Socioeconomic inequalities in the consumption of minimally processed and ultra-processed foods in Brazilian adolescents

Desigualdades socioeconômicas no consumo de alimentos minimamente processados e ultraprocessados em adolescentes no Brasil

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Abstract *In this study, we evaluated socioeconomic inequalities in the consumption of in natura/minimally processed and ultra-processed foods among adolescents. We used data from the Brazilian National Survey of School Health (PeNSE), 2015. According to the self-reported consumption of beans, vegetables and fruits, a score of in natura/minimally processed foods was generated (0-21 points). Sodas, sweets, instant noodles, and ultra-processed meat were used for the score of ultra-processed foods (0-21 points). Equality indicators were gender, maternal education, and socioeconomic level. Absolute difference, ratios, concentration index and slope index of inequality were calculated. Adolescents (n=101,689, 51% girls, 14.2 years) reported a mean score of 9.97 and 11.46 for ultra-processed foods and in natura/minimally processed foods, respectively. Absolute and relative differences between adolescents with the highest and lowest socioeconomic level, there were differences of 2.64 points and 33% for consumption of in natura/minimally processed foods; and 1.48 points and 15% for ultra-processed foods. Adolescents from higher socioeconomic level ate more in natura/minimally processed foods and ultra-processed foods.*

Key words *Healthy eating, Adolescent, Food consumption, Fast foods*

Resumo *Nesse estudo, avaliamos as desigualdades socioeconômicas no consumo de alimentos in natura/minimamente processados e ultraprocessados entre adolescentes. Foram utilizados dados da Pesquisa Nacional de Saúde do Escolar (PeNSE), 2015. De acordo com o consumo autorrelatado de feijão, hortaliças e frutas, foi gerado um escore de alimentos in natura/minimamente processados (0-21 pontos). Refrigerantes, doces, macarrão instantâneo e carnes ultraprocessadas prontos para o consumo foram utilizados para a pontuação dos alimentos ultraprocessados (0-21 pontos). Os indicadores de equidade foram gênero, educação materna e nível socioeconômico. Foram calculados a diferença absoluta, razões, índice de concentração e índice de inclinação de desigualdade. Os adolescentes (n=101.689, 51% meninas, 14,2 anos) relataram escore médio de 9,97 e 11,46 para alimentos ultraprocessados e in natura/minimamente processados, respectivamente. As diferenças absolutas entre os adolescentes de alto e baixo nível socioeconômico foram mais altos e mais baixos, houve diferenças de 2,64 pontos e 33% para o consumo de alimentos in natura/minimamente processados; e 1,48 pontos e 15% para alimentos ultraprocessados. Adolescentes de níveis socioeconômicos mais elevados comeram mais alimentos in natura/minimamente processados e alimentos ultraprocessados comparado aos seus pares.*

Palavras-chave *Alimentação saudável, Adolescente, Consumo de alimentos, Fast Foods*

Introduction

Nutrition is crucial for the healthy development of adolescents[1,2]. The Dietary Guidelines for the Brazilian Population suggests that Brazilians' diet should be based on *in natura* or minimally-processed foods, which is nutritious, available in great variety, and produced by environmentally sustainable foods systems[2]. Considering the classification of foods according to the degree and purpose of processing, just over half of the calories consumed by the Brazilian population came from *in natura* or minimally-processed foods. Among these, rice, beef, beans and poultry meat were the most frequently consumed[3]. On the other hand, among the ultra-processed foods with the highest frequency of consumption were margarine, crackers, packaged snacks and breads[3].

The higher participation of ultra-processed foods in the diet is associated with a lower quality diet. In adolescents, the intake of these foods has increased over the years and has been related to sociodemographic factors[4], such as sex, maternal education and socioeconomic level. In addition, consumption of ultra-processed foods has been associated with increased risk of overweight and obesity, cardiovascular diseases, and cancer[5].

Identifying possible health inequalities among subgroups[6], such as sex and socioeconomic level, is important to plan and implement policies supporting the adoption and maintenance of healthy diets. Some studies have indicated better eating habits in adolescent girls[7] and those with higher level of maternal educational[8], possibly due better accessibility to heathy foods options[9]. Although these findings highlight inequities in fruit and vegetable consumption, they describe the social organization and eating habits of high-income countries[7-9]. Exploring the differences in dietary behaviors across socioeconomic level in low- to middle-income countries may provide overall evidence of the magnitude of existing inequalities[6]. In this study, we assessed socioeconomic inequalities in the consumption of *in natura* or minimally processed and ultra-processed foods in Brazilian adolescents.

Methods

We used cross-sectional data from the Brazilian National Survey of School Health (*Pesquisa Nacional da Saúde do Escolar* - PeNSE) carried out in 2015. Additional information about the PeNSE methods and sampling procedures has been pub-

lished elsewhere[10]. Briefly, PeNSE enrolled two independent samples of students attending high school and 9th grade, mostly aged between 14 and 15 years. In this study, we analyzed data from 9th grade students from public and private schools from 27 Brazilian federative units.

The sampling strategy included stratification per cluster and multi-stage selection. The primary and secondary sample units were schools and classes, respectively. School selection was proportional to the number of 9th grade classes, while classes were selected at random. Schools with at least two 9th grade classes had one class selected while schools with three or more classes had two classes selected. All students enrolled in the selected classes were invited to participate in the study. Those who agreed to participate answered a standardized questionnaire utilizing smartphones provided by the research team[10]. The questionnaire was based on the School-Based Student Health Survey[10] and the Youth Risk Behaviour Surveillance System, which were adapted to the Brazilian context[11]. Adolescents responded to the questionnaire at school, guided by a researcher.

Assessment of diet

Adolescents reported their consumption of *in natura* or minimally processed foods and ultra-processed foods through the following question "In the last seven days, how many days did you consume…?" regarding each one of the following foods: beans, vegetables, fresh fruits, fried salty foods (e.g. french fries, fried chicken), sweets (e.g. candies, bubble gum), ultra-processed meat (e.g. ham, chicken nuggets), instant noodles, fast foods, and soda. The answers ranged from zero to seven days, and portion size was not reported. These questions have been validated for Brazilian adolescents[12].

Dietary scores were calculated for each foods group, summing the weekly frequency of each diet indicator included (0-7 days/week). For the *in natura* or minimally-processed foods score, the indicator variables were beans, vegetables, and fresh fruits consumption. Consumption of soda, sweets, and ultra-processed foods were indicators for the ultra-processed foods score. As the weekly frequency of three items were used as indicators for each score, the score variables ranged from 0 to 21, meaning they adolescents ate none of the items weekly, or every item every day, respectively. Fast foods and fried salty foods were not included in any score, as their descrip-

tion does not clearly discriminate the degree and purpose of foods processing[2].

Equality indicators

Equality indicators were sex (male or female), maternal education, and socioeconomic level. Maternal education was obtained by asking the question "What level of education did your mother achieve?" and it was categorized as follows: 0-8, 9-11, ≥12 years of study, and unknown. The socioeconomic level was obtained through the possession of goods (landline phone, cell phone, computer, internet service, car, motorcycle, number of bathrooms), and the presence of a maid in the home. The choice of such variables was based on the original research report[10] which uses the variables of sex, maternal education, possession of goods, number of bathrooms at home and availability of maid services at home to characterize socioeconomic aspects. The method used in this article has been widely used in national surveys[13,14]. In addition, the World Health Organization[15] suggests the use of more complex analyses, such as principal components analysis, which considers statistical methods to determine the weights of items in the index.

Statistical analysis

Descriptive statistics were provided for the whole sample and for those in the first and fifth quintile of the socioeconomic level, which were calculated using principal component analysis, as a reduction method to define this variable[13]. The variable was calculated based on the first component, and the weights of each asset were used to calculate a score, which was grouped in quintiles, with the first quintile being the lowest socioeconomic level. The first component explained 29.71% of the variance of the socioeconomic level indicators used.

The average score of the dependent variables (*in natura* or minimally processed foods and ultra-processed foods) were described according to the categories of each equality indicator (socioeconomic level, sex, maternal education). Simple measures of inequality were estimated between sex, maternal education categories, and between the lowest and the highest socioeconomic level (pairwise comparisons). Simple linear regression models were used to calculate mean differences and 95% confidence intervals between dichotomous equality indicators (e.g. participants in the lowest socioeconomic level scored an average

-2.64 (95%CI -2.87; -2.40) in the ultra-processed foods score compared to those in the highest socioeconomic level). For ratios, Poisson regression with robust variance were used (e.g. participants in the lowest socioeconomic level had a 25% (0.75; 95% CI 0.73; 0.78) lower ultra-processed foods score compared to those in the highest socioeconomic). The coefficients of the dependent variables for each social indicator and their respective 95% confidence intervals were reported.

The slope index of inequality and the concentration index were calculated to evaluate inequalities between socioeconomic level in relation to the consumption of *in natura*/minimally-processed foods and ultra-processed foods. Slope index of inequality analyses the distance of extreme categories (lowest and highest socioeconomic level) against the midpoint of the cumulative range of the socioeconomic level. Where the slope indicates the extent of inequality (with values close to zero indicating no inequalities), positive values suggesting that the dietary indicator is more prevalent in adolescents with higher socioeconomic level, and negative values suggesting it is more prevalent adolescents with lower socioeconomic level. The concentration index provides a gradient value across subgroups ranked by socioeconomic level, where negative values suggest the outcome measure is concentrated in lower socioeconomic level, with values ranging between -1 and +1, and values above 0.2 representing reasonable levels of relative inequality[6].

All analyses were performed using Stata, version 15.0 for Windows.

Ethical considerations

This study was conducted according to the guidelines laid down in the Declaration of Helsinki and all procedures involving research study participants were approved by the *Comissão Nacional de Ética em Pesquisa* (CONEP) (Brazilian National Ethics Committee, protocol No. 1.006.467, of 30.03.2015). Written informed consent was obtained from all subjects/patients.

Results

A total of 101,689 adolescents participated in the study (51% girls; 14.2 years). The proportion of boys was higher among those in the highest socioeconomic level (52%) compared to those in the lowest socioeconomic level (46%). Maternal

education was higher among adolescents in the highest socioeconomic level (43% of mothers had ≥12 years of education) compared to the lowest socioeconomic level (3% of mothers had ≥12 years of education) (Table 1).

Table 2 shows the mean differences and ratios of consumption of *in natura*/minimally processed foods and ultra-processed foods by socioeconomic level, sex, and maternal education. Consumption of *in natura*/minimally processed foods and ultra-processed foods were higher among participants in the highest socioeconomic level compared to the lowest socioeconomic level. Participants whose mother had ≥12 years of education consumed more ultra-processed foods compared to those who had mothers with ≤8 years of education. Differences found in the scores of *in natura* or minimally processed foods and ultra-processed foods between boys and girls were smaller than 1 point.

The slope index of inequality indicated that *in natura*/minimally-processed foods and ul-

tra-processed foods were more prevalent in the highest socioeconomic level (Table 3). However, values were close to zero (0.0143 for *in natura*/minimally-processed foods score, and 0.0346 for ultra-processed foods score), suggesting a small difference in the consumption of *in natura*/minimally-processed foods and ultra-processed foods across socioeconomic level. Similar results were observed for the concentration index of inequality analyses, with small but statistically significant differences in the *in natura*/minimally-processed foods score (CIX=0.0215) and ultra-processed foods (CIX=0.0475), suggesting that both dietary score were concentrated among adolescentes with higher socioeconomic level.

Discussion

This study examined differences in adolescents' consumption of *in natura*/minimally-processed foods and ultra-processed foods according to so-

Table 1. Participants characteristics according to socioeconomic level. PeNSE 2015.

	Whole sample		Lowest socioeconomic group* (first quintile)		Highest socioeconomic group* (fifth quintile)	
	Mean/ percentage	95%CI	Mean/ percentage	95%CI	Mean/ percentage	95%CI
Sex						
Male	49%	(48; 49)	46%	(44; 47)	53%	(50; 53)
Female	51%	(50; 52)	54%	(53; 55)	47%	(46; 49)
Age (years)	14.2	(14.26; 14.31)	14.63	(14.59; 14.67)	14.03	(14.00; 14.06)
Maternal education						
≤8 years	25%	(24; 25)	41%	(39; 42)	10%	(09; 11)
9-11 years	30%	(29; 31)	22%	(20; 22)	29%	(27; 31)
≥12 years	18%	(17;19)	3%	(02; 03)	43%	(40; 45)
Not Known	27%	(26; 28)	34%	(32; 35)	18%	(16; 18)
Consumption of dietary foods (days/week)						
Beans	5	(4.70; 4.80)	5	(4.57; 4.72)	5	(4.42; 4.60)
Salad or vegetables	3	(3.45; 3.52)	3	(2.98; 3.12)	4	(3.85; 4.02)
Fresh fruits	3	(3.20; 3.25)	3	(2.74; 2.87)	3	(3.47; 3.63)
Sweets	4	(3.78; 3.85)	3	(3.28; 3.42)	4	(3.94; 4.09)
Soft drinks	3	(2.87; 2.95)	2	(2.24; 2.38)	3	(3.03; 3.22)
Ultra-processed meat (e.g. sausage)	3	(3.19; 3.26)	2	(2.46; 2.59)	4	(3.62; 3.75)

*Socioeconomic score was generated using scores from the Principal Component Analysis using indicators of landline phone, cell phone, computer, internet service, car, motorcycle, number of bathrooms, and housemaids; CI: Confidence Intervals. PENSE: *Pesquisa Nacional de Saúde do Escolar* (Brazilian National Survey of School Health).

Source: Authors.

Table 2. Absolute and relative differences in relation to the consumption of in natura/minimally-processed foods and ultra-processed foods or processed foods among Brazilian adolescents by socioeconomic level, sex, and maternal education subgroups. PeNSE, 2015.

	n	Scores*	
		Consumption of ultra-processed food[1]	Consumption of in natura and minimally processed food[2]
National	101,689	9.97 (9.89;10.05)	11.46 (11.37;11.54)
Socioeconomic level			
Q1 (Lowest socioeconomic group)	19,320	8.18 (8.03;8.34)	10.51 (10.36;10.67)
Q5 (Highest socioeconomic group)	20,876	10.84 (10.66;11.01)	12.00 (11.84;12.17)
Difference (Q5-Q1)		2.64 (2.40; 2.87)	1.49 (1.27;1.71)
Ratio (Q5/Q1)		1,32 (1.29; 1.36)	1.14 (1.12;1.16)
Sex			
Male	49,044	9.68 (9.59;9.78)	11.78 (11.69;11.87)
Female	52,639	10.24 (10.13;10.35)	11.15 (11.03;11.26)
Difference (Female-Male)		0.55 (0.41;0.68)	-0.63 (-0.76;-0.50)
Ratio (Female/Male)		1.05 (1.04; 1.07)	0.94 (0.93;0.95)
Maternal Education			
≤8 years	23,674	9.35 (9.23;9.48)	11.21 (11.09;11.33)
≥12 years	22,643	10.48 (10.33;10.63)	11.74 (11.6;11.87)
Difference (≤8 Years- ≥12 Years)		1.13 (0.94;1.31)	0.89 (0.70;1.09)
Ratio (≤8 years/ ≥12 Years)		1.12 (1.10;1.14)	1.08 (1.06;1.09)

*Data expressed as mean and 95% Confidence Intervals. [1]Between 0-21, summing weekly frequency of the consumption of soda, sweets, and processed foods; [2]Between 0-21, summing weekly frequency of the consumption of fresh fruits, vegetables, and beans.

Source: Authors.

Table 3. Complex measures of inequality in the consumption of in natura/minimally processed and ultra-processed foods or processed foods among Brazilian adolescents by socioeconomic level. PeNSE, 2015.

Quintiles of Socioeconomic Level Score (1=poorest; 5=richest) Indicators	Slope Index of inequality (SII)	p-value	Concentration index of inequality (CIX)	p-value
Consumption of ultra-processed or processed food (score*)[1]	0.0346	<0.001	0.0475	<0.001
Consumption of in natura/ minimally-processed food (score*)[2]	0.0143	<0.001	0.0215	<0.001

*Data expressed as mean and 95% Confidence Intervals. [1]Between 0-21, summing weekly frequency of the consumption of soda, sweets, and processed foods. [2]Between 0-21, summing weekly frequency of the consumption of fresh fruits, vegetables, and beans.

Source: Authors.

cioeconomic level, sex, and maternal education. The largest differences in consumption of *in natura*/minimally-processed foods and ultra-processed foods were found between the lowest and the highest socioeconomic level. Adolescents in the highest socioeconomic level reported consuming more *in natura*/minimally processed foods, but also more ultra-processed foods, compared to adolescents in the lowest socioeconomic level.

Similar results have been found in high-income countries[9,16-18]. However, in high-income countries, socioeconomically disadvantaged groups have lower consumption of fruits and vegetables and higher consumption of energy-dense products[16-18]. In our study, Brazilian adolescents in the lowest socioeconomic level reported consuming less *in natura*/minimally processed foods, but also less ultra-processed foods

compared to those in the highest socioeconomic level. The availability of *in natura*/minimally processed foods, such as fruits and vegetables, may be limited in disadvantaged neighbourhoods[19-21]. Moreover, other individual characteristics, such as knowledge and self-efficacy for changing dietary behaviors are likely less prevalent in adolescents with low socioeconomic level[9], which may also explain these differences.

In our study, participants in the highest socioeconomic level consumed more ultra-processed foods compared to those participants in the lowest socioeconomic level, which differs from studies carried out in high-income countries. This may be due to ultra-processed foods being cheaper and easily accessible in high-income countries[20,21], but more costly for the Brazilian population[22], especially in smaller stores, compared to supermarkets[23]. In addition, living in poor neighborhoods may be a barrier for accessing cheaper healthy foods in supermarkets, compared to those who live close to such establishments[24,25] or those who can afford to own a car[26]. These differences in price may play an important role in the accessibility to ultra-processed foods. In high-income countries, ultra-processed foods are more aggressively advertised[27], which usually is very appealing and, thus, preferred by children and adolescents[28]. The impact of the advertisement is not clear in Brazil, as marketing these products to children and adolescents is prohibited[29]. In addition, our results indicate that adolescents living in households of higher socioeconomic level had higher consumption of all evaluated foods groups. The lowest consumption of foods in the most vulnerable group does not occur uniformly because this group has restricted access to all types of foods. In addition, the amount of foods consumed is low. The ideal consumption of fresh/minimally processed foods should be 21 points, that is, daily consumption of these foods. However, the group with the highest socioeconomic level consumed just over half. Therefore, despite being a higher consumption than the group with lower socioeconomic level, it is still an insufficient consumption, indicating even more precarious foods consumption among the most vulnerable adolescents.

Our findings corroborate studies analyzing Brazilian and North American adolescents, which found no significant differences between the eating behavior of boys and girls[9,30]. However, studies with European adolescents have found that girls eat more healthy foods and avoid eating sugar-rich foods compared to boys[7,31]. These findings point out the differences between Europeans' eating behavior compared to Americans', with the latter being similar to our findings. Similar foods consumption between boys and girls may be the result of the widespread consumption of rice and beans among the Brazilian population[30], as well as the implementation of national policies, such as the National School Foods Program (*Programa Nacional de Alimentação Escolar* - PNAE), which has incorporated *in natura*/minimally-processed foods into the school meals, and discourage the commercialization of energy dense processed foods in school canteens.

Maternal education was not strongly associated with consumption of *in natura*/minimally processed foods and ultra-processed foods. These findings differed from studies in European countries where adolescents (aged 8-12 years) with more educated mothers reported eating more fruits and vegetables, while their counterparts with less educated mothers reported eating more fried foods[8,32]. Mothers with more education may have more knowledge related to healthy eating behavior, which could impact their children's diet[8]. A review of interventions at the family setting showed that increased knowledge can improve dietary habits (e.g., increase fruit intake and reduce fat intake)[33]. Additionally, maternal education could be highly related to income[8,9,20,32], which may also positively impact the availability of healthy foods at home[31] and overall foods diversity. This has been evidenced in high-income countries, which may be explained by more disposable income by families with higher socioeconomic level, but not related specifically to maternal education[34]. However, a study with a national sample of Brazilian adolescents (aged 13-15 years) found that those with mothers that are more educated ate more sweets and drank softer drinks[35], which differs from results found in high-income countries. Our study revealed small differences when comparing adolescents' diet by maternal education, which may reflect that it is not only health-related knowledge that affects eating behaviors but inequalities due to access and distribution of foods[36]. Educational interventions may have a positive effect on healthy foods consumption[33], and policies aimed at the school setting (e.g. PNAE) may improve diversity and distribution of healthy foods among children and adolescents in low socioeconomic level. Finally, changes in the social structure may be needed to consistently improve these inequalities in the long-term[37].

This study has some strength, such as the nationally representative sample, which included adolescents from diverse backgrounds. We used two different scores to report the dietary con-

sumption of Brazilian adolescents, and calculated simple and complex measures of inequality by socioeconomic level, sex and maternal education. Our study also has some limitations. Consumption of *in natura*/minimally and ultra-processed foods were self-reported and limited to a relatively small number of dietary indicators. In addition, the questionnaire did not include foods preparation and amount consumed. However, information related to weekly foods consumption frequency revealed to be useful to identify differences between socioeconomic level in a large representative sample of adolescents.

In conclusion, adolescents from higher socioeconomic level ate more *in natura*/minimally processed foods, but also ultra-processed foods, compared to adolescents from lower socioeconomic level. Differences in the consumption of *in natura*/minimally processed foods and ultra-processed foods between sex and maternal education subgroups were small. Future studies should focus on understanding the causal pathways between socioeconomic level and the consumption of *in natura*/minimally processed foods and ultra-processed foods, in order to inform effective policies and interventions.

Collaborations

All authors of this research paper have directly participated in the planning, execution, and/or analysis of the study and have read and approved the final version submitted.

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