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Article

Estimation of intake of critical nutrients associated with non-communicable diseases according to the PAHO/WHO criteria in the diet of school-age children in Montevideo, Uruguay.

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Abstract: Unhealthy diet is an important health problem in the region of the Americas, and Uruguay does not escape this reality. Nutritional problems in Uruguayan school-age children are overweight and obesity. Caloric intake is excessive for 60% of children and 28% of calories come from ultra-processed products (UPP) [CODICEN 2021] [MIDES 2020) (Köncke, Toledo, 2021). In 2018, an evaluation of food intake was conducted in a representative sample of public schools in the city of Montevideo. Food and preparations were categorized according to the NOVA system, later they were analyzed according to the Pan American Health Oganization nutrient profile model (PAHO NPM). Only 0.52% of children consumed exclusively natural foods, unprocessed, minimally processed or culinary ingredients. Twenty-five percent of children consumed ≥ 4 products categorized with excessive content of free sugars, total fat or saturated fat according to the PAHO NPM; in the case of excessive sodium this was 40%. In general, children who included products with excessive free sugars, sodium or saturated fat in their diet exceeded the limits established by PAHO and as a result their diet is of poorer nutritional quality compared to children who did not consume such products.

Keywords: ultra-processed products; school feeding; nutrient profile model

1. Introduction

Unhealthy diet is a major health problem in the region of the Americas, and Uruguay does not escape this reality (1–6). The existing evidence reaffirms the need for children to eat adequately, because it is their right, and because meeting dietary guidelines results in healthy and strong children, who learn better, and reach their maximum potential (7) (8). The latest information available shows that the main nutritional problem of school-age children is overweight and obesity, which profoundly affects their current and future health and wellbeing (8,9). Childhood overweight and obesity result from the imbalance between caloric intake and caloric expenditure, a situation that has been largely related to the so-called obesogenic environments. This is also part of profound changes in dietary patterns, displacing a diet based on healthy and real foods for ultra-processed products [UPP]. The latter have a very low nutritional value and their consumption has been proposed as an indicator of the nutritional quality of the diet, in particular for the study of nutrients related to noncommunicable diseases [NCDs] (10–13).

UPP contain excessive amounts of calories, fat and sugar, and a low amount of vitamins, minerals and other essential micronutrients for young children (8,14,14–18). The definition of UPP was taken according to the "NOVA food classification", that has been described elsewhere(1). This classification defines UPP as those products that include a

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large number of ingredients, many of them exclusively for industrial use, and that are the result of a sequential process in the industry (19,20). The sale of these products showed an exponential growth between 2000 and 2013, of 146%, while the region reached a 68% increase in average. This increase in sales and household consumption may lead to an excessive intake of free sugars, sodium, total fat, saturated fat, and trans fatty acids (20).

Research carried out in multiple countries has demonstrated the relationship between UPP consumption and nutrient intake imbalances, characterized by a high concentration of nutrients associated with NCDs and low in health-protective nutrients (14,15,18,20–26). In addition, high intake of UPP has been associated with a highe incidence of hypertension, dyslipidemia, diabetes and cancer (12). Unhealthy diet is the main risk factor for NCDs (27). In 2018, the four main NCDs were estimated to be the cause of 54.5% of all deaths in the country (28).

The average group intake in children that participated in this study, exceeds the daily calorie recommendation by 13%, and 54% of them have an excessive caloric intake, with one out of every three calories consumed from UPP. The average intake of free sugars was close to 100 grams per day, and 2000 mg in the case of sodium. Additionally, children in the study have an insufficient consumption of foods recommended by dietary (2,4,5). School-age children showed an average consumption of fruits and vegetables that did not reach 50% of the recommendation, which is reflected in the low intake of dietary fiber (2,4,5).

This study estimates the effect of the consumption of products with excessive amount of critical nutrientes according to the PAHO NPM on the quality of the diet of children 4 to 12 yrs in Montevideo, Uruguay. Specifically, it describes: 1] intake of products with excessive amount of critical nutrients according to the PAHO NPM, 2] the difference in the intake of critical nutrients associated with NCDs when any quantity of products with excessive critical nutrientes according to the PAHO NPM compared to when no such product is consumed, 3] the difference in the prevalence of non-recommended intake levels of critical nutrients associated with NCDs, between the condition of consumption of products with excessive content in these nutrients compared to the no-consumption condition, and 4] the contribution of the amount consumed of products with excessive content of critical nutrients associated with NCDs according to the PAHO MPN on the total intake in the diet of these critical nutrients and the percentage increase in this intake above the limits recommended by the WHO (24,25) (31,32).

2. Materials and Methods

2.1. Data sources

The data source for this analysis is the study of the Estimation of Food Intake by multiple pass 24-hour dieetary recall [24HR] conducted within the Evaluation of the School Feeding Program and monitoring of the nutritional status of children of public and private elementary schools in Uruguay in 2018. The methodology of the study is described elsewhere. (2,3)

The estimation of food intake was carried out in a representative subsample of 21 public elementary schools in the city of Montevideo, which had a school canteen service. The children evaluated correspond to students of initial level 4 years, second and fifth grade selected by sampling in the second semester of the year. The survey was carried out by licensed nutritionists or advanced nutrition students, trained on the application of the tool and in the use of the available materials to quantify the intake. 332 first 24HR were performed and a second was applied to 18% of them (9,11). The methodology of the study is described in the document of the Division of Research, Evaluation and Statistics [DIEE] (9). This study was based on the analysis of the first 332 24HR.

2.2. Classification of foods according to their processing

The NOVA system groups food according to the nature, extent and purposes of the industrial processed they undergo. This system classifies foods and food products into

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four groups: group 1 unprocessed and minimally processed foods [G1]; group 2 processed culinary ingredients [G2]; group 3 processed [G3]; group 4 ultra-processed foods [G4] (4,5,5).

According to the parameteres of the PAHO NPM, for this study the NOVA classification was adapted only with groups NOVA 3 [G3] and NOVA 4 [G4], according to the following.

Group 3: includes canned, bottled or brined foods and culinary preparations that are prepared following traditional methods and using unprocessed of minimally processed foods and are made by adding excessive culinary ingredients such as salt, sugar, butter or oil, or even preservatives. Some examples of foods in G3 are cheese, fruits and vegetable preserves.

Group 4: ultra-processed foods include foods, beverages and other industrial preparations designed and marketed by the food industry. This implies adding artificial additives from G3 or formulation of ingredientes used in processed foods like sugar, oils, fats or salt, and other sources of energy and nutrients that are not normally used in culinary preparations, or other products of additional processing such as hydrogenation, interesterification of oils, protein hydrolization, or food components such as soy protein isolate, maltodextrins, inverted sugar, sugar syrup, and other additives that mimic or increase the sensory characteristics of foods, or that decrease less desired characteristicas in the final product. Production of UPP requires a variety of processes in sequence, that do not have domestic equivalence to combine the several ingredients and get to the final product. Some examples of products in G4 are sugar-sweetened beverages, candy, ice cream, and sweet and savory snacks.

2.2.1. Criteria utilized for harmonization of records obtained by 24HR with the NOVA classification

A criteria was created to differentiate home made or restaurant preparations baed on unproccessed or minimally processed foods from those that have similar characteristicas but are industrially made.

Homemade culinary or traditional preparations are made from foods in G1, but similar processed products of such preparations with added salt, sugar, butter or oil, as well as additives and antioxidants were classified in G3. If to those products were added with artificial additives to mimic sensory qualitites of G1 or if the product contains high quantities of ingredients in G4 or are products designed or marketed industrially, they were classified in G4.

Foods and beverages that must be evaluated with the PAHO nutrient profile model are processed and ultra-processed products, and there is no evidence to support the need to apply it to unprocessed or minimally processed foods. According to the PAHO NPM, processed and ultra-processed products are classified as follows: with an excessive amount of sodium, if the ratio between the amount of sodium [mg] in any given amount of the product and the energy [kcal] is equal to or greater than 1:1; with an excessive amount of free sugars, if in any given quantity of the product the amount of energy [kcal] from free sugars [grams of free sugars x 4 kcal] is equal to or greater than 10% of the total energy [kcal]; with an excessive amount of total fat, if in any given quantity of the product the amount of energy [kcal] from total fat [grams of total fat x 9 kcal] is equal to or greater than 30% of total energy [kcal]; with an excessive amount of saturated fat, if in any given quantity of the product the amount of energy [kcal] from saturated fat [grams of saturated fat x 9 kcal] is equal to or greater than 10% of the total energy [kcal] (6) .

2.2.2. Assessment of energy and nutrient input of foods

Uruguay does not have an updated and accessible food composition table. In this scenario, an *ad hoc* table was generated, based on a pre-existing composition table to which food, preparations and products commonly consumed by school-age children were

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added. In this study, only the caloric intake and the contribution of nutrients related to NCDs are analyzed: total and saturated fat, free sugars and sodium.

2.2.3. Data processing and analysis

To estimate nutrient intake using the 24HR data, food was transformed into their respective nutrients using the Diet Intake Evaluation Program [EVINDI v4] of the School of Nutrition and Dietetics of the University of Antioquia. For this, and previously, the database of preparations, foods and beverages consumed in Uruguay and representative data of the chemical composition were updated. The database obtained was transformed to Stata/SE 12.0 where it was linked to sociodemographic variables [sex, age group and educational level of the adult informant] defined as covariates for subsequent analysis.

Analysis include descriptive statistics including prevalences of intake of products with excess of critical nutrients, averages of the proportion of energy intake from each critical nutrient and sodium intake in mg, and the prevalence of critical nutrient intake according to the WHO intake goals, as well as the respective 95% confidence intervals. The averages of intake of critical nutrients [expressed as a proportion of energy or as a ratio of mg of sodium/kcal] and the prevalences of intake of nutrients above or below the WHO intake goals were estimated for the total population and for the domains of interest, that is, for the subset of the population that did not consume and that consumed excessive products according to PAHO.

Linear regression models were adjusted to estimate the significance of the contribution of the consumption of products with excess in free sugars, total fats, saturated fats above the average intake of the proportion of energy in the diet from each of these critical nutrients, adjusting by sociodemographic variables [i.e. age, sex and educational level]. To estimate the significance of the contribution of the consumption of products with excessive sodium, sodium intake measured in mg was included in the linear regression models as a response variable. The statistics considered the structural information of the sample design.

Prevalence ratios were estimated to compare the proportions of the population and subsets of interest that did not meet the WHO nutrient intake goals. Logistic regression models with a Poisson probit link function adjusted for the sociodemographic variables were used to estimate the significance of the contribution of the consumption of products with excess in critical nutrients according to the PAHO NPM and the probability of the intake of the critical nutrients being above the goals recommended by the WHO. Finally, linear regression models were adjusted to analyze the significance of the contribution of grams of products with excessive nutrients on the distance from the intake of critical nutrients to the WHO goals.

3. Results

Table 1 shows the results by the schoolchildren of the consumption of foods categorized as those that do not apply to the NPM, that is, the group of schoolchildren who exclusively consume natural, unprocessed, minimally processed or culinary ingredients [0.52%], the group that consume ultra-processed or processed products without an excessive content of one of the nutrients related to NCDs according to the MPN and finally those that consume products that are excessive in the nutrients studied.

The proportion of schoolchildren who do not include products defined as not excessive in any of the nutrients evaluated is 5% [Table 1].

On the other hand, more than half of girls and boys consume products with excess in their content of nutrients related to NCDs. It is noteworthy that a fifth of the school-age children included at least one product with excessive free sugars, and the same proportion consumed products with excessive total fat. When analyzing the prevalence of consumption of multiple products with excessive amounts of critical nutrients, it was identified that 61% of children between 4 and 12 years consumed 3 or more products that were

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excessive in sodium. In the case of free sugars or total fats, this proportion reaches about 50%. [Table 1]

Table 1. Consumption of products defined as excessive in NCD-related critical nutrients according to PAHO-NPM ‡ ‡.

% of individuals with consumption of:	Free sugars	Total fat	Saturated Fats	Sodium
	% [95% CI]	% [95% CI]	% [95% CI]	% [95% CI]
Only foods that do not apply to the PAHO NPM [a]	0,52 [-0,5– 1,5]	0,52 [-0,5– 1,5]	0,52 [-0,5– 1,5]	0,52 [-0,5– 1,5]
Products defined as non excessive in NCD-related critical nutrients according to PAHO NPM [b]	4,4 [1,5 – 7,2]	8,6 [5,1 – 12,2]	10,4 [6,4 – 14,2]	3,7 [1,3 – 6,1]
Products defined as excessive in NCD-related critical nutrients according to PAHO NPM [c]				
1 product	21,2 [16,3-27,0]	22,0 [16,9 -29,0]	19,5 [14, 8-25,3]	12,3 [8,7 - 17,0]
2 products	25,8 [20,5 -32,0]	22,6 [17,7 - 28,5]	21,3 [16,4 – 27,0]	22,2 [17,2 – 28,1]
3 products	22,3 [17,4 - 28,1]	19,9 [15,2 - 25,5]	23,5 [18,4 - 29,6]	21,7 [16,9 – 27,5]
>= 4 products	25,7 [20,8 – 31,4]	26,4 [21,2 - 32,2]	24,8 [19,9 - 30,5]	39,6 [33,5 – 46,0]

Assessment of Dietary Intake. School Feeding Program children 4/12 years. Total population estimate: N=15070 [n=332]. 95% CI: 95% Confidence Interal; NCD: noncommunicable diseases; PAHO-NPM: Pan American Health Organization Nutrient Profile Model. [a] Foods that do not apply to the PAHO NPM: Natural of minimally processed foods and culinary processed ingredients. [b] Foods that apply to the PAHO NPM: Products with and without high content of NCD-related nutrients according to the PAHO-NPM [for free sugars < 10% of total energy, for total fat < 30% of total energy, for saturated fats < 10% of total energy, for sodium <1 mg per kcal]. c Products with excessive content of NCD-related nutrients according to PAHO-NPM [for free sugars >= 10% of total energy, for total fat >= 30% of total energy, for saturated fats >=10% of total energy, for sodium >= 1 mg per kcal].

From the analysis of the caloric intake provided by the studied nutrients to the total energy of the diet for the entire population studied, it is observed that 18.2% of the total energy comes from free sugars. In the population that consumes products with excessive content according to the PAHO-NPM, it was observed that 18.8% of total energy comes from free sugars. The contribution of free sugars to total calories falls to 4.9% in the group of children who do not include products with excessive content of critical nutrients [Table 2].

The contribution of total fat to the total energy of the diet for the whole population studied is within the goal of intake recommended by the WHO [29.4%], and is similar among the subgroup of the population that consumes products with excessive total fat [29.7%]. Despite this, it is observed that the adequacy improves significantly when there is no consumption of food products with excessive total fat according to the PAHO-NPM

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[26%]. The proportion of energy from this nutrient is 4.4 percentage points lower [p <0.01] among those who do not consume products with excessive fat. [Table 2]

Saturated fat intake exceeds that recommended by the WHO in the group of school-age children who consumed ultra-processed or processed products with an excess of this critical nutrient is 11%, being significantly lower [p <0.01] and meeting recommendations among those children that included only foods without excessive content in this nutrient according to PAHO [9.5%]. [Table 2]

The average sodium intake of the group of school-age children studied exceeds the limits established by the WHO for the intake of these nutrient, reaching 1910.7 mg. The population group that included products with excessive sodium products in this mineral exceeded the established limit [1939.7 mg], and the population that did not include such products in their diet had a significantly lower [p <0.01] and adequate sodium intake [1242.5 mg]. [Table 2]

Table 2. Mean content of NCD-related critical nutrients according to PAHO NPM in the overall daily diet of school-age children population and in the diet of two population subgroups defined according the presence or absence of products containing excessive amounts of critical nutrients fractions.‡. Fractions of the population according the presence or absence in the diets of products excessive in critical nutrients according to PAHO.

Nutrient dietary content	Overall diet		With excessive content of NCD-related critical nutrients [a, b]		Without excessive content of NCD-related critical nutrients [c]		Coef. [95% CI] [d]	
Nutrient dietary content	**Mean [95% CI]**	**[95% Conf. Interval]**	**Mean [95% CI]**	**[95% Conf. Interval]**	**Mean [95% CI]**	**[95% Conf. Interval]**		**[95% Conf. Interval]**
Free sugars [% of total energy intake]	18,2	[16,8- 19,6]	18,8	[17,4 – 20,2]	4,9	[3,2 - 6,7]	13,8*	[11,6 - 16,0]
Total fats [% of total energy intake]	29,4	[28,5 – 30,3]	29,7	[28,9 - 30,6]	26,0	[21,8 – 30,2]	4,4**	[2,7 - 8,5]
Saturated fats [% of total energy intake]	11,0	[10,5 - 11,4]	11,2	[10.7 – 11,6]	9,5	[7.7 - 11,4]	1,8**	[1,1 – 3,6]
Sodium [mg] Children between 5 and 10 y	1910,6	[1773,7 – 2047,6]	1939,8	[1799,3 - 2080,2]	1242,6	[933,1 - 1552,0]	743,7*	[449,3 - 1038,1]

‡ Assessment of Dietary Intake. School Feeding Program, children 4/12 years. Total population estimate: N= 15070 [n = 332]. *Children 4, 11 and 12 years were excluded for this analysis. ** DIET, NUTRITION AND THE PREVENTION OF CHRONIC DISEASES, WHO Technical Report Series 916, Report of a Joint WHO/FAO Expert Consultation. 95% CI: 95% Confidence Interval; NCD: noncommunicable diseases; PAHO-NPM: Pan American Health Organization Nutrient Profile Model a Linear regressions for sodium. * Different from fraction of the diet made up of products without excessive content of NCD-related critical nutrients, * P ≤ 0.001. b Products with excessive content of NCDs related nutrients according to PAHO-NPM [for free sugars >= 10% of total energy, for total fat >= 30% of total energy, for saturated fats >= 10% of total energy, for sodium >= 1 mg per kcal]. c Foods that do not apply to the PAHO NPM Products and without high content of NCDs related nutrients according to PAHO-NPM [for free sugars < 10% of total energy, for total fat < 30% of total energy, for saturated fats < 10% of total energy, for sodium <1 mg per kcal]. d Lineal regression models adjusted age groups, sex, education. * P ≤ 0.001. ** P ≤ 0.05. † Content of NCD-related critical nutrients: Free sugars, total fat, saturated fats [% of the total energy intake]. Sodium content: total sodium [mg] less the recommended value per age group [2000mg [for adults and adolescents]; 1640mg [for children aged [5-10[years old]; and 1122mg [for children aged <5 years old]]. Guideline: sodium intake for adults and children. World Health Organization; 2012; Human energy requirements. FAO/WHO/UNU; 2004.

The prevalence of inadequate nutrient intake levels associated with NCDs indicates that 75.4% of children exceed the WHO recommended limit of 10% or less of total daily calories from free sugars. Approximately 40% do not meet the recommendation for total fat, 57% do not meet the recommendation for saturated fat and 56.6% do not meet the sodium recommendation. [Table 3]

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When this analysis is carried out by fractions of the population according to the presence or not in the diet of products with excessive amounts of these nutrients, a higher prevalence of inadequacy is observed among those who consume a diet that contains products with excess in these nutrients according to PAHO .

The highest prevalence of inappropriateness is found among school-age children who consume products with excess in free sugars. About four out of five school-age children who consume products with excessive free sugars, do not meet the WHO recommendation. On the other hand, the prevalence of school-age children with inadequate intake of free sugars, saturated fats, and sodium is significantly lower among those who have a diet free of products with excessive amounts of these nutrients according to the PAHO MPN. [Table 3].

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Table 3. Prevalence of non-recommended intake levels of NCD-related critical nutrients† in the whole population and by fractions of population diet with and without products with excessive content in these critical nutrients.

	Fraction of the population diet made up of products											
NCD-related critical nutrient	**Whole population**		**With excessive content of NCD-related critical nutrients [a, b]**		**Without excessive content of NCD-related critical nutrients [c]**		**Coef. [95% CI] [d]**		**PR [95% CI] e**			
	Individuals who did not meet the recommendation [%]†						**Adjusted §**	**[95% Conf. Interval]**	**Crude**	**[95% Conf. Interval]**	**Adjusted §**	**[95% Conf. Interval]**
	Mean [95% CI]	**[95% Conf. Interval]**	**Mean [95% CI]**	**[95% Conf. Interval]**	**Mean [95% CI]**	**[95% Conf. Interval]**						
Free sugars	75,7	[69,2 – 80,6]	78,0	[71,9 - 83,1]	24,3	[6,2 - 60,8]	1,48*	[0,6 – 2,3]	3,21*	[1,1 - 9,3]	3,2**	[1,1- 9,3]
Total fat	39,9	[33,8 – 46,3]	40,4	[34,0 - 47,1]	35,0	[16,9 - 58,8]	1,99	[-0,9 - 3,2]	1,15	[0,6 - 2,1]	1,2	[0,6 - 2,2]
Saturated fats	57,4	[51,0 - 63,6]	60,1	[53,3 - 66,6]	35,0	[18,3 - 56,4]	0,67**	[0,1- 1,2]	1,72	[0,98 - 2,98]	1,7**	[1,0- 2,99]
Sodium	56,7	[50,3 - 62,8]	58,7	[52,2 - 49,0]	10,5	[9,9- 58,2]	1,49**	[0,4 - 2,6]	5,57	[0,9 - 35,7]	5,5	[0,9- 34,4]

‡ Assessmeng of Dietary Intake. School Feeding Program [PAE], children 4-12 years. Total population estimate: N= 15070 [n = 332]. 95% CI: 95% Confidence Interval; NCD: non communicable diseases; PAHO-NPM: Pan American Health Organization Nutrient Profile Model. † Content of NCD-related critical nutrients: Free sugars, total fat, saturated fats, Sodium content: total sodium [mg] less the recommended value per age group [2000mg [for adults and adolescents]; 1640mg [for children aged [5-10[years old]; and 1122mg [for children aged <5 years old]]. Guideline: sodium intake for adults and children. World Health Organization; 2012; Human energy requirements. FAO/WHO/UNU; 2004. a Values are percentages derived from Probit regression models. * Different from fraction of the diet made up of products without excessive content of NCD-related critical nutrients, P ≤ 0.001. b Products with excessive content of NCD-related critical nutrients according to PAHO NPM [for free sugars >= 10% of total energy, for total fat >= 30% of total energy, for saturated fats >= 10% of total energy, for sodium >= 1 mg per kcal]. c Foods that do not apply to the PAHO NPM Products and without high content of NCDs related nutrients according to PAHO nutrient profile [for free sugars < 10% of total energy, for total fat < 30% of total energy, for saturated fats < 10% of total energy, for sodium <1 mg per kcal].e PR, prevalence ratios estimated using Poisson regression. * P ≤ 0.001. § Adjusted age, sex, education level and family income.

When analyzing the association between the consumption of products with excessive content in grams of fat, saturated fat, sodium and free sugars with the content of critical nutrientes in the diet, and with the prevalence of the non-recommended intake of these nutrients, we observed a dose effect response in which the probability of inadequate consumption of these nutrients and excess intake above the limit established by the WHO are associated with the increase in the consumption of products with excessive content.

As seen in Table 4, the consumption of each additional gram of products that contain excessive amounts of free sugars, total fat, saturated fat or sodium according to the PAHO-NPM results in not meeting WHO intake goals. For each gram of product with excessive free sugars according to PAHO, intake moves away from the WHO intake goal by 0.0002 percentage points. In the case of fats, each gram of product with excessive total fat and each gram of product with excessive saturated fat, distances from the WHO intake goal by 0.0002 and 0.00001 percentage points, respectively.

Each gram of product with excessive sodium according to PAHO increses dietary sodium intake by 4.67 mg more sodium above that recommended by the WHO. This means that the intake of any amount of products with excessive critical nutrients according to PAHO, generates a significant negative impact on the diet, moving it away from what is recommended by the WHO.

Table 4. Association between consumption of products with excessive content of NCD-related critical nutrients [grams] according to PAHO NPM and the content provided by the respective nutrients† and the prevalence of non-recommended intake of these nutrients in the whole diet‡.

	Effect size over the content of NCD-related critical nutrients †			**Prevalence of non-recommended intake of NCD-related critical nutrients††**		
	Coef. [95% CI] a	**[95% Conf. Interval]**		**PR [95% CI] b**	**[95% Conf. Interval]**	
Free sugars	0,0001841*	.0001357	.0002326	1,000005*	1.000002	1.000007
Total fat	0,0001839*	.0001207	.0002472	1,000018*	1.000011	1.000025
Saturated fats	0,000076*	.0000465	.0001054	1,000013*	1.000008	1.000018
Sodium	4,670705*	3.5052	5.83621	1,000018*	1.000012	1.000024

Assessment of Dietary Intake. School Feeding Program [PAE], children 4/12 years. Total population estimate: N= 15070 [n = 332].95% CI: 95% Confidence Interval; NCD: noncommunicable diseases; PAHO-NPM: Pan American Health Organization Nutrient Profile Model. † Content of NCD-related critical nutrients: Free sugar, total fat, saturated fat [% of the total energy intake]. Sodium content: total sodium [mg] less the recommended value per age group according the WHO {2000mg [for adults and adolescents]; 1640mg [for children aged from 5 to 9.9 years old]; and 1122mg [for children aged <5 years old]}, Guideline: sodium intake for adults and children, World Health Organization; 2012.†† For free sugar >= 10% of total energy intake, for total fat >= 30% of total energy intake, for saturated fat >= 10% of total energy intake, for sodium >= 2000mg [for adults and adolescents]; >= 1640mg [for children aged from 5 to 9.9 years old]; >= 1122mg [for children aged <5 years old] [sodium intake recommendation for children were derived from average energy requirements for children with moderate physical activity level as estimated by FAO/WHO/UNU]. a Lineal regression models for free sugar, total fat, saturated fat intake, and linear regression models for sodium adjusted for age groups, sex, education level and family income. * P ≤ 0.001. ** P ≤ 0.05. b PR, prevalence ratios estimated using Poisson regression models adjusted for age, sex, education level and family income. * P ≤ 0.001.** P ≤ 0.05.

4. Discussion

The results of this study show that Montevideo school-age children who consume ultra-processed and processed products with excessive amounts of free sugars, total fats, saturated fats or sodium according to the PAHO-NPM, have a diet with poorer nutritional quality and a greater probability of not meeting the WHO recommendations for critical nutrients related to NCDs, compared to school-age children who do not consume such products.

Uruguay faces a great challenge in terms of public policies related to health protection and healthy diets, especially with regard to children. Currently, school-age children diet exceeds the national caloric goals for this age group (9). In addition, this study

confirms previous findings, which indicate an imbalance in relation to the intake of nutrients that are associated with NCDs, the main cause of death and disability in the country. We found that the energy intake from free sugars is almost two times the WHO recommended threshold (4,5).

The PAHO nutrient profile model has been developed as a food classification tool to develop public policies to reduce the demand and supply of ultra-processed and processed food products in order to help populations achieve critical nutrient intake goals established by WHO. Multiple studies with different populations in various countries of the world have confirmed that a higher consumption of ultra-processed products is associated with a poorer diet quality, exceeding limits of nutrients associated with NCDs, such as free sugars, total fats, saturated fats and sodium, and contributing less than the recommended intake for fiber, vitamins and essential minerals (9,10,–13,15,18,31–34).

Likewise, consumption of processed products with excessive amounts of fat, saturated fat, trans fat, sugar, and sodium are also associated with noncommunicable diseases and all-cause mortality (16–19). Our study shows that the consumption of products with excessive nutrients explains the imbalance in the diet of school-age children in Montevideo in relation to the WHO dietary recommendations. Half of the children who consumed ultra-processed and processed products with excess of some of the nutrients linked to the development of NCDs included three or more of these products in their diet. Consequently, from the study of dietary intake, it was found that those children with consumption of ultra-processed and processed products with excessive content of these nutrients according to the PAHO-NPM present greater dietary inadequacy due to excess in the consumption of these nutrients.

Excess weight and the consumption of ultra-processed and processed products that impact dietary intake of the population present a complex scenario to overcome. At the international political level, there is consensus on the urgent need to implement population-based measures that aim at reducing the impact that unhealthy diet has on childhood (20). Undoubtedly, the great challenge is to improve the diet of children, promoting dietary practices that are based on fresh or minimally processed foods, and reducing the consumption of processed and ultra-processed food products with excessive sugars, fats and sodium, which will result in better growth, development and allow children to achieve their full potential.

International agencies such as PAHO/WHO, UNICEF and FAO have have repeatedly pointed out the need to generate multisectoral strategies to reduce the health and economic impact that this situation will have on the entire population, but especially on children of all ages (21). Furthermore, following international recommendations, Uruguay has made recent progress in the development of policies, actions and strategies for national application. On the one hand, the Dietary Guidelines for the Uruguayan population, published by the Ministry of Public Health (1) contain recommendations and messages that seek to promote the application of dietary practices by the general population that are compatible with achieving healthy and sustainable diets and food systemsguide the general population in the daily application of dietary practices compatible with the achievement of a healthy and sustainable diet and food systems, promoting a diet based on natural foods and avoiding the consumption of ultra-processed products. On the other hand, progress has been made in inter-institutional consensuses that seek to protect the health of children through the promotion of healthy dietary practices, integrated transversally into the life and educational trajectory of all children (22–24). Additionally, in February 2021, Uruguay began the application of the front-of-package nutritional warning labeling on food products that included modifications to the nutrient profile model established in the original regulations approved in 2018 (25). The regulations in force in Uruguay established looser limits that exempt more products with excess of critical nutrients, than what is recommended by PAHO, from the obligation to apply warnings on the front of the package.

Considering the progress in Uruguay, and the results of this study, there are still adjustments to be made to the policies adopted by the country, to guarantee that all the

products with excessive nutrients associated with NCDs according to the PAHO-NPM are regulated, and that the regulatory measures on labeling, school environments and others, are aligned with WHO recommendations.

The dose response effect found in this study reveals that the intake of any amount of products classified as excessive in nutrients of public health concern, that must be regulated according to the PAHO-NPM, compromise reaching a healthy diet. The sale of ultra-processed products is on the rise in Latin America (26), and between 2000 and 2013, Uruguay presented the highest increase in sales of ultra-processed products in the region, with 7.2% growth per year (26). Compared to 2000, 243g more of ultra-processed products were sold per capita per day in 2013. Taking this figure, it could be estimated, based on the result of the dose response effect of this study, that each additional contribution to the diet of 243g of ultra-processed products that are excessive in sugars, fats, saturated fats, and sodium, would make it 44.7% more excessive in free sugars, 14.9% more excessive in fats, 18.5% more excessive in saturated fats and 56.7% more excessive in sodium, according to WHO recommendations.

The main limitations of the study are: a] Uruguay does not have an updated food composition table, due to this the intake was estimated considering a compilation of multiple sources; b] there is insufficient information to estimate the intake of trans fat; c] the representativeness of the sample; d] intake of foods and beverages analyzed here is representative of the spring [survey in October and November].

The main strengths of the study can be summarized as: a] the data collection was carried out by nutrition graduates or advanced students trained specifically for this study; b] part of the information was collected by direct observation, minimizing the bias associated with recall of the interviewee; c] the food composition table includes an estimation of nutrients in foods and preparations of usual consumption carried out by the School of Nutrition of the UdelaR, as well as all the preparations provided by the School Feeding Program.

Results of this study show that policies to reduce demand and supply of products, which aim at improving the diet of populations, including school-age children, and protect public health, will be better aligned with those recommended by the WHO if they adopt the PAHO-NPM. Diets free of ultra-processed and processed products with excess free sugars, total fats, saturated fats and sodium were the best option for school-age children in Montevideo, increasing their chances of meeting WHO recommendations. Meanwhile, intake of products with excessive critical nutrients according to PAHO, and each additional gram consumed of such products, significantly worsens diets, preventing them from meeting WHO recommendations.

6. Patents

This section is not mandatory but may be added if there are patents resulting from the work reported in this manuscript.

Supplementary Materials: The following are available online at www.mdpi.com/xxx/s1, Figure S1: title, Table S1: title, Video S1: title.

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Informed Consent Statement: Informed consent was obtained from lawful representants of all subjects involved in the study.

Data Availability Statement: https://evaluacionpae.anep.edu.uy/.

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