healthy food access driven by both the location of stores and the in-store products availability may create disparities in food environments with possible implications for health, which by favoring those living in richer areas, may ultimately contribute to the widening of health inequalities (Monteiro et al., 2007; Auchincloss et al., 2011).

Although evidence regarding in-store measures is less available for restaurants, our results corroborate previous findings in terms of the differences between fast food and full service restaurants (Saelens et al., 2007), as well as neighborhood differences in in-store content favoring more affluent areas (Lewis et al., 2005). Fast food restaurants located in higher SES neighborhoods scored higher than comparable types of outlets located in lower SES neighborhoods.

Bars and bakeries – typical Brazilian food away from home venues, found in most large and small cities of the country that serve both complete meals and sandwich/burger-based meals – were 45% of all restaurant-type establishments and scored lower than fast food restaurants. Therefore, focusing solely on full service and fast food restaurants when studying food environments in Brazil could be problematic to their fully understanding.

The study is subject to some limitations. Firstly, it was conducted within a single large metropolitan region and census tracts were used as proxies for the geographic area (or neighborhood) potentially relevant for food shopping. There is little information on which to base the definition of the spatial units relevant to food shopping (Cummins et al., 2007; Diez-Roux, 2007; Mathews, 2008). However, given that the purpose of the analyses was to describe patterns of food access associated with area socioeconomic status, the use of census tracts is informative, even if it may mis-specify the geographic area relevant for food shopping.

Another possible limitation is the non-probabilistic sampling. The rationale behind our sampling option relied in the segregated distribution of wealth in the city: the centrally located neighborhoods have higher levels of income and education, whereas neighborhoods located in the peripheral areas of the city offer inferior living conditions to their residents (PMSP, 2007). We also considered the unequal distribution of supermarkets, grocery stores, and chain fast food stores in Sao Paulo (Jaime et al., 2011). Although selection bias cannot be ruled out, similar findings to those previously reported in various contexts build confidence in our findings. Thirdly, we used 2000 Brazilian Census education data as an area socioeconomic status variable. This could have introduced misclassification if area SES changed over time.

Strengths of our study include: a systematic and detailed assessment of the in-store content, a diversity of food stores studied, and its location – the understudied context of a large Latin American urban agglomeration. Though our assessment was labor and time intensive, we included fewer questions than previous tools (Glanz et al., 2007; Saelens et al., 2007), and yet our tools were feasible and discriminated across store types and neighborhoods. We, thus, encourage further applications of our tools in other Brazilian and Latin American cities to have their feasibility tested in various settings.

In conclusion, we found differences in the availability of food stores and restaurants across neighborhoods of diverse education levels in the city of Sao Paulo and generally greater availability of healthy foods in higher SES areas. These findings suggest that spatially patterned differences in food access may contribute to health inequalities.

Lower availability of healthy foods in poorer neighborhoods could be due to low demand and an inverse causality cannot be ruled out (Cummins & Macintyre, 2006). Nonetheless, supply-side interventions linked to food availability and affordability (Auchincloss et al., 2011; Weatherspoon et al., 2013), as well as demand-side communications designed to increase consumption of healthy foods appear to be effective (Dumanovsky et al., 2011, Gittelsohn et al., 2012; Dannefer et al., 2012) and should be further tested in various contexts. Zoning and fiscal policies are also relevant strategies to influence the location of stores and healthy foods purchasing (Powell & Chaloupka, 2009; Chen & Florax, 2010; Thow et al., 2010; Claro et al., 2012). Considering the many different factors that influence urban food environments, multiple tactics involving input from governmental, academic, and community groups will be required for interventions to be successful.

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Appendix

Appendix 1

Scoring system for the Healthy Retail Food Store Index (HFSI).

Variable	Score
Fresh fruits and vegetable availability	0 points if not available; 1 point if available
Fresh fruits and vegetable located near the entrance of the store	0 points if not located near the entrance of the store; 1 point if located
Different types of fruits	0 points if not available; 1 point if 1–7 types of the 10 most purchased fruits are available; 2 points if 8–10 of the 10 most purchased fruits are available
Fruits variety	0 points if not even 1 fruit variety is available; 1 point if up to 14 varieties are available; 2 points if 15 or more varieties are available
Different types of vegetables	0 points if not available; 1 point if 1–7 types of the 10 most purchased vegetables are available; 2 points if 8–10 of the 10 most purchased vegetables are available
Vegetables variety	0 points if not even 1 vegetable variety is available; 1 point if up to 14 varieties are available; 2 points if 15 or more varieties are available
Fruits and vegetable signage/promotion	0 points if not available; 1 point if available

Variable	Score
Soft drinks availability	0 points if available; 1 point if not available
Sugar-sweetened nectar/juice availability	0 points if available; 1 point if not available
Chocolate filled cookies availability	0 points if available; 1 point if not available
Corn chips availability	0 points if available; 1 point if not available
Highly processed foods signage/advertising	0 points if available; 1 point if not available

Appendix

Appendix 2

Scoring system for the Healthy Meal - Restaurant Index (HMRI)

Variable	Score
Salad bar availability	0 points if not available; 1 point if available
Fresh fruits availability	0 points if not available; 1 point if available
Fresh fruit juices availability	0 points if not available; 1 point if available
Fruits and vegetable signage/promotion	0 points if not available; 1 point if available
Highly processed foods signage/advertising	0 points if available; 1 point if not available
All-you-can-eat buffet only	0 points if available; 1 point if not available
Nutrition facts available in the menu	0 points if not available; 1 point if available
Nutrition facts available in other store locations	0 points if not available; 1 point if available

Highlights

- Access to healthy foods has been poorly measured in low and middle-countries.
- We examined associations between in-store measures and neighborhood characteristics.
- Store type and neighborhood characteristics were associated with in-store food measures.
- More fast food restaurants were found at neighborhoods with lower education level.
- Grocery stores located at poorer neighborhoods carried fewer healthy foods.

Figure 1.

Census tracts sampling.

* An Extra district was selected in this stratum (high SES-high food environment) in order to offset potential data loss.

Table 1Characteristics of the census tracts ^{*}.

Number of census tracts	52
Total area (km ²)	5.09
Mean (Standard deviation-SD) area (km ²)	0.09 (0.15)
Mean (SD) population density (residents/km ²)	14,331 (13,221)
Mean (SD) total population	602.94 (506.50)
Mean (SD) number of residents per household	3.22 (0.50)
Mean (SD) years of education of adults over 25 years of age	9.17 (2.67)
Mean (SD) monthly household income [#]	R\$ 4,500 (R\$ 2,847)
Restaurants	
Mean (SD) number/census tract	9.08 (8.53)
Mean (SD) density (per 10,000 inhab)	170.85 (173.05)
Mean (SD) density (per km ²)	212.34 (272.61)
Types of restaurants (%)	
Full service restaurants	24.15
Fast food restaurants	30.30
Bars	32.84
Bakeries and coffee shops	12.71
Retail food stores	
Mean (SD) number/census tract	6.02 (5.27)
Mean (SD) density (per 10,000 inhab)	104.01 (88.31)
Mean (SD) density (per km ²)	153.35 (271.28)
Types of stores (%)	
Supermarkets	2.87
Local grocery stores	80.83
Fruits and vegetable markets	4.79
Delis and convenience stores	11.50

^{*} Data from 2010 Brazilian Census, except for mean years of education (2000 Brazilian Census).

[#] As of Jan 2011, R\$ 1.70 = US\$ 1.00

Table 2

Distribution (%) of type of stores in a neighborhood and mean (SD) of HMRI and HFSI scores Indexes by neighborhood characteristics and store type.

	Census tract education level								p-value (ANOVA)
	Total		Lower		Medium		High		
	%	mean(SD)	%	mean(SD)	%	mean(SD)	%	mean(SD)	
HFSI		(n=313)		(n=102)		(n=109)		(n=102)	
Fruits and vegetable markets	2.9	13.13 (2.69)	2.9	11.00 (3.61)	7.3	13.88 (1.64)	3.9	13.25 (3.59)	0.128
Supermarkets	4.8	10.33 (2.87)	2.0	8.50 (3.54)	3.7	9.25 (2.50)	2.9	13.00 (1.00)	0.308
Local grocery stores	80.8	3.07 (2.50)	94.1	2.57 (1.92)	81.7	3.04 (2.64)	66.7	3.81 (2.87)	0.007
Delis and convenience stores	11.5	2.53 (1.46)	1.0	4.00 -	7.3	2.38 (1.41)	26.5	2.52 (1.50)	0.590
Total	100.0	3.70 (3.44)	100.0	2.95 (2.55)	100.0	4.02 (3.92)	100.0	4.11 (3.58)	0.027
HMRI		(n=472)		(n=158)		(n=154)		(n=160)	
Full service restaurants	24.2	3.34 (1.05)	13.3	3.33 (1.15)	26.0	3.28 (1.04)	33.1	3.40 (1.02)	0.859
Fast food restaurants	30.3	2.63 (0.87)	37.3	2.39 (0.69)	24.7	2.82 (1.06)	28.8	2.78 (0.84)	0.021
Bakeries and coffee shops	12.7	2.58 (0.81)	7.6	2.67 (0.65)	14.3	2.36 (0.73)	16.3	2.73 (0.92)	0.275
Bars	32.8	2.23 (0.73)	41.8	2.14 (0.80)	35.1	2.20 (0.63)	21.9	2.43 (0.70)	0.151
Total	100.0	2.66 (0.96)	100.0	2.43 (0.89)	100.0	2.66 (0.97)	100.0	2.90 (0.96)	<0.001

Abbreviations: SD=Standard deviation; HMRI=Healthy Restaurant Index; HFSI=Healthy Food Store Index

Table 3

Adjusted mean differences in HFSI scores by store type and neighborhood characteristics.

	Model 1				Model 2				Model 3				Model 4			
	β	SE	CI 95%	β	SE	CI 95%	β	SE	CI 95%	β	SE	CI 95%	β	SE	CI 95%	
Type of store																
Fruits and vegetable markets	ref			ref			ref			ref			ref			
Supermarkets	-2.69	0.98	(-4.62; -0.77)**	-2.73	0.98	(-4.65; -0.81)**	-2.71	0.98	(-4.63; -0.79)**	-2.65	0.98	(-4.57; -0.73)**	-2.65	0.98	(-4.57; -0.73)**	
Local grocery stores	-9.76	0.62	(-10.98; -8.54)*	-9.73	0.62	(-10.95; -8.50)*	-9.77	0.62	(-10.99; -8.55)*	-9.71	0.62	(-10.93; -8.49)*	-9.71	0.62	(-10.93; -8.49)*	
Delis and convenience stores	-10.70	0.73	(-12.13; -9.26)*	-10.89	0.74	(-12.33; -9.45)*	-10.84	0.74	(-12.28; -9.40)*	-10.87	0.74	(-12.32; -9.43)*	-10.87	0.74	(-12.32; -9.43)*	
Local CT Education tertiles																
Lower				ref						ref						
Middle				0.80	0.51	(-0.20; 1.81)				1.02	0.49	(0.05; 1.98)**				
High				1.26	0.51	(0.26; 2.26)**				1.72	0.65	(0.44; 3.0)**				
Neighboring CT Education tertiles																
Lower							ref						ref			
Middle							-0.95	0.51	(-1.96; 0.06)	-1.14	0.47	(-2.06; -0.22)	-0.93	0.60	(-2.10; 0.25)	
High							0.06	0.48	(-0.88; 1.00)	-0.93	0.60	(-2.10; 0.25)	-0.93	0.60	(-2.10; 0.25)	
ICC		0.30			0.28				0.29						0.25	

* p<0.001;

** p<0.05

Abbreviations: SE=Standard error ; CI=confidence intervals; CT=census tract; ICC=Intraclass Correlation Coefficient; HMRI=Healthy Restaurant Index; HFSI=Healthy Food Store Index

Table 4
Adjusted mean differences in HMRI scores by store type and neighborhood characteristics.

	Model 1				Model 2				Model 3				Model 4			
	β	SE	CI 95%	β	SE	CI 95%	β	SE	CI 95%	β	SE	CI 95%	β	SE	CI 95%	
Type of store																
Full service restaurants	ref			ref			ref			ref			ref			
Fast food restaurants	-0.70	0.11	0.91 ; -0.48)	-0.68	0.11	(-0.89 ; -0.46) *	-0.68	0.11	(-0.89 ; -0.47) *	-0.71	0.11	(-0.92 ; -0.50) *	-0.71	0.11	(-0.92 ; -0.50) *	
Bakeries and coffee shops	-0.76	0.13	1.02 ; -0.48	-0.75	0.14	(-1.01 ; -0.48) *	-0.75	0.13	(-1.01 ; -0.48) *	-0.76	0.13	(-1.02 ; -0.50) *	-0.76	0.13	(-1.02 ; -0.50) *	
Bars	-1.10	0.11	1.31 ; -0.89	-1.07	0.11	(-1.28 ; -0.85) *	-1.06	0.11	(-1.27 ; -0.85) *	-1.08	0.11	(-1.29 ; -0.87) *	-1.08	0.11	(-1.29 ; -0.87) *	
Local CT Education tertiles																
Lower				ref						ref						
Middle				0.07	0.14	(-0.20 ; 0.34)				-0.12	0.13	(-0.38 ; 0.13)	-0.12	0.13	(-0.38 ; 0.13)	
High				0.31	0.14	(0.03 ; 0.58) **				-0.55	0.28	(-1.10 ; -0.01)	-0.55	0.28	(-1.10 ; -0.01)	
Neighboring CT Education tertiles																
Lower							ref			ref			ref			
Middle							0.27	0.13	(0.02 ; 0.52) **	0.32	0.13	(0.06 ; 0.57) **	0.32	0.13	(0.06 ; 0.57) **	
High							0.47	0.12	(0.24 ; 0.69) *	0.92	0.26	(0.42 ; 1.39) *	0.92	0.26	(0.42 ; 1.39) *	
ICC		0.24			0.23				0.19			0.18				

* p<0.001;

** p<0.05

Abbreviations: SE=Standard error ; CI=confidence intervals; CT=census tract; ICC=Intraclass Correlation Coefficient; HMRI=Healthy Restaurant Index; HFSI=Healthy Food Store Index