Challenges for obesity prevention: Study of the consumers' food environment around public schools in a small municipality

Desafios para a prevenção da obesidade: estudo do ambiente alimentar do consumidor no entorno de escolas públicas de um município de pequeno porte

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ABSTRACT

Objective

Evaluate the consumer's food environment in food retailers around public schools in the municipality of Governador Celso Ramos, state of Santa Catarina, in southern Brazil.

Methods

A survey was carried out in the surroundings of three public schools, from March to May 2022. Food retailers located in a pre-established 800m buffer zone were identified. A location system device recorded latitude and longitude. An audit of the establishments was performed using a specific validated instrument for auditing the consumer food environment (AUDITNOVA). These establishments were grouped into: Group 1 – predominantly selling fresh foods, Group 2 – mixed establishments, and Group 3 – predominantly selling ultra-processed foods. These establishments were assessed using a Consumer Food Environment Healthiness Score evaluation system. The data were analyzed using the statistical software Stata version 16.0.

Results

The study audited 21 establishments, 47.6% of which were small neighborhood food markets, 23.8% bakeries, 14.3% butchers/fishmongers, 9.5% grocery stores and 4.8% supermarkets. It was found that privately-owned vegetable markets had a higher availability of fresh and minimally processed food categories, while the lowest scores for this category were found in bakeries. Regarding ultra-processed foods, the most commonly found items were sugary beverages and candies, chocolates, and filled cookies.

Conclusion

More audit studies ought to be carried out in the surroundings of schools to broaden the understanding of the relationship between access, availability, prices and food advertisement in order to support the construction of strategies aimed at preventing obesity in the population.

Keywords: Access to healthy foods. Built environment. Food deserts. Food publicity. Students.

RESUMO

Objetivo

Avaliar o ambiente alimentar do consumidor em estabelecimentos de comercialização de alimentos no entorno de escolas públicas no município de Governador Celso Ramos, estado de Santa Catarina, no Sul do Brasil.

Métodos

Foi realizada, entre março e maio de 2022, no entorno de três escolas públicas, auditoria nos comércios varejistas localizados em uma zona pré-estabelecida de 800m. Um equipamento com sistema de localização realizou o registro da latitude e longitude. Esta auditoria foi realizada utilizando um instrumento validado próprio para auditoria do ambiente alimentar do consumidor (AUDITNOVA). Estes foram agrupados em Grupo 1 – com venda predominante de alimentos in natura; Grupo 2 – estabelecimentos mistos; Grupo 3 – com venda predominante de alimentos ultraprocessados. Os estabelecimentos foram avaliados por um sistema de avaliação de saudabilidade do ambiente alimentar do consumidor. Os dados foram analisados no programa estatístico Stata versão 16.0.

Resultados

O estudo auditou 21 estabelecimentos, sendo 47,6% mercados de bairro, 23,8% padarias, 14,3% açougues/peixarias, 9,5% sacolões/hortifrutis privados e 4,8% supermercados. Foi identificado que sacolões/hortifrutis privados apresentaram maior oferta de alimentos da categoria in natura e minimamente processados, enquanto os menores scores desta categoria de alimentos foram encontrados em padarias. Em relação aos alimentos ultraprocessados, os alimentos mais presentes foram bebidas açucaradas e balas, chocolates e biscoito recheado.

Conclusão

Sugere-se a realização de mais estudos de auditoria em comércios varejistas no entorno de escolas para ampliar a compreensão da relação entre o acesso, disponibilidade, preços e propagandas dos alimentos de modo a subsidiar a construção de estratégias que visem a prevenção da obesidade na população.

Palavras-chave: *Acesso a alimentos saudáveis. Ambiente construído. Desertos alimentares. Publicidade de alimentos. Estudantes.*

INTRODUCTION

Physical and economic access to food is a determining factor for food and nutritional security, which corresponds to everyone's right to obtain a healthy and adequate diet, without compromising the satisfaction of other essential needs and based on dietary practices that respect cultural and social diversity [1,2]. Furthermore, the socioeconomic situation of the population is a determining factor that affects food choices as well as food availability and access to food in relation to prices [3]. Therefore, individuals who live in areas with better access to food outlets where food options considered healthy are offered, tend to have more balanced diets and lower rates of obesity [4]. Thus, public policy actions are important to develop food environments conducive to healthy and accessible choices, in order to influence individuals to adopt and maintain healthy behaviors [5,6].

Conceptual models are important because they help a reflection about factors (political, economic, social, cultural) involved with food choices in different environments. Glanz et al. [7] proposed a conceptual model that includes four types of food environments: community; organizational; consumer and information. The community food environment is characterized by the number of establishments that sell food, type of establishments, their availability, location and accessibility.

The organizational food environment comprises the place where the individual lives, such as home, work and school. The consumer's food environment refers to the availability of food, price, promotions, location of food in the establishments, availability of nutritional information and environmental quality. The food information environment, in turn, encompasses the media and advertising that influence consumption and healthy choices by both the individual and the community [7].

Espinoza et al. [8] developed a conceptual model encompassing five interrelated food environments: The home environment, which constitutes the main space for socialization, where food preferences and traditions are defined. The public environment, which refers to the sale of food on the streets, means of transport and others. The institutional and organizational environments, which refer to the place where food is sold or provided to workers or students in institutions and organizations such as schools, universities, and companies. The restaurant environment which refers to the habit of eating outside the home like in restaurants, bars or at the home of relatives and friends. And the supply environment, which in addition to being a food environment, modulates the possibilities of other environments, its main characteristic being the spatial distribution of food acquisition sources and accessibility to them. This model enhances relevant aspects of this environment, such as the type and quality of accessible food, food programs and highlights the presence of food outlets in schools.

In a complementary way, Swinburn et al. [9] present the subdivision of the environment into macro and micro. The microenvironment is one in which groups of people come together for specific purposes, such as at home, supermarkets, schools, universities, and hospitals. The macroenvironment is one that has an influence on the general population, such as the food industry, transportation and health systems, technology, and the media. And when assessing the food environment of schools, it involves all spaces, infrastructures and conditions in and around schools, where food is made available, obtained, purchased and consumed. Furthermore, it also involves information about food and nutrition and the promotion and pricing of food [9].

Accessibility to points of sale that offer healthier items can influence purchasing behaviors, eating habits and nutritional status [10]. Studies focusing on neighborhoods, communities and around schools zones have been developed with the aim of understanding the social and territorial dynamics that influence access to food, especially healthy foods [11]. Studies have linked the number of food outlets with a higher prevalence of overweight and obesity in schoolchildren [12-14]. The *Estudo da Prevalência da Obesidade em Crianças e Adolescentes* (Study of the Prevalence of Obesity in Children and Adolescents) conducted with schoolchildren, revealed a prevalence of excess weight (including overweight and obesity) of 33.7% and a prevalence of obesity of 11.3% in the population assessed [13,15]. As the consumer's food environment is one of the main influencers of food choices, it is necessary to better understand the impact of food outlets on the health of schoolchildren and implement strategies to promote healthier food choices in this environment.

It is known that the quality of food offered around schools can significantly influence schoolchildren's food choices [16]. Food sold around schools has a great influence on food consumption, and can act either positively as facilitator, with an offer of fresh and minimally processed foods considered healthy, or negatively, as barriers of ultra-processed foods, considered unhealthy [17]. The use of audit tools in retail stores expands the understanding of the role that the consumer's food environment plays in the health of schoolchildren and in the development of chronic non-communicable diseases, such as obesity, in order to generate support for the development of policies, actions, laws and regulations related to health that are appropriate to the country's reality.

The fact that students move around schools and are more exposed to food advertising;can be acknowledged as an obstacle to the adoption of a healthy diet [18]. The World Health Organization published a report highlighting the role of advertising and marketing of unhealthy foods on the health of children and adolescents, pointing out the importance of public policies aimed at the environment that regulates these aspects in order to protect children and adolescents [19]. In addition to food advertising, small businesses and convenience stores often sell foods with low nutritional density, mainly processed and ultra-processed foods [20-21].

Brazilian studies on the food environment around schools have been carried out for the most part, in capitals and large municipalities. Therefore, little is known about the environment in the territory surrounding schools in small and medium-sized municipalities, where approximately two thirds of the population live, and whose urban and commercial organization is different from that of large municipalities [13,16].

In this connection, our study aimed at evaluating the consumer's food environment in food selling establishments located around public schools in a small municipality in southern Brazil.

METHODS

This is a cross-sectional study, using a descriptive and analytical approach. The survey was conducted between March and May 2022, with the target population composed of students attending the 9th year of elementary school who were enrolled in the public municipal school network of Governador Celso Ramos (small municipality), in the State of Santa Catarina. This study is part of a broader research project, entitled "Association between food consumption in 9th year elementary school pupils and characteristics of the food macro and microenvironment around municipal public schools in two municipalities of different socioeconomic levels and urbanization of Santa Catarina". Our protocol was submitted and approved by the Human Research Ethics Committee of Universidade Federal de Santa Catarina (process nº 4,533,681).

Governador Celso Ramos municipality where the survey took place, has an estimated population of 14,739 inhabitants, in a territory of 127,556km² with a population density of 110.93 inhabitants/km² and Municipal Human Development Index (IDHM) of 0.747, which is considered low [22].

Data regarding the municipal public schools in Governador Celso Ramos were all provided by each Municipal Department of Education. As Governador Celso Ramos is a small municipality, all municipal public schools that had 9th grade elementary school classes at the beginning of the study were included, totaling a set of three schools.

To identify retail outlets that sold food in the vicinity of each school, an 800m buffer zone was established around the schools [23]. This approach has been frequently employed in studies on the urban environment and health outcomes [24]. This distance is based on the fact that school children can walk through it in about 10 minutes [25]. The existence of commercial establishments selling food located close to the school, may be related to healthy or unhealthy behaviors [26]. Data from the audited establishments (n=21) were provided by the Treasury Department of the State of Santa Catarina; they included information such as company's name, trade name, full address, the number of *Classificação Nacional das Atividades Econômicas* (CNAE, National Classification of Economic Activities) and the classification of the type of establishment based on the CNAE number.

A team of six researchers, composed of undergraduate and postgraduate students from the UFSC nutrition course, underwent training for three days and used the "Application Manual for the Food Environment Audit Instrument Based on the New Food Classification of the Guide

Food (NEW)" [17]. To improve the application of the instrument and ensure the quality of the information collected, the pilot test was carried out in the territory of one of the municipalities to be investigated and followed the entire research protocol, with delivery of the Free and Informed Consent Form to the person in charge of the establishments, which allowed auditing of the food outlets surrounding the school.

During the audit of food outlets located around the participating schools, food sales establishments that were actually in operation were identified. A pair of researchers traveled throughout the territory, and with the help of Global Positioning System (GPS) equipment (Garmin brand, model eTrex® 20x), they recorded the latitude and longitude of food sales establishments. At the end of this process, the establishments found were grouped according to the types of businesses in the AUDITNOVA instrument as follows: butchers/fishmongers/meat packing stores; fruit and vegetable markets; municipal outlets; private network outlets; local or neighborhood markets; small markets; large chain supermarkets and bread and pastry stores/bakeries [27].

For the audit process in the retail trade, an adapted validated instrument (AUDITNOVA) was applied in each establishment to assess the food environment in terms of availability and price and food advertising [28]. The adapted AUDITNOVA consists of 14 blocks of checklist questions, with Block 1: general information (business name, address, collection date, collection start and end time). Block 2: types of businesses and products sold according to NOVA (butchers/fishmongers/meat packing stores, municipal fruit and vegetable markets, municipal grocery stores, private grocery stores, local or neighborhood markets, small chain markets, large chain supermarkets/ hypermarkets of large chains/wholesalers, bread and pastry stores/bakeries, others); food groups sold in the establishment: fresh/minimally processed foods, culinary ingredients, processed foods, ultra-processed foods, main food group. Block 3: items observed when entering the establishment, such as items available at the checkout counters. Block 4: advertisements and information about food within establishments. Block 5: advertisements and information about food outside the establishment. Block 6: fruit section. Block 7: vegetable section. Block 8: roots, tubers and corn section. Block 9: beans and rice section. Block 10: meat and egg section. Block 11: milk section. Block 12: culinary ingredients section. Block 13: processed bread section 14: ultra-processed food and beverage section.

The instrument adapted for this investigation allowed us to evaluate a list of 54 foods that can be classified according to their degree of processing. Fresh and minimally processed foods are those that do not undergo significant changes in their original composition after harvesting or slaughter, while processed foods are those that go through processes such as cooking, fermentation, grinding, among others, with the aim of making them more durable, palatable or safe for consumption. The category of culinary ingredients are substances that come from fresh foods through processes such as pressing, refining, grinding, crushing or spraying like oils, fats, salt and sugar. Ultra-processed foods are those that contain different ingredients and additives, generally with a high sugar, fat and sodium content, in addition to being highly palatable and convenient for consumption, but with low nutritional value [29].

To identify the availability of food in establishments, businesses that had at least one food available within the groups assessed were considered. During this stage, the food environment was assessed by surveying the products sold in the food establishments [17]. In each dimension, a set of indicators was created consisting of dichotomous variables (yes or no) according to the AUDITNOVA tool. A range of scores was assigned to each indicator depending on the healthiness of the consumer's food environment.

Based on the food trade grouping methodology proposed by the *Câmara Interministerial de Segurança Alimentar e Nutricional* (Interministerial Chamber of Food and Nutritional Security)

[12], and from the data obtained with the application of AUDITNOVA, we were able to classify the food commercial establishments into the following categories, group 1: with the predominant sale of fresh foods, (composed of fishmongers, fruit and vegetable stores, butchers); group 2: mixed establishments, where the sale of ultra-processed foods is more than 50% of total sales, (consisting of hypermarkets, bakeries, dairy retailers, food product retailers in general); group 3: food retailers with a predominance of ultra-processed food sales (convenience stores, sweets retailers). According to Monteiro et al. [29], the NOVA classification aims to characterize the type of food based on its degree of processing.

The food establishments were further classified using the Consumer Food Environment Healthiness Score (CFEHS), a tested and validated tool, which is composed of two dimensions, one related to availability and promotional price, called the food dimension, and the other related to advertising, called dimension of the environment. For the analyses, a scale from 0 to 100 points was standardized: the higher the score (closer to 100), the healthier the food sold in the retail stores [27]. For the dimension of the environment, scores were assigned in accordance with the Food Guide for the Brazilian Population [2] which considers advertising and food placement strategies in audited retail stores, such as displays, tabloids and folders. Positive scores were associated with the group of fresh and minimally processed foods, thus constituting a facilitator for healthy eating, and negative scores were related to foods in the ultra-processed group, constituting a barrier to healthy eating.

Based on the scores obtained in the evaluation instruments of food sales establishments, a descriptive statistical analysis of the sample was carried out, including the determination of the median, the percentile distribution (P25 and P75) and a detailed description of the data relating to the classification of the establishments into healthy, unhealthy and mixed categories [30]. For this analysis, the data were initially typed and organized into spreadsheets in Microsoft Excel Worksheets, where data from each establishment were grouped. Subsequently, the data set was transferred to the Stata 16.0 program, where it was processed to obtain the results.

R E S U L T S

In our study 21 food sales establishments were retrieved and audited; they were located around three municipal public schools in the municipality of Governador Celso Ramos. In Figure 1, the location of the establishments surveyed, was mapped using GPS and was marked using the Google Earth software. Data collection time ranged between 10 minutes and 36 minutes (average time: 21.5 minutes), depending on the size of the establishment and the variety of products sold.

The businesses audited (n=21), included 47.62% (n=10) neighborhood markets, 23.81% (n=5) bakeries, 14.29% (n=3) butchers/fishmongers, 9.52% (n=2) private grocery stores and 4.76% (n=1) supermarkets.

Among the businesses audited, in the group of fresh and minimally processed foods, the foods most commonly foundwere rice and eggs, available in 90.5% (n=19) and 81% (n=17) of the establishments, respectively. In turn, fish andcorn on the cob were the foods with the least availability, found in only 19% (n=4) of the establishments. The categoryof culinary ingredients comprising oil, olive oil, salt, crystal sugar, refined sugar and butter was identified in 95.2%(n=20) of the establishments audited. In the processed foods category, French bread (bread rolls) was found in 42.9%(n=9) of the establishments. The group of ultra-processed foods included 95.2% (n=20) sugary drinks (soft drinks,nectar, powdered drinks), followed by 85.7% (n=18) candies/chocolate/ stuffed biscuits; the lowest percentage foundin this category was breakfast cereals, available in 28.6% (n=6) of the establishments (Table 1).

Legend

Schools (n=3)

Detailed Network Buffer (800 meters)

Street Network (OSM)

Geographical Boundaries of Governador Celso Ramos

Neighbouring Cities (Municipalities)

Commercial Establishment

Neighborhood Market

Bakery

Butcher/Fish Shop

Supermarket

Grocery Stores/Private Hortifruti

Imagery Source: OSM - Open Street Map©

Projected Coordinate System: SIRGAS 2000
Universal Transverse Mercator Coordinate System: Zone 22S

Produced by:

LOPES AAS, PhD
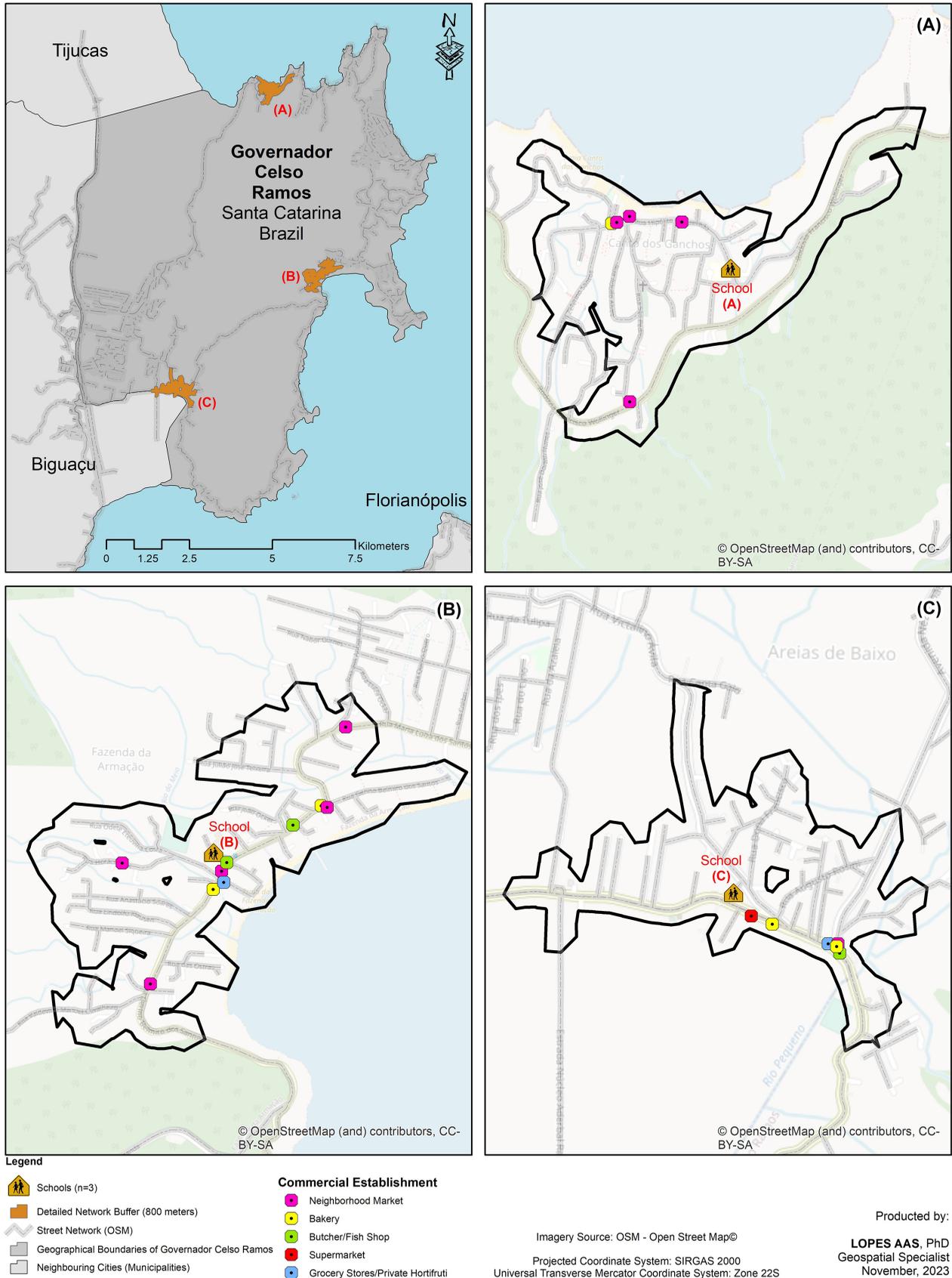Geospatial Specialist
November, 2023

Figure 1 – Distribution of food-selling establishments audited in the 800m buffer zone, around three municipal public schools in the Governador Celso Ramos municipality, 2022.

Table 1 – Availability of fresh and minimally processed, processed and ultra-processed food categories in audited establishments in the Governador Celso Ramos municipality, 2022.

Food available (percentage of stores)*	N	%
Fresh and minimally processed category		
Fruits (orange, banana, papaya, apple, watermelon, other fruits)	12	57.1
Vegetables (tomato, onion, lettuce, carrot, zucchini, chayote, green chilli, other vegetables)	13	61.9
Roots and tubers (potatoes, cassava, other roots)	14	66.7
Eggs	17	81
Beef	10	47.6
Chicken meat	11	52.4
Fish	4	19
Bean	15	71.4
Rice	19	90.5
Green corn on the cob	4	19
Culinary Ingredients Category		
(oil, olive oil, salt, crystal sugar, refined sugar, butter)	20	95.2
Processed category		
French bread	9	42.9
Ultra-processed category		
Ultra-processed meats (sausages and hot dog)	17	61
Dairy beverage	13	61.9
Instant noodles	16	76.2
Ready seasoning	15	71.4
Loaf bread	15	71.4
Morning cereal	6	28.6
Ready-made pizza	10	47.6
Ice cream	11	52.4
Candies, chocolate, stuffed biscuit	18	85.7
Sugary drinks (soft drinks, nectar, powdered drink)	20	95.2
Corn snacks	17	81

Note: *Stores that had the availability of at least 1 type of food in the food groups studied were included.

In the food environment dimension, food availability and promotional prices were surveyed and given a score only for foods that are markers of healthy eating, such as fruits, vegetables, beans and fish, as well as for unhealthy foods (soft drinks, nectar and sweets). Thus, the scores of each food outlet were computed and it was found that private grocery stores/fruit and vegetable stores catering fresh and minimally processed foods had the highest scores (69.05), followed by neighborhood markets (50.6). In the same dimension, with the lowest score (29.76) were bakeries that predominantly sell ultra-processed foods.

As shown in Table 2, private fruit and vegetable stores exhibited the highest score (75) associated with the advertising of healthy foods, followed by butchers and fishmongers (score 52.94). Supermarkets had the lowest score (26.47), as they offer advertising for healthy and unhealthy products, featuring foods from the ultra-processed group on display shelves and at the gondola ends. According to the CFEHS, it was found that private fruit and vegetable stores/grocery stores had the highest score (72.02), indicating greater healthiness in the consumers' food environment. The lowest healthiness was observed in bakeries (score 25.74), which predominantly sold ultra-processed foods.

Table 3 presents the median and the quartiles (P25 and P75), of the characteristics of food sales around the three schools. Higher scores were observed in school A, suggesting that it has higher levels of healthiness in the consumer's food environment compared to other schools.

Table 2 – Consumer Food Environment Healthiness Score and its food and environmental dimensions according to the different categories of food retailers, Governador Celso Ramos municipality, 2022.

Food Retailer	Total	Food Dimension Score			Room Dimension Score			CFEHS (Food and Environmental Dimension)		
	N	Median	P25	P75	Median	P25	P75	Median	P25	P75
Neighborhood markets	10	50.6	47.6	57.14	44.12	35.29	44.12	46.17	42.89	50.63
Bakeries	5	29.76	21.42	30.95	26.47	26.47	26.47	25.74	24.29	28.11
Butcher/Fishmongers	3	41.67	39.26	45.23	52.94	44.11	52.94	46.11	44.67	47.3
Private grocery stores/vegetable stores	2	69.05	65.48	72.62	75	70.58	79.41	72.02	71.6	72.44
Supermarket	1	50	50	50	26.47	26.47	26.47	38.24	38.24	38.24
Total	21	47.61	34.5	54.76	44.12	26.47	52.94	44.68	37.39	47.3

Note: CFEHS: Consumer Food Environment Health Score.

Table 3 – Consumer Food Environment Health Score and its food and environmental dimensions around schools in Governador Celso Ramos municipality, 2022.

School	Total	Food Dimension Score			Environ Dimension Score			CFEHS (Food and Environmental Dimension)		
	N	Median	P25	P75	Median	P25	P75	Median	P25	P75
A	5	48.8	47.61	54.76	44.12	44.12	44.12	46.46	45.87	50.63
B	10	45.83	39.29	57.14	44.12	35.29	52.94	44.67	39.32	47.30
C	6	38.09	21.76	50.00	30.88	26.47	44.11	35.67	28.12	44.67

Note: CFEHS: Consumer Food Environment Health Score.

Table 4 shows the availability of foods on sale according to category. In the fresh and minimally processed category, there were offers for beef, chicken, fish and rice in 4.7% (n=1) of the establishments. In the ultra-processed food category, sandwich and chocolate biscuits were offered in 19% (n=4) of the outlets. Furthermore, sweets and nectar were found in 9.5% (n=2) of the establishments as well as promotion of powdered soft drinks and corn snacks in 4.7% (n=1) of the outlets.

Table 4 – Availability of food on promotion according to the fresh and minimally processed food category in audited food retailers. Governador Celso Ramos, 2022.

Promotional foods available (percentage of stores)*	N	%
Fresh and minimally processed category		
Beef	1	4.7
Chicken meat	1	4.7
Fish	1	4.7
Rice	1	4.7
Ultra-processed category		
Stuffed cookie	4	19
Chocolates	4	19
Candy	2	9.5
Nectar	2	9.5
Powdered drink	1	4.7
Corn snacks	1	4.7

Note: *Stores that had the availability of at least 1 type of food in the food groups studied in the promotion were included.

DISCUSSION

In this study, we could evaluate the healthiness of the food sales establishments located around the schools and that were audited; they were attributed scores that encompass both the dimensions of food availability and environmental dimensions such as pricing, advertising and positioning strategies. Private fruit and vegetable stores/grocery stores had a greater supply of fresh and minimally processed foods and advertising of healthy food in these establishments also scored higher.

In a systematic review of the food environment around schools, a direct association was identified between the presence of establishments such as fast food restaurants, convenience stores and grocery stores and overweight/obesity in children and adolescents [31] .The review presented different methods of classification, location and analysis of food retail establishments, a situation that can make it difficult to observe the association between the children and adolescents' nutritional status and the environment [31].

In our study, we found that the type of establishments around schools were mostly neighborhood markets; this can be explained by the fact that it is a small municipality, without the presence of large food marketing networks. As presented by Costa et al. [32], in a study carried out in Brazil, neighborhood markets are the second type of establishment that most contributes to household food availability (16.5%), selling a variety of foods similar to that of hypermarkets.

A study carried out in Belgium by Smets and Vandevijvere [33] assessed the changes in the consumer food environment around schools over 12 years. They found that these food environments were unhealthy, with children and adolescents having a great exposure to unhealthy foods, such as those available in convenience stores and fast food. Furthermore, the number of bakeries and greengrocers that sold fresh and minimally processed foods and stores that sold products of animal origin decreased during the study monitoring period [33].

These food establishments' exposure profile around schools was also identified in Brazil in different regions. Leite et al. [34] evaluated the presence of food sales stores, according to the degree of food processing, around three public schools in São Paulo. The study found that the ultra-processed foods outlets were significantly closer to schools than those that offered less processed foods. These results suggest that students are exposed to an environment that encourages the consumption of ultra-processed foods through easier access in the stores investigated. The Food Guide for the Brazilian Population [2] suggests that shopping should preferentially occur in outdoor markets, grocery stores that sell fruits, vegetables, fresh and minimally processed foods, including organic and agroecological-based foods, or in other places such as markets and supermarkets where you can find different types of food.

In Mexico, Alvear-Galindo et al. [35] observed a similar scenario in a study carried out with students with the aim of identifying the eating behavior of schoolchildren around schools and identified that schoolchildren reported consuming soft drinks and canned juices in high frequency and quantity (80%) and low consumption of foods of animal origin, such as meat, sausages and eggs. In addition, they consumed highly caloric processed dairy products with low protein content. They also observed that 30% of children fed 4 or 5 times a day, while 10% fed once or twice a day. These results were associated with the anthropometric characteristics of those students, where 37.6% were overweight or obese and 12% were underweight [35].

In the Brazilian framework, Costa Peres et al. [31] observed that the most common establishments around schools were cafeterias, restaurants, and bars. Schools located in higher-income areas tended to have a greater surrounding concentration of these establishments, except for grocery stores and supermarkets. This predominance of establishments that sell ultra-processed foods, especially bars and cafeterias, exposes children and adolescents to an unhealthy food environment [31]. This evidence highlights the influence of the economic factor on food choices, where economically disadvantaged individuals face financial restrictions which lead to diets with a low share of fruits and vegetables, and greater consumption of high-calorie foods, such as processed cereals, oil and sugar [36].

Still in Brazil, an investigation carried out in areas around public and private schools in Rio de Janeiro, considered all formal and informal food outlets within a radius of 500 m, from the school gates. There was a greater supply of ultra-processed foods, with a highest rate of sweets (candies, gum, bonbons and chocolates), biscuits (salty and sweet), popsicles, processed drinks and soft drinks, compared to fresh foods and/or minimally processed food around both private and public schools [37].

In London, Smith et al. [38] carried out a study around schools between 2001 and 2005 and evaluated, using a questionnaire, the adolescents' diets. Eating habits were addressed in the questionnaire and food sales establishments around three schools were identified. Longitudinal analyses showed a decrease in mean healthy (-1.12, margin of error 0.12) and unhealthy (-0.48, margin of error 0.16) diet scores. Furthermore, there were significant positive associations between distances traveled to grocery stores and healthy diet scores. Significant negative associations between proximity to takeout food outlets and unhealthy diet scores also resulted in small parameter estimates.

In Ireland, Kelly et al. [39] carried out research on the impact of food environments on students' food choices. The results revealed that students were attracted to discount outlets, candy counters, and sweets, which influenced their food choices. Factors such as price, convenience and variety played a relevant role in preference for establishments and foods. Student perceptions of the food environment provided valuable information about resources that can be manipulated to enable healthy choices. These factors can act as both facilitators and barriers, as is evident in data associated with the use and selection of foods by adolescents.

In this scenario, the implementation of food advertising regulation is extremely important to improve the outlook of food consumption among schoolchildren around schools. Corroborating the findings of Alvear-Galindo et al. [35], in our study, a high availability of sugary drinks was found in the audited establishments. Purchases of drinks with high sugar content decreased significantly after the implementation of the Food Labeling and Advertising Law in Chile, with purchase volume decreasing by 23.7% [40]. Hence, the influence of public policies in modifying the consumer's food environment is evident, since the promotion of ultra-processed foods demonstrates a greater supply and consequent impact on the health of schoolchildren. The results found show how information and advertising about ultra-processed foods, as well as the low frequency of promotions and advertising of fresh and minimally processed foods predominate in most food outlets, resulting in a lower score based on the CFEHS criteria [27].

In New Zealand, Vandevijvere et al. [41] found that around 65% of foods and beverages, especially sugary drinks and fast food, advertised in locations around schools did not comply with the World Health Organization criteria for marketing aimed at children. This enhances the perception that schools are exposed to intense advertising of unhealthy foods aimed at children, which causes a negative impact on their eating habits [42]. Furthermore, the growing prevalence of obesity appears to coincide with the growth of the food and beverage industry's marketing budget geared to children and youth, as energy-dense, nutrient-poor foods and beverages make up the majority of products marketed in the United States [43].

In our study, few fresh and minimally processed foods were offered as promotion items with the exception of beef, chicken, fish and rice, for which promotional offers were observed. In the ultra-processed food category, many products had some type of promotion (stuffed biscuits, chocolates, sweets, nectar, powdered drinks and corn chips), which is a barrier to healthy eating. This fact can be explained by the change in prices of the basic food basket items, in connection with the COVID-19 pandemic. In 2021, the increase in food prices of items such as cereals, legumes and oilseeds, and especially of rice reached 41.8%, meat 16.0% and oil and fats 41.2%, with emphasis on

soybean oil in the culinary ingredients category whose price increased 64.1%, impacting the supply and demand of food in food sales establishments [44].

Changing the food environment around schools has been listed as one of the strategies for reversing the scenario of childhood obesity. Among the actions foreseen in the implementation of the *Estratégia Nacional para a Prevenção e Atenção à Obesidade Infantil* (National Strategy for the Prevention and Care of Childhood Obesity) [45], is the training of local food traders and retailers, presenting them with strategies to make the food trade healthier, improving the availability and accessibility to healthy foods in small municipalities. Another relevant action for changing the consumer's food environment is giving support to managers who wish to map the surroundings of schools, from the perspective based on the Food Guide for the Brazilian Population, in order to guide consumers in choosing healthier food establishments for their food purchases.

Another relevant aspect of our study was the fact that the economy of the municipality of Governador Celso Ramos is based on fishing activities, and stands out in the capture and distribution of fish and seafood, encompassing industrial, artisanal fishing and mariculture [46]. However, the number of fish selling establishments was relatively smaller when compared to other types of food outlets, which can be explained by the fact that fishermen sell directly to the end consumer, but were not found around schools [47].

Studies like ours, which assess the food environment around schools, help diagnosing territories in which the presence of children and adolescents is relevant. Schoolchildren are often exposed to an unhealthy food environment, which can be challenging in preventing obesity and also in the formation of appropriate eating habits. Furthermore, this study can help propose improvements in the population's eating and nutritional conditions, fostering a food environment that respects and preserves food choices aligned with a sustainable diet and better adapted to the contexts in which people live. We suggest that more audit studies be carried out in the retail trade around schools associated with different parameters such as nutritional status, food consumption, and students' health conditions.

This study has limitations with regard to the audit tool, AUDITNOVA, as the instrument does not allow auditing some establishments, such as food retailers (cafeterias, restaurants and bars), albeit these food outlets can directly impact the availability of food around schools. In future studies, we intend to include the assessment of these types of establishments.

As strengths of our work, we highlight the fact that it involved a small municipality and has a robust conceptual model that supports it and used instruments validated for the Brazilian framework; in addition it was based on the NOVA food classification [48]. The foods that make up the instrument were those that are most frequently purchased by the Brazilian population, according to data from the *Pesquisa de Orçamentos Familiares* (Consumer Expenditure Survey) 2008-2009 [49]. It is noteworthy that the data collection team underwent training on the instrument with a methodological manual and a pilot test was carried out to ensure the quality of the information collected. Another important factor was the use of the buffer zone considering street connectivity and not the Euclidean buffer, which measures the distance between two points in a straight line [23].

CONCLUSION

The consumers' food environment around schools in the municipality under study is characterized by the large availability of establishments that sell ultra-processed foods, a condition that could be a barrier to adequate and healthy eating. It is known that availability, prices and advertising of ultra-processed foods around schools can negatively influence students' eating habits.

Therefore, it is necessary to adhere to strategies that aim to encourage the consumption of fresh and minimally processed foods, as extensively covered in the Food Guide for the Brazilian Population [2].

The consumers' food environment plays an essential role in the health of schoolchildren and prevention of obesity. Therefore, it is essential to implement policies and strategies that promote a healthy food environment, with emphasis on fresh and minimally processed foods, expanding consumer access to healthy foods. Therefore, the continuous assessment of the consumers' food environment through audit tools can be a valuable contribution to the development of policies, actions and regulations that promote health and combat chronic non-communicable diseases, ensuring schoolchildren the right to healthy nutrition.

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CONTRIBUTORS

KC PINHEIRO participated in the conception and planning of the work and data analysis; as well as in the writing of the manuscript. G ROCKENBACH coordinated the project, reviewed the content of the manuscript and approved its final version. RS FIGUEIRA participated in the writing of the manuscript. PF HINNIG performed the statistical analysis and interpretation of the data. AAS LOPES worked on the analysis of geospatial data and their graphical representation. EN CORRÊA conceived and designed the cross-sectional study, coordinated the project, reviewed the content of the manuscript and approved its final version. All authors contributed critically to the discussion and interpretation of the data and reviewed and approved the final manuscript.