



Applied nutritional investigation

Temporal trend of adequate consumption of fruits and vegetables and associated factors in schoolchildren aged 7 to 14 years in a capital city in southern Brazil, from 2007 to 2019

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ABSTRACT

Objective: This study aimed to verify the trend of adequate fruits and vegetables (FV) consumption and its associated factors in schoolchildren aged 7 to 14 years in Florianópolis, SC, from 2007 to 2019.

Methods: This was a cross-sectional panel analysis of a total of 7,003 schoolchildren, with the use of anthropometric, sociodemographic, and FV consumption data, collected in three waves during the Prevalence Study of Obesity in Children and Adolescents (EPOCA) conducted during the years 2007, 2012/2013, and 2018/2019. Multiple logistic regression analysis was performed to test the association between FV consumption and the independent variables. Model adequacy was assessed through tests of global significance, multicollinearity, and calibration.

Results: A significant temporal association was observed (joint Wald test: $\chi^2 = 10.29$; $p = 0.0058$), absence of multicollinearity (mean variance inflation factor [VIF] = 1.55; maximum = 2.22), and good calibration (Hosmer–Lemeshow: $p = 0.41$). Adequate FV consumption was significantly associated with the private school network and the third evaluation wave (2018/2019). Students attending private schools were more likely to report adequate FV consumption than those from public schools. Overall, a reduction in the prevalence of adequate FV consumption was observed between 2007 and 2018/2019.

Conclusion: These findings indicate a declining trend in adequate FV intake among schoolchildren and highlight disparities between public and private schools, reinforcing the need for continuous strategies to promote healthier dietary patterns in both educational settings.

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Introduction

Adequate consumption of fruits and vegetables (FV) has been recognized for decades as a fundamental pillar for the prevention of chronic non-communicable diseases (NCDs) [1]. The World Health Organization (WHO) recommends a minimum daily intake of 400g FV, equivalent to five servings, as an essential measure for cardiovascular protection and maintenance of a healthy metabolism [1–3]. Scientific evidence shows that regular FV intake contributes to the reduction of blood pressure in overweight and obese individuals, decreasing the risk of cardiovascular disease

(CVD) and premature mortality [4–6]. Furthermore, the anti-inflammatory and antioxidant properties, as well as the presence of dietary fiber and phytochemicals in FV, improve insulin sensitivity and reduce oxidative stress, mechanisms recognized in the literature as determinants of metabolic health [7,8].

Despite a robust scientific basis, fruits and vegetables consumption remains below the recommended levels in much of the world [1]. In children and adolescents, this insufficiency is especially concerning, in view of the importance of adequate consumption of this food group for establishing lasting healthy eating habits and for healthy growth and development [2]. Therefore, many countries have developed additional recommendations for this age group, taking into account the particularities related to nutritional needs and eating habits [9].

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The international literature indicates that insufficient FV consumption among schoolchildren is influenced by a set of factors, including aspects of the family and school environment, parental education, nutritional status, among others [10–12]. A large-scale investigation conducted in Texas (USA), with over 650,000 schoolchildren in a multiethnic population, found a significant association between FV consumption and demographic factors, including sex, conditions on each side of the border, race/ethnicity, and socioeconomic level [12].

In Brazil, research has enhanced this multifactorial perspective, indicating that fruits and vegetables consumption among schoolchildren is associated with the variables family and educational environment, as well as the individual and contextual characteristics of children and adolescents [13–16]. Studies conducted in Florianópolis (SC), for example, have shown an association between adequate fruits and vegetables consumption and sociodemographic factors [15,16].

In the scientific literature, analyses of long-term temporal trends in FV consumption among schoolchildren are still scarce, particularly in middle-income countries undergoing rapid food and nutritional transitions [17,18]. Therefore, conducting studies on temporal analyses of FV consumption in this age group is relevant and timely, both to fill the existing knowledge gap and to identify changes in dietary patterns over time, and to support the development and evaluation of public policies in the fields of health and nutrition.

Considering the relevance of FV to the health of children and adolescents and the importance of enhancing government strategies to encourage adequate consumption of these foods, this study aimed to examine the temporal trend of adequate FV consumption and its associated factors in schoolchildren aged 7 to 14 years in Florianópolis (SC), from 2007 to 2019.

Method

Study type and sample

This is a trend analysis of three cross-sectional panels involving children and adolescents aged 7 to 14 years from Florianópolis, Santa Catarina State, Southern Brazil, using data from the Estudo de Prevalência da Obesidade em Crianças e Adolescentes (EPOCA, Study of Prevalence of Obesity in Children and Adolescents), collected in 2007, 2012/2013, and 2018/2019 [15,16,19].

The methodological procedures for data collection and review were standardized and were similar in the three procedures. Schoolchildren who attended the data collection sessions and

whose parents/guardians signed the Free and Informed Consent Form were included in the study. Pregnant adolescents and children/adolescents with disabilities that did not allow anthropometric assessment were excluded from the study.

The parameters used for calculating the sample selection and size in the three waves are summarized in Table 1, and have been described in more detail in other papers [15,16,19].

To estimate the sample size for EPOCA, the following parameters were used in the year 2007: the school population in 2006 ($n = 53,679$, according to the Municipal Health Department), prevalence of 22.1% overweight (including obesity) for children aged 7 to 10 years and 12.6% for children aged 11 to 14 years, with an acceptable margin of error of 3 percentage points and a design effect of 1.5. After adding 10% for losses, the necessary sample size was estimated as being 3100 students. Out of a total of 87 schools, 17 were randomly selected, stratified by geographic area and school type (public and private). Data were collected from 2826 students [15].

In the 2012/2013 and 2018/2019 panels, the sample size estimate was based on information from the 2010 School Census ($n = 45,247$ students and 85 schools) and 2017 ($n = 34,318$ students and 82 schools); prevalence of overweight including obesity of 38% in the year 2013 and 39% in 2019; with an acceptable margin of error of 3.5 percentage points, a 95% confidence interval, and a design effect of 1.8. The required sample size was doubled to allow comparisons with previous surveys and to allow subgroup analysis, with an additional 10% for potential losses and refusals. The final sample consisted of 2,880 schoolchildren in 2012 [16] and 2891 in 2018 [19].

The sampling procedure was carried out by clusters, with the primary units being the schools in the municipality; these schools were allocated into strata according to their administrative region and type of school. In each stratum, the sample units were randomly selected, totaling 30 schools. The selection of classes was carried out by a systematic random sampling process based on the list of enrolled students (2012/2013) and the list of available classes (2018/2019). All students from the selected classes were asked to participate in the survey. Data were collected from 2506 students in 2012/2013 and from 1671 students in 2018/2019 [16,19].

Data collection and variables investigated

In the three panels investigated, data collection was carried out during the following periods: May to October 2007, September 2012 to June 2013 and November 2018 to December 2019.

The exposure variables investigated were biological (sex and age), socioeconomic (mother's education and type of school net-

Table 1

Sample of the three cross-sectional cuts in the years 2007, 2012/2013 and 2018/2019. ÉPOCA Project, Florianópolis, SC, Brasil.

Parameters	2007 [15]	2012/2013 [16]	2018/2019 [17]
School population aged 7–14 in the municipality	53,679	45,247	34,318
Total number of elementary schools in the municipality	87	85	82
Total number of schools included in the survey*	17	30	30
Prevalence of Overweight/Obesity	10.0 %	38.0%	39.0%
Sample error	3 %	3.5% (two-tailed) with a 95% confidence interval	3.5% (two-tailed) with a 95% confidence interval
Design effect	1.5	1.8	1.8
Additional (Losses/Refusals)	10%	10%	10%
Expected Final Sample	3,100	2,880	2,891
Total number of schoolchildren investigated	2,826	2,506	1,671
Total number of schoolchildren called	2,936	4,082	6,133
Membership fee	79%	61.4%	27.2%

*The schools were randomly selected based on geographic region, type of administration (public and private), and number of students.

work), and the child/adolescent's body weight status. The variables sex, age, and school network were collected from lists provided by the schools. The mother's education was obtained through a self-administered questionnaire distributed to parents or guardians. Body weight status was measured using anthropometric measurements following the standard procedure proposed by Lohman et al. [20] using a private room in the school. Body weight was measured once using a Marte electronic scale. Height was also measured once using an Altuxata portable stadiometer. Body weight status was categorized as: overweight (overweight/obesity) and underweight (low weight/eutrophy), based on the body mass index (BMI-z) Z-score for age and sex, according to the classification proposed by the World Health Organization [21].

The outcome variable (adequate consumption of fruits and vegetables) was collected in the 2007 and 2012/2013 panels through the application of the 3rd version of the *Questionário Alimentar do Dia Anterior* (QUADA Previous Day's Food Questionnaire), which consists of a 24-h food recall, illustrated and structured to qualitatively assess the schoolchildren's food consumption. The questionnaire helps obtaining food consumption data from six meals ordered chronologically (breakfast, morning snack, lunch, afternoon snack, dinner, and evening snack). For each meal, there is a 21 foods or food groups illustration: crackers and bread; chocolate milk; coffee with milk; milk; yogurt; cheese; rice; soda; sweets; packaged snacks; French fries; pizza and hamburger; fruits; beans; pasta; fish and seafood; beef and chicken; natural juice; vegetables; vegetable soup and greens. The QUADA was validated in schoolchildren aged 6 to 11 years and showed high sensitivity and specificity for most food items, indicating that the instrument is valid for assessing the schoolchildren previous day's food consumption [22].

In the 2018/2019 panel, dietary data were collected using the online questionnaire Web-CAAFE (Food Consumption and Physical Activity Monitoring System for Schoolchildren), an updated web-based version derived from the previously used illustrated dietary assessment instruments and developed and validated for schoolchildren in the Florianópolis municipal school system [23]. The food consumption section consists of six predefined meals set in chronological order (breakfast, morning snack, lunch, afternoon snack, dinner, and evening snack). The presence of an animated character (avatar) helped the child identify which meal was being described at that moment, situating it in the time of the day it occurs, based on quick definitions. For breakfast, the avatar explained: "breakfast is the first meal we have in the day after waking up," and for each subsequent meal, a definition was presented. For each meal, images of food items or food groups were displayed on the computer screen so that the children could make their own food selection (rice, vegetables, greens, vegetable soup, beans, *farofa*, pasta, instant noodles, French fries, meat/chicken, eggs, fish/seafood, corn/potatoes/mashed potatoes, sausage, breakfast cereal, fruits, bread, cheese bread, simple cake, water, cheeses, coffee with milk, milk, yogurt, chocolate milk, fruit juices, filled cookies, soft drinks, sweets (chocolate, candies, ice cream, cake with frosting), "packaged snacks" such as chips, snacks such as sandwiches/pizza/hot dogs/savory pastries).

The dietary assessment instruments used across the study waves were part of the same methodological framework and underwent a process of progressive refinement over time. The QUADA and Web-CAAFE are qualitative, illustrated questionnaires specifically developed for schoolchildren and designed to assess food consumption on the previous day. Both instruments collect information according to six chronologically ordered meals and use visual representations of foods and food groups to facilitate recall and reporting by children. The Web-CAAFE was developed

from the earlier paper-based instruments used in the previous panels, preserving the same conceptual approach while incorporating technological and usability improvements, such as online administration, an animated avatar, and an expanded list of food items and groups. Previous validation studies demonstrated acceptable validity and reproducibility for both instruments, supporting their use in monitoring dietary behaviors over time among schoolchildren [22,23].

For the analysis, FV consumption was defined as the reported intake of fruits, leafy vegetables and legumes. Since the QUADA and web-CAAFE were not designed to obtain information on frequencies and quantities, adequate FV consumption was defined when the intake of fruits plus vegetables occurred five or more times per day, and inadequate when the intake of fruits and vegetables occurred less than five times per day, in an adaptation based on the WHO's recommended intake of fruits and vegetables [1–3].

Data analysis

The variables assessed included: sex (male or female), age (7–10 or 11–14 years), maternal education (0–8, 9–11, or ≥ 12 years schooling), type of school (public or private), body weight status (without overweight/obesity or with overweight/obesity), and consumption of fruits and vegetables (< 5 lt; 5 times/day or ≥ 5 times/day). These variables were described considering the sample weights, with estimated frequencies and relevant 95% confidence intervals (95% CI), stratified by year of data collection (2007, 2013, and 2018).

For the temporal trend analysis, the databases from each cross-sectional panel were combined, creating the variable "year of evaluation" (2007, 2013, or 2018). Initially, the independent variables were evaluated in simple logistic regression models, with fruits and vegetables consumption as the outcome. Variables that presented a p -value < 0.20 at this stage were included in the final logistic regression model.

The adequacy of the model was examined through global significance tests, multicollinearity diagnosis, and calibration analysis. Global significance was assessed using the joint Wald test, multicollinearity using the variance inflation factor (VIF), and model calibration using the Hosmer–Lemeshow test.

The adjusted probabilities of adequate fruits and vegetables consumption, estimated from the final model, were displayed graphically and stratified by year of evaluation.

Data analysis was performed using the Stata software (Stata Corporation, College Station, Texas) version 18.0, using the survey (svy) command for complex samples. Associations with a p -value < 0.05 were considered statistically significant.

Ethical aspects

The three studies that originated the 2007, 2013, and 2019 panels were approved by the Ethics Committee of the Federal University of Santa Catarina, in accordance with the norms established by Resolutions 196/96 and 466/2012 of the National Health Council, as per protocols 028/06 dated April 24, 2006; 120.341 dated August 8, 2012; and 2730 239 dated June 22, 2018, respectively.

Results

This study included a total of 7003 schoolchildren (2826 in 2007, 2506 in 2012/2013, and 1671 in 2018/2019). A summary of the biological and sociodemographic characteristics of the schoolchildren investigated in the three panels can be seen in Table 2. In all the panels, a higher proportion of females was observed (2007,

Table 2
Characteristics of schoolchildren aged 7–14 years, Florianópolis (SC), Brazil, 2007, 2013 and 2018.

Variables	2007		2013		2018	
	n (%)	95%CI	n (%)	95%CI	n (%)	95%CI
Total	2820 (100)	-	2506 (100)	-	1671 (100)	-
Sex						
Female	1465 (51.3)	48.8–53.7	1334 (56.5)	53.3–59.6	935 (53.1)	50.3–55.8
Male	1355 (48.7)	46.3–51.2	1172 (43.5)	40.4–46.7	736 (46.9)	44.2–49.7
Age (years)						
7–10	1227 (44.1)	37.1–51.4	1531 (63.2)	58.7–67.5	930 (59.0)	50.3–67.1
11–14	1593 (55.9)	48.5–62.9	975 (36.8)	32.4–41.2	626 (41.0)	32.9–49.7
Education network						
Public	2126 (66.0)	44.0–82.6	1637 (63.5)	52.9–72.9	1052 (66.7)	24.6–92.5
Private	694 (34.0)	17.3–55.9	869 (36.5)	27.0–47.0	619 (33.3)	7.5–75.4
Mother's education level (years)						
0–8	959 (30.9)	22.0–41.6	637 (24.5)	20.2–29.4	322 (10.2)	2.9–30.4
9–11	943 (30.3)	21.8–40.3	849 (36.2)	30.8–41.8	499 (23.5)	13.1–38.3
≥12	823 (38.8)	23.6–56.4	903 (39.3)	31.3–47.8	776 (66.3)	39.8–85.4
Body weight status						
Without OW/OB	1981 (70.3)	67.4–72.9	1575 (65.5)	63.1–67.8	1028 (66.2)	63.4–68.9
With OW/OB	839 (29.7)	27.1–32.5	793 (34.5)	32.2–36.9	517 (33.8)	31.1–36.6
FV consumption						
<5x/day	2711 (96.3)	95.3–97.0	2406 (95.9)	94.0–97.1	1628 (96.5)	95.9–97.7
≥5x/day	109 (3.7)	2.9–4.7	100 (4.1)	2.8–5.9	43 (3.5)	2.2–4.1

95% Confidence Interval: 95% confidence interval; OW/OB: overweight/obesity; FV: fruits and vegetables.

51.3%; 2012/2013, 56.5%; and 2018/2019, 53.1%). Regarding the age range, in 2007 the majority (55.9%) was composed of schoolchildren aged 11 to 14 years, while in 2012/2013 and in 2018/2019, children aged 7 to 10 years were predominant, accounting for 63.2% and 59.0%, of the total sample respectively. It was also observed that the most prevalent school system across all data points was the public school system (66%, 63.5%, and 66.7%, respectively). The variable of mother's education level greater than or equal to 12 years of schooling (highest education level) was predominant in all panels, being 38.8%, 39.3%, and 66.3%, respectively. As for body weight status, the overweight/obesity category showed rates of 29.7%, 34.5%, and 33.8%, respectively. Consumption of FV less than 5 times a day was predominant in all three panels (96.3%, 95.9%, and 96.5%, respectively).

Figure 1 presents the adjusted probability of adequate FV consumption in the study's cut-off years. We can observe that the trend of adequate FV consumption decreased over the years.

Table 3 presents the crude and adjusted odds ratios and *p*-values of the association between the exposure variables and the investigated outcome (adequate FV consumption) in the three panels of the study. School network, mother's education level, and year of the evaluation panel were associated with adequate FV

consumption. However, in the adjusted model, only the type of school network (private) and the third year of the evaluation panel (2018/2019) were statistically relevant for the adequacy of FV consumption, observing that students who attended private schools had 83% more odds of adequate FV consumption (OR 1.83, 95% CI 1.32–2.53) compared to those attending public schools. Regarding the evaluation years, the data indicate a significant decrease in adequate fruits and vegetables consumption between 2007 and 2018/2019 (OR 0.55, 95% CI 0.38–0.79).

The adequacy of the analysis model was evaluated through global significance tests, multicollinearity diagnosis, and calibration analysis. The overall effect of the year variable was evaluated by the joint Wald test, indicating a significant temporal association ($\chi^2 = 10.29$; $p = 0.0058$). No multicollinearity was observed among the covariates, with low values of the variance inflation factor (mean VIF = 1.55; maximum VIF = 2.22). The model calibration proved adequate, as indicated by the Hosmer–Lemeshow test ($p = 0.41$).

Discussion

This study assessed the temporal trend and factors associated with adequate fruits and vegetables (FV) consumption among schoolchildren aged 7 to 14 years in Florianópolis (SC) over a 12-year period (2007–2019). The results show that the majority of schoolchildren in the three panels assessed, did not reach the minimum FV consumption recommendation established by the World Health Organization (WHO) reflecting an insufficient dietary pattern; this pattern has actually been observed in different children and adolescents populations around the world [24–26].

In the United States, dietary data for children and adolescents extracted from the National Health and Nutrition Examination Survey (NHANES) conducted from 2015 to 2018 have shown that most of this population does not consume adequate amounts of vegetables or fruits in a typical day, with particularly low intake of dark green and orange-color vegetables [27]. Data from samples of children and adolescents from the California Health Interview Surveys conducted from 2017 to 2020 indicated low daily FV consumption. Among children aged 5 to 11 years, only 28.8% consumed 5 or

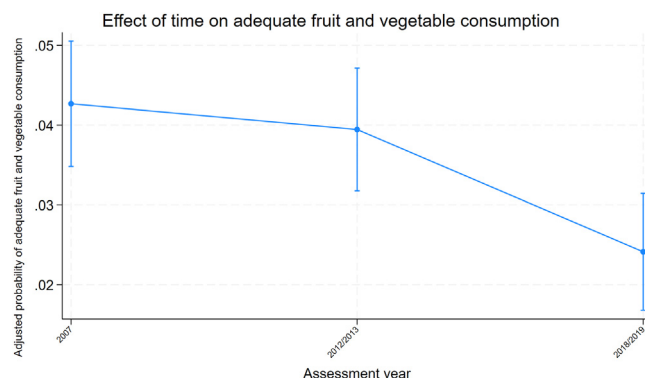


Fig. 1. Distribution of the adjusted probability of adequate consumption of fruits and vegetables in schoolchildren aged 7 to 14 years in Florianópolis, SC, Brazil, 2007, 2012/2013, and 2018/2019.

Table 3

Factors associated with adequate consumption of fruits and vegetables in schoolchildren aged 7 to 14 years. Florianópolis, SC, 2007, 2013, and 2018.

Variables	Unadjusted			*Adjusted		
	OR	95CI	p-value	OR	95CI	p-value
Sex						
Male	1	-	-	-	-	-
Female	0.95	0.74–1.23	0.750	-	-	-
Age (years)						
7–10	1	-	-	1	-	-
11–14	0.99	0.77–1.27	0.949	0.99	0.78–1.29	0.984
Education network						
Public	1	-	-	-	-	-
Private	2.03	1.57–2.61	<0.001	1.80	1.30–2.49	<0.001
Mother's education level (years)						
0–8	1	-	-	-	-	-
9–11	1.52	1.06–2.20	0.023	1.40	0.96–2.04	0.073
≥12	2.01	1.42–2.84	<0.001	1.42	0.93–2.18	0.100
Body weight status						
Without OW/OB	1	-	-	-	-	-
With OW/OB	0.95	0.72–1.25	0.726	-	-	-
Year of evaluation						
2007	1	-	-	-	-	-
2013	1.03	0.78–1.36	0.814	0.92	0.69–1.22	0.567
2018	0.65	0.45–0.93	0.022	0.55	0.38–0.79	0.002

*Analysis adjusted for variables with a p-value <0.20.95% CI, 95% confidence interval; OR, odds ratio.

more FV servings per day, and among adolescents aged 12 to 17 years, only 27.7% consumed 5 or more servings per day [17].

Similar results were observed in other countries. A review study conducted in 22 Arab countries with adolescents aged 10 to 19 years during the year 2022 found that the proportion of adolescents who met the recommended intake of FV (≥ 5 servings/day) ranged from 10% to 29%. Fruits showed a lower daily intake compared to vegetables (4.2% to 53.7% for fruits and 7.8% to 66.3% for vegetables) [24]. Another study with 1,094 schoolchildren aged 8 to 13 years conducted in Santiago, Chile, identified a low prevalence of adequate consumption of fruits (28.4%) and vegetables (9%) [25]. A study conducted in Benin in a rural area (Boukombe) and in an urban area (Natitingou), with 303 high school students, found that 8.8% of students in the rural area and 11% in the urban area consumed fruits at least twice a day but than 80% of the students had not consumed any fruit in the previous 24 hours. Furthermore, 9.9% of the rural students and 11.4% of the urban students consumed vegetables at least twice a day [26].

In Brazil, similar evidence has been observed, indicating that the consumption of fruits and vegetables among Brazilian children and adolescents also remains below the nutritional recommendations. A study conducted in 2019 with school adolescents in Pelotas (RS) found that less than 3% of the study participants regularly consumed markers of healthy eating, including fruits and vegetables, indicating low adherence to the recommendations for FV consumption among Brazilian adolescents [28]. Data from the *Pesquisa Nacional de Saúde do Escolar* (PeNSE-2019, National School Health Survey) showed that in different geographic regions of Brazil, the regularity of fruits and vegetables consumption was low; in fact prevalence of regular fruits consumption was less than 30% in certain regions and regular vegetables consumption was also lower in the same areas [18].

Taken together, these findings confirm that low FV consumption among children and adolescents is a recurring dietary pattern in different regions of the world, regardless of the level of economic development of the countries.

Although some countries have recorded stability or slight advances in fruits and vegetables consumption in certain periods, the literature indicates that, in general, the intake of those foods remains below recommendations and, in some scenarios, shows

signs of stagnation or decline [29]. This phenomenon occurs in parallel with the increased availability, access and consumption of ultra-processed foods and sugary drinks, which compete directly with fresh and minimally processed foods in the contemporary food environment [30–32]. Therefore, it is emphasized that these findings may be related to changes in the dietary consumption patterns of the Brazilian population as a whole, observed over the years. Various studies have shown a process of dietary transition, characterized by a trend towards increased consumption of ultra-processed foods and a reduction in traditional dietary patterns during the period of 2007–2019, both in the general population and among children and adolescents [33–36].

When comparing the results of the three survey waves, we observe that, in 2018/2019, adequate FV consumption showed a significant reduction in relation to the values found in 2007 and 2012/2013. The trend of reduced consumption of adequate fruits and vegetables throughout the period reviewed is part of a broader context of persistent dietary inadequacy among children and adolescents [29,32].

In Brazil, this finding raises relevant questions, especially considering the existence of consolidated public policies aimed at promoting healthy eating in the school environment, such as the *Programa Nacional de Alimentação Escolar* (PNAE, National School Feeding Program) and the regulation by the municipality of Florianópolis of the Canteen Law, which banned the sale of sugary artificial drinks, sweets, snacks, and candies in school canteens, both in the public and private education systems [37,38].

The persistence and, in this study, the reduction in adequate FV consumption suggest that isolated strategies, while fundamental, have limited impact when not articulated with continuous actions in food and nutrition education, family involvement, and improvement of the food environment, including the school environment and food production and distribution systems. The literature indicates that policies restricted to the school environment without intersectoral integration aimed at expanding access to, availability of, and consumption of FV tend to be insufficient, especially in contexts marked by structural inequalities [39,40].

The findings also reinforce the need to expand public policies beyond the school setting and adopt broader intersectoral strategies capable of transforming the food environment in which

children and adolescents live. Evidence from Brazil suggests that changes in dietary patterns over recent decades have been strongly influenced by the increasing availability, affordability, and marketing of ultra-processed foods, alongside persistent barriers to the acquisition and consumption of fresh foods such as fruits and vegetables [30,31]. In this context, promoting adequate FV consumption requires coordinated actions involving the health, education, agriculture, food supply, and social protection sectors. Measures such as strengthening family farming and local food systems, improving the distribution and affordability of fresh foods, regulating food marketing directed at children, implementing front-of-package nutrition labeling, and creating healthier community food environments may contribute to increasing FV consumption and reducing dietary inequalities [37–40]. Therefore, future strategies should combine educational interventions with structural measures that facilitate healthy food choices and promote equitable access to nutritious foods throughout childhood and adolescence.

In this study, private school attendance was associated with a higher likelihood of adequate fruits and vegetables (FV) consumption. This finding can be interpreted as an expression of broader socioeconomic inequalities. Studies indicate that socioeconomic and educational conditions are related to diet quality, with higher family income and caregivers' higher education levels being associated with greater fruits and vegetables consumption [16,18,41,42]. Thus, the variable "school type network" can be understood as a proxy for socioeconomic and educational conditions that influence access to, availability of, and food selection by children and adolescents.

In a study conducted in low- and middle-income countries, Peltzer and Pengpid [42] observed that adolescents whose parents had a higher level of education were more likely to meet the recommended serving of fruits and vegetables, an association partially explained by more favorable family dietary practices and greater availability of these foods at home.

In Brazil, a study conducted using secondary data from the 2019 National School Health Survey (PeNSE) showed that adolescents in private schools have a higher prevalence of regular consumption of fruits (PR = 1.06; 95% CI = 1.04–1.09) and vegetables (PR = 1.09; 95% CI = 1.07–1.12) when compared to those enrolled in public schools, as well as lower consumption of soft drinks (PR = 0.93; 95% CI = 0.90–0.97) [18].

These results, supported by the literature, reflect the complex interaction between socioeconomic, educational, and environmental factors that influence the daily food selection of children and adolescents. Although variables such as sex, age, and weight status were not associated with FV consumption in our adjusted analysis model, it is important to emphasize that the literature has indicated that multiple, complex, and potential factors have been associated with FV consumption by children and adolescents. Among these factors, the most strongly supported by evidence are: age, sex, socioeconomic status, preferences, parental intake, and availability/accessibility of these foods. There is evidence that girls and younger children tend to have higher or more frequent consumption than boys and older children. Socioeconomic status, preferences, parental intake, and availability/accessibility have also shown a consistent positive association with FV consumption [43–47]. Therefore, it is necessary to continue paying attention to these factors in future investigations.

The limitations of the present study include the use of single-day food consumption measures, which do not reflect habitual FV consumption, and the cross-sectional design of the panels, which prevents causal inferences. However, the large sample size and the repeated panels conducted over more than a decade lend robustness to the temporal analysis and allow us to observe trends that

are relevant to the formulation of public policies and health strategies.

Although different versions of the dietary assessment instrument were used across the study waves, these instruments were developed within the same methodological framework and shared key characteristics, including qualitative assessment of previous-day intake, illustrated food items, and meal-based reporting. The Web-CAAFE represents an evolution of the paper-based questionnaires previously used, maintaining the same conceptual structure while incorporating technological and usability improvements. Therefore, the temporal trend observed is unlikely to be explained solely by differences in the dietary assessment instruments. Nevertheless, some degree of measurement variability resulting from instrument refinement and changes in the mode of administration over time cannot be completely ruled out and should be considered when interpreting the findings.

Another limitation of this study relates to the availability and completeness of socioeconomic variables across survey waves. Although family income is an important determinant of dietary quality, this variable presented a substantial proportion of missing data and was therefore not included in the adjusted analyses. Instead, school type and maternal education were used as proxy indicators of socioeconomic position. Additionally, information on race/ethnicity was only collected in the 2018/2019 survey wave, preventing its inclusion in the temporal analyses. Consequently, residual confounding by unmeasured socioeconomic and demographic factors cannot be ruled out.

Therefore, future studies should seek to incorporate more comprehensive and consistently collected measures of socioeconomic and demographic inequalities to better understand their influence on fruit and vegetable consumption trajectories throughout childhood and adolescence.

The findings of this study enhance the need to strengthen public policies and intersectoral actions to promote healthy eating that take into account the behavioral, social, and environmental determinants of FV consumption. Integrated strategies, including broader school environment policies and continuous food and nutrition education, may be essential to overcome barriers to an adequate fruits and vegetables consumption among children and adolescents.

Conclusion

This study shows that adequate FV consumption among schoolchildren remains below the recommended level and shows a downward trend along the years of this eating habit evaluation (2007–2019). The results enhance the fact that FV consumption is conditioned by social determinants, since students from private schools - a marker of better socioeconomic and educational conditions - had greater opportunities of adequate FV consumption.

Therefore, it is essential to strengthen intersectoral actions that consider the broader food environment, social inequalities, and the role of the family in shaping eating habits, in order to promote healthy choices since childhood and adolescence.

Finally, it is important to highlight the need for studies on trends and factors associated with FV consumption among schoolchildren, in order to monitor changes thus contributing to the development of public policy strategies aimed at enhancing appropriate FV consumption in this population.

Declaration of competing interest

The authors declare the following financial interests/personal relationships which may be considered as potential competing

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CRediT authorship contribution statement

Andreia Pereira Silva: Writing – original draft, Methodology, Formal analysis, Data curation, Conceptualization. **Larissa da Cunha Feio Costa:** Writing – review & editing, Writing – original draft, Visualization, Methodology. **Bernardo Paz Barboza:** Writing – review & editing, Supervision, Software, Formal analysis, Data curation, Conceptualization. **Patrícia de Fragas Hinnig:** Writing – review & editing, Supervision, Project administration, Methodology, Investigation, Funding acquisition, Conceptualization. **Francisco de Assis Guedes de Vasconcelos:** Writing – review & editing, Supervision, Resources, Project administration, Methodology, Investigation, Funding acquisition, Data curation, Conceptualization.

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