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Food environments in schools and in the immediate vicinity are associated with unhealthy food consumption among Brazilian adolescents

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ABSTRACT

Background. Evidence of the influence of the school food environment on adolescent diet is still little explored in low- and middle-income countries. We aimed to evaluate the association between food environment in schools and the immediate vicinity and the regular consumption of unhealthy food among adolescents.

Methods. We used cross-sectional data collected by the Brazilian National Survey of School Health (PeNSE) from a representative sample of adolescents attending 9th grade public and private schools in Brazil, in 2012. We estimated students' regular consumption (>5 days/week) of unhealthy food (soft drinks, bagged salty snacks, deep fried salty snacks and sweets) and school availability, in the cafeteria or an alternative outlet, of the same food plus some healthy options (fruit and natural fruit juice). We performed multilevel logistic regression models.

Results. Having a cafeteria inside school selling soft drinks (private schools OR = 1.23; 95% CI = 1.14–1.33; public schools OR = 1.13; 95% CI = 1.06–1.20) and deep fried salty snacks (private schools OR = 1.41 95% CI = 1.26–1.57; public schools OR = 1.16 95% CI = 1.08–1.24) was associated with a higher consumption of these unhealthy foods of among students. In private schools, cafeteria selling fruit and natural fruit juice was associated with lower student consumption of bagged salty snacks (OR = 0.86; 95% CI 0.77–0.96) and soft drinks (OR = 0.85; 95% CI = 0.76–0.94). In addition, eating meals from the Brazilian School Food Program in public schools was associated with a lower consumption of unhealthy foods.

Conclusions. Foods available in the school food environment are associated with the consumption of unhealthy food among adolescents in Brazil.

1. Introduction

Poor dietary intake patterns, such as higher consumption of ultra-processed food are a key factor in the obesity epidemic (Monteiro et al., 2013), especially during adolescence, a period of healthy habit formation (Birkhead et al., 2006). Adolescents spend a considerable part of their day at school and, in many countries, eat at least one meal a day there (Glanz, 2009; Story et al., 2008). Therefore, it is reasonable to expect that the school environment plays an important role in youth eating habits, through the food environment and/or nutritional education (O'Toole et al., 2007; Rovner et al., 2011).

However, the evidence concerning the influence of the school food environment and its surroundings on student's food purchases, consumption and body weight is not consistent (Williams et al., 2014). Effects have been found to vary even between studies of the same food type, and between different school grades (Vericker, 2013; Cullen and Zakeri, 2004; Kubik et al., 2003). Moreover, studies have mainly been

Abbreviations: BSFP, Brazilian School Food Program; ICC, intraclass correlation coefficient; PeNSE, National Survey of School Health; OR, odds ratio; 95% CI, 95% confidence interval; PCV, proportional change in variance; SES, socioeconomic status.

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conducted in high-income countries, such as US and Canada (Williams et al., 2014), and their findings cannot easily be generalized to low- to middle-income countries (LMICs), since income level, school organization, meal programs, and regulation of food outlets differ extensively between countries.

For instance, in Brazil there is a national program, the Brazilian School Food Program (BSFP), which offers good quality, free meals to all students in public schools (Brasil, 2009). Private schools are not covered by the BSFP and sources of food are often commercial venues (e.g. cafeterias and similar outlets). Even though they are not recommended by federal guidelines, these commercial venues (outsourced to a private supplier) are also found in public schools. Public and private schools may also have mobile vendors located inside or in their immediate vicinity outside the school grounds. We have used the term 'alternative food outlets' to describe these. Unhealthy snacks options and sugar-sweetened beverages are common in all school food outlets, despite federal guidelines which limit/prohibit their sale (Brasil, 2006).

To the best of our knowledge, there are no studies assessing the influence of the school food environment on adolescent food consumption in a nationally representative sample from LMICs. Therefore, this study aimed to assess the association between food environment in public and private schools and in the immediate surroundings and the regular consumption of unhealthy food among Brazilian adolescents.

2. Methods

We used cross-sectional data from the National Survey of School Health (Pesquisa Nacional de Saúde do Escolar — PeNSE), carried out in 2012, assessing students enrolled in 9th grade in public and private schools in Brazil (IBGE, 2013).

The sampling framework was based on the 2010 School Census Database. Stratified multi-stage sampling was used. In the first stage, a stratified random sample of counties was selected from each of the five geographical districts of Brazil. The selected counties, together with the 26 state capitals and the Federal District were used as a sampling frame to select a stratified sample of schools (second stage). In the third stage, classrooms were randomly selected from within the chosen schools. All students from selected classrooms were then invited to participate in the study (IBGE, 2013). On the data collection days, 84% (110,873) of the total number of students attended school, but 1651 refused to participate and 118 did not report their gender or age and were excluded from the analysis (response rate = 82.7%). Students completed a self-answered electronic questionnaire during regular school hours. The questionnaire was based on the Global School-Based Student Health Survey (WHO, 2009) and the Youth Risk Behavior Surveillance System (Eaton et al., 2010); adapted to the Brazilian setting and tested in previous surveys (IBGE, 2009). School principals answered a questionnaire concerning contextual school characteristics. PeNSE further details can be found elsewhere (IBGE, 2013).

The school level variables measured the school availability of food groups, assessed through the principals' questionnaire, which was pre-tested. The principals were asked if there was a cafeteria in the school and if there were alternative outlets at school or the immediate area (school entrance). If available, they were asked if students could buy the following items: soft drinks, bagged salty snacks, deep fried salty snacks, sweets, fruit, and natural fruit juice. These questions constituted dichotomous variables.

The students' food intake was assessed through a previously validated questionnaire (Tavares et al., 2014) based on the frequency of consumption in the previous seven days of the following items: soft drinks, bagged salty snacks, deep-fried salty snacks, and sweets. For data analysis purposes, food consumption was categorised as regularly consumed (at least five days in the previous seven days) or not (Castro et al., 2008). These indicators of regular consumption of unhealthy food presented satisfactory accuracy and validity compared to three 24-hour recall (Tavares et al., 2014). Students attending public schools, which are those covered by the BSFP, were also asked if they eat meals offered by school. Available answers were: never, rarely, 1–4 times/week and every day.

The following socio-demographic variables were included in the analysis: sex; age (in years); ethnicity/skin colour (white, black and brown, Asian, American Indian); mother's educational level (incomplete middle school, complete middle school, complete high-school, complete higher education). We also assessed the type of city of residence (state capital, non-capital); and geographical region (North, Northeast, South, Southeast and Mid-West).

Multiple imputation by chained equations was used to attribute numerical values to the mother's educational level, which had 17% missing values, as described elsewhere (Azeredo et al., 2014). The imputed data exhibited satisfactory statistical reproducibility according to Monte Carlo error analysis (Royston and White, 2011).

First of all, the prevalence and distribution of student and school characteristics were described. All the analyses were performed separately by school status (public or private).

Regular consumption of the four unhealthy foods was the dependent variable in our multilevel logistic regression models. These models were developed in sequential steps. An empty model was initially performed to determine the clustering of regular consumption of each unhealthy food by school. Through this model, we obtained the school variance of food consumption over the total model variance (intraclass correlation coefficient — ICC). We used the latent variable method (Merlo et al., 2006; Rasbash et al., 2009) to convert the individual level variance to the logistic scale, assuming that regular food consumption follows a logistic distribution, with individual-level variance equal to $\pi^2/3$ (that is, 3.29).

We then performed an unadjusted investigation of the association between regular food intake of each unhealthy food and: 1) the sale of the same unhealthy food (main predictor) in the cafeteria and in an alternative outlet; 2) the sale of natural fruit juice (for soft drink consumption) or fruit (for deep fried salty snacks, bagged salty snacks and sweets consumption) in the cafeteria and in an alternative outlet; 3) student consumption of meals offered by the BSFP, only for public schools.

The multiple analyses were performed using several models. In private schools, three step models were built for each food intake: the first model included regular intake of a specific unhealthy food (e.g. soft drinks) and all the socio-demographic variables. In the second step, we included the sale of the same unhealthy food in the cafeteria and in an alternative outlet. In the third step, we included the sale of natural fruit juice (for soft drinks) or fruit (for all other food intakes). In public schools, the modelling followed the same steps but with the addition of a fourth step for student consumption of food provided by the BSFP.

Finally, we verified the proportional change in variance (PCV) of food consumption across schools after adjusting for socio-demographic characteristics and then keeping these variables plus all school availability of food (full model) (Merlo et al., 2005). The analyses were performed using Stata 13.1 software, and only the descriptive analysis considered the sampling design of the survey.

The PeNSE was approved by the National Commission for Research Ethics (Brazilian Ethics Committee) (record no. 16805), according to the Declaration of Helsinki, and all participants gave their informed consent through a self-administered questionnaire.

3. Results

Characteristics of the students and schools are reported in Table 1. Students from private schools were predominantly white, had mothers with a high educational level and around 16% were 15 years old or more. Students from public schools were predominantly black and brown, had mothers with a low educational level and around 35% were 15 years old or more. Regarding school characteristics, just under half the schools contained a cafeteria; these were more often found in private (95.5%)

Table 1
Distribution of student and school characteristics.
PeNSE 2012 (IBGE, 2013).

Variable	Private Schools		Public Schools		Total	
Student characteristics* (n = 109,104)	N	%	N	%	n	%
Sex						
Male	11,066	49.3	40,949	47.5	52,015	47.8
Female	11,438	50.7	45,651	52.5	57,089	52.2
Age range						
11–14 years	19,143	83.9	54,200	65.3	73,343	68.5
15 years or older	3361	16.1	32,400	34.7	35,761	31.6
Ethnicity/skin colour						
White	11,456	52.8	26,218	33.5	37,674	36.8
Black and brown	9031	38.1	53,719	59.2	62,750	55.6
Asian	1234	5.5	3587	3.8	4821	4.1
American Indian	778	3.6	3012	3.5	3790	3.5
Mother's educational level						
Incomplete middle school	1881	11.9	35,748	44.6	37,629	38.9
Complete middle school	2467	13.0	16,511	18.8	18,978	17.8
Complete high school	9181	41.6	26,267	28.5	35,448	30.7
Complete higher education	9426	33.6	7589	8.2	17,015	12.5
Geographical areas						
North	2814	4.6	19,96	8.6	22,774	8.0
North east	8455	23.1	22,846	25.7	31,301	25.3
South east	4895	56.3	14,765	41.8	19,660	44.3
South	2588	9.2	12,290	15.7	14,878	14.6
Mid-west	3752	6.8	16,739	8.1	20,491	7.9
Regular intake of unhealthy food[a]						
Soft drinks	7885	37.3	27,716	32.4	35,601	33.3
Fried salty snacks	3961	17.5	13,026	15.5	16,987	15.8
Bagged salty snacks	2256	11.4	10,406	13.4	12,662	13.0
Sweets	9046	41.0	35,381	41.3	44,427	41.3
School Characteristics (n = 2842)[b]	608	21.4	2234	78.6		
Has cafeteria[c]	581	94.7	795	35.1	1.376	46.7
Sells soft drink	280	48.2	366	46.0	646	46.9
Fried salty snacks	316	54.4	329	41.4	645	46.8
Sells bagged salty snacks	311	53.5	380	47.8	691	50.2
Sells sweets	415	71.4	425	53.5	840	61.0
Sells fruit	280	48.2	132	16.6	412	29.9
Sells natural juice	513	88.3	534	67.2	1.047	76.1
Has alternative outlet inside or outside school	172	28.3	912	40.8	1.084	38.1
Sells soft drink	67	39.0	437	47.9	504	46.5
Sells fried salty snacks	85	49.4	618	67.8	703	64.9
Sells bagged salty snacks	79	45.9	575	63.0	654	60.3
Sells sweets	121	70.3	717	78.6	828	76.4
Sells fruit	22	12.8	66	7.2	88	8.1
Sells natural juice	69	40.1	333	36.5	402	37.1

[a] Consumption ≥5 days/week
[b] Proportions of students and schools were calculated using sample weights and sample structure (PSU, SSU and strata).
[c] Percentages of specific food sales in cafeteria and alternative outlets had as denominator, number of schools who had cafeteria and alternative outlets, respectively.

than in public schools (35.7%). In addition, cafeterias in private schools offered both more healthy and unhealthy foods. Additionally, alternative outlets, which were more frequently found near public schools, resulted only in a greater offer of unhealthy food (Table 1).

The ICC for regular soft drink intake showed that 3.8% and 4.6%, in public and private schools respectively, of the total variance in soft drink intake was explained at the school-level. Students' regular consumption of soft drinks was associated with cafeteria sales of soft drinks within private and public schools (Table 2). Additionally, cafeteria selling natural fruit juice was associated with lower intake of soft drinks among students attending private schools. In public schools, the consumption of the BSFP meals was associated with lower odds of regular soft drink consumption among students. It is worth noting that the inclusion of the BSFP in the public schools model and of sales of natural fruit juice in the private schools model did not change the relationship between soft drink consumption and cafeteria sales of soft drinks (Table 2).

The empty model found that 6.8% and 3.2% of the total variance in the regular deep-fried salty snack intake was explained at school-level, for private and public schools respectively. Higher odds of students' regular consumption of deep fried salty snacks were associated with the sale of the corresponding food by cafeteria, in private and public schools. The existence of an alternative outlet selling deep fried snacks was associated with higher odds of its intake in public schools (Table 3). The consumption of the BSFP meals was associated with lower intake of deep fried salty snacks among public school students. The inclusion of the BSFP in the model resulted in a small change in the relationship between regular intake of deep fried salty snacks related to cafeteria and alternative outlet sales of this food.

For regular bagged salty snacks, 5.5% (private schools) and 3.5% (public schools) of the total variance in intake was explained at the school-level. Higher odds of bagged salty snack intake were associated with cafeteria sales of this food, in private schools. On the other hand, sales of fruit in the cafeteria were associated with lower consumption of bagged salty snacks in private schools. Nonetheless, the fruit sales did not change the relationship between regular intakes of bagged salty snacks associated with the cafeteria sales of this food. In public schools, cafeteria sales of bagged salty snacks were not associated with their regular intake in the fully adjusted model, which included student consumption of BSFP meals. In addition, the consumption of BSFP meals was associated with lower odds of regular consumption of bagged salty snacks (Table 4).

In private and public schools, 2.9% and 2.7% respectively of the total variance in regular sweet intake was explained at the school-level. For this food, the associations were found only among public schools. Alternative outlets selling sweets were associated with higher odds of student consumption; and the consumption of BSFP meals was associated with lower sweet consumption. Despite the negative association between BSFP meals and regular sweet intake, the inclusion of the BSFP did not change the association between alternative outlets sales of sweets and their regular intake (Table 5).

In private schools, when socio-demographic variables were included in the model, the proportional change in the school variance for each food was: soft drinks (21.2%), deep-fried salty snacks (37.2%), bagged salty snacks (44.0%), and sweets (7.2%). Finally, after adding school food environment variables in the previous model, the proportional change in school variance became 29.0%, 44.1%, 54.7%, and 7.9%, respectively. In public schools, the inclusion of the first set of variables caused lower proportional change in school variance for soft drinks (26.9%), deep-fried salty snacks (0.7%), bagged salty snacks (9.2%), and sweets (17.6%). In the full model, the proportional change in variance became 25.0%, 8.7%, 9.4%, and 21.6%, respectively.

4. Discussion

Our results show that a cafeteria selling unhealthy food inside a school, regardless of the school's administrative status, is associated with a higher consumption frequency of these items among students. The associations were particularly apparent for cafeterias selling soft drinks and deep fried salty snacks but less clear for the availability of bagged salty snacks or sweets. Our analysis also indicated a negative association between a cafeteria selling fruit and natural fruit juice and the regular intake of unhealthy food in private schools. In public schools, there was a negative association between the intake of BSFP meals and the regular intake of unhealthy food. Despite this, the availability of healthy food did not change the association between unhealthy food consumption and cafeteria or alternative outlet sales of unhealthy food.

Table 2
Odds ratio of regularly consumption (≥5 times/week) of soft drinks by adolescents according to availability of specific food at school and its surroundings. PeNSE 2012 (IBGE, 2013).

	Soft drinks (consumed ≥5 d/week)						
	Private schools			Public schools			
	Unadjusted model	Model 1[a]	Model 2[a]	Unadjusted model	Model 1[a]	Model 2[a]	Model 3[a]
Covariates	OR (95% CI)	OR (95% CI)	OR (95% CI)	OR (95% CI)	OR (95% CI)	OR (95% CI)	OR (95% CI)
Student[b]							
Eat meals offered by school							
Never				1			1
Rarely				**0.84 (0.81–0.87)**			**0.85 (0.82–0.88)**
1–4 times/week				**0.71 (0.66–0.75)**			**0.72 (0.68–0.77)**
Every day				**0.72 (0.70–0.75)**			**0.74 (0.71–0.77)**
School							
Cafeteria sells soft drinks							
No	1	1	1	1	1	1	1
Yes	**1.27 (1.17–1.37)**	**1.23 (1.13–1.33)**	**1.23 (1.14–1.33)**	**1.23 (1.16–1.30)**	**1.16 (1.09–1.23)**	**1.15 (1.08–1.23)**	**1.13 (1.06–1.20)**
Alternative outlet sells soft drinks							
No	1	1	1	1	1	1	1
Yes	1.04 (0.92–1.19)	1.07 (0.95–1.20)	1.07 (0.92–1.23)	0.98 (0.93–1.04)	1.02 (0.97–1.07)	1.03 (0.98–1.09)	1.02 (0.96–1.08)
Cafeteria sells natural juice							
No	1		1	1		1	1
Yes	**0.81 (0.72–0.90)**		**0.86 (0.77–0.96)**	**1.16 (1.10–1.22)**		1.01 (0.96–1.07)	0.99 (0.94–1.05)
Alternative outlet sells natural juice							
No	1		1	1		1	1
Yes	1.02 (0.90–1.16)		0.99(0.86–1.15)	0.96 (0.90–1.02)		0.96 (0.90–1.02)	0.95 (0.89–1.01)

PeNSE, Pesquisa Nacional de Saúde do Escolar (National Survey of Schoolchildren's Health). Bold data reflect statistical significance ($p < 0.05$).
[a] Multilevel logistic regression model. Model 1: the sale of soft drinks in the cafeteria and in an alternative outlet, adjusted for all the socio-demographic variables. Model 2: the sale of soft drinks and natural fruit juice in the cafeteria and in an alternative outlet, adjusted for all the socio-demographic variables. Model 3: the sale of soft drinks and natural fruit juice in the cafeteria and in an alternative outlet, and student consumption of food provided by the BSFP, adjusted for all the socio-demographic variables. Socio-demographic characteristics are: sex, age, maternal educational level, ethnicity/skin colour, geographical area and county type (capital or non-capital).
[b] Only public schools offer free meals in Brazil as part of the national program.

The actual situation of public and private schools in different countries may limit direct comparisons; further, most of the information available has focused on public schools (Briefel et al., 2009; Kubik et al., 2003; Masse et al., 2014; Park et al., 2010; Rovner et al., 2011). Nonetheless, our results are consistent with the literature for public schools, suggesting the importance of the school food environment for adolescent food consumption (Briefel et al., 2009; Kubik et al., 2003; Masse et al., 2014; Park et al., 2010; Rovner et al., 2011). Studies

Table 3
Odds ratio of regular consumption (≥5 times/week) of deep fried salty snacks by adolescents according to availability of specific food at school and its surroundings. PeNSE 2012 (IBGE, 2013).

	Deep fried salty snacks (consumed ≥5 d/week)						
	Private schools			Public schools			
	Unadjusted model	Model 1[a]	Model 2[a]	Unadjusted model	Model 1[a]	Model 2[a]	Model 3[a]
Covariates	OR (95% CI)	OR (95% CI)	OR (95% CI)	OR (95% CI)	OR (95% CI)	OR (95% CI)	OR (95% CI)
Student[b]							
Eat meals offered by school							
Never					1		1
Rarely					**0.79 (0.75–0.83)**		**0.81 (0.77–0.85)**
1–4 times/week					**0.77 (0.71–0.83)**		**0.80 (0.74–0.87)**
Every day					**0.69 (0.66–0.73)**		**0.72 (0.69–0.76)**
School							
Cafeteria sells fried salty snacks							
No	1	1	1	1	1	1	1
Yes	**1.69 (1.52–1.87)**	**1.41 (1.27–1.57)**	**1.41 (1.26–1.57)**	**1.21 (1.13–1.28)**	**1.20 (1.12–1.28)**	**1.20 (1.12–1.28)**	**1.16 (1.08–1.24)**
Alternative outlet sells fried salty snacks							
No	1	1	1	1	1	1	1
Yes	1.17 (1.00–1.35)	1.10 (0.97–1.25)	1.12 (0.97–1.29)	**1.10 (1.05–1.16)**	**1.10 (1.04–1.16)**	**1.10 (1.04–1.16)**	**1.08 (1.03–1.15)**
Cafeteria sells fruit							
No	1		1	1		1	1
Yes	0.97 (0.87–1.08)		1.00(0.90–1.10)	1.04 (0.95–1.15)		0.99 (0.90–1.09)	0.98 (0.89–1.08)
Alternative outlet sells fruit							
No	1		1	1		1	1
Yes	1.01 (0.76–1.35)		0.91 (0.70–1.20)	1.05 (0.92–1.21)		0.99 (0.86–1.14)	0.98 (0.85–1.12)

PeNSE, Pesquisa Nacional de Saúde do Escolar (National Survey of Schoolchildren's Health). Bold data reflect statistical significance ($p < 0.05$).
[a] Multilevel logistic regression model. Model 1: the sale of deep fried salty snacks in the cafeteria and in an alternative outlet, adjusted for all the socio-demographic variables. Model 2: the sale of deep fried salty snacks and fruit in the cafeteria and in an alternative outlet, adjusted for all the socio-demographic variables. Model 3: the sale of deep fried salty snacks and fruit in the cafeteria and in an alternative outlet, and student consumption of food provided by the BSFP, adjusted for all the socio-demographic variables. Socio-demographic characteristics are: sex, age, maternal educational level, ethnicity/skin colour, geographical area and county type (capital or non-capital).
[b] Only public schools offer free meals in Brazil as part of a national program.

Table 4
Odds ratio of regular consumption (≥5 times/week) of bagged salty snacks by adolescents according to availability of specific food at school and its surroundings. PeNSE 2012 (IBGE, 2013).

	Bagged salty snacks (consumed ≥5 d/week)						
	Private schools			Public schools			
	Unadjusted model	Model 1[a]	Model 2[a]	Unadjusted model	Model 1[a]	Model 2[a]	Model 3[a]
	OR (95% CI)	OR (95% CI)	OR (95% CI)	OR (95% CI)	OR (95% CI)	OR (95% CI)	OR (95% CI)
Student[b]							
Eat meals offered by school							
Never					1		1
Rarely					**0.83 (0.78–0.87)**		**0.82 (0.78–0.87)**
1–4 times/week					**0.69 (0.63–0.76)**		**0.72 (0.66–0.79)**
Every day					**0.80 (0.75–0.84)**		**0.82 (0.78–0.87)**
School							
Cafeteria sells bagged salty snacks							
No	1	1	1	1	1	1	1
Yes	**1.45 (1.29–1.62)**	**1.32 (1.19–1.47)**	**1.34 (1.20–1.49)**	1.05 (0.98–1.12)	**1.09 (1.02–1.16)**	**1.09 (1.02–1.16)**	1.06 (0.99–1.14)
Alternative outlet sells bagged salty snacks							
No	1	1	1		1	1	1
Yes	**1.19 (1.01–1.39)**	1.14 (0.99–1.31)	1.14 (0.98–1.33)	1.02 (0.96–1.08)	0.99 (0.93–1.05)	0.98 (0.92–1.04)	0.97 (0.92–1.03)
Cafeteria sells fruit							
No	1		1	1		1	1
Yes	**0.82 (0.73–0.92)**		**0.85 (0.76–0.94)**	0.97 (0.88–1.08)		0.98 (0.88–1.09)	0.97 (0.87–1.08)
Alternative outlet sells fruit							
No	1		1	1		1	1
Yes	1.04 (0.74–1.45)		1.05 (0.79–1.39)	1.04 (0.90–1.21)		1.06 (0.91–1.23)	1.05 (0.90–1.22)

PeNSE, Pesquisa Nacional de Saúde do Escolar (National Survey of Schoolchildren's Health). Bold data reflect statistical significance ($p < 0.05$).
[a] Multilevel logistic regression model. Model 1: the sale of bagged salty snacks in the cafeteria and in an alternative outlet, adjusted for all the socio-demographic variables. Model 2: the sale of bagged salty snacks and fruit in the cafeteria and in an alternative outlet, adjusted for all the socio-demographic variables. Model 3: the sale of bagged salty snacks and fruit in the cafeteria and in an alternative outlet, and student consumption of food provided by the BSFP, adjusted for all the socio-demographic variables. Socio-demographic characteristics are: sex, age, maternal educational level, ethnicity/skin colour, geographical area and county type (capital or non-capital).
[b] Only public schools offer free meals in Brazil as part of a national program.

among high-income countries supported the association between the availability of unhealthy foods and the consumption of these items (Briefel et al., 2009; Kubik et al., 2003); and that sales of unhealthy food options compete with sales of healthy food, and are often chosen by students (Cullen and Zakeri, 2004; Kubik et al., 2003; Park et al., 2010).

Table 5
Odds ratio of regular consumption (≥5 times/week) of sweets by adolescents according to availability of specific food at school and its surroundings. PeNSE 2012 (IBGE, 2013).

	Sweets (consumed ≥5 d/week)						
	Private schools			Public schools			
	Unadjusted model	Model 1[a]	Model 2[a]	Unadjusted model	Model 1[a]	Model 2[a]	Model 3[a]
	OR (95% CI)	OR (95% CI)	OR (95% CI)	OR (95% CI)	OR (95% CI)	OR (95% CI)	OR (95% CI)
Student[b]							
Eat meals offered by school							
Never					1		1
Rarely					**0.99 (0.96–1.04)**		**0.98 (0.94–1.01)**
1–4 times/week					**0.83 (0.78–0.88)**		**0.87 (0.82–0.93)**
Every day					**0.84 (0.81–0.87)**		**0.87 (0.84–0.90)**
School							
Cafeteria sells sweets							
No	1	1	1	1	1	1	1
Yes	1.01 (0.93–1.10)	1.00 (0.92–1.09)	1.01(0.93–1.11)	1.03 (0.98–1.08)	1.02 (0.97–1.06)	1.01 (0.97–1.06)	1.00 (0.96–1.05)
Alternative outlet sells sweets							
No	1	1	1	1	1	1	1
Yes	1.02 (0.93–1.12)	1.02 (0.93–1.12)	1.01(0.91–1.11)	1.02 (0.98–1.06)	**1.07 (1.03–1.11)**	**1.07 (1.03–1.12)**	**1.06 (1.02–1.11)**
Cafeteria sells fruit							
No	1		1	1		1	1
Yes	0.93 (0.86–1.00)		0.95(0.87–1.03)	0.99 (0.93–1.08)		1.01 (0.94–1.09)	1.01 (0.94–1.09)
Alternative outlet sells fruit							
No	1		1	1		1	1
Yes	1.04 (0.85–1.28)		1.09 (0.88–1.35)	0.97 (0.87–1.08)		0.96 (0.87–1.07)	0.96 (0.86–1.07)

PeNSE, Pesquisa Nacional de Saúde do Escolar (National Survey of Schoolchildren's Health). Bold data reflect statistical significance ($p < 0.05$).
[a] Multilevel logistic regression model. Model 1: the sale of sweets in the cafeteria and in an alternative outlet, adjusted for all the socio- demographic variables. Model 2: the sale of sweets and fruit in the cafeteria and in an alternative outlet, adjusted for all the socio-demographic variables. Model 3: the sale of sweets and fruit in the cafeteria and in an alternative outlet, and student consumption of food provided by the BSFP, adjusted for all the socio-demographic variables. Socio-demographic characteristics are: sex, age, maternal educational level, ethnicity/skin colour, geographical area and county type (capital or non-capital).
[b] Only public schools offer free meals in Brazil as part of a national program.

We found a negative association between cafeterias selling natural fruit juice and fruit and the regular consumption of unhealthy food in private schools but not in public schools. This result suggests two possibilities: firstly, in public schools, these foods are offered in the BSFP (Brasil, 2013) so their cafeterias are less likely to sell them; only 17% of the surveyed cafeterias in public schools sold fresh fruit. Secondly, the higher socioeconomic status (SES) of students at private schools compared to public schools may lead private school students to preferentially purchase healthy food over unhealthy when it is available. Evidence for this includes the fact that higher SES is associated with lower consumption of unhealthy food compared to healthy food (French et al., 1994; Jeffery and French, 1996), and that unhealthy options tend to be more expensive than healthy options in Brazil, and high SES students would have more financial resources to afford them (Moubarac et al., 2013). A higher vulnerability of students from poor families to the school food environment has been reported in the US (Vericker, 2013), which is not consistent with the above finding. However we did find a protective association between BSFP meal consumption and unhealthy food consumption. There was no extensive difference in the magnitude of association between food availability and food consumption when students from private and public schools were compared. Between-school variance in adolescent food intake has been reported for public schools (Rovner et al., 2011), and is in keeping with our results. We also highlight a wider school variance of regular intake of all unhealthy food assessed (soft drinks, bagged salty snack, fried salt snacks and sweets) and stronger associations with school variables in private than in public schools. These results indicate that changes in the school food environment may have a higher impact in private schools; possibly because public schools have the long-term influence of the BSFP (Brasil, 2009). Despite the higher influence of school food environment in private schools, regular intake of unhealthy food was similar among students from private and public schools (Table 1). Clearly other environments, such as family and neighbourhood, also contribute to student unhealthy intake and further studies taking into account a complex framework of food environments (Story et al., 2002) are needed to better understand the determinants of dietary consumption (Burgoine and Monsivais, 2013).

The association between alternative outlets selling unhealthy food and student food intake was only found in public schools. As the outlets could be either inside the school or in the immediate school vicinity, it is not possible to be sure of their location. However, alternative outlets are far more common than cafeterias in public schools, which suggests the need for further research into regulation around these outlets, and the types of products that are permitted to be sold in or around schools in Brazil. Also, a previous study showed that stores offering ultra-processed foods were significantly closer to public schools than those offering minimally processed foods in a Brazilian city (Leite et al., 2012); and food retailers near schools were associated with student lunchtime food intake (Seliske et al., 2013).

To date, there is no national regulation in this area and only a minor number of state or city regulations — usually restricting the commercialization of soft drinks and sweets — could be found (Brasil, 2007). Thus, interventions designed to specifically test the effectiveness of such restrictions could be an important step in the promotion of healthy eating in Brazilian schools, and useful to guide policy makers. Our results also suggest the need to increase school programs on food and nutrition education. A wider initiative, which also includes private schools, to provide repeated and sustained exposure to healthy foods, comprehensive and consistent food standards, and skills and literacy-oriented nutrition education for the entire school community are essential (Hawkes et al., 2015).

In line with the need for such a healthy environment, we found that the BSFP was associated with lower consumption of unhealthy food. This could be due to the BSFP legislation, which states that 70% of the resources provided must be used for the purchase of staple foods (of which 200 g must be fruits and vegetables), which restricts the availability of processed foods and prohibits the provision of ultra-processed foods (Brasil, 2013). Moreover, sugar-sweetened beverages are forbidden, and sweets are limited to no more than twice a week in the BSFP. The BSF menu has to be developed by a dietitian and approved by the school food committee (Brasil, 2013). It is worth mentioning that school meal public programs, through the provision of high quality food, have the potential to mitigate the dual-burden of under and overnutrition, which are co-existing conditions in LIMCs (Jaacks et al., 2015; Popkin et al., 2012).

Regarding our results, it is noteworthy that the magnitude of the associations was small. However, since the school food environment affects all students in a school, even small magnitudes may highlight important associations from a public health standpoint. We have classified regular food consumption as a frequency of consumption five or more times per week, but we also analysed our dataset using different consumption cutoffs and found similar results (data not shown).

Regarding the multilevel analysis, it was not possible to consider the complex sampling design in the models due to operational limitations of the software. However, previous studies have found no differences in the results of association analysis when comparing models that accounted for the sample design with models that did not (Lemeshow et al., 1998; Rai et al., 2013). Despite this, the standard errors and consequently the 95% CI might have been affected by not incorporating the complex sample design in our analysis; therefore readers should interpret any weak associations with caution.

A limitation of our study is that alternative outlet points were collected independently of location, limiting our understanding of this contextual aspect. The measurement of food consumption did not exclude weekends or the period in which students were not at school. Therefore, it is not possible to assume that the consumption of unhealthy and healthy food really occurred in school. However, the availability of unhealthy food in schools was associated with consumption; thus, it is plausible to assume that at least part of the consumption is at school. In addition, consumption over the last seven days might not represent the usual consumption of all the students, and some non-differential misclassification is expected; however, longer periods of report could be affected by recall bias. The PeNSE questionnaire assessed only a limited number of indicators of healthy food availability in schools: fruit and fruit juice sales and BSFP consumption (for public schools). Despite this, we found a negative association between healthy food availability and unhealthy food consumption. Finally, vending machines are still scarce in Brazil and vandalism and lack of security make operators reluctant to install more of them in environments like schools.

There are differences between schools in terms of the social position of the student population, and despite the adjustments performed, we cannot exclude the possibility of residual confounding. Moreover, the cross-sectional nature of this study should be taken into account when interpreting our results.

5. Conclusion

Our study provides evidence on the association between school food environment and the regular consumption of unhealthy foods among adolescents in a middle-income country. We used a large representative sample from Brazil and a robust multilevel analysis, controlling for other individual-level factors. Our findings provide support to government actions designed to promote the availability of healthy food and prohibiting the sale of unhealthy options in schools and their surrounding areas.

Conflict of interests

The authors have no conflict of interest to declare.

Authors' contributions

CMA, LFMR and RBL conceptualized the study, performed statistical analysis and drafted the manuscript; DSC was involved in drafting the manuscript; RMC, MFTP, OCL, IFJ, SK and SH participated in the interpretation of the results and revised critically the manuscript. All authors read and approved the final manuscript.

Transparency Document

The Transparency Document associated with this article can be found, in online version.

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References

Azeredo, C.M., de Rezende, L.F., Canella, D.S., Moreira Claro, R., de Castro, I.R., Luiz, O.D., Levy, R.B., 2014. Dietary intake of Brazilian adolescents. Public Health Nutr. 1–10.

Birkhead, G.S., Riser, M.H., Mesler, K., Tallon, T.C., Klein, S.J., 2006. Youth development is a public health approach. J. Public Health Manag. Pract. 12, S1–S3.

Brasil, 2006. In: FNDE., F.N.D.D.D.E.- (Ed.), Alimentação Escolar. Portaria Interministerial n. 1.010, de 8 de maio de 2006. Institui as diretrizes para a Promoção da Alimentação Saudável nas Escolas de educação infantil, fundamental e nível médio das redes públicas e privadas, em âmbito nacional.

Brasil, 2007. Experiências estaduais e municipais de regulamentação da comercialização de alimentos em escolas no Brasil:identificação e sistematização do processo de construção e dispositivos legais adotados, in: Básica, M.d.S.S.d.A.à.S.D.d.A. (Ed.), (Brasília).

Brasil, 2009. In: União, D.O.d. (Ed.), Lei n° 11.947, de 17 de junho de 2009. Dispõe sobre o atendimento da alimentação escolar e do Programa Dinheiro Direto na Escola aos alunos da educação básica. Ministério da Saúde.

Brasil, 2013. In: União, D.O.d. (Ed.), Resolução n° 26, de 17 de junho de 2013. Dispõe sobre o atendimento da alimentação escolar aos alunos da educação básica no âmbito do Programa Nacional de Alimentação Escolar — PNAE. Ministerio da Educação.

Briefel, R.R., Crepinsek, M.K., Cabili, C., Wilson, A., Gleason, P.M., 2009. School food environments and practices affect dietary behaviors of US public school children. J. Am. Diet. Assoc. 109, S91–107.

Burgoine, T., Monsivais, P., 2013. Characterising food environment exposure at home, at work, and along commuting journeys using data on adults in the UK. Int. J. Behav. Nutr. Phys. Act. 10.

Castro, I.R., Cardoso, L.O., Engstrom, E.M., Levy, R.B., Monteiro, C.A., 2008. Surveillance of risk factors for non-communicable diseases among adolescents: the experience in Rio de Janeiro, Brazil. Cad. Saude Publica 24, 2279–2288.

Cullen, K.W., Zakeri, I., 2004. Fruits, vegetables, milk, and sweetened beverages consumption and access to à la carte/snack bar meals at school. Am. J. Public Health 94, 463–467.

Eaton, D.K., Kann, L., Kinchen, S., Shanklin, S., Ross, J., Hawkins, J., Harris, W.A., Lowry, R., Mcmanus, T., et al., 2010. In: Services, D.O.H.A.H. (Ed.), Youth Risk Behavior Surveillance — United States — 2009. Centers for Disease Control and Prevention (CDC), United States, p. 148.

French, S.A., Perry, C.L., Leon, G.R., Fulkerson, J.A., 1994. Weight concerns, dieting behavior, and smoking initiation among adolescents: a prospective study. Am. J. Public Health 84, 1818–1820.

Glanz, K., 2009. Measuring food environments: a historical perspective. Am. J. Prev. Med. S93–S98 (Netherlands).

Hawkes, C., Smith, T.G., Jewell, J., Wardle, J., Hammond, R.A., Friel, S., Thow, A.M., Kain, J., 2015. Smart food policies for obesity prevention. Lancet.

IBGE, 2009. Pesquisa Nacional de Saúde do Escolar 2009. In: O.e.G.I.D.d.P.C.d.P.e.I.S. (Ed.), Ministério do Planejamento. Instituto Brasileiro de Geografia e Estatística, Rio de Janeiro, p. 138.

IBGE, 2013. Pesquisa Nacional de Saúde do Escolar 2012. In: I.B.d.G.e. (Ed.), Estatística, p. 256 (Rio de Janeiro).

Jaacks, L.M., Slining, M.M., Popkin, B.M., 2015. Recent trends in the prevalence of under- and overweight among adolescent girls in low- and middle-income countries. Pediatr. Obes. 10, 428–435.

Jeffery, R.W., French, S.A., 1996. Socioeconomic status and weight control practices among 20- to 45-year-old women. Am. J. Public Health 86, 1005–1010.

Kubik, M.Y., Lytle, L.A., Hannan, P.J., Perry, C.L., Story, M., 2003. The association of the school food environment with dietary behaviors of young adolescents. Am. J. Public Health 93, 1168–1173.

Leite, F.H., Oliveira, M.A., Cremm, E.C., Abreu, D.S., Maron, L.R., Martins, P.A., 2012. Availability of processed foods in the perimeter of public schools in urban areas. J. Pediatr. 88, 328–334.

Lemeshow, S., Letenneur, L., Dartigues, J.F., Lafont, S., Orgogozo, J.M., Commenges, D., 1998. Illustration of analysis taking into account complex survey considerations: the association between wine consumption and dementia in the PAQUID study. Personnes Ages Quid. Am. J. Epidemiol. 148, 298–306.

Masse, L.C., de Niet-Fitzgerald, J.E., Watts, A.W., Naylor, P.J., Saewyc, E.M., 2014. Associations between the school food environment, student consumption and body mass index of Canadian adolescents. Int. J. Behav. Nutr. Phys. Act. 29 (England).

Merlo, J., Chaix, B., Ohlsson, H., Beckman, A., Johnell, K., Hjerpe, P., Rastam, L., Larsen, K., 2006. A brief conceptual tutorial of multilevel analysis in social epidemiology: using measures of clustering in multilevel logistic regression to investigate contextual phenomena. J. Epidemiol. Community Health 60, 290–297.

Merlo, J., Chaix, B., Yang, M., Lynch, J., Råstam, L., 2005. A brief conceptual tutorial of multilevel analysis in social epidemiology: linking the statistical concept of clustering to the idea of contextual phenomenon. J. Epidemiol. Community Health 59, 443–449.

Monteiro, C.A., Moubarac, J.C., Cannon, G., Ng, S.W., Popkin, B., 2013. Ultra-processed products are becoming dominant in the global food system. Obes. Rev. 14, 21–28.

Moubarac, J.C., Claro, R.M., Baraldi, L.G., Levy, R.B., Martins, A.P., Cannon, G., Monteiro, C.A., 2013. International differences in cost and consumption of ready-to-consume food and drink products: United Kingdom and Brazil, 2008–2009. Glob. Public Health 8, 845–856.

O'Toole, T.P., Anderson, S., Miller, C., Guthrie, J., 2007. Nutrition services and foods and beverages available at school: results from the School Health Policies and Programs Study 2006. J. Sch. Health 77, 500–521.

Park, S., Sappenfield, W.M., Huang, Y., Sherry, B., Bensyl, D.M., 2010. The impact of the availability of school vending machines on eating behavior during lunch: the youth physical activity and nutrition survey. J. Am. Diet. Assoc. 110, 1532–1536.

Popkin, B.M., Adair, L.S., Ng, S.W., 2012. Global nutrition transition and the pandemic of obesity in developing countries. Nutr. Rev. 70, 3–21.

Rai, D., Zitko, P., Jones, K., Lynch, J., Araya, R., 2013. Country- and individual-level socioeconomic determinants of depression: multilevel cross-national comparison. Br. J. Psychiatry 195–203 (England).

Rasbash, J., Steele, F., Browne, W.J., Goldstein, H., 2009. A User's Guide to MLwiN. University of Bristol, United Kingdom.

Rovner, A.J., Nansel, T.R., Wang, J., Iannotti, R.J., 2011. Food sold in school vending machines is associated with overall student dietary intake. J. Adolesc. Health 48, 13–19.

Royston, P., White, I.R., 2011. Multiple imputation by chained equations (MICE): implementation in stata. J. Stat. Softw. 45, 1–20.

Seliske, L., Pickett, W., Rosu, A., Janssen, I., 2013. The number and type of food retailers surrounding schools and their association with lunchtime eating behaviours in students. Int. J. Behav. Nutr. Phys. Act. 10, 19.

Story, M., Kaphingst, K.M., Robinson-O'Brien, R., Glanz, K., 2008. Creating healthy food and eating environments: policy and environmental approaches. Annu. Rev. Public Health 29, 253–272.

Story, M., Neumark-Sztainer, D., French, S., 2002. Individual and environmental influences on adolescent eating behaviors. J. Am. Diet. Assoc. 102, S40–S51.

Tavares, L.F., Castro, I.R., Levy, R.B., Cardoso, L.O., Passos, M.D., Brito Fdos, S., 2014. Relative validity of dietary indicators from the Brazilian National School-Based Health Survey among adolescents in Rio de Janeiro, Brazil. Cad. Saude Publica 30, 1029–1041.

Vericker, T.C., 2013. Limited evidence that competitive food and beverage practices affect adolescent consumption behaviors. Health Educ. Behav. 19–23 (United States).

WHO, 2009. In: Organization, W.H. (Ed.), Global school-based student health surveillance (GSHS).

Williams, J., Scarborough, P., Matthews, A., Cowburn, G., Foster, C., Roberts, N., Rayner, M., 2014. A systematic review of the influence of the retail food environment around schools on obesity-related outcomes. Obes. Rev. 15, 359–374.