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Local food environment and fruit and vegetable consumption: An ecological study

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ABSTRACT

Ecological studies are essential for understanding the environment-diet relationship. The purpose of this study was to describe environmental conditions and their relationship with fruit and vegetable (FV) consumption among Brazilian public health service users in the city of Belo Horizonte. We evaluated food stores contained within 1600 m buffer zones at 18 Health Academy Programme sites, from 2013 to 2014. Variables at the community (density, proximity and type) and the consumer (sectional location of FV; availability, quality, variety, price and advertising of FV and ultra-processed foods) nutrition environment were measured by direct observation, while aggregate data from users (income and FV consumption) were obtained by interview. Data were analysed using the Kernel intensity estimator, average nearest neighbour value and Local Moran's Index for local spatial autocorrelation. We interviewed 3414 users and analysed 336 food stores. Major geographical variations in the FV consumption were identified. Average consumption was higher (site 2A: 410.5 ± 185.7 g vs. site 4B: 311.2 ± 159.9 g) in neighbourhoods with higher income and concentration of food stores, and better index of access to healthy foods. Sites with poor FV consumption had the most stores with poor access to healthy foods (index in the first tertile, ≤10). In conclusion, negative characteristics of the food environment, as seen in the present study, may contribute to low FV consumption, suggesting the need for the development and consolidation of public policies aimed at creating healthy environments through built environment interventions that increase access to and consumption of healthy foods like FV.

1. Introduction

Fruit and vegetables (FV) are considered an important proxy for healthy eating and determinant of health. A diet low in fruit was found to be the most important dietary contributor to mortality and lost years of healthy life, and a diet low in vegetables the forth contributor (Forouzanfar et al., 2015). Despite its importance to health, FV consumption worldwide is still far below the recommended levels. Brazil is in line with this global panorama, where just 24.1% of population present an adequate intake (BRASIL, 2015).

Evidence about the relationship between environmental conditions and food consumption is increasing. Ecological models and literature suggest that the driving force for the increasing prevalence of poor eating habits is an obesogenic environment, rather than metabolic defects or genetic mutations in individuals (Pessoa et al., 2015; Hawkes et al., 2015).

The built environment can influence on opportunities or barriers to healthy behaviour, such as FV consumption (Kirkpatrick et al., 2014; Ni Mhurchu et al., 2013; Caspi et al., 2012). Food environment characteristics that can favour FV consumption opportunities include type, location and geographic access to food stores as well as the quality, price and diversity of products (Caspi et al., 2012; Robinson et al., 2013; Duran et al., 2015a). Income inequalities are also a major factor in explaining food disparity, determining differences in food availability, access and consumption. Several studies have shown that individuals with favorable socioeconomic status enjoyed in their neighbourhoods higher access of healthy foods as FV (Duran et al., 2015a; Story et al., 2008; Duran et al., 2015b; Lee et al., 2013).

Despite the growing use of the ecological approach for understanding food consumption, a review revealed that most of the investigations (88.9%) explore the relationship of FV consumption with only one or two environmental measurements (Richard et al., 2011). However, food intake is a highly complex phenomenon resulting from the interaction between multiple influences in different contexts, which require a broad understanding on how individuals are embedded in their environments (Story et al., 2008).

Abbreviations: FV, Fruit and vegetables; HAP, Health Academy Programme; HFSI, Healthy Food Store Index.

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Other studies that consider different aspects of the environment and their relationship with behaviour are necessary. Therefore, this study aimed to conduct a descriptive analysis of the characteristics of the food environment and their relationship with FV consumption among the users of Brazilian public health care services, i.e. the Health Academy Programme (HAP).

The HAP was selected as the research setting because it is a key part of the Brazilian Primary Health Care System, which aims to overcome structural barriers to practice physical activity and to adopt healthy habits, especially among vulnerable populations. The program operates according to the health promotion concept, encouraging community participation in dealing with the social determinants of health and the construction of a healthy environment (BRASIL, 2013).

2. Methods

2.1. Study design and the Health Academy Programme

This is an ecological epidemiological study about built environment and its relation to FV consumption in the neighbourhoods of HAP centres in Belo Horizonte. The city is divided into nine administrative regions and is the sixth most populous in Brazil, with a population of 2,375,15. It has an uneven distribution of wealth with a Gini index of 0.611 (BRASIL, 2011). The Gini index is an economic metric used to assess the distribution of income among nation's residents: an index of 0 represents perfect equality, while an index of 1 implies perfect inequality.

The HAP are public spaces constructed for the promotion of healthy living by offering opportunities for regular physical exercise classes, healthy eating and community education activities at no cost (BRASIL, 2013). Group-education activities regarding nutrition can be provided by professionals of Primary Care. The centres are spaces with infrastructure, equipment and human resources, which are located primarily in vulnerable areas.

The profile of HAP users reveals important vulnerabilities, mostly in women with low education and income, who present with relevant dietary inadequacies (such as low consumption of FV, and high consumption of sweets, sugar-sweetened beverages, sausages and processed meats) and high prevalence of overweight and other chronic diseases (Mendonça et al., 2015). Investigations that described how similar or different HAP users were from non-HAP users have identified that those exposed to HAP were more active (Reis et al., 2010). Meanwhile, non-HAP users had a higher proportion of self-rated health as fair or poor. Among HAP users, 98.9% reported that the program achieves its goals; 73% and 23% reported high and medium satisfaction with the program, respectively (Hallal et al., 2010).

2.2. Study sample

The study selected a representative sample of the HAP units. 42 centres were found to be eligible out of the 50 HAP centres operating at the time of study. Eighteen centres were selected for the study via simple conglomerate sampling stratified by the nine administrative regions of the city. These centres were representative of the HAP units with 95% confidence and <1.4% error based on an estimation of the population proportion (Costa et al., 2015).

To define the neighbourhood of HAP centres, we used their geographical position and created buffers with 1 mile (1600 m) around each centre (Robinson et al., 2013; Laska et al., 2010; Hattori et al., 2013). All commercial FV food stores contained within these buffer zones were included in the study (Costa et al., 2015).

All HAP centre users aged 20 years or older were interviewed. Out of a total of 3763 individuals listed as users, 3414 individuals participated in this study (refusals = 6.3%, exclusions = 3.0%). All participants interviewed in the present study provided written informed consent. The study was conducted according to the guidelines laid down in the Declaration of Helsinki and was approved by the Ethics Research Committee of the University and City Hall.

2.3. Data collection

Data were obtained using two procedures: face-to-face interviews with HAP users; and direct observation of the food environment, which consisted of FV food store audits.

Data used through face-to-face interviews included gender, age, education level, monthly income per capita, home addresses and FV consumption. Those measures were aggregated in order to describe HAP participants.

Daily FV consumption was investigated via questions adapted from International Surveillance Systems (CDC, 2013; WHO, 2016). These questions addressed the frequency and quantity of FV consumption as well as the FV preparation method. In order to analyse consumption, the frequency of intake was calculated as daily consumption. We quantified intake in grams considering 80 g as the standard portion size (FAO/WHO, 2004). Consumption adequacy was evaluated considering the World Health Organization recommendation of at least 400 g FV intake per day (FAO/WHO, 2004).

The following food stores were included: establishments registered in geo-referenced databases of the Municipal Joint Taxation Secretariat, open-air food markets listed at the municipality City Hall site, and stores not registered in public databases but identified on site by field staff. The stores not registered in the list provided included informal stores, with recent activity or under implementation, between others. Such findings suggest the need for changes in data monitoring and updating, by encouraging regularization of commercial stores with the Municipal Government (Costa et al., 2015).

Data collected for the community nutrition environment (or macro-level) included location, proximity, density and type of commercial food store. Consumer nutrition environment variables (or micro-level) were assessed using the Food Store Observation Tool (ESAO-S). This instrument is a reliable tool adapted to the Brazilian context from several measures as the Nutrition Environment Measures Survey in Stores (NEMS-S) (Duran et al., 2015b). Besides ESAO-S components, analysis of consumer nutrition environment included investigation of price and quality of food (Costa et al., 2015; Duran et al., 2015b).

Based on the ESAO-S instrument, the healthy food store index (HFSI) provided summarized information on better quality of food stores at the micro-level, allowing an easier comparison between areas using a single food environment score. HFSI ranged from 1 to 16 and included variables concerning the availability, variety and advertising of FV and ultra-processed products. An HFSI higher value indicated better access to healthy food and lower access to ultra-processed products.

The instrument assessed the 10 most frequently purchased fruits (banana, orange, papaya, watermelon, apple, mango, pineapple, tangerine, grape and melon) and vegetables (pumpkin, chayote, tomato, carrot, lettuce, zucchini, cabbage, beetroot, kale and okra) in the municipality in addition to the five most frequently consumed ultra-processed products in Brazil, including sugar-sweetened beverages (soda and juices), cookies and salty snacks (The Brazilian Institute of Geography and Statistics (IBGE), 2010).

The food store audit also included the following measures: The location of the FV section was investigated by its close presence at the store's main entrance. The availability was evaluated by the presence of at least one unit of each purchasable item. In order to assess variety, we determined the number of different types within each item, e.g., Iceberg lettuce, Green-leaf lettuce, Red-leaf lettuce. The average price of analysed foods was expressed per kg for FV and per unit for ultra-processed food. The FV quality was rated as acceptable or unacceptable depending on whether most of the food was withered, bruised, overripe or old looking. Advertising was analysed by checking signs or advertisements in the stores that encouraged the purchase of FV or ultra-processed

foods, such as signs with nutrition information, tasting counters, giveaways, etc (Duran et al., 2015b).

2.4. Statistical analyses

In descriptive analysis continuous variables are presented as mean and standard deviation for normally distributed variables, and as median and interquartile range (P25–P75) for not normally distributed variables.

Data of FV consumption and income were aggregated and prevalence was estimated for each neighbourhood with HAP centres. Thematic maps were used to provide events' spatial visualisation through ArcView software.

Proximity of users' homes to food stores was calculated using the *Near* command from ArcView, which determines the closest distance between two points.

The Kernel method was used to analyse the spatial distribution of food stores and to identify the possible existence of cluster areas. This estimator is an interpolator that enables estimation of event intensity in the study area. The bandwidth parameter, which defines the neighbourhood of the point to be interpolated and controls the continuous surface generated, was set at 1600 m, corresponding to the value of the radius (Camara and Carvalho, n.d.).

The Local Moran's Index (LISA) was used to estimate local spatial autocorrelation for FV consumption in HAP areas. It allows comparison between each area and its neighbours using a standard indicator, which is the difference between the global average and the area value divided by the standard deviation. Thus, it identifies areas with local spatial correlation significantly different from that for the rest of the data (BRASIL, 2007).

3. Results

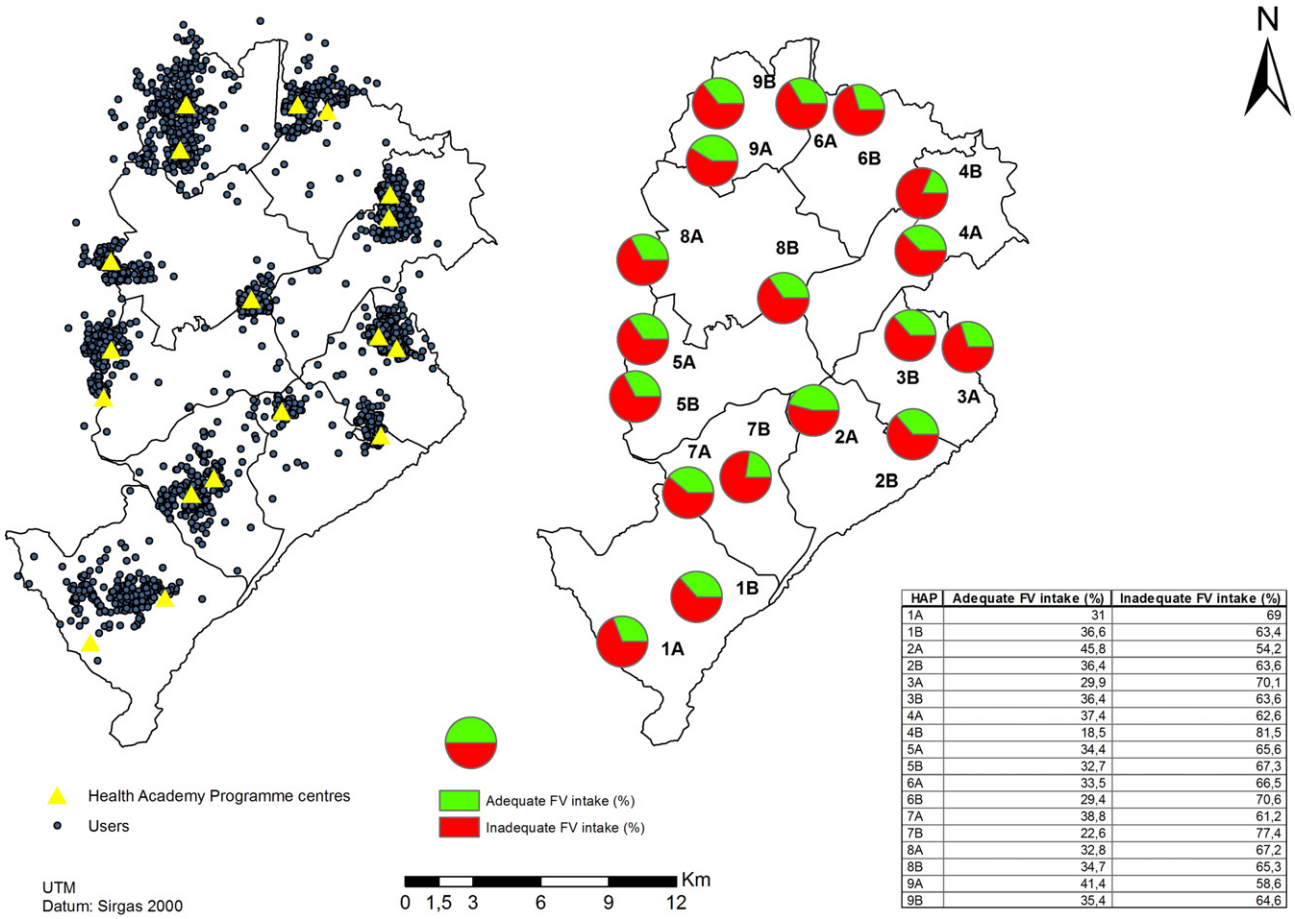
We interviewed 3414 users in 18 centres, with about 104 to 294 participants in each centre. Most users (88.1%) were female and the average age was 56.7 ± 11.8 years. Most users had a low educational level (7.2 ± 4.1 years) and monthly income per capita [$ 301.3 (P25–P75:188.4-444.4)].

The average of FV intake ranged from 311.2 ± 159.9 g to 410.5 ± 185.7 g in the centres, with an overall average of 369.5 ± 180.5 g (Table 1) and adequacy (≥400 g) of 34.2%.

Table 1
Food environment characteristics of Health Academy Programme centres, Belo Horizonte, Brazil, 2013.

Region	HAP	FV intake (g)	Income ($)[a]	Food store density[b]	Food store proximity (m)	Food store type % (n)		
						Super-market	Specialised FV market or Open-air food market	Local/small market
1	A	353.3 ± 208.2	241.3 (160.9–355.6)	1.2	1290.9 (1104.1–1439.1)	20.0 (2)	50.0 (5)	30.0 (3)
	B	400.2 ± 213.9	333.3 (222.2–444.4)	1.2	344.5 (220.7–551.0)	10.0 (1)	70.0 (7)	20.0 (2)
2	A	410.5 ± 185.7	580.3 (191.1–400.0)	6.0	186.8 (109.6–301.8)	21.3 (10)	72.3 (34)	6.4 (3)
	B	387.0 ± 188.7	277.8 (60.3–2222.2)	1.5	319.1 (179.4–544.2)	0.0	75.0 (9)	25.0 (3)
3	A	333.2 ± 162.6	355.6 (245.1–614.9)	4.1	188.7 (115.5–274.6)	21.2 (7)	63.6 (21)	15.2 (5)
	B	373.9 ± 181.9	333.3 (222.2–494.4)	3.9	204.5 (149.1–313.5)	25.8 (8)	61.3 (19)	12.9 (4)
4	A	358.8 ± 143.1	277.8 (155.6–444.4)	2.1	300.5 (210.9–497.3)	17.6 (3)	52.9 (9)	29.4 (5)
	B	311.2 ± 159.9	248.8 (155.0–352.6)	2.0	292.5 (192.5–412.4)	12.5 (2)	50.0 (8)	37.5 (6)
5	A	373.3 ± 168.6	323.9 (222.2–516.7)	2.2	598.4 (375.0-749.3)	33.3 (6)	61.1 (11)	5.6 (1)
	B	381.7 ± 227.2	301.3 (177.8–405.6)	1.2	479.5 (327.4–588.8)	20.0 (2)	60.0 (6)	20.0 (2)
6	A	376.1 ± 175.5	301.3 (200.9–444.4)	1.4	330.5 (174.6–536.5)	18.2 (2)	36.4 (4)	45.5 (5)
	B	349.3 ± 164.5	226.0 (150.7–355.6)	1.1	1153.2 (863.0–1668.8)	11.1 (1)	44.4 (4)	44.4 (4)
7	A	402.4 ± 185.6	400.9 (290.5–622.2)	2.1	443.2 (300.5–594.3)	23.5 (4)	76.5 (13)	0.0 (0)
	B	332.3 ± 177.6	222.2 (148.9–303.8)	2.7	221.0 (153.0–367.9)	36.4 (8)	50.0 (11)	13.6 (3)
8	A	360.5 ± 166.3	237.0 (150.7–355.6)	1.2	605.34 (325.5–912.2)	20.0 (2)	70.0 (7)	10.0 (1)
	B	373.0 ± 195.3	397.8 (222.2–596.7)	1.9	230.9 (170.1–467.8)	35.7 (5)	35.7 (5)	28.6 (4)
9	A	384.6 ± 156.0	321.8 (200.0–444.4)	3.9	282.9 (175.0–408.9)	12.9 (4)	74.2 (23)	12.9 (4)
	B	370.9 ± 179.2	311.1 (192.7–444.4)	2.0	515.7 (293.9–816.7)	12.5 (2)	62.5 (10)	25.0 (4)
Total	18	369.5 ± 180.5	301.3 (188.4–444.4)	2.3	388.8 (218.1–680.8)	20.7 (69)	61.7 (206)	17.6 (59)

Notes: Symmetric variables are described as mean ± standard deviation; asymmetric data are represented as median values (P25–P75). For ethical reasons, HAP A and HAP B are fictitious names given to the two centres of each region of the city. FV — fruit and vegetables. Income[a] — Brazilian Real to Dollar ($): 2.25 was the average exchange rate during the data collection period. Food stores density (units/km^2)[b]: number of stores/area.



HAP	Adequate FV intake (%)	Inadequate FV intake (%)
1A	31	69
1B	36,6	63,4
2A	45,8	54,2
2B	36,4	63,6
3A	29,9	70,1
3B	36,4	63,6
4A	37,4	62,6
4B	18,5	81,5
5A	34,4	65,6
5B	32,7	67,3
6A	33,5	66,5
6B	29,4	70,6
7A	38,8	61,2
7B	22,6	77,4
8A	32,8	67,2
8B	34,7	65,3
9A	41,4	58,6
9B	35,4	64,6

Fig. 1. Distribution of Health Academy Programme centres and their fruit and vegetable consumption. Note: FV — fruit and vegetables. Belo Horizonte, Brazil, 2013.

Fig. 1 shows the geographic distribution of HAP centres and users as well as spatial variation of the adequacy of FV consumption. While centre 2A showed 45.8% of adequacy, centre 4B had only 18.5% of adequacy.

We worked with a total of 336 establishments. Users resided on average 388 m (218.1-680.8 m) from at least one FV food store. The most common establishments in the study were specialised FV markets and open-air food markets (61.7%) (Table 1).

Among food stores audited, 78% ($n = 262$) contained their FV section near the main entrance, and only 22% ($n = 74$) had advertising encouraging FV purchase. The quality of fruits was better and the price was lower compared to vegetables. The average number of items available for purchase was 15.9 for fruits and 11.6 for vegetables (Table 2).

The HFSI median was 11 with values ranging from 5 to 16 between centres (Table 2). Only 35% ($n = 120$) of establishments had a higher index score (higher tertile: ≥13.1 scores). Fig. 2 shows the positive linear relationship between FV consumption and HFSI, as well as between the FV consumption and median income.

The three centres with the lowest FV intake (areas 3A, 4B and 7B) had the most food stores with poor access to healthy foods (HFSI in the first tertile, ≤10). Conversely, the three centres with higher FV consumption (1B, 2A and 7A) revealed the existence of a spatial cluster area of food stores, which was identified by the Kernel intensity estimator, and food stores with better access to healthy food (HFSI ≥ 13.1) (Costa et al., 2015).

The Local Moran's Index identified spatial autocorrelation of FV consumption between the centres of regional 7 ($p = 0.01$). The correlation was of *high-low* type, which reveals an area with high value of FV consumption (7A) surrounded by neighbours with low FV consumption (7B).

Table 3 shows consumer nutrition environment characteristics related to ultra-processed products, which are considered to be markers of unhealthy diet.

The majority (58.3%) of stores sold at least one kind of ultra-processed food and 31% ($n = 104$) had all five of the ultra-processed products investigated. The number of different brands and flavours ranged from 1 to 69 with a median of 4. The average price of the ultra-processed products assessed was $ 0.82 per unit and in 23% of stores existed advertising encouraging their purchase.

4. Discussion

This ecological study revealed that HAP neighbourhoods have limited access to healthy food according to the consumer nutrition environment assessment by HFSI, which may possibly have reflected in lower FV consumption among aggregate users. However, there were significant geographic variations. FV intake was higher in areas with higher income and better quality of food stores at the micro-level. Geographic distribution of food stores was also important, with higher consumption in areas with clustering patterns of stores, i.e., areas with higher concentration of stores.

Exploratory analyses of built environment characteristics and FV consumption in individuals revealed three scenarios. As a first main finding explored, region 2A presented best results for FV consumption as well as the following characteristics: central location in the city, highest median income, higher density and areas with concentration of food stores, greater proximity between stores and users' residence, predominance of specialized FV or open-air food markets, great variety and quality of FV, and better index access to healthy foods according to

Table 2
Consumer nutrition environment characteristics of Health Academy Programme centres, Belo Horizonte, Brazil, 2013.

			Fruit			Vegetable					
Region	HAP	FV intake (g)	Variety	Average price ($)[a]	Quality (%)	Variety	Average price ($)[a]	Quality (%)	FV section near to entrance % (n)	FV Advertising % (n)	HFSI
1	A	353.3 ± 208.2	15.8 ± 6.8	0.76 ± 0.11	97.5 ± 7.9	10.4 ± 3.3	1.00 ± 0.30	90.8 ± 21.7	70.0 (7)	20.0 (2)	10 (5–15)
	B	400.2 ± 213.9	18.8 ± 5.4	0.73 ± 0.09	100.0 ± 0.0	12.2 ± 3.1	1.20 ± 0.29	97.5 ± 7.9	80.0 (8)	30.0 (3)	13 (6–15)
2	A	410.5 ± 185.7	19.1 ± 10.2	0.99 ± 0.32	98.3 ± 8.4	13.3 ± 7.6	1.03 ± 0.47	96.7 ± 11.9	89.6 (43)	20.8 (10)	11 (6–16)
	B	387.0 ± 188.	16.7 ± 6.4	0.94 ± 0.24	91.7 ± 19.5	11.9 ± 3.8	1.04 ± 0.24	94.4 ± 19.3	75.0 (9)	16.7 (2)	11 (5–14)
3	A	333.2 ± 162.6	14.9 ± 6.0	0.88 ± 0.18	84.1 ± 22.1	11.1 ± 3.2	1.36 ± 0.23	78.3 ± 22.6	75.8 (25)	18.2 (6)	11 (6–16)
	B	373.9 ± 181.9	15.3 ± 6.0	0.88 ± 0.18	83.3 ± 24.4	11.3 ± 3.3	1.38 ± 0.23	75.3 ± 26.1	77.4 (24)	19.4 (6)	11 (6–16)
4	A	358.8 ± 143.1	14.1 ± 5.0	0.70 ± 0.15	84.8 ± 15.9	10.8 ± 2.6	0.94 ± 0.20	77.4 ± 21.6	64.7 (11)	23.5 (4)	9 (6–15)
	B	311.2 ± 159.9	11.8 ± 6.5	0.77 ± 0.20	83.8 ± 19.4	9.9 ± 3.0	1.02 ± 0.21	80.7 ± 19.7	68.8 (11)	25.0 (4)	9 (6–14)
5	A	373.3 ± 168.6	17.6 ± 5.4	0.78 ± 0.09	88.0 ± 20.5	12.0 ± 4.5	0.99 ± 0.32	85.6 ± 20.0	83.3 (15)	16.7 (3)	11 (6–15)
	B	381.7 ± 227.2	13.7 ± 5.9	0.79 ± 0.09	79.2 ± 26.1	10.1 ± 4.1	1.12 ± 0.30	81.7 ± 12.9	80.0 (8)	20.0 (2)	11.5 (6–14)
6	A	376.1 ± 175.5	12.7 ± 4.3	0.79 ± 0.12	90.1 ± 17.8	9.2 ± 2.6	0.96 ± 0.36	84.1 ± 20.2	36.4 (4)	9.1 (1)	8 (5–13)
	B	349.3 ± 164.5	11.8 ± 3.7	0.77 ± 0.12	88.0 ± 19.2	8.6 ± 2.5	1.04 ± 0.34	88.9 ± 18.2	44.4 (4)	0.0 (0)	6 (5–13)
7	A	402.4 ± 185.6	17.8 ± 4.0	0.84 ± 0.20	89.7 ± 25.1	12.9 ± 2.2	1.08 ± 0.26	83.8 ± 27.9	94.1 (16)	23.5 (4)	13 (7–15)
	B	332.3 ± 177.6	16.4 ± 5.2	0.92 ± 0.21	92.8 ± 14.4	12.3 ± 3.2	1.12 ± 0.33	94.3 ± 10.7	77.3 (17)	18.2 (4)	10 (5–10)
8	A	360.5 ± 166.3	14.1 ± 4.9	0.73 ± 0.10	81.7 ± 17.5	12.3 ± 4.2	1.33 ± 0.41	80.0 ± 15.8	100.0 (10)	40.0 (4)	12 (6–15)
	B	373.0 ± 195.3	14.1 ± 6.7	0.92 ± 0.26	85.0 ± 23.6	11.2 ± 4.2	1.29 ± 0.40	72.2 ± 23.7	73.3 (11)	33.3 (5)	10 (6–14)
9	A	384.6 ± 156.0	17.4 ± 5.8	0.74 ± 0.21	99.2 ± 4.5	12.0 ± 3.9	1.17 ± 0.35	91.9 ± 20.8	80.6 (25)	29.0 (9)	12 (5–16)
	B	370.9 ± 179.2	15.4 ± 5.2	0.69 ± 0.15	94.8 ± 11.3	11.3 ± 3.6	1.06 ± 0.40	89.1 ± 20.3	87.5 (14)	31.3 (5)	11 (6–16)
Total	18	369.5 ± 180.5	15.9 ± 6.7	0.84 ± 0.22	90.2 ± 18.4	11.6 ± 4.4	1.14 ± 0.35	85.7 ± 21.0	78.0 (262)	22.0 (74)	11.0 (8–14)

Notes: Symmetric variables are described as mean ± standard deviation and asymmetric variables are represented as median (P25–P75). For ethical reasons, HAP A and HAP B are fictitious names given to the two centres of each region of the city. FV — fruit and vegetables. Price[a] — Brazilian Real to Dollar ($): 2.25, average exchange rate during the data collection period.

HFSI, including low access to ultra-processed products. Other studies also indicate that higher socio-economic areas have higher FV consumption, possibly by better access to healthy foods and lower exposure to unhealthy food (Duran et al., 2015a; Jaime et al., 2011; Matozinhos et al., 2015).

Despite these favourable conditions, average FV prices were not lower in this area compared to other areas, but were consistent with higher income. In this way, region 2A seems to have a better purchasing power. This result suggests the importance of simultaneously monitoring food prices and the population's affordability (Lee et al., 2013).

As a second main finding, FV consumption inequality was found in region 7, with diametrically opposed consumption averages. The area 7A had the second highest average FV consumption, while the centre 7B had the second worst average, possibly related to economic disparity, since centre 7A had a much higher average income. This finding also shows the importance of not restricting analysis to community nutrition environment indicators (Duran et al., 2015b). Although density and proximity of food stores are greater in centre 7B, consumer nutrition environment indicators show the quality of these stores are worse (lower HFSI indicating less access to healthy food and better access to ultra-processed products) (Cannuscio et al., 2014).

This possible relationship between increased access to ultra-processed products and lower FV consumption deserves to be explored and constitutes the third interesting finding explored. Like centre 7B, centre 4B had the lowest FV consumption, concomitant with the better availability and variety of ultra-processed products. This reinforces the observation that current dynamics of commercial establishments favour a shift from consumption of natural or minimally processed foods to ultra-processed food, leading to the deterioration of traditional cultures (Duran et al., 2015a; Gustafson et al., 2013).

The availability of ultra-processed products in this study was high considering that most stores were specialized FV markets/open-air food markets with specialized equipment for the distribution of horticultural products and higher HFSI values (12,6 ± 2,0) compared to supermarkets (8,0 ± 1,7) and local/small markets (7,8 ± 2,8) (Costa et al., 2015). However, centres with greater availability of ultra-processed products (6A, 6B and 8B) were the only neighbourhoods where specialized FV/open-air food markets were not predominant. Conversely, about 70% of the stores in the three centres with an adequate average FV consumption were classified as specialized FV/open-air food markets.

In the present study, specialized FV markets/open-air food markets were a proxy for access and consumption of healthy foods. This finding is in line with another Brazilian study that explored differences in HFSI by store type and verified the highest scores for FV markets (Duran et al., 2013). However, research in developed countries showed that

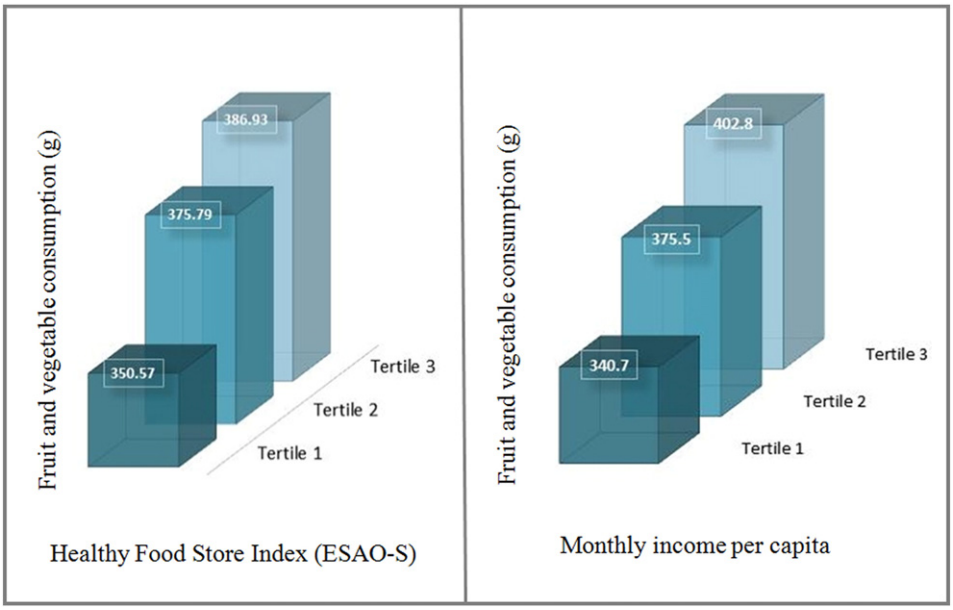


Fig. 2. Relationship between fruit and vegetable consumption, median income of users, and Healthy Food Store Index from Obesogenic Environment Study (ESAO)- Food Store Observation Tool. Note: ESAO-S, Food Store Observation Tool. Belo Horizonte, Brazil, 2013.

increased access to supermarkets was associated with healthy diets. Hence, conducting studies in different contexts is important, since dynamic trading and consumption probably differ significantly between countries, providing differentiated evidence and new possibilities for action (Robinson et al., 2013; Jaime et al., 2011). Additionally, it is important to consider that supermarkets offer healthy products as well as ultra-processed products. Thus, food choices will be influenced by different issues such as feeding behaviour, marketing, price, family and culture (Gustafson et al., 2011, 2013).

We observed that the average FV intake was adequate only in three neighbourhoods. Insufficient consumption of these foods is verified both at the international and national level, (BRASIL, 2015; Centers For Disease Control And Prevention (CDC), 2013) despite their recognized nutritional properties and beneficial health effects (Institute for Health Metrics and Evaluation (IHME), 2013).

Low FV intake observed in this study is consistent with the limited access to quality stores as measured by the consumer nutrition environment assessment. The median score found for the stores was similar with the findings of a study that used the same instrument in other Brazilian city, São Paulo, which showed a HFSI of 13.13 and 10.33 for specialized FV markets and supermarkets, respectively (Duran et al., 2013). Limited access to this sort of establishment may represent a barrier to healthy eating habits, particularly in socio-economically disadvantaged areas (Pessoa et al., 2015; Story et al., 2008; Duran et al., 2015b). Therefore, preliminary results suggest a relationship between a better food environment quality and increased FV consumption, which is consistent with the literature (Kirkpatrick et al., 2014; Ni Mhurchu et al., 2013; Caspi et al., 2012; Duran et al., 2015a).

Regarding the availability of markets that sell FV, it does not seem to be a problem in most of the areas investigated. Similar patterns have

Table 3
Access characteristics for ultra-processed products of Health Academy Programme centres, Belo Horizonte, Brazil, 2013.

Region	HAP	FV intake (g)	Availability	Variety of brands and flavours	Average price ($)[a]	Advertising % (n)
1	A	353.3 ± 208.2	4.0 (0.0–5.0)	15.0 (0.0-60.0)	0.80 ± 0.12	30.0 (3)
	B	400.2 ± 213.9	1.5 (0.0–5.0)	3.0 (0.0-58.0)	0.88 ± 0.27	10.0 (1)
2	A	410.5 ± 185.7	0.0 (0.0–5.0)	0.0 (0.0-69.0)	0.89 ± 0.28	14.6 (7)
	B	387.0 ± 188.	3.0 (0.0–5.0)	12.0 (0.0-49.0)	0.98 ± 0.12	33.3 (4)
3	A	333.2 ± 162.6	1.0 (0.0–5.0)	0.0 (0.0-62.0)	0.74 ± 0.16	9.1 (3)
	B	373.9 ± 181.9	1.0 (0.0–5.0)	2.0 (0.0-62.0)	0.73 ± 0.18	9.7 (3)
4	A	358.8 ± 143.1	3.0 (0.0–5.0)	15.0 (0.0-53.0)	0.76 ± 0.31	29.4 (5)
	B	311.2 ± 159.9	2.5 (0.0–5.0)	6.5 (0.0-48.0)	0.85 ± 0.32	18.8 (3)
5	A	373.3 ± 168.6	0.5 (0.0–5.0)	2.5 (0.0-57.0)	0.82 ± 0.14	22.2 (4)
	B	381.7 ± 227.2	0.0 (0.0–5.0)	0.0 (0.0-43.0)	0.68 ± 0.08	20.0 (2)
6	A	376.1 ± 175.5	5.0 (0.0–5.0)	23.0 (0.0-56.0)	0.78 ± 0.15	54.5 (6)
	B	349.3 ± 164.5	5.0 (0.0–5.0)	22.0 (0.0-48.0)	0.77 ± 0.17	55.6 (5)
7	A	402.4 ± 185.6	0.0 (0.0–5.0)	0.0 (0.0-65.0)	0.72 ± 0.06	29.4 (5)
	B	332.3 ± 177.6	3.0 (0.0–5.0)	12.0 (0.0-66.0)	0.85 ± 0.13	36.4 (8)
8	A	360.5 ± 166.3	0.0 (0.0–5.0)	0.0 (0.0-39.0)	0.68 ± 0.11	20.0 (2)
	B	373.0 ± 195.3	5.0 (0.0–5.0)	24.0 (0.0-63.0)	0.86 ± 0.24	40.0 (6)
9	A	384.6 ± 156.0	1.0 (0.0–5.0)	1.0 (0.0-59.0)	0.88 ± 0.22	22.6 (7)
	B	370.9 ± 179.2	1.0 (0.0–5.0)	3.0 (0.0-62.0)	1.01 ± 0.30	18.8 (3)
Total	18	369.5 ± 180.5	1.0 (0.0–5.0)	4.0 (0.0-69.0)	0.82 ± 0.21	22.9 (77)

Notes: Symmetric variables are described as mean ± standard deviation and asymmetric are represented as median (P25–P75). Ultra-processed products ($n = 5$): soda, sugar-sweetened nectars or juices, fruit-flavoured drink mixes, chocolate sandwich cookies and chips. For ethical reasons, HAP A and HAP B are fictitious names given to the two centres of each region of the city. FV — fruit and vegetables. Price[a] — Brazilian Real to Dollar ($): 2.25, average exchange rate during the data collection period.

also been observed in the few Brazilian studies found (Pessoa et al., 2015; Canella et al., 2015). However, this study identified geographic disparities among areas, especially in socio-economically disadvantaged areas, which demonstrates the need for food supply policies that promote better access, an increase in specialized FV market and open-air food market units (Pessoa et al., 2015; Hawkes et al., 2015; Duran et al., 2015a; Story et al., 2008; Jaime et al., 2011). Although the HAP is a key service for health promotion, nutritional interventions may have limited effect when sites have low structural access to high quality food stores (Hawkes et al., 2015). Thus, we encourage intersectoral collaboration, with integration of different public facilities and policies, for the effective promotion of healthy food environments in HAP areas.

Open-air food markets and public specialized FV markets (*Sacolões de Alimentos à Baixo Custo* — ABC) reflect public policies concerning the food and nutritional security of the city and are internationally recognized for bolstering the supply of healthy food at affordable prices. Twenty horticultural products on ABC must be sold at the maximum price of $0.44 per kg. The open-air food market operates in streets and squares and must sell proven handicraft products from agriculture or rural industry, such as fruit, vegetables, fish and eggs. The public monitoring regarding price, quality and products in those venues are essential to improve access and the direct purchase of food for the population, especially those in vulnerable situations.

Despite these innovative initiatives in the municipality, the implementation of these policies has some unfavourable characteristics such as the trading of ultra-processed products, and their higher concentration in the central city area. The open-air food market also showed unsatisfactory food variety and were mostly small markets with an average of only four tents (ranging from 2 to 9). We suggest, therefore, that public policies should prioritize better distribution of open-air food and specialized FV markets with implementation in more remote and poor areas, which will favour FV access, improve local economy and reduce inequalities of material and social resources (Duran et al., 2015a; Jaime et al., 2011). However, longitudinal and experimental studies should be conducted, especially in Latin America, allowing causal inferences to be drawn with confidence.

The study design limits our ability to draw any causal associations. Studies with different approaches are necessary and complementary in order to try to understand the complexity involved in the relation between food intake and environment. This ecological research will subsidise an upcoming study that will evaluate factors at different analysis levels, which can influence FV eating behaviour, thus contributing to greater understanding of differences between the areas and its population.

We believe the robust methodology presented in this study may help to address some gaps and inconsistencies presented by literature, such as lack of studies covering consumer nutrition environmental aspects (Pessoa et al., 2015; Duran et al., 2015b) and the use of primary data, which allow us to determine the real access and quality of food stores (Caspi et al., 2012). Additionally, this article reinforces the initially mentioned need to conduct more comprehensive assessments that are consistent with the interactive, real and complex food environment in which people live, and are not restricted to just one aspect of this environment.

Study limitations and strengths

- So far almost all evidence on the association between food environment and fruit and vegetable consumption has been drawn from studies conducted in U.S. and other developed countries.
- 3414 individuals were interviewed and the daily fruit and vegetable consumption was quantified.
- We use primary measurement of the food environment and 754 food stores registered in the municipal administration were visited by the researchers, which allow us to determine the real access to fruit and vegetable and the quality within food stores.
- Rather than just access macro-level of the food environment, strength of this study is to combine comprehensive consumer nutrition environment assessments that considered availability, price, quality, promotion and variety of foods.
- Limitations include a sample with low socio-economic variability and the use of a buffer to define the area to be investigated.
- The study design limits our ability to draw any causal associations.

5. Conclusion

In the Consumer nutrition environment, HAP neighbourhoods revealed limited access to shopping facilities with adequate quality, i.e. availability and variety of healthy foods, which in turn may be reflected in low FV consumption in HAP users. Geographical variations also revealed FV consumption proportional to concentration of income and food stores.

We suggest development of interventions in the built environment aimed at raising access and consumption of healthy foods as well as construction of public facilities such as open-air food and specialized FV markets in more remote and poor areas. We thereby strengthen the need for development and consolidation of effective public policies that are consistent with different socio-economic contexts, aimed at creating environments that promote healthy behaviour.

Conflicts of interest

None.

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