The pandemic lockdown affected nutritional status and dietary patterns including ultra-processed foods of semi-marginalized schoolchildren in Northwest Mexico

La reclusión por la pandemia afectó nutrición y patrones dietarios incluyendo alimentos ultra-procesados de escolares semi-marginados en el noroeste de México

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ABSTRACT
Objective: The aim was to compare dietary patterns and nutritional status of medium-marginalized schoolchildren in Hermosillo, Mexico, pre- and post-pandemic. **Materials and Methods:** Diet of 100 schoolchildren pre-pandemic and 100 post-pandemic were evaluated using 24-hour recalls. Principal components analysis was performed to identify dietary patterns. Anthropometric measurements were taken to calculate Z BMI-for-age. In the post-pandemic period, labels of ultra-processed foods were analyzed to identify sweeteners. **Results:** Prevalence of overweight and obesity increased ($p<0.05$) from 37% pre-pandemic to 54% post-pandemic, along with energy intake (1610 to 1816 kcal/d). There were 3 dietary patterns: Ultra-processed, Healthy, and Poor. Proportions of children in each pattern were comparable pre-pandemic, but the Poor pattern increased ($p<0.05$) post-pandemic (34% vs. 42%). Protein intake was lower in children in the Ultra-processed pattern pre-pandemic, but post-pandemic, protein and fat intake were lower in children in the Poor pattern, increasing ($p<0.05$) their overweight and obesity prevalence (9% vs. 21%). The most consumed ultra-processed products included 36 types of sweetened beverages, 33 types of candy, 20 different types of chips, and 15 varieties of cookies, most of which contained non-caloric sweeteners such as acesulfame K, aspartame, and sucralose. **Conclusions:** The pandemic reduced the diet quality and increased the prevalence of overweight and obesity in medium-marginalized schoolchildren in Northwest Mexico, with high consumption of ultra-processed foods containing non-caloric sweeteners
Key words: Dietary patterns, schoolchildren, nutritional status, ultra-processed food.

RESUMEN
Objetivo: Comparar patrones alimentarios y estado nutricio de escolares semi-marginados en Hermosillo, Sonora, antes y después de la pandemia. **Materiales y Métodos:** Se aplicaron a 100 niños, recordatorios de 24 h pre- y 100 post-pandemia, para identificar patrones alimentarios mediante análisis de componentes principales. Se evaluó antropometría y calculó Z-IMC/edad. Se identificaron los edulcorantes declarados en las etiquetas de los productos ultra-procesados. **Resultados:** La prevalencia de sobrepeso y obesidad aumentó ($p<0.05$) de 37% a 54% después de la pandemia, así como la ingestión de energía (1610 vs. 1816 kcal/d). Se identificaron tres patrones alimentarios: ultra-procesado, saludable y deficiente, con distribución similar antes de la pandemia, pero el patrón deficiente aumentó ($p<0.05$) de 34% a 42% después de la pandemia. La ingestión de proteínas fue menor en el patrón ultra-procesado pre-pandemia. Post-pandemia, la ingestión de proteínas y grasas fue menor en los niños del patrón deficiente, quienes aumentaron ($p<0.05$) de 9% a 21% su prevalencia de sobrepeso y obesidad (9% vs. 21%). Después de la pandemia, los productos ultra-procesados más consumidos incluían 36 tipos de bebidas endulzadas, 33 golosinas, 20 frituras y 15 galletas, la mayoría contenían edulcorantes no calóricos como acesulfame K, aspartame y sucralosa. **Conclusiones:** La pandemia afectó la calidad de la dieta y aumentó la prevalencia de sobrepeso y obesidad en escolares hermosillenses semi-marginados, con gran consumo de alimentos ultra-procesados conteniendo edulcorantes no calóricos
Palabras clave: patrones dietarios, escolares, estado nutricio, ultra-procesados.

Introduction

According to the Mexican Health and Nutrition Survey of 2021, schoolchildren are the primary consumers of ultra-processed foods, such as sweetened beverages, deli meats, snacks, and candies[1]. The intake of these food items has doubled in Mexican households in the last three decades[2]. Therefore, their high contribution to the diet could be an indicator of poor dietary

quality and may be responsible for the increased prevalence of overweight and obesity, which is at 39.5% among schoolchildren in the northwest area of the country, compared to 38.2% nationwide[1].

In order to reduce the prevalence of obesity and maintain public health, the Mexican government amended the food labeling law in 2020. The law now requires five visible warning seals to be placed on products indicating excessive levels of calories, sugars, saturated fats, and sodium[3]. Trans-fats, which are now prohibited, also require a warning seal[4]. Additionally, there are two cautionary notices about caffeine-containing and non-caloric sweeteners, which are not recommended for children[3].

This labeling system has improved the understanding of the nutritional value of packed food products[5], and it was predicted at least 24% less purchasing of ultra-processed foods after its implementation[6]. However, its impact on dietary habits appears to be weak after the pandemic. For instance, only 17.3% of the general population reduced their intake of sweetened beverages, while approximately 15% increased their consumption of fruits and vegetables post-pandemic. Such favorable changes were even weaker in the northwestern population[1].

We do not have dietary data about children at home during the pandemic lockdown that lasted for more than two years, particularly from those in Hermosillo City who have a strong preference for ultra-processed foods. However, we do have data on schoolchildren from a medium-marginalized area of Hermosillo City in Northwest Mexico, collected two years before the lockdown. Therefore, the current objective is to compare the dietary patterns and nutritional status of similar cohorts of children between the pre- and post-pandemic periods.

Materials and Methods

The study was cross-sectional and conducted in two periods (2017 and 2022) in seven randomly selected public elementary schools located in the same medium-marginalized areas of Hermosillo City in Northwest Mexico[7]. The protocol was approved by the institutional Ethics Committee (CE/016/2014). After obtaining agreement from principals, teachers, and signed informed consent from parents, healthy children aged 7-12 years old were included. Children who refused to participate, those with dietary restrictions, or those who had recently used antibiotics were excluded from the study.

The diet was evaluated by 2 or 3 non-consecutive 24-hour recalls applied to the children. Mothers were asked to provide details on meal preparation if necessary. Energy and nutrients were calculated according to Ortega et al.[8], and dietary patterns were obtained by principal components analysis after classification into 13 different groups: 1) fats and oils, 2) sweetened beverages, 3) vegetables, 4) fresh fruits, 5) cereal- or potato-containing meals, 6) animal-

origin products, 7) sugar and candies, 8) chips and snacks, 9) wheat-based products, 10) legumes, 11) cookies and pastries, 12) sausages and deli meats, and 13) dairy products. Additionally, in post-pandemic period, the label declarations of the ultra-processed foodstuffs consumed by children were collected to analyze caloric and non-caloric sweeteners added.

Height and weight were measured using a digital scale AND® (model FG-50_K) and a portable Seca® stadiometer (model 214), respectively. Z-BMI was calculated, and nutritional status was classified according to the World Health Organization's cutoffs[9].

Statistical Analysis

A principal components analysis with orthogonal transformation (varimax rotation) was performed to determine dietary patterns. Components were chosen based on factor variance (eigenvalues > 1.0), and only food groups with factor loadings ≥ 0.25 were included. Mean and standard deviation were reported after normality analyses, and differences were examined using one-way ANOVA and Tukey-Kramer test. If normality failed, medians and interquartile ranges (IQR) were reported, and differences were evaluated using Kruskal-Wallis and Dunn's multiple comparisons test. Differences between proportions were evaluated using a chi-square test. All analyses were performed using the NCSS 7.0 software with a significance level of $p < 0.05$.

Results

The diet of 200 children, 100 from the pre-pandemic period and 100 from the post-pandemic period, was evaluated by 24-hour recall. Their average age was 9.7 ± 1.5 years old, with 49% girls, and they attended schools located in medium-marginalized areas of Hermosillo, one of the main cities in Northwest Mexico.

Three dietary patterns were identified, together they explained 40.7% of the total variability in the data. The first pattern was Ultra-processed, composed of fats and oils, sweetened beverages, sugar and candies, chips and snacks, wheat-based products (bread, pasta, and tortillas), cookies and pastries, as well as sausages and other deli meats. The second pattern was Healthy, it included vegetables, dishes based on cereals and potatoes, animal-origin foods, cookies and pastries, and dairy products. The third pattern was Poor, it was composed of sweetened beverages, dishes based on cereals and potatoes, wheat-based products, and legumes, principally beans (Table 1).

Table 1. Factor loads for each food group in the three dietary patterns.

Food group	Ultra-processed	Healthy	Poor
Fats and oils[‡]	0.4346	0.1151	-0.0326
Sweetened beverages	0.3540	-0.1423	0.3683
Vegetables	0.0948	0.4073	0.2369
Fresh fruits	0.0452	0.4473	-0.1850
Rice, oats, potato and corn	-0.0802	0.3491	0.2619
Meat, poultry, fish and eggs	-0.0073	0.2789	0.2266
Sugar and candies	0.4530	-0.0183	-0.0334
Corn or potato chips and snacks	0.4565	-0.0713	-0.0342
Wheat-based products [§]	0.3044	-0.0259	0.3134
Legumes	-0.0377	-0.0251	0.6233
Cookies and pastries	0.2651	0.2739	-0.2201
Sausages and deli meats	0.2907	-0.0254	-0.3312
Dairy products	-0.0762	0.5639	-0.0762

‡: It includes high fat dairy products (e. g., cream cheese, nacho-style cheese).
§: It includes bread, pasta, and wheat-flour tortillas.
Factor loads not selected are presented as faded numbers in each category.

Before the pandemic lockdown, the proportion of schoolchildren with ultra-processed (37%), healthy (29%), or poor (34%) patterns was comparable ($p>0.05$). After the pandemic, there was a trend ($p=0.07$) towards a higher proportion of children in the poor dietary pattern (42%) compared to those in the healthy (25%) and ultra-processed patterns (33%).

Before the pandemic lockdown, there were no differences in energy or macronutrient intake between dietary patterns, except for protein, which was lower ($p<0.05$) in children with the ultra-processed pattern. Additionally, fiber intake was higher ($p<0.05$) in children with the poor pattern. However, after the lockdown, there was a change, with protein and fat intake being lower

($p<0.05$) in children with the poor dietary pattern compared to the other patterns (Table 2).

The schoolchildren consumed a wide variety of ultra-processed foods. After the pandemic lockdown, there were 36 different sweetened beverages from 5 brands, 33 types of candy from 11 brands, 20 kinds of chips or snacks from 3 brands, and 15 types of cookies and pastries from 2 brands, in addition to other minor products. It is notable that 93% of the children consumed soft drinks such as sodas, juices, dairy drinks, and beverages prepared from powdered drink mix. Among these, 80% had at least one serving of soda per day, and 54% had two or more servings per day. Some children consumed 4-5 servings of soft drinks per day, for

example, they drank soda for breakfast, juice for mid-morning snack, soda again for lunch, soda or juice for afternoon snack, and a beverage made from powdered drink mix for dinner.

Table 2. Energy, macronutrients, and fiber intake according to dietary pattern at pre- and post-pandemic periods.

	PRE-PANDEMIC DIETARY PATTERNS			
Nutrients	**Ultra-processed** **Median (Q1-Q3)** n=37	**Healthy** **Median (Q1-Q3)** n=29	**Poor** **Median (Q1-Q3)** n=34	***p***
Energy (kcal)*	1652.7 (1340.1-2033.7)	1501.9 (1296.1-1736.6)	1481.4 (1128.6-1868.9)	0.55
Protein (%)*	10.3 (8.4-11.5) [b]	12.5 (10.3-16.0)[a]	12.3 (10.5-14.2)[a]	0.00
Total fat (%)[§]	35.5 (31.1-43.8)	37.2 (32.4-40.0)	34.2 (29.6-36.0)	0.18
Saturated fat (%)[§]	10.8 (8.9-13.0)	10.6 (8.6-13.2)	9.0 (7.9-11.6)	0.28
Carbohydrates (%)[§]	56.0 (48.1-59.6)	54.4 (45.3-57.0)	53.1 (49.1-57.9)	0.49
Fiber (g/d)*	13.1 (10.4-16.2)[b]	13.7 (10.4-19.0)[b]	19.3 (13.5-27.3)[a]	0.01
	POST-PANDEMIC DIETARY PATTERNS			
	Ultra-processed n=33	**Healthy** n=25	**Poor** n=42	***p***
Energy (kcal) [§]	1929.4 (1421.9-2518.3)	1777.6 (1355.7-2176.8)	1834.0 (1546.1-2043.9)	0.19
Protein (%)*	13.1 (10.5-14.8)[a]	14.1 (13.1-16.7)[b]	11.1 (10.7-13.0)[a]	0.00
Total fat (%)[§]	39.3 (35.7-42.6)[b]	37.2 (34.5-42.7)[b]	35.2 (30.9-38.6)[a]	0.02
Saturated fat (%)[§]	11.4 (9.7-13.0)[b]	11.3 (10.0-13.9)[b]	9.2 (7.6-10.9)[a]	0.00
Carbohydrates (%)[§]	49.7 (45.3-54.4)[b]	50.4 (47.9-53.9)[b]	55.5 (52.7-62.4)[a]	0.00
Fiber (g/d)*	12.9 (9.3-18.1)	15.0 (9.4-18.6)	17.1 (11.3-20.9)	0.20

Q1-Q3: interquartile rank; Q1: first quartile; Q3: third quartile.
%: Percentage of the total energy intake.
*: Differences between groups analyzed by Kruskall-Wallis test.
[§]: Differences between groups analyzed by Tukey-Kramer test.
[a, b]: Differences between groups.

The labels of these products showed extensive addition of non-caloric and caloric sweeteners in soft drinks, chewing gums, jellies, and pastries. The most frequently employed non-caloric sweeteners were acesulfame K, aspartame, and sucralose (Figure. 1). Notably, some types of food do not have alternative products sweetened with cane sugar or high fructose syrup.

After the pandemic lockdown, there were generally more children with overweight and obesity than in the pre-pandemic period (54% vs. 37%).

Concomitantly, the energy intake of the children was higher (p<0.05) after the pandemic lockdown (1816.1; IQR: 1481.0-2237.2) than before the pandemic period (1610.8; IQR: 1280.1-1860.3). Comparative analysis of the nutritional status of the school children according to their dietary patterns did not show any differences before and after the pandemic, except for a notable difference (p<0.05) between children with overweight and obesity in the poor dietary pattern (Figure. 2).
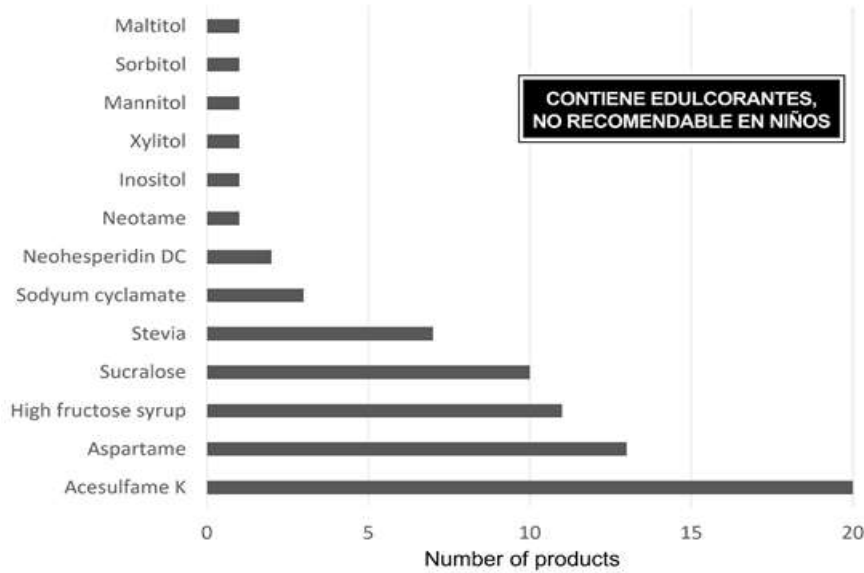
Figure 1. Sweeteners in ultra-processed products consumed by children in post-pandemic period. Insert: warning seal on package meaning "Sweetener-containing product non recommended for children".
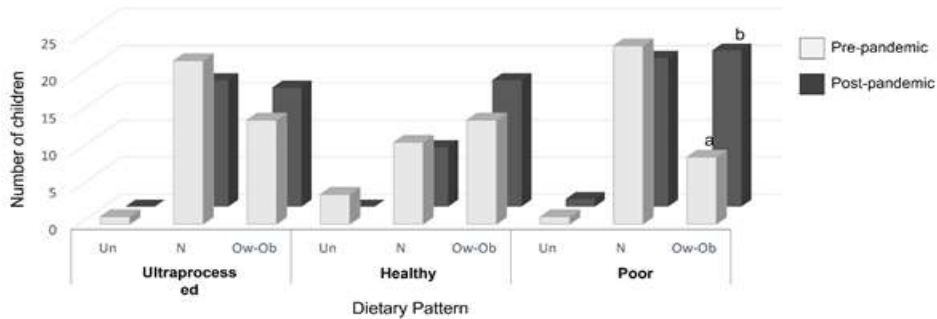

Figure 2. Nutritional status according to dietary patterns at pre-pandemic and post-pandemic period. Un: undernutrition; N: normal; Ow-Ob: Overweight and Obesity. a,b: differences between periods.

Discussion

During the pandemic in Hermosillo, an important city in Northwest Mexico, public elementary schools remained closed from March 2020 to January 2022, and public parks were also closed for several months. Currently, around 45% of schoolchildren's mothers in semi-marginalized areas work as housekeepers or laborers, as do their fathers. Due to the lockdown,

several places closed, and many people lost their jobs, so primarily mothers were at home with their kids. Therefore, it was expected that children would consume healthier meals prepared by their mothers. However, in Northwest Mexico (a desert area), fruits and vegetables are expensive, and households were economically impacted by the pandemic [7,10-11].

The pandemic lockdown does not affect the consumption of ultra-processed foods by schoolchildren in our study. More than 33% of them followed an ultra-processed pattern both pre- and post-pandemic, and children with healthy and poor dietary patterns also included ultra-processed foods in their diet. For instance, the intake of cookies and pastries was common in the healthy pattern, while children in the poor pattern were fond of sweetened beverages such as soda, juices, and beverages prepared from powdered drink mix. These beverages have a high content of non-caloric sweeteners, colorants, and artificial flavors, in addition to sugar in soft drinks [12-13]. This could represent a major problem to children's health as the intake of sweetened beverages by schoolchildren is quite common, as 93% of them drink them in Mexico [1].

In the pre-pandemic period, the intake of ultra-processed foods could have been related to poor compliance with regulations regarding their sale and the adverse food environment in elementary schools [14]. However, our post-pandemic data collection was conducted from February to June 2022, during which schoolchildren only attended school twice a week for short periods, and there was no sale of foodstuffs. Therefore, the intake of ultra-processed foods was not related to school hours, but rather to pre-existing eating habits established at home.

The most lamentable result post-pandemic is the large proportion of children (42%) with a poor dietary pattern. In this pattern, there was a low diversity of foods. Beans and tortillas were not enough as a protein source due to the limited quantity, and fruits were practically unknown to them. However, several of them drank even 3-4 servings of soft drinks and canned juices per day, and no milk, in spite of comparable costs between both beverages [15]. It is difficult to explain the 12% increase in overweight and obesity in children with the poor pattern found after pandemic, while it was around 2-3% in children of other patterns. Partially, this could be because in the ultra-processed and healthy patterns, the energy intake increased by 15%, while it was 20% in the poor pattern children. In addition, possibly children with an ultra-processed pattern, because of pandemic troubles in the economy, moved to a poor dietary pattern, but their energy intake was not modified while their physical activity decreased due to pandemic mobility restrictions.

In a meta-analysis, Poorolajal et al. found that the only risk associated with the diet for children

who are overweight or obese is drinking sugar-sweetened beverages at least four times a week[16]. The prevalence of overweight and obesity in children in our study increased from 37% pre-pandemic to 54% post-pandemic, which is significantly higher than the 39.5% found by the national survey in our geographical northwestern area[1]. Coincidentally, some of the children in our study drank 3-4 servings of such beverages per day. Almost all the children in our study consumed sweetened beverages containing both caloric and non-caloric sweeteners, including the most commonly ingested cola soda. Thus, it is clear the need to change the dietary habits of children, not just by replacing sweetened beverages with water.

Regarding to non-caloric sweeteners, despite the Mexican warning seal on packages stating that they are not recommended for children, their consumption is quite high among our children. In our country, the majority of sweetened beverages such as soft drinks or canned fruit juices contain both caloric and non-caloric sweeteners[12]. The published findings on this topic are very controversial. In a meta-analysis of the diet and body composition of children and adolescents with overweight and obesity, the substitution of sugar-sweetened beverages with non-caloric ones reduced body fat but did not have an effect on Z-BMI[17]. Another study affirms that saccharin, sucralose, aspartame, and stevia affect glycemia and impact gut microbiota composition[18].

Finally, there are several factors involved in our results. The preference for sweetened beverages and other ultra-processed foods is sustained by their accessibility even in more marginalized areas in our city, in addition to the well-known strong marketing campaigns of these products[8,19]. Additionally, the children's physical activity was reduced during lockdown without schools or public parks accessible, and it increased the time spent in sedentary activities, like screen time[20].

Conclusions

In conclusion, since October 2020, the federal government has required mandatory warning labels on packaged ultra-processed foods, in addition to the negative effects of the pandemic lockdown in March 2020 on the economy and food security. However, the consumption of ultra-processed foods with non-caloric sweeteners by schoolchildren in medium-marginalized areas of Hermosillo, in Northwest Mexico, was still as diverse as it was before the pandemic. Overall, the quality of their diet was worse than in the pre-pandemic period, and it increased their Z-BMI related to higher energy intake. To reverse the addictive potential of ultra-processed foods and other unhealthy eating behaviors, creative and motivating intervention programs are needed.

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Conflict of interest

The authors have no conflicts of interest to declare.

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