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Dietary patterns of young adolescents in urban areas of Northeast Brazil

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Abstract

Background: **Temporal trends in dietary patterns reveal associations between food consumption and increased prevalence of non-communicable chronic diseases.**

Objectives: **This study characterized dietary patterns in adolescents in urban area located in northeast of Brazil, relating it to the markers of a healthy diet.**

Methods: **A cross-sectional study used two 24-hour recalls to assess dietary intake in 430 public school students from Natal-RN, Brazil. Principal component analysis was used to derive dietary patterns according to consumption of food based on weight (grams), energy (Kcal), or fiber (grams). These models resulted in a number of different main components, 7, 8 and 4, respectively (cumulative variance >70%; factor loadings >0.4). The association between independent variables and the factor scores of all components obtained was determined by the Prevalence Ratio (CI 95%).**

Results: **The dietary patterns derived were: (1) Pure Traditional Food System, the highly representative pattern in young adolescents and the first component of the analytical models, (2) Combined and Risk Food System; extraction of total food weight and energy revealed markers of unhealthy diets based on high sugar, saturated fat, and salt consumption, and (3) Modified Traditional Food System represented by fiber; pattern 1 was observed within this model too. The associations observed, predominantly from the TFSm pattern, distinguished by sex, age and nutritional status.**

Conclusions: **Patterns 1 and 3 are characterized by preserved regional food practices that prevent chronic disease, whereas pattern 2 is characterized by health risks. These inter-sectorial findings should be considered in the development of health care policies for children and adolescents.**

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Key words: *Adolescents. Principal component analysis. Eating.*

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LOS PATRONES DIETETICOS DE LOS ADOLESCENTES JOVENES DE LAS ZONAS URBANAS DEL NORESTE DE BRASIL

Resumen

Introducción: **Estudios nacionales de evolución temporal encuentran que la tendencia del consumo alimentario se asocia con aumento de la prevalencia de las enfermedades crónicas.**

Objetivos: **Caracterizar los hábitos alimentarios de los adolescentes en un área urbana del Noreste de Brasil, relacionándolos con los marcadores dietéticos saludables.**

Métodos: **Estudio transversal con adolescentes (n=430) de las escuelas públicas de Natal-RN, Brasil. El consumo alimentario se evaluó mediante dos recordatorios 24h. La técnica de Análisis de Componentes Principales fue utilizada para derivar patrones dietéticos, de acuerdo con: alimentos en gramos (g), la energía en Kcal y la fibra en gramos, lo que resulta, respectivamente, en un número de diferentes componentes principales, 7, 8 y 4 (varianza acumulada >70%; cargas factoriales >0,4). La asociación entre las variables independientes y los escores de los factores de todos los componentes obtenidos, se determinó por la razón de prevalencia (IC 95%).**

Resultados: **Los patrones dietéticos fueron: el (1) Sistema Alimentario Tradicional puro representó el primero componente de los modelos; el (2) Sistema Alimentario Combinado y de riesgo reveló marcadores de alimentación no saludables, debido a la alta frecuencia de azucares refinados, grasas saturadas y sal; y el (3) Sistema Alimentario Modificado fue identificado en el modelo de las fibras, el patrón 1 de nuevo fue observado en este patrón. Las asociaciones observadas, en particular del patrón SATm, distinguen por sexo, edad y estado nutricional.**

Conclusiones: **Los patrones dietéticos 1 y 3 se caracterizaron por la preservación de las prácticas regionales de alimentos, muy saludables, desde el punto de vista de la prevención de las enfermedades crónicas, mientras que el 2 representó alerta y riesgo para la salud. Los hallazgos pueden subvencionar Políticas de Atención a la Salud para infancia y adolescencia en carácter intersectorial.**

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Palabras clave: *Adolescentes. Análisis de componentes principales. Consumo de alimento.*

List of Abbreviations

BMI: Body Mass Index.
CFSr: Combined and Risk Food System.
CNPq: *Conselho Nacional de Desenvolvimento Científico e Tecnológico (*National Council for Scientific and Technological Development).
IBGE: *Instituto Brasileiro de Geografia e Estatística* (Brazilian Institute of Geography and Statistics).
KMO: Kaiser-Meyer-Olkin.
NCD: Non-communicable Chronic Diseases.
PCA: Principal Component Analysis.
PeNSE: *Pesquisa Nacional de Saúde do Escolar* (National Survey of School Health).
POF: *Pesquisa de Orçamentos Familiares* (Household Budget Survey).
TFSm: Modified Traditional Food System.
TFSp: Pure Traditional Food System.
USDA: United States Department of Agriculture.
WHO: World Health Organization.

Introduction

The World Health Organization (WHO) has recognized the increasing prevalence of NCDs: Non-communicable Chronic Diseases and its proportional relationship to mortality. Thus, the WHO has defined guidelines for the adoption of public policies aimed at promoting healthy lifestyles and dietary habits. Prevention of epidemic NCDs in adulthood is feasible, but is dependent on lifestyle learned during childhood and adolescence[1].

National studies have found that temporal evolution in food consumption patterns are consistent with the increased prevalence of NCDs and the continuous increase in obesity prevalence, even among teenagers. However, little is known about the approximate determinants of obesity, such as diet and physical activity, in low-income groups; Brazil lacks reliable data on secular trends in socioeconomic patterns of food intake and physical activity[2].

Nationwide studies on adolescent food intake in Brazil[3,4] have identified markers for unhealthy food, like sugars, that are consumed concomitantly with typical beans and rice diets[5], which is the combination specific to the traditional food system in all regions of the country.

Recent publications on Brazilian regional dietary patterns derived from household food availability data have shown that individuals in majority of the Brazilian regions consume traditional rice and beans as a major food staple food. In the northeast, this staple is associated with the presence of adolescents in families, among other factors[6].

The strategic adoption of *a posteriori* analytical methods, such as the principal component analysis (PCA) technique, has been used in exploratory research to investigate food consumption patterns in adolescents[7-14].

We believe that it is justifiable, therefore, to characterize dietary patterns, thus obtaining knowledge on the indicators of the remaining healthy regional dietary habits, particularly in the vulnerable segments of the population, by using either young adolescents[15] or proxies of socioeconomic status, such as students from public schools in the urban areas of northeast Brazil.

Materials and Methods

Study Population

The cross-sectional study was conducted on elementary school students (grades 3-9) from public schools between 2007 and 2008 in Natal, which is located in the northeast of Brazil.

The Ethics Committee on Research of the Universidade Federal do Rio Grande do Norte approved the study (under protocol No. 112/06). All participants and their guardians provided informed consent at no cost.

Sampling Plan

The samples were collected in 2 stages and comprised stratification by district for school selection. The base population (39,920 students) was weighted according to the number of students from each of the city's 4 health districts (N_{north} = 19,270; N_{south} = 4,128; N_{east} = 3,728; and N_{west} = 12,794).

The parameter used to calculate sample size was the prevalence of high blood pressure ($\hat{p}$), which was estimated in pilot studies that were conducted in each district and measured as follows: $\hat{p}_{north}$ = 14.6%, $\hat{p}_{south}$ = 8.8%, $\hat{p}_{east}$ = 17.9%, and $\hat{p}_{west}$ = 27.5%.

The estimated error and percentage of loss were 4% and 20%, respectively, which corresponded to the final sample size of 436 students. We used stratified sampling with Neyman allocation to define the sample sizes for the districts: N_{north} = 192, N_{south} = 33, N_{east} = 40, and N_{west} = 161.

To determine the number of schools, we considered the average number of students per school and assumed approximately equal variances in the districts. The sample size of schools obtained was N = 21 and according to proportional allocation, it was distributed by district: N_{north} = 9; N_{south} = 3; N_{east} = 3, and N_{west} = 6. Schools were selected by random draw and the student sample was distributed randomly according to district and was proportional to the total number of students in the respective schools[16].

Inclusion criteria for participants consisted of regular school attendance and adolescent age (range, 10-19 years) at the first time of data collection. Exclusion criteria included genetic syndromes associated with obesity or other diseases, pregnancy, and adolescents with special needs[16].

Data Collection

Trained investigators collected data on adolescent identification, maternal education, anthropometric measurements, typical diet, and other aspects related to lifestyle and health through structured interviews using standard questionnaires.

The age group categories were based on WHO adolescent classification of stages of development[15]: young (10-13 years), middle (14-17 years), and late (18-19 years).

Maternal education was categorized broadly as "up to primary schooling" or "high school and/or university."

Assessment of Nutritional Status

The body mass index (BMI) was classified according to Cole et al. (2000)[17]. An individual was defined as overweight if the BMI was greater than or equal to 25 kg/m^2.

Assessment of Food Consumption

Food consumption data were obtained by a trained team, who administered two 24-hour dietary recalls (R24) spaced 30-45 days apart. Photos of household measurements expressed in utensils and portions were used to aid the collection process. The procedures and standards for the food and preparation types and conversions reported in household measures relied on adaptations of *per capita* and preparation datasheets.

Energy and fiber consumption was estimated by using the Virtual Nutri Plus® software (2007), modified in relation to the list of foods and nutritional information for more than 90% of the items. Nutritional information was obtained from the Brazilian Food Composition Table (2006), the National Nutrient Database for Standard Reference-USDA (2004), and labels (from a consultation conducted in 2008). The data produced in Virtual® were exported to the Excel® version 2007 and organized within spreadsheets.

Statistical Analysis

To assess dietary patterns, we used the PCA technique according to 3 distinct models—food consumption expressed by the total weight of food consumed (g), total energy (Kcal), and dietary fiber (g) as markers of healthy eating. For each analysis, median consumption was included in the food criteria because it represents the best parameter, among those tested, for obtaining the PCA model.

The generated correlation matrix showed a linear correlation between the variables according to Pearson's correlation coefficient ($r \leq 0.90$). Significant correlations were indicated by the determinant $\neq 0$. Data adjustments were tested by Kaiser-Meyer-Olkin (KMO) measure of sampling adequacy, and included values above 0.6. Communality values greater than 0.5 represented the basis for variance acceptance, as explained by the factors produced by each variable; lower values were excluded from the dataset, which restarted the analysis process[18].

With regard to analysis of factor loadings, values above 0.4 were included[19]; the higher the factor loading value, the greater that particular food contributes to the respective component[20,21].

Factor extraction was based on eigenvalues (*Kaiser criteria*) greater than 1, and explained more than 70% of the variation in the variables entered into the model. The Varimax orthogonal rotation was applied to all analyses[22].

The association between independent variables (age categorized by median, sex, maternal education, overweight and not overweight) and the factor scores of all components obtained, categorized by median, was determined by the Prevalence Ratio (PR), with a confidence interval of 95%.

Statistical analysis was performed using Statistica version 10 (Stata Corp; College Station, USA) in descriptive and exploratory mode.

Identification of Food Patterns

The designation of dietary patterns was based on the interpretation of the variable combinations for each component, with the inclusion of the highest factorial loads (>0.4) and respective inverse associations (negative charges close to 0.4). The Pure Traditional Food System (TFSp) was applicable to components that showed the presence of foods specific to regional diets[23,24] such as beans and rice. The Combined and Risk Food System (CFSr) was applicable to components that consisted mainly of healthy foods specific to typical regional consumption (e.g., corn couscous, fruit, milk, and beef) in combination with sugar from various sources, saturated fat and/or sodium, markers of unhealthy diets, historic customary foods (sugar and sweets), or foods classified recently as habitual and local (e.g., biscuits and similar, vegetable oil and margarine used in casseroles, stews, sauces, and fried foods, and sausages). The Modified Traditional Food System (TFSm) was applicable to components that consisted of healthy foods recently incorporated into the usual regional diet (e.g., chicken instead of beef).

Results

The sample of adolescents from public schools in Natal was distributed proportionally with regard to sex. Most of the adolescents were aged between 10 and 13 years, had normal weight, and were born to women with low education levels (Table I).

Table I
Demographic and anthropometric characteristics of adolescent sample from public schools in Natal. Brazil (N = 430)

Variables	*N*	*%*
Sex		
Male	216	50.2
Female	214	49.8
Age (years)		
10-13	399	92.8
14-17	29	6.7
18-19	2	0.5
Maternal education[a]		
Illiterate or attended primary school only	233	74.8
Attended high school or college	77	25.2
Excess weight		
Without	364	84.7
With	66	15.3

[a]Unknown data for 120 adolescents.

The distribution of foods consumed by adolescents is based on the average of the two R24. The foods consumed most frequently by adolescents were expressed as median of food weight (g), energy (Kcal) and fiber (g) (Table II).

The principal components that were extracted from the profile of adolescent food intake were expressed as the food's average weight (g), energy (Kcal), or dietary fiber (g). In addition, we presented the variables of median consumption (which corresponded to factor loading), cumulative percentage variance, and specific components (Tables III, IV, and V).

For all the analytical models, the first component represented a TFSp pattern (bean and preparation ingredients) and exhibited high specific variance relative to cumulative variance: 22.2 versus 78%, 19.4 versus 73%, and 35.1 versus 73% (Tables III, IV, and V).

In the PCA quantitative model for food quantity, we observed CFSr patterns in all the other components of foods consumed: in component 2, table sugar along with fruits; in 3, beef and oil; in 4, sausages, corn couscous, and oils; in 6, margarine and breads; and in 7, biscuits inversely related to breads. In component 5, chicken alone nearly represented the TFSm, but vegetable oil appears with a loading factor of 0.36, which suggested a CFSr pattern (Table III).

In the PCA model for energy (Kcal) derived from food, the CFSr patterns were observed mostly: in component 2, table sugar and fruits; in 3, oil, beef and sugar; in 4, sweets (and similar) and milk; in 5, sausages and corn couscous; in 6, biscuits inversely related to breads; and in 8, margarine and bread. A TFSm pattern was observed only in component 7 because chicken was related inversely to beef (Table IV).

In the model based on sources of dietary fiber, the TFSm pattern occurred in components 2 and 3; breads related inversely to corn couscous and a mix of cookies and fruit. Component 4 also showed TFSp pattern because of the strong presence of rice (Table V).

The estimated prevalence ratios between independent variables and factor scores of the factor analysis model showed no associations between maternal education and any component of the different models. Associations with overweight were observed only for the analytical model developed for energy. Associations with sex were demonstrated in all the models.

Table II
Distribution of foods consumed by young adolescents, derived from the average of two 24-hor recalls and expressed as median of food weight (g), energy (kcal), and fiber (g)

	Frequency				
Food	*N*	*%*	*Amount (g)*	*Energy (kcal)*	*Fiber (g)*
Onion	422	98.1	14.5	5.7	0.32
Sugar	412	95.8	34.5	153.5	0.00
Pepper	412	95.8	5.0	1.1	0.13
Beans	406	94.4	94.0	82.1	7.31
Rice	405	94.2	87.5	113.8	0.96
Vegetable oil	427	93.0	9.5	84.0	0.00
Tomato	395	91.9	7.5	1.1	0.09
Beef	356	82.8	38.0	99.0	0.00
Bread	356	82.8	60.3	182.3	1.72
Biscuits and similar	343	79.8	45.0	255.6	1.07
Margarine	323	75.1	6.0	36.9	0.00
Dairy	312	72.6	84.1	50.4	0.00
Fruit	199	69.5	48.0	32.4	0.94
Corn couscous	256	59.5	22.5	26.6	0.49
Chicken	249	57.9	21.5	35.4	0.00
Sausages	225	52.3	7.5	21.4	0.00
Carrot	223	51.9	2.0	0.6	0.05
Sweets and similar	208	48.4	0.0	19.7	0.00

Table III

Principal components extracted from food consumed by young adolescents and expressed as the average weight of food (g), median consumption, respective factor loadings (>0.4), and percentage of variance

	Components[a]						
Food	*1*	*2*	*3*	*4*	*5*	*6*	*7*
Sugar		0.82					
Biscuits and alike							0.73
Beef			0.90				
Onion	0.92						
Corn couscous				0.50			
Sausages				0.89			
Beans	0.86						
Chicken					0.89		
Fruits		0.81					
Margarine						0.89	
Bread						0.49	*
Pepper	0.91						
Vegetable oil			0.72	0.43			
Tomato	0.75						
% variance	22.19	11.38	9.91	9.13	8.08	7.73	7.27

[a]Sampling adequacy (KMO) = 0.62; communality (min-max) = 0.59–0.92; percentage of cumulative variance = 77.95%
*negative factor loading =-0.68

Table IV

Principal components extracted from food consumed by young adolescents, expressed as the average amount of energy (kcal) from food, median consumption, respective factor loadings (> 0.4), and percentage of variance

	Components[a]						
Food	*1*	*2*	*3*	*4*	*5*	*6*	*7*
Sugar		0.83	0.60				
Rice							
Biscuits and similar						0.63	
Beef			0.65				**
Onion	0.92						
Corn couscous					0.64		
Sweets and similar				0.83			
Sausages					0.79		
Beans	0.78						
Chicken							0.84
Fruits		0.81					
Dairy				0.72			
Margarine							0.88
Bread						*	0.42
Pepper	0.90						
Vegetable oil			0.75				
Tomato	0.76						
% variance	19.38	10.40	8.26	8.15	7.15	6.83	6.33	6.07

[a]Sampling adequacy (KMO) = 0.61; communality (min-max) = 0.55–0.88; percentage cumulative variance = 72.57%.
*negative factor loading = -0.74.
**negative factor loading = -0.57.

The factor scores resulting from the factor analysis model developed according to the total amount of food items consumed revealed no associations between maternal education and overweight and any of the components analyzed. In relation to sex, boys were 1.27 times more likely to consume food items containing component 6 (CI 95% 1.05-1.54). For this same component, adolescents up to 11.4 years of age were 1.23 times more likely to consume foods containing it (CI 95% 1.02-1.49). Adolescents older

Table V
Principal components extract from food consumed by young adolescents and expressed as the average amount of dietary fiber (g) from food, median consumption, respective factor loadings >0.4, and a percentage of variance

	Components[1]			
Food	*1*	*2*	*3*	*4*
Rice				0.85
Biscuits and similar			0.76	
Onion	0.94			
Corn couscous		*		
Beans	0.87			
Fruits			0.66	
Bread		0.70		
% variance	35.13	13.09	13.02	12.10

[a]Sampling adequacy (KMO) = 0.77; communality (min-max) = 0.59–0.89; percentage of total variance = 73.34%
*negative factor loading = -0.75

than 11.4 years were 1.32 times more likely to consume foods containing component 7 (CI 95% 1.08-1.61).

The analysis model developed from energy intake (Kcal) demonstrated the following associations: component 2 and overweight (PR = 0.61, CI 95% 0.38-0.97); component 6 and being male (PR = 1.25, CI 95% 1.03-1.51); component 7 and being male (PR = 1.32, CI 95% 1.09-1.49); component 8 and age up to 11.4 years (PR = 1.24, CI 95% 1.02-1.49); and component 8 and overweight (PR = 1.87, CI 95% 1.17-2.99).

The factor analysis model based on fiber intake showed no associations between age, maternal education and overweight and any of the primary components. With respect to sex, boys were 1.25 times more likely to consume foods containing component 1 (CI 95% 1.03-1.51), where as boys were 1.28 more likely to consume foods with component 3 (CI95% 1.06-1.55).

Discussion

The sample studied was homogeneous with regard to age (predominantly young teenagers) and was proportionally balanced between genders. The study sample is justified by the design, which included students in the final years of primary school (age, 10–14 years). Most of the adolescents in the study attended municipal public schools and were considered socioeconomically disadvantaged based on maternal education status. The National Survey of School Health (PeNSE) corroborated this finding in a study involving a comparison of the education of mothers of students from public and private schools[4]. We found that the prevalence of overweight young adolescents was lower than the national or regional prevalence[25].

The relationship between dietary patterns and socioeconomic conditions is recurrent in Brazilian studies, especially the association between traditional dietary patterns and less educated households[26] .The association between the adoption of healthy food habits and high socioeconomic status was determined inclusively within the same region[27].

Consumption of traditional Brazilian food has been linked to nutritional status in adolescents, particularly eutrophic individuals[28], and is also associated with decreased risk of excess weight and obesity[13].

Tables II and III show the diversity and frequency of food consumption by adolescents, which is comparable to the consumption profile observed in recent national studies[5].

Some findings on markers of unhealthy diets are of particular epidemiological concern, such as the high consumption of sucrose-rich foods[5,15]. These patterns can be explained by the customary use of sucrose to sweeten drinks[29]; the amount and manner of vegetable oil and margarine used in cooking and other preparations; and increased consumption of sausages and other sources of sodium and saturated fats[24].

An inter-regional comparison revealed that, per household, foods like beans, biscuits, bread, sugar, and margarine are consumed at a greater percentage in northeast Brazil than in other large regions[30].

The interpretation of the principal components and the resulting designation of food standards indicate that careful consideration was given to implicit settings related to healthy food[24] and associated dietary markers.

It was observed that the TFSp pattern, which consisted of beans and a mixture of characteristic ingredients (e.g., onions, peppers, and tomatoes) was predominant in the dietary spectrum of young adolescents. The TFSp pattern represented the amount of food and energy and also a healthy food pattern based on the dietary fiber marker. Therefore, the evidence for preservation of habitual, cultural and nutritionally enhanced consumption of food is strong[24].

Nonetheless, the CFSr patterns were identified the most in consecutive components extracted from analytical models for the total amount of food and energy. In sequence principal component comparisons, the only changes observed were in the ranking of food, especially unhealthy food markers such as sugary food, oils and fats, and sausages.

TFSp and TFSm patterns were observed in the extraction of components from fiber-based food sources, which is compatible with markers of the following healthy food groups: legumes, grains and cereals, and fruits.

Viewed individually, beans represented nearly 5 times the median value of fiber as a food source; bread ranked second. Fruits represented approximately one-eighth of the median value of fiber intake.

Other studies show the importance of Brazilian beans as a source of dietary fiber and also as a marker of healthy eating habits in adolescents[31,32].

Nevertheless, the association between beans and the prevention of NCD, particularly cardiovascular disease, requires further study. This need is strengthened further considering the scientific logic that stipulated increased consumption of fruits and vegetables helps reduce the risk of hypertension, coronary heart disease, and stroke[1,33].

The markers of unhealthy eating habits observed in CFSr, especially sugary items, also were found in Brazilian studies on food intake in adolescents[3,4,32].

The CFSr pattern standards, which are related to components that combine sodium and saturated fat sources, become especially relevant with the consideration of risk factors for cardiovascular disease, such as low levels of high-density lipoprotein-cholesterol (HDL-C) and hypertriglyceridemia, which were observed in the same young adolescent population sample[34].

The prevalence ratios estimated from the analysis model for total amount of foods indicated higher intake of the component represented by breads and margarine among boys and adolescents up to 11.4 years of age. However, adolescents older than 11.4 years consumed more of the predominant component in cookies.

The associations of factor scores resulting from the analytical model developed based on the energy derived from food items showed that overweight adolescents consumed less sugar and fewer fruits and more of the component contained in margarine and breads. Boys consumed more components from cookies and the like and chicken. Those aged up to 11.4 years ate more margarine and bread, as was observed in the model for total amount of foods.

Association tests involving factor scores from the analytical model of fibers revealed that girls consumed fewer foods with the component contained in beans and ingredients, whereas boys consumed more of the component represented by cookies and fruits.

The associations observed, predominantly from the TFSm Pattern, reinforce those obtained in other Brazilian studies on the food preferences of this population group, distinguished by sex, age and nutritional status[13,28].

An association between traditional food patterns and lower schooling was observed by Marchioni et al. (2011)[26] in their analysis of food acquisition as reported by the National Household Sampling Survey-PNAD-2002-2003. The food patterns of children in Northeast Brazil, aged between 4 and 11 years, depended on the socioeconomic status of the families, such that the consumption of healthier food items was associated with higher socioeconomic levels[27].

The traditional adolescent diet has been associated with lower risk of overweight and obesity in logistic models adjusted for diet, age, leisure physical activity and occupation[13].

The limitations specific to these types of studies include the cross-sectional nature, homogeneity of the population group studied, biases related to dietary assessment methods, and even arbitrary decisions related to dietary standardization and the PCA method[22,24,25,35].

Some of these features may have favored the robustness of the analysis, such as the prior decision to include only the food items of median food consumption in the PCA models and the homogeneity of the adolescent sample.

Although the factorial model has its limitations, like the subjectivity involved in the various stages of analysis and the reduction of a large number of variables into a smaller number of components[19], the model has revealed eating behaviors of young and socioeconomically disadvantaged adolescents.

In conclusion, the TFSp and TFSm dietary patterns are characterized by the preservation of regional and very beneficial food practices that help prevent chronic disease, whereas the CFSr pattern represents a health risk alert.

Therefore, this study should serve as input toward the planning of inter-sectorial food and nutrition, including policies of health care for children and adolescents.

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