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Temporal trend of simultaneous risk factors for chronic non-communicable diseases: National School Health Survey 2009, 2012, 2015

Tendência temporal dos fatores de risco simultâneos para doenças crônicas não transmissíveis: Pesquisa Nacional de Saúde do Escolar 2009, 2012, 2015

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ABSTRACT: *Objective*: To analyze the temporal trend of simultaneous occurrence of behavioral risk factors for chronic non-communicable diseases in Brazilian school adolescents. *Methods*: Ecological time-series study that analyzed data from the three editions of the National Survey of School Health with students in the 9th year of public and private schools. Cluster analysis was performed to identify the simultaneity of the following factors: irregular consumption of fresh or minimally processed foods, regular consumption of processed and ultra-processed foods, insufficient level of physical activity during leisure time, consumption of alcoholic beverages, use of cigarettes and illicit drugs. The cluster trend was tested using simple linear regression. *Results*: The sample was composed of 173,310 school adolescents. Sixty-four possible combinations were evaluated, resulting in the formation of six clusters. The grouping formed by all factors showed the highest ratios observed/expected prevalence in the last two years of the series. The highest ratios were observed for combinations in which alcohol and cigarettes were present. These substances integrated five of the six clusters. One of the groups (insufficient level of physical activity during leisure time + consumption of alcoholic beverages + use of cigarettes and illicit drugs) had an upward trend throughout the series. *Conclusion*: The trend analysis showed four out of six clusters remaining stable throughout the series, which shows that the factors are persistently present among school adolescents.

Keywords: Noncommunicable diseases. Teenagers. Risk factors. Cluster analysis.

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RESUMO: *Objetivo*: Analisar a tendência temporal da ocorrência simultânea de fatores de risco comportamentais para doenças crônicas não transmissíveis em adolescentes escolares brasileiros. ***Métodos***: Estudo ecológico de série temporal, que analisou os dados das três edições da Pesquisa Nacional de Saúde do Escolar dos alunos do 9º ano de escolas públicas e privadas. Realizou-se a análise de *cluster* para a identificação da simultaneidade dos seguintes fatores: consumo irregular de alimentos *in natura* ou minimamente processados, consumo regular de alimentos processados e ultraprocessados, nível insuficiente de atividade física no lazer, consumo de bebidas alcoólicas, uso de cigarro e de drogas ilícitas. A tendência dos *clusters* foi testada utilizando-se regressão linear simples. ***Resultados***: A amostra constituiu-se de 173.310 escolares. Sessenta e quatro possíveis combinações foram avaliadas, havendo a formação de seis *clusters*. O agrupamento formado por todos os fatores apresentou as maiores razões entre prevalências observadas e esperadas para os dois últimos anos da série. As maiores razões foram verificadas para as combinações em que estavam presentes o álcool e o cigarro. Além disso, essas substâncias integraram cinco dos seis *clusters*. Um dos agrupamentos (nível insuficiente de atividade física no lazer + consumo de bebidas alcoólicas + uso de cigarro e drogas ilícitas) apresentou tendência crescente durante toda a série. ***Conclusão***: A análise de tendência constatou que quatro de seis *clusters* mantiveram-se estáveis durante toda a série, demonstrando que os fatores continuam presentes de forma persistente entre os adolescentes escolares.

Palavras-chave: Doenças não transmissíveis. Adolescentes. Fatores de risco. Análise por conglomerados.

INTRODUCTION

Adolescence is a growth phase marked by intense physical, psychological, and emotional changes[1]. In this stage, certain acquired behaviors such as poor diet, sedentary lifestyle, alcohol consumption, tobacco use and illicit drug use constitute risk factors (RF) for the development of chronic non-communicable diseases (NCDs)[2-4].

According to the World Health Organization (WHO), most deaths from NCDs are caused by a set of RFs that usually occur simultaneously[5]. Studies show that multiple behaviors point to a higher risk of developing NCDs and mortality when compared to engaging in only one or no risky behavior[6].

In order to avoid this, the WHO proposed monitoring the health of adolescents through the creation of RF surveillance and health protection systems in school environment[7]. From this perspective, the Surveillance System for Risk Factors for Chronic Non-Communicable Diseases was started in Brazil, under the responsibility of the Brazilian Institute of Geography and Statistics (IBGE) in partnership with the Ministries of Health and of Education. The system is based on data from the National Survey of School Health (PeNSE), which has been carried out since 2009 to obtain information to guide the knowledge and dimensioning of RFs and adolescent health protection[8-10].

This type of strategy focused on the development of healthy behaviors and the opportunity to prevent diseases and injuries at an early age is an indispensable method for health promotion, even though it is not being fully explored[1,11].

Therefore, this study aimed to analyze food consumption, physical activity, consumption of alcoholic beverages, use of cigarettes and illicit drugs among students of the 9th grade of elementary school (former 8th grade) in public and private schools of Brazilian capitals and the Federal District (DF), based on data collected from PeNSE, to answer the following question: is there a temporal trend of RF clusters for CNCDs among Brazilian school adolescents?

In Brazil, most epidemiological studies that evaluated RFs among adolescents sought to analyze their occurrence in isolation[11-14]. Although it is relevant to identify and implement actions aimed at the prevalence of RF in isolation, it is also important to consider their simultaneity, since behavior is multi-determined, and an individual assessment of factors may not reflect the true risk of individuals[15]. To date, few studies have analyzed simultaneous RFs in adolescents, and some have focused on evaluating data from only one edition of PeNSE[4,15,16]. Thus, this work fills a gap when it assesses the simultaneous occurrence of main behavioral RFs for CNCDs among adolescents, using data from the three editions of PeNSE.

Thus, this paper's purpose was to analyze the temporal trend of simultaneous behavioral RFs for CNCDs in Brazilian school adolescents with data from PeNSE 2009, 2012 and 2015.

METHODS

This is a time series ecological study which verified the main RFs for the development of CNCDs in Brazilian school adolescents, using secondary data from the 2009, 2012 and 2015 editions of PeNSE, available on the IBGE website (http: //www.ibge.gov.br).

Only data from 9th grade students that contained information common to the three editions were included, the adolescents being selected from public and private schools of the 26 Brazilian capitals and the Federal District. This allowed a temporal comparison between editions. In this way, the responses of 173,310 school adolescents were analyzed, 60,973 from PeNSE 2009, 61,145 from PeNSE 2012 and 51,192 from PeNSE 2015.

Irregular consumption of in natura or minimally processed foods, regular consumption of processed and ultra-processed foods, insufficient level of leisure-time physical activity, consumption of alcoholic beverages, cigarette use and illicit drug use were considered RFs.

For the analysis of food consumption, the Food Guide for the Brazilian Population[17], which classifies foods as in natura or minimally processed, processed and ultra-processed, was taken into account. Thus, two major food groups were considered:

1. In natura or minimally processed food;
2. Processed and ultra-processed food.

To identify RFs, we chose the concepts of "regular consumption" (≥5 times in the previous week), which was validated through a 24-hour recall among adolescents[18], and "irregular consumption" (<5 times in the previous week)[19]. Thus, consumption of in natura or minimally processed foods was considered irregular when it had happened less than five

times in the seven days prior to the survey; and consumption of processed and ultra-processed foods was considered regular when consumed five or more times in the seven days prior to the survey.

Regarding physical activity, activities performed during leisure time were considered, not counting physical education classes (sports, dance, gymnastics, weight training). Adolescents were asked about the frequency and duration of these activities in the seven days prior to the survey. Based on this, the variable "insufficient level of physical activity during leisure time" was generated, considering adolescents who did not practice at least 300 minutes of physical activity per week[20].

According to the WHO[21], adolescents are more vulnerable to damages caused by the consumption of alcohol, tobacco and illicit drugs, and therefore these substances should not be marketed to this group. Thus, any level of consumption of these substances in the last 30 days prior to the survey was considered as RF[16].

For the sociodemographic analysis, the following variables were considered: sex (male; female); skin color or race (white; black; yellow; brown; indigenous); age (13 years or younger; 14 to 15 years; 16 years or older); region of residence (North; Northeast; South; Southeast; Midwest); and school network (public; private).

The data used for the development of this study were downloaded directly from the IBGE website by the researchers, in June and July 2021; then, they were organized in Microsoft Excel 2010 spreadsheets for further statistical analysis.

The distribution of sociodemographic characteristics and RFs for CNCDs was presented as percentages and respective 95% confidence intervals (95%CI) for each year of the series. The RFs were coded as dichotomous variables (1=presence and 0=absence). The prevalence of multiple RFs was calculated by the sum of indicators presented.

The presence of clusters was studied by comparing observed (OP) and expected (EP) prevalence. The EP for each combination was calculated by multiplying the probabilities of each RF, based on its distribution in the studied population. Clustering was defined when OP/EP ratio was greater than 1.20[22]. Confidence intervals (CI) for the OP/EP ratios were obtained using the Newton method and assuming the Poisson distribution[23]; combinations in which the 95%CI did not contain a null value were considered clusters. The RFs were assumed to have occurred independently.

After identifying the RF clusters in each year of the survey, the temporal trend was tested across the series. As in a previous study[13], a simple linear regression model was used, whose dependent variable (indicator) was the value of the OP/EP ratio of each combination tested, and whose independent variable was time (year of research).

All analyses were performed in the STATA program, version 14.1 (Stata Corporation, College Station, Texas)[23] and took into account the weighting for the complex sample structure as established by PeNSE, so that it could represent the Brazilian population of adolescents residing in the 26 capitals and in the Federal District.

The three editions of PeNSE were approved by the National Research Ethics Committees (CONEP), opinions 11,537/2009, 16,805/2012 and 1,006,467/2015. For this study, the

recommendation of Resolution 510/2016 by the National Health Council on information in the public domain was followed"[24].

RESULTS

The sample consisted of 173,310 school adolescents residing in the 26 Brazilian capitals and in the Federal District in 2009, 2012 and 2015. Table 1 describes their sociodemographic characteristics and the RFs for CNCD.

In the entire series, the highest prevalence was observed for adolescents aged between 14 and 15 years old, living with both parents, studying in public schools and residing in the Southeast Region. As for gender, the highest percentages in the three years of the series seem to be among female adolescents, which shows significant differences only in the first two years. With regard to skin color, the percentage of school adolescents who reported being brown had a small increase throughout the whole series, being significantly higher in 2015 (Table 1).

In the three editions of the series, insufficient level of physical activity during leisure time was the most frequent RF among students (present in more than 84% of them), followed by the regular consumption of processed and ultra-processed foods. Data suggest, during the years of research, a decrease in the regular consumption of processed and ultra-processed foods and consumption of alcoholic beverages. On the other hand, the irregular consumption of fresh or minimally processed foods and the use of illicit drugs seem to have increased (Table 1).

Table 2 describes the OP and EP of the 64 possible combinations evaluated, among which six had OP/EP above 1.20, which corresponded to the grouping of RF. Table 1 (supplementary material) describes the factors that make up the six risk behaviors for NCDs in Brazilian school adolescents.

Cluster 1 resulted in OP/EP of 26.00 in 2009, 38.00 in 2012 and 45.00 in 2015, but remained stable for the period (p>0.05). Considering that the higher the OP/EP ratio, the greater the number of times the clustering can be observed, if these factors are independent, cluster 1 will still be the one with the strongest relationships and/or with the greatest possibility of occurring in the last two years of the series (Table 2).

The highest OP/EP ratios were found for combinations in which alcohol and cigarettes were present; these substances were part of five of the six identified clusters, indicating an association between factors (Table 2).

The trend analysis showed that clusters 1, 2, 3 and 6 remained stable throughout the series, while cluster 4 decreased by 0.04% per year (p<0.017) and cluster 5 increased by 1.5% (p<0.041) (Table 2).

As for the clusters with the highest OP in the entire series, 6 stood out, in which the irregular consumption of fresh or minimally processed foods, along with insufficient level of physical activity during leisure time, had a prevalence corresponding to 5% in 2009, 6.78%

Table 1. Frequency of sociodemographic characteristics and risk factors for chronic non-communicable diseases in Brazilian school adolescents. National School Health Survey 2009, 2012 and 2015.

Sociodemographic characteristics	2009 (n=60,973)	2012 (n=61,145)	2015 (n=51,192)
	% (95%CI)	% (95%CI)	% (95%CI)
Sex			
Male	47.5 (46.8–48.1)	49.2 (48.4–49.9)	49.2 (48.3–50.1)
Female	52.5 (51.9–53.2)	50.8 (50.1–51.6)	50.8 (49.9–51.7)
Age group			
13 years or younger	24.4 (23.4–25.5)	19.0 (18.1–20.0)	20.3 (19.4–21.3)
14–15 years	65.3 (64.4–66.3)	69.5 (68.5–70.4)	70.9 (69.9–71.9)
16 or older	10.2 (9.4–11.0)	11.5 (10.6–12.4)	8.7 (8.1–9.4)
Skin color or race			
White	40.1 (38.9–41.4)	37.7 (36.2–39.3)	36.5 (35.1–38.0)
Black	12.9 (12.2–13.5)	14.2 (13.4–14.9)	13.5 (12.8–14.2)
Yellow	3.7 (3.4–4.1)	4.5 (4.2–4.8)	5.0 (4.7–5.4)
Brown	39.1 (38.0–40.3)	39.9 (38.6–41.2)	41.7 (40.5–43.0)
Indigenous	4.1 (3.8–4.4)	3.7 (3.4–3.9)	3.2 (3.0–3.4)
Living with parents			
None of the parents	5.2 (4.9–5.6)	5.6 (5.3–5.9)	5.1 (4.7–5.4)
One of the parents	36.4 (35.6–37.3)	37.9 (37.0–39.0)	39.2 (38.2–40.2)
Both parents	58.3 (57.4–59.3)	56.5 (55.4–57.5)	55.7 (54.5–56.8)
School network			
Public	79.2 (77.9–80.4)	74.5 (70.7–78.3)	72.9 (71.9–73.9)
Private	20.8 (19.5–22.1)	25.5 (21.7–29.3)	27.1 (26.1–28.1)
Geographic region			
North	11.2 (10.4–12.0)	11.7 (11.0–12.4)	12.8 (12.2–13.4)
North East	23.9 (22.7–25.1)	23.7 (22.7–24.6)	23.8 (23.0–24.7)
South	6.8 (6.3–7.3)	7.2 (6.6–7.7)	6.0 (5.7–6.4)
Southeast	47.0 (45.0–49.0)	45.1 (43.6–46.7)	44.6 (43.4–45.9)
Midwest	11.1 (10.4–11.8)	12.3 (11.6–13.1)	12.7 (12.0–13.4)
Risk factors			
Irregular intake of fresh or minimally processed foods	20,7 (20,0–21,4)	24,4 (23,5–25,3)	25,0 (24,3–25,7)
Regular intake of processed and ultra-processed foods	73,1 (72,4–73,9)	67,3 (66,5–68,1)	62,8 (62,0–63,7)
Insufficient level of physical activity during leisure time	84,3 (83,7–84,8)	84,1 (83,4–84,8)	85,3 (84,7–86,0)
Consumption of alcoholic beverages	26,9 (26,1–27,7)	26,7 (25,8–27,7)	23,2 (22,2–24,2)
Cigarette use	6,2 (5,8–6,7)	6,1 (5,6–6,6)	5,3 (4,9–5,8)
Use of illicit drugs	3,2 (3,0–3,6)	3,8 (3,4–4,2)	4,8 (4,4–5,2)

Source: the authors, based on the National Survey of School Health 2009, 2012, 2015 (IBGE, 2009; 2013; 2016).

Table 2. Frequency and trend of grouped six risk behaviors for chronic non-communicable diseases in Brazilian school adolescents. National School Health Survey 2009, 2012 and 2015.

Number of factors	Risk factors						Series years									AAV	p-value
							2009			2012			2015				
	AI	UP	IPA	AL	CI	ID	OP (%)	EP (%)	OP/EP	OP (%)	EP (%)	OP/EP	OP (%)	EP (%)	OP/EP		
6	+	+	+	+	+	+	0.26*	0.01*	26.00*	0.38*	0.01*	38.00*	0.45*	0.01*	45.00*	(+) 3.20	0.096
5	+	+	+	+	+	-	0.47*	0.21*	2.24*	0.46*	0.22*	2.09*	0.42*	0.16*	2.63*	(+) 0.07	0.507
	+	+	+	+	-	+	0.17*	0.10*	1.70*	0.14	0.13	1.08	0.28*	0.14*	2.00*	-	-
	+	+	+	-	+	+	0.02	0.02	1.00	0.02	0.02	1.00	0.08*	0.03*	2.67*	-	-
	+	+	-	+	+	+	0.05	0.00	-	0.07	0.00	-	0.06	0.00	-	-	-
	+	-	+	+	+	+	0.09	0.00	-	0.11	0.00	-	0.16	0.00	-	-	-
	-	+	+	+	+	+	1.01*	0.03*	33.67*	0.97*	0.03*	32.33*	0.87*	0.02*	43.5*	(+) 1.64	0.403
4	+	+	+	+	-	-	2.79	3.11	0.90	3.27	3.34	0.98	2.82	2.80	1.01	-	-
	+	+	+	-	-	+	0.03	0.28	0.11	0.04	0.36	0.11	0.09	0.47	0.19	-	-
	+	+	-	-	+	+	0.00	0.00	-	0.00	0.00	-	0.01	0.00	-	-	-
	+	-	-	+	+	+	0.01	0.00	-	0.02	0.00	-	0.04	0.00	-	-	-
	-	+	+	+	+	-	1.66*	0.79*	2.10*	1.33*	0.67*	1.99*	0.89*	0.47*	1.89*	(-) 0.04	0.017*
	-	+	+	+	-	+	0.43	0.40	1.08	0.56*	0.41*	1.37*	0.88*	0.42*	2.10*	-	-
	-	+	+	-	+	+	0.07	0.07	1.00	0.04	0.07	0.57	0.14*	0.08*	1.75*	-	-
	-	+	-	+	+	+	0.24	0.00	-	0.25	0.00	-	0.26	0.00	-	-	-
	-	-	+	+	+	+	0.15*	0.01*	15.00*	0.20*	0.01*	20.00*	0.24*	0.01*	24.00*	(+) 1.5	0.041*

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Table 2. Continuation.

Number of factors	Risk factors						Series years									AAV	p-value
							2009			2012			2015				
	AI	UP	IPA	AL	CI	ID	OP (%)	EP (%)	OP/EP	OP (%)	EP (%)	OP/EP	OP (%)	EP (%)	OP/EP		
3	+	+	+	-	-	-	8.19	8.46	0.97	8.74	9.16	0.95	9.76	9.29	1.05	-	-
	+	+	-	-	-	+	0.00	0.05	-	0.00	0.07	0.00	-	0.08	-	-	-
	+	-	-	-	+	+	0.00	0.00	-	0.00	0.00	0.00	-	0.00	-	-	-
	-	-	-	+	+	+	0.05	0.00	-	0.05	0.00	0.00	0.07	0.00	-	-	-
	+	-	-	+	+	-	0.01	0.01	1.00	0.05*	0.02*	2.50*	0.01	0.02	0.50	-	-
	-	-	+	+	+	-	0.28	0.29	0.97	0.32	0.32	1.00	0.25	0.28	0.89	-	-
	-	+	+	-	+	-	0.57	2.15	0.27	0.53	1.83	0.29	0.37	1.57	0.24	-	-
	+	-	+	-	+	-	0.06	0.21	0.29	0.11	0.29	0.38	0.09	0.31	0.29	-	-
	-	-	+	+	-	+	0.08	0.15	0.53	0.16	0.20	0.80	0.25	0.25	1.00	-	-
	-	+	+	+	-	-	10.83	11.92	0.91	9.67	10.33	0.94	7.60	8.39	0.91	-	-
	+	+	-	-	+	-	0.01	0.10	0.10	0.02	0.11	0.18	0.01	0.09	0.11	-	-
	+	+	-	+	-	-	0.45	0.58	0.78	0.54	0.63	0.86	0.36	0.48	0.75	-	-
2	+	+	-	-	-	-	0.94	1.58	0.59	1.09	1.73	0.63	1.12	1.60	0.70	-	-
	+	-	-	-	-	+	0.00	0.02	0.00	0.00	0.03	0.00	0.01	0.05	0.20	-	-
	-	-	-	-	+	+	0.01	0.00	0.00	0.00	0.01	0.00	0.02*	0.01*	2.00*	-	-
	-	-	-	+	+	-	0.01	0.05	0.20	0.05	0.06	0.83	0.05	0.05	1.00	-	-
	-	-	+	+	-	-	2.54	4.38	0.58	2.74	5.02	0.55	2.63	4.96	0.53	-	-

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Table 2. Continuation.

Number of factors	Risk factors						Series years									AAV	p-value
							2009			2012			2015				
	AI	UP	IPA	AL	CI	ID	OP (%)	EP (%)	OP/EP	OP (%)	EP (%)	OP/EP	OP (%)	EP (%)	OP/EP		
2	-	+	+	-	-	-	34.4	32.43	1.06	29.67	28.32	1.05	28.95	27.84	1.04	-	-
	+	-	-	-	-	+	0.00	0.02	0.00	0.00	0.03	0.00	0.01	0.05	0.20	-	-
	+	-	-	-	+	-	0.01	0.04	0.25	0.02	0.05	0.40	0.00	0.05	0.00	-	-
	+	-	-	+	-	-	0.11	0.21	0.52	0.17	0.31	0.55	0.19	0.28	0.68	-	-
	+	-	+	-	-	-	5.04*	3.11*	1.62*	6.78*	4.45*	1.52*	6.70*	5.49*	1.22*	(-) 0.07	0.179
	-	+	-	-	-	+	0.03	0.20	0.15	0.06	0.21	0.29	0.04	0.24	0.17	-	-
	-	+	-	-	+	-	0.10	0.40	0.25	0.11	0.35	0.31	0.07	0.27	0.26	-	-
	-	+	-	+	-	-	2.63	2.23	1.18	2.27	1.95	1.16	1.58	1.44	1.10	-	-
1	+	-	-	-	-	-	0.41	0.58	0.71	0.57	0.84	0.68	0.60	0.94	0.64	-	-
	-	+	-	-	-	-	6.77	6.05	1.12	6.09	5.34	1.14	4.99	4.78	1.04	-	-
	-	-	+	-	-	-	13.3	11.91	1.12	15.73	13.76	1.14	19.31	16.46	1.17	-	-
	-	-	-	+	-	-	0.11	0.82	0.13	0.17	0.95	0.18	0.19	0.85	0.22	-	-
	-	-	-	-	+	-	0.03	0.15	0.20	0.01	0.17	0.06	0.04	0.16	0.25	-	-
	-	-	-	-	-	+	0.00	0.07	0.00	0.01	0.10	0.10	0.04	0.14	0.29	-	-
0	-	-	-	-	-	-	2.55	2.22	1.15	2.96	2.60	1.14	3.74*	2.83*	1.32*	-	-

Source: the authors, based on the National Survey of School Health 2009, 2012, 2015[8-10]. AI: irregular consumption of in natura or minimally processed foods; UP: regular consumption of processed and ultra-processed foods; IPA: insufficient level of leisure-time physical activity; AL: consumption of alcoholic beverages; CI: cigarette use; ID: use of illicit drugs; OP: observed prevalence; EP: expected prevalence; OP/EP: ratio between observed and expected prevalence; AAV: average annual variation. p-value: descriptive level or probability of significance; *there was cluster formation.

in 2012 and 6.7% in 2015. It is also worth mentioning that the OPs for the occurrence of no RF were 2.55% in 2009, 2.96% in 2012 and 3.74% in 2015 (Table 2).

As for the combinations, the one formed by the regular consumption of processed and ultra-processed foods and insufficient level of physical activity during leisure time had the highest OP of all three editions of the survey (34.4% in 2009; 29.67% in 2012; and 28.95% in 2015). Despite the high frequency of these combinations, the OP/EP ratio was close to 1, with no cluster formation (Table 2).

DISCUSSION

Studies have addressed the issue of RF for NCDs in adolescents in order to monitor the situation of risk and vulnerability[4,11-16,25]. Thus, this study emphasized the identification of frequency, trend and prevalence—isolated and simultaneous—, of behavioral RFs and sociodemographic characteristics for the development of CNCDs in Brazilian school adolescents, using data from PeNSE.

In the three years of the series, adolescents aged between 14 and 15 years were the majority of the sample and the highest percentages were found among females. A study carried out with data from the Global School-based Student Health Survey (GSHS) between 2007 and 2016 analyzed 304,779 adolescents aged 11 to 17 years from 89 countries, also reporting a higher prevalence of female adolescents (52.2%)[26]. A study carried out in Liberia based on GSHS data also observed that more than half of those evaluated were women (52.5%) aged 15 years (85.3%)[27].

The isolated analysis of RFs showed that insufficient level of physical activity during leisure time and regular consumption of processed and ultra-processed foods were the most common ones in all three editions. Although our study had a possibility of drop in regular consumption of processed and ultra-processed foods, the prevalence of this indicator across the years was still high and worrying, especially considering that irregular consumption of in natura or minimally processed foods seems to be increasing.

Our results show that factors such as insufficient level of physical activity and inadequate diet are the main conditions associated with CNCDs in adolescents[16,25], and this is no different when evaluating studies carried out in other regions of the world. A survey conducted with data from the National Health and Nutrition Examination Survey (NHANES) from 2011 to 2016, which evaluated 7,714 school children and adolescents in the United States, showed that insufficient physical activity levels (53.4%) and consumption of food without nutritional quality (60.0%) were among the most prevalent factors in all editions of the survey[28].

Also, a study carried out with data from GSHS in 2015 and 2016 in Nepal, with 5,795 children aged between 13 and 17 years, also obtained the highest prevalence for insufficient intake of fruits and vegetables (95.33%), followed by insufficient physical activity (84.77%)[29]. Another survey based on cross-sectional data from the National Longitudinal Survey of

Children and Youth (NLSCY) found that physical inactivity was the most prevalent RF among adolescents (62%)[30].

Regarding the cluster analysis, of the 64 possible combinations evaluated in this study, six corresponded to the grouping of RFs. The comparison with other studies[4,16,26,30-32] is still restricted by the fact that our study used a larger number of factors and/or different RFs to identify the clusters. In addition, different methods were adopted in previous studies for the simultaneous assessment and classification of factors.

For example, a cross-sectional investigation carried out in Sousse, Tunisia, with adolescents aged 11 to 16 years, performed cluster analysis with the variables tobacco use, physical inactivity, unhealthy diet and overweight and formed four clusters[33]. Another study that used NHANES data from 2011 to 2016 and evaluated excessive screen time, low-quality diet, low physical activity level, fast food consumption and smoking identified the formation of 20 unhealthy clusters[28]. Although both studies used cluster analysis, it is not possible to make direct comparisons, given the different formations of clusters with different RFs.

When analyzing clusters, we found that the highest OP/EP ratio was found when the six RFs were present simultaneously, that is, the chance of them to occur in conjunction is greater than in isolation. A cross-sectional, multicenter study carried out with 73,624 Brazilian adolescents showed that the OP/EP ratio was always higher in participants who had several RFs[34].

In this research, the group formed by two RFs (low consumption of fresh or minimally processed foods and insufficient level of leisure-time physical activity) presented the highest OP between groups. A similar study carried out in 89 countries also found that the most prevalent grouping was composed of low consumption of fruits and vegetables and physical inactivity[26].

The combination consisting of regular consumption of processed and ultra-processed foods and insufficient level of physical activity during leisure time had the highest OP in all three editions; however, despite the high frequency, these factors did not group together.

A global disease investigation analyzed the effects of individual dietary factors on NCD mortality in 195 countries, quantifying the overall impact of poor dietary habits on mortality from these diseases. According to results, one in five deaths could be prevented by diet improvements alone. In addition, researchers have indicated that an inadequate diet can cause more deaths than other RFs. Thus, it is possible to assess the level of impact of dietary factors on the development of CNCD[35].

There is evidence that consuming fresh and minimally processed foods is protective against cardiovascular diseases, cancer, among others[5,17,36]. However, in this research, the consumption of these foods remains insufficient among adolescents, a result that does not differ from studies such as the Health Behavior in School-Aged Children (HSBC). Carried out in Europe, it showed that only 36% of adolescents aged 13 years eat fruit—and this percentage is even lower in adolescents aged 15 years (31%)[11].

Regarding the OP of not having any of the RFs evaluated in this study, our results showed low prevalence throughout the series. These results are still lower than those found in a cross-sectional study that assessed the prevalence and grouping of five RFs in Canadian adolescents and reported 10% of them without any of the RFs[30]. Likewise, a study conducted in southwestern Nigeria observed that 4.6% of adolescents did not present any of the RFs studied[31]. Although there is a methodological difference between studies, if we compare adolescents from some regions of the world, Brazilians evaluated in the three years of PeNSE may be less likely to have no RFs for CNCD.

With regard to the highest OP/EP ratios found in this study, the correlation between alcohol and cigarettes was present in five of the six clusters identified. Similarly, in a cross-sectional study carried out with 4,724 young Canadians, the use of these products was present in three of four clusters identified, representing the strongest combination of the factors, although they are also less prevalent[30]. Likewise, Rocha and Velasquez-Melendez[4] reported the group formed by low consumption of fruits and vegetables, smoking and alcohol as the most prevalent.

The positive and simultaneous relationship between alcohol and tobacco is well known, since the former tends to encourage the use of the latter[37]. This may explain the OP and EP relationships of these variables verified in this study.

The trend analysis showed that four of the six clusters remained stable throughout the series, which shows that these factors are persistently present among adolescents. However, the simultaneous occurrence of regular consumption of processed and ultra-processed foods, insufficient level of leisure-time physical activity, consumption of alcoholic beverages and cigarette use has decreased significantly throughout the series. On the other hand, the cluster formed by insufficient level of physical activity during leisure time, consumption of alcoholic beverages, use of cigarettes and illicit drugs increased, showing that, although the chances of this grouping occurring among students are already high, it grew over the years.

To date, no study has evaluated the trend of RF clusters among adolescents, which highlights the innovation of our results. As already mentioned, it is important to consider the simultaneity of RFs among adolescents, and the importance of health actions aimed not only at the control of RFs seen individually, but considering the individual as a whole, understanding that these factors behave in a multideterminant way[15].

Some limitations were identified in this study because, as it is a cross-sectional study, it prevents inferences on causal directions of reported associations. In addition, when conducting research on risk behaviors, there may be a systematic bias of social desirability, since participants may provide answers that underestimate the prevalence[4].

The cluster method may have limitations, since, when identifying patterns, it is possible that the same individual adheres to more than one[38]. It is also worth noting that the temporal trend shows the changes of a population group over a period, but not of individuals[39].

Then, health actions originating from macropolitics, represented by official national health and education bodies, should induce health promotion and the prevention of CNCDs

among adolescents, mainly aiming to face the various factors that compromise the full development of this group. It is important that continuous evaluations of these actions are carried out to correct whatever is not achieved. It is also up to school managers, together with students' families and the community, to identify contexts that expose adolescents to health risk behaviors, as well as engage in social actions to monitor what has been implemented.

ETHICS COMMITTEE IDENTIFICATION/APPROVAL NUMBER

According to Resolution 510/2016 of the National Health Council (CNS), "research using public domain information will not be registered or evaluated by the CEP/CONEP system".

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