ORIGINAL ARTICLE

Dietary quality and household food insecurity among Mexican children and adolescents

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Abstract

Seventy percent of Mexican households experience some level of food insecurity (FI). Studies have shown positive associations between FI and poor dietary quality. As far as it is known, this is the first time the Healthy Eating Index (HEI-2010) has been used to assess dietary quality of children and adolescents in Mexico, and to examine if FI is related to it. The objective of this research is to assess dietary quality and its association with FI among Mexican children and adolescents from a nationally representative cross-sectional sample. We analyzed data from 4635 2–19-year-old Mexican children and adolescents participating in the Mexican National Health and Nutrition Survey (Ensanut 2012). FI was measured using the Latin American and Caribbean Household Food Security Scale (ELCSA) and dietary quality with the HEI-2010. We examined the association between FI and dietary quality using multivariate linear regressions. Dietary quality was worst as FI became more severe among children and adolescents compared with their counterparts living in households with food security. Specifically, FI had a negative association with fruits, vegetables, and protein foods, and a positive association with refined grains consumption. Dairy intake was negatively associated with FI among older children and adolescents. Added sugars were not associated with FI, but intake was excessive across the population at 15% of total daily energy intake. Decreasing FI may help improve dietary quality of Mexican children and adolescents.

KEYWORDS

adolescent, children, dietary quality, food insecurity, Healthy Eating Index-2010

1 | INTRODUCTION

Food insecurity (FI) is defined as the limited or uncertain availability of food, which prevents meeting the nutritional requirements of individuals (Anderson, 1990). In Mexico, roughly 70% of households experience some level of FI (Gutiérrez et al., 2012). Evidence shows that adults and children experiencing FI have a greater risk of experiencing poor mental and physical health (Pérez-Escamilla & Vianna, 2012; Valencia-Valero & Ortiz-Hernández, 2014), such as diabetes and hypertension among American and Mexican adults (Pérez-Escamilla, Villalpando, Shamah-Levy, & Méndez-Gómez Humarán, 2014; Seligman, Laraia, & Kushel, 2010). FI manifests itself in a restricted ability to buy healthy foods (e.g., vegetables, fruits, and animal products) because of their higher cost compared to foods high in fat or added sugar (Maillot, Darmon, Darmon, Lafay, & Drewnowski, 2007;

Monsivais, Aggarwal, & Drewnowski, 2012). Latin-American studies have found correlations between FI and poorer dietary quality among adults, particularly low intake of fruits, vegetables, meat, and dairy products (Hackett, Zubieta, Hernandez, & Melgar-Quinonez, 2007; Segall-Corrêa, Panigassi, Archanjo, Marin-Leon, & Pérez-Escamilla, 2007). In addition, among Mexican children, FI has been negatively associated with vitamin A-rich foods and energy intake (Mundo-Rosas, de la Cruz-Góngora, Jiménez-Aguilar, & Shamah-Levy, 2014), and with inadequate calcium intake among US adolescents (Eicher-Miller, Mason, Weaver, McCabe, & Boushey, 2011).

Diets low in quality that are energy dense and nutrient poor are one of the primary factors that increase the risk of obesity, cardiovascular disease, type 2 diabetes, and certain cancers (Global Strategy on Diet, Physical Activity and Health, 2004; Pérez-Escamilla et al., 2012). Mexico is a middle-income country undergoing an epidemiologic

transition characterized by an increased life expectancy, along with an increase in chronic diseases accompanied by a remarkable obesity epidemic in children. Among children under 5 years, the prevalence of overweight/obesity increased from 7.8% in 1988 to 9.7% in 2012, among 5–11 year olds from 26.9% to 34.4% from 1999 to 2012, and among adolescent women (12–19 years) from 11.1% in 1988 to 35.8% in 2012 (Gutiérrez et al., 2012). Dietary quality has also changed; namely, there has been an increase in the purchases of highly processed foods and beverages, especially those with added sugar, along with a decrease in the purchases of meat, milk, fruits, and vegetables, between 1984 and 2006 (Rivera, Campos, Barquera, & de González, 2012).

The Healthy Eating Index (HEI-2010) measures dietary quality following the federal Dietary Guidelines for Americans. These guidelines provide advice on healthy eating, to achieve and maintain a healthy weight, with the purpose of improving the health of all Americans ages 2 years and older (McGuire, 2011). The HEI-2010 is composed of 12 different food components that add up to a maximum of 100 points (p). A diet with a total score greater than 80p is considered “good,” scores of 51–80p indicate a diet that “needs improvement,” and a diet quality score of less than 51p is considered a “poor” diet (Guenther et al., 2007). The HEI has been used to assess dietary quality of pediatric populations in the USA and some Mediterranean countries, where it has been found that the majority of children consume diets that need improvements (Angelopoulos, Kourilaba, Kondaki, Fragiadakis, & Manios, 2009; Banfield, Liu, Davis, Chang, & Frazier-Wood, 2016; Manios et al., 2009). The US Third National Health and Nutrition Examination Survey showed that American preschool children with a high HEI score were less likely to exhibit early childhood caries, which if left untreated can lead to acute infection, nutritional insufficiencies, and learning and speech problems (Nunn et al., 2009). In the USA, FI has been found to be inversely associated with diet quality of lower income adults (Leung, Epel, Ritchie, Crawford, & Laraia, 2014), as well as with greater intakes of added sugars, fat, and calories (Fram, Ritchie, Rosen, & Frongillo, 2015). To our knowledge, this is the first time the HEI has been used to assess dietary quality of youth in Mexico. The objective of this study is to examine the association between FI and dietary quality in a large nationally representative cross-sectional sample of Mexican children and adolescents 2–19 years old participating in the Mexican National Health and Nutrition Survey of 2012 (Ensanut 2012).

2 | METHODS

2.1 | Study population

Ensanut 2012 is a cross-sectional survey with probabilistic sampling that is representative at the state, regional, rural, and urban strata. Data from 50,528 households, out of an estimated 29,429,252 nationwide, were collected between October 2011 and May 2012 (Gutiérrez et al., 2012). Details of the sampling design and sample size have been described elsewhere (Romero-Martínez et al., 2013).

Dietary information was collected via a Food Frequency Questionnaire (FFQ) in a subset of 1,338 children aged 0–4 years old. Children less than 2 years of age were excluded ($n = 296$) because the HEI-2010 does not apply to them (Guenther et al., 2013a). Furthermore, additional 17 subjects were excluded from the main analysis due to lacking FI status information. The subset of school-aged children (5–11 years) and adolescents (12–19 years) whose dietary information was analyzed was 1,390 and 2,203, respectively. Of these, 30 and 50 subjects were excluded, respectively, from the main analysis due to lacking information on FI status. We examined if the 97 subjects missing FI data (2% of the total sample) varied by dietary quality, age, and other important demographic factors in comparison with those with valid FI data and found no significant differences.¹

2.2 | Household food insecurity measurement

Perceived FI was measured using the well-validated Mexican-adapted version of the experience-based Latin American and Caribbean Household Food Security Scale (ELCSA; Comité científico de la ELCSA, 2012), which included 15 questions targeted to the head of the family or the woman in charge of meal preparation. The reference time frame included the 3 months prior to the survey administration. A decision on the use of this time frame, which is different from the 12-month time frame used in the USA, was made by an expert panel advising the government of Mexico on this measure. A 3-month time frame was endorsed because FI is much more prevalent in Mexico than in the USA; that is, a 12-month reference period was deemed to be unduly long for the Mexican context (Villagómez-Ornelas et al., 2014). Eight of the items refer to aspects of the FI situation in the household, and seven items apply to minors under 18 years. Food security (FS) existed when “all people, at all times, had physical and economic access to sufficient, safe and nutritious food to meet their dietary needs and food

¹Data not shown.

Key Messages

- This study uses for the first time the Healthy Eating Index-2010 to assess dietary quality of children and adolescents in Mexico.
- Mexican children and adolescents living in severe food insecure households have lower dietary quality compared to their counterparts living in less food insecure households.
- Latin American and Caribbean Household Food Security Scale is an instrument useful for food security policy making as it clearly identified key dietary quality findings that went above and beyond what is captured by standard poverty indicators.

preferences for food to lead an active and healthy life.” Otherwise, it was categorized into mild, moderate, and severe insecurity.

2.3 | Dietary assessment

Dietary information was collected through a previously validated, semi-quantitative 130-item FFQ (Hernández-Avila et al., 1998; Rodríguez-Ramírez, Mundo-Rosas, Jiménez-Aguilar, & Shamah-Levy, 2009). Data collected included the number of days, times per day, serving size, and the number of times during the 7 days prior to the interview that each listed food and beverage were consumed. The questionnaire was administered to the parent or caregiver for children (<12 years of age), and directly to the adolescent (≥12 years).

2.4 | Diet quality assessment

The HEI-2010 includes 12 components: total fruit, whole fruit, total vegetables, greens and beans, whole grains, dairy, total protein foods, seafood and plant proteins, fatty acids, refined grains, and sodium and empty calories, which combined add up to a maximum of 100p. Empty calories come from solid fats, added sugars, and any alcohol above 13 g/1,000 kcal. The first eight components receive a greater score with increased consumption, fatty acids receive a higher score with a larger ratio of polyunsaturated and monounsaturated to saturated fatty acids, and the latter three components were assigned a better score with reduced consumption (Table S1; Guenther et al., 2013b). Details on the development and rationale for scoring of food components are described in detail elsewhere (Guenther et al., 2007).

Foods and beverages on the FFQ were measured and averaged per subject in grams per day, and those composed of more than one ingredient were disaggregated into their individual ingredients. These values were converted to standard 2010 Dietary Guideline measurements (i.e., ounces and cups; McGuire, 2011). For foods or beverages for which standard recipes were not available, we used comparable foods found on the United States Department of Agriculture Food Equivalents Database (United States Department of Agriculture, 2014) to calculate their HEI-2010 score. Of particular importance to the Mexican diet are intake of the staples beans and tortillas. Whereas whole corn tortillas were counted as part of the whole grains group, wheat and corn flour tortillas were counted as part of the refined grains group. Beans were first counted towards the total protein foods and seafood and plant proteins groups until the maximum score was met for these categories. Any remaining bean consumption was then counted towards the greens and beans group.

2.5 | Anthropometric measurements

Nutritional status was assessed by anthropometric indices constructed through measurements of weight and height, which were transformed to standard Z-scores using the sex-specific and age-specific growth standards of the World Health Organization (World Health Organization, 2006). Measurements were collected by standardized methods by trained staff. Z-score for body mass index (BMI) for age and sex was calculated ($BMI = kg/m^2$); school-aged and adolescents were classified as overweight when Z-scores were above +2 standard deviations, and as obese when Z-scores were above +3 standard deviations (World

Health Organization, 2006). Data were included and considered valid for BMI between -5.0 and +5.0 Z (Olaiz-Fernández et al., 2007) from the mean of the reference population (World Health Organization, 2006). Sensitivity analyses were conducted to assess whether those with very low (<10) or very high (>38) BMI values were significant outliers and influenced our results ($n = 20$; Cossío, Rivera, González-Castell, Unar-Munguía, & Monterrubio, 2009). Including or excluding children and adolescents with low or very high BMI did not change the mean HEI-2010 scores across food (in)security categories. We therefore retained these subjects in our analyses.

2.6 | Type of locality

Locality was classified as rural when the number of inhabitants was <2500 and urban when the number of inhabitants was ≥2500.

2.7 | Socioeconomic status

Socioeconomic status (SES) and other household information were obtained through a questionnaire administered to the survey respondent. An index of wellbeing (WBI) conditions was calculated using a principal components analysis, which included characteristics of housing construction materials, housing utilities (water, sewage, and electricity), household appliances (fridge, washing machine, microwave, stove, and boiler), and availability of television, cable television signal, radio, telephone, and computer in the household. WBI emerged as the first component, accounting for 40.5% of the total variability ($\lambda = 3.24$). The index of the WBI was then classified into socioeconomic quintiles: very low, low, medium, high, and very high (Gutiérrez et al., 2012; Hair, Anderson, Tatham, & Back, 1992).

2.8 | Head of household education level

Respondents were asked to report the head of household-attained education level. Participants were classified into two mutually exclusive education categories: high school or less, or college and more.

3 | DATA ANALYSES

3.1 | Outcome variable

The outcome variable was dietary quality as measured by the HEI-2010, estimated with the foods and beverages included in the FFQ of Ensanut 2012. Dietary quality was modeled as a continuous variable ranging from 0 to maximum for the total HEI score, and each of its 12 food groups.

3.2 | Primary independent variable

The primary independent variable was FI as measured by the ELCSA and categorized as either FS, mild FI, moderate FI, or severe FI based on recommended cut-off points (Comité científico de la ELCSA, 2012).

3.3 | Secondary independent variables/covariates

The multiple regression model was adjusted for parental education level, area, SES, *Prospera* beneficiary (a conditional cash transfer program, previously named *Oportunidades*), ethnicity (indigenous vs. non-indigenous), child age, and BMI category. Inclusion of these covariates was based on known confounders for the association between FI and dietary quality, as well as significant bivariate relationships among covariates with our variables of interest.

3.4 | Statistical analyses

All analyses were performed using STATA statistical software 13.1 (College Station, TX, StataCorp, 2013). The 'svy' module was used to conduct multiple linear regression analyses for a continuous outcome adjusting estimates for the complex survey design, taking into account the expansion factor, strata, and primary sampling unit parameters to ensure that the results were representative of the Mexican population. We tested if dietary quality was normally distributed and found this to be the case at each household FI level. Given that multiple pairwise differences were explored between all four levels of FI, the Bonferroni correction was applied to all models to prevent inflating the multiple comparisons type-I error rate. Interaction effects of FI with potential moderators (age group, BMI category, SES, indigenous status, *Prospera* beneficiary, and education) were examined and found significant ($p < .05$) for age group. Analyses were therefore stratified by age group.

To understand if being in a household with more than one child affected the findings, we replicated our analyses on the 82% of the households with only one child. On the 18% of the households with two children, we also replicated the analyses first using only the youngest child, and then using the oldest child. The association between FI and dietary quality remained nearly identical compared to the entire sample.² Thus, we are reporting the findings for the entire sample.

3.5 | Ethical considerations

Parents or caregivers of children gave their informed consent to participate and provide information. The protocol was reviewed and approved by the Ethics and Research Committee and the respective committees of Biosafety Research and the National Institute of Public Health, Mexico. Only unidentified public domain data were used in the secondary data analysis conducted for this study.

4 | RESULTS

4.1 | Sample characteristics

Table 1 presents the HEI distribution for general characteristics of the study population. The mean HEI score for the entire sample was 61.5p (95% CI 60.9–61.9) and was inversely associated with age (p -value for trend $<.001$). Pre-school children had a mean HEI of 65.1p (95% CI 64.1–65.9), school-aged children a mean of

61.7p (95% CI 60.9–62.4), and adolescents a mean of 59.8p (95% CI 59.1–60.6). Specifically, the consumption of total fruit, whole fruit, and dairy decreased with age, whereas consumption of whole grains, total protein foods, refined grains, sodium, and empty calories increased with age. There was also a positive association between the consumption of healthier fatty acids and age (Table 2). The subset of the population with the highest HEI-2010 score were those considered indigenous (66.9p vs. 60.6p in non-indigenous), followed by those living in rural zones (64.9p vs. 59.7p in urban), and those with a high education level (63.3p vs. 61.1p in those with high school or less). However, none of these subgroups were classified in the "good diet" category (HEI > 80 p). Conversely, populations with the lowest HEI-2010 scores were those living with severe FI (59.3p vs. 62.2p among those with FS).

4.2 | Household food insecurity and HEI-2010 score: multivariate linear analyses

Children and adolescents living in households with severe FI had lower dietary quality compared with their counterparts living in households with FS, as well as with mild and moderate FI. The mean HEI-scores were 62.2p (95% CI 61.1–63.3), 61.4p (95% CI 60.7–62.2), 61.3p (95% CI 60.3–62.3), and 59.3p (95% CI 58.1–60.4) for FS, mild, moderate, and severe FI, respectively. In addition, there was a statistically significant downward trend in the mean HEI-2010 score with worsening FI (p -value for trend $<.001$) suggesting a dose-effect response. The analyses of individual HEI components comparing different age groups presented in the following section provide further insights into the association of FI with dietary quality (Tables 3–6).

4.3 | HEI components score and food insecurity

Among the whole sample, first, total fruit intake was lower in those living with severe FI, 3.3p (95% CI 3.1–3.5) compared to 3.7p (95% CI 3.5–3.9) in those with FS. Second, whole fruit and total vegetable intake was lower with worsening FI (p -value for trend $<.001$). Third, intake of total protein foods was lower among those living with severe FI, 2.9p (95% CI 2.8–3.1); however, this difference was only statistically significant compared to those living with mild FI 3.3p (95% CI 3.1–3.4). Third, dairy intake was negatively associated with worsening FI (p -value for trend $<.001$); those living with severe FI had a mean score of 5.7p (95% CI 5.2–6.1), those with moderate FI a mean of 5.8p (95% CI 5.5–6.1) compared to those living with mild FI, who had a mean of 6.5p (95% CI 6.3–6.7), and those with FS a mean of 6.6p (95% CI 6.3–6.9). And lastly, fatty acids intake tended to improve with worsening FI (p -value for trend .011).

Pre-school children showed the greatest differences in consumption of total fruit, whole fruit, refined grains, and sodium across different levels of FI. Those in severe and moderate FI had total fruit mean scores of 3.3p (95% CI 2.8–3.8) and 3.7p (95% CI 3.4–4.0), respectively, compared with those living with FS who had a mean score of 4.4p (95% CI 4.2–4.6). Likewise, those with severe FI had a whole fruit score of 4.0p (95% CI 3.6–4.4) versus

²Data not shown.

TABLE 1 Mean HEI distribution for general characteristics of the study population

	Sample (n)	Expansion (thousands)	%	Mean HEI	CI 95%
Whole sample	4,635	44,185	100	61.5	(60.9, 61.9)
Age group					
2–4 ^a	1,042	6,934	15.7	65.1	(64.1, 65.9)
5–11	1,390	16,076	36.4	61.7 ^b	(60.9, 62.4)
12–19	2,203	21,174	47.9	59.8 ^{b,e}	(59.1, 60.6)
Food insecurity					
Food secure ^a	980	9,330	21.8	62.2	(61.1, 63.3)
Mild food insecurity	2,000	18,450	43.1	61.4	(60.7, 62.2)
Moderate food insecurity	972	9,267	21.7	61.3	(60.3, 62.3)
Severe food insecurity	586	5,724	13.3	59.3 ^{b,c,d}	(58.1, 60.4)
Area					
Urban ^a (≥2,500 inhabitants)	2,880	31,280	70.8	59.7	(59.1, 60.4)
Rural (<2,500 inhabitants)	1,755	12,905	29.2	64.9 ^b	(63.9, 66.0)
Socioeconomic status					
Very low ^a	1,073	9,000	20.4	62.7	(61.3, 64.1)
Low	938	7,974	18.0	61.1	(59.9, 62.3)
Medium	944	8,452	19.1	61.2	(60.2, 62.2)
High	941	9,815	22.2	60.4	(59.4, 61.5)
Very high	739	8,944	20.2	60.8	(59.7, 62.0)
BMI					
Underweight	66	661	1.6	62.3	(60.8, 61.9)
Normal weight ^a	2,994	27,999	67.4	61.4	(60.1, 62.3)
Overweight	782	7,804	18.8	61.2	(59.1, 62.1)
Obese	533	5,063	12.2	60.5	(59.0, 65.5)
Head of household education level					
High School or less ^a	4,309	40,668	92	61.1	(60.5, 61.6)
College or more	326	3,516	8	63.3 ^b	(61.5, 65.1)
Indigenous					
No ^a	4,078	39,659	89.8	60.6	(60.1, 61.2)
Yes	557	4,526	10.2	66.9 ^b	(65.5, 68.4)
Prospera beneficiary					
No ^a	2,656	26,624	72.2	60.8	(60.2, 61.4)
Yes	1,279	10,266	27.8	62.5 ^b	(61.4, 63.6)

Note. Total sample size: 4,635; total expansion: 44,184,737.

Models adjusted for education, area, socioeconomic status, *Prospera* beneficiary, indigenism, age, and BMI category.

FI, food insecurity; HEI, Healthy Eating Index.

^aReference.

^bStatistically significant compared to reference (Bonferroni-corrected, $p < .05$).

^cStatistically significant compared to mild FI (Bonferroni-corrected, $p < .05$).

^dStatistically significant compared to moderate FI (Bonferroni-corrected, $p < .05$).

^eStatistically significant compared to 5–11 age group (Bonferroni-corrected, $p < .05$).

4.7p (95% CI 4.6–4.9) among those with FS. Similarly, those with severe FI had a lower mean score for sodium, 8.3p (95% CI 7.5–9.1) versus 9.4p (95% CI 9.2–9.6) among those in FS households. In addition, mean score for refined grains was lower for those living with moderate FI, 5.1p (95% CI 4.4–5.9) compared to 7.0p (95% CI 6.2–7.7) among those in FS households. In contrast, mean score for greens and beans was higher among pre-school

children living with severe FI, 1.7p (95% CI 1.1–2.3) compared to 0.7p (95% CI 0.4–1.1) among those in FS households. And lastly, dairy intake was not associated with FI.

Similar trends were observed for individual food groups among school-aged children and adolescents, compared to the whole group; however, dairy intake was lower with worsening FI for older children. In school-aged children, those living with severe FI, had a

TABLE 2 Score means of HEI-2010 components, expressed as absolute scores

Component	Age group						p-Value for trend
	Preschool		School-aged		Adolescents		
	Mean	CI 95%	Mean	CI 95%	Mean	CI 95%	
Total fruit ^c	4.0	(3.8, 4.1)	3.6 ^a	(3.5, 3.8)	3.4 ^a	(3.2, 3.5)	<.001
Whole fruit ^c	4.6	(4.5, 4.7)	4.4 ^a	(4.3, 4.5)	4.1 ^{a,b}	(4.0, 4.2)	<.001
Total vegetables ^c	3.0	(2.8, 3.1)	3.0	(2.9, 3.1)	3.0	(2.9, 3.1)	.98
Greens and beans ^c	1.0	(0.9, 1.2)	0.7	(0.6, 0.8)	0.9	(0.7, 1.0)	.23
Whole grains ^d	3.1	(2.8, 3.4)	3.2	(2.9, 3.5)	3.6 ^{a,b}	(3.3, 3.9)	.02
Dairy ^d	8.4	(8.1, 8.6)	6.9 ^a	(6.6, 7.1)	5.2 ^{a,b}	(5.0, 5.4)	<.001
Total protein foods ^c	3.1	(2.9, 3.2)	3.0	(2.9, 3.1)	3.4 ^{a,b}	(3.3, 3.5)	.01
Seafood and plant proteins ^c	3.1	(2.9, 3.3)	3.2	(3.1, 3.3)	3.2	(3.1, 3.4)	.36
Fatty acids ^d	1.5	(1.3, 1.7)	2.2 ^a	(2.1, 2.4)	3.2 ^{a,b}	(3.0, 3.3)	<.001
Refined grains ^d	5.9	(5.5, 6.3)	4.3 ^a	(4.0, 4.6)	4.0 ^a	(3.8, 4.3)	<.001
Sodium ^d	9.1	(8.9, 9.3)	8.9	(8.8, 9.1)	8.3 ^{a,b}	(8.1, 8.5)	<.001
Empty calories ^e	18.3	(18.0, 18.6)	18.1	(17.9, 18.4)	17.6 ^{a,b}	(17.4, 17.9)	.01
HEI-2010 score ^f	65.1	(64.1, 65.9)	61.7 ^a	(60.9, 62.4)	59.8 ^{a,b}	(59.1, 60.6)	<.001

Note. Model adjusted for education, area, socioeconomic status, *Prospera* beneficiary, indigenism, and BMI category.

HEI, Healthy Eating Index.

^aSignificantly different compared to preschool children (Bonferroni-corrected, $p < .05$).

^bStatistically significant compared to school-aged children (Bonferroni-corrected, $p < .05$).

^cMaximum score: 5.

^dMaximum score: 10.

^eMaximum score: 20.

^fMaximum score: 100.

TABLE 3 Score means of HEI-2010 components, expressed as absolute scores (all age groups)

Component	Food insecurity								p-Value for trend
	Food security		Mild		Moderate		Severe		
	Mean	CI 95%	Mean	CI 95%	Mean	CI 95%	Mean	CI 95%	
Total fruit ^d	3.7	(3.5, 3.9)	3.6	(3.4, 3.7)	3.5	(3.4, 3.7)	3.3 ^a	(3.1, 3.5)	.01
Whole fruit ^d	4.3	(4.2, 4.5)	4.3	(4.2, 4.4)	4.2	(4.1, 4.4)	4.0	(3.8, 4.2)	.04
Total vegetables ^d	3.1	(2.9, 3.2)	3.0	(2.9, 3.1)	2.9	(2.8, 3.1)	2.8	(2.6, 3.0)	.05
Greens and beans ^d	0.8	(0.6, 1)	0.9	(0.8, 1)	0.8	(0.6, 0.9)	0.8	(0.6, 1)	.75
Whole grains ^e	3.5	(3.1, 3.9)	3.3	(3.1, 3.6)	3.6	(3.2, 3.9)	3.1	(2.7, 3.6)	.29
Dairy ^e	6.6	(6.3, 6.9)	6.5	(6.3, 6.7)	5.8 ^{a,b}	(5.5, 6.1)	5.7 ^{a,b}	(5.2, 6.1)	<.001
Total protein foods ^d	3.2	(3.1, 3.4)	3.3	(3.1, 3.4)	3.3	(3.1, 3.4)	2.9 ^b	(2.8, 3.1)	.04
Seafood and plant proteins ^d	3.0	(2.9, 3.2)	3.2	(3.1, 3.4)	3.3	(3.1, 3.5)	3.3	(3.0, 3.5)	.17
Fatty acids ^e	2.4	(2.2, 2.7)	2.5	(2.3, 2.6)	2.7	(2.5, 2.9)	3.0	(2.5, 3.4)	.01
Refined grains ^e	4.7	(4.4, 5.1)	4.3	(4.0, 4.6)	4.4	(4.1, 4.8)	4.0	(3.5, 4.5)	.03
Sodium ^e	8.7	(8.6, 8.9)	8.6	(8.5, 8.8)	8.7	(8.5, 8.9)	8.5	(8.2, 8.8)	.39
Empty calories ^f	17.9	(17.6, 18.3)	17.9	(17.6, 18.1)	17.9	(17.6, 18.3)	17.8	(17.4, 18.3)	.74
HEI-2010 score ^g	62.2	(61.1, 63.3)	61.4	(60.7, 62.2)	61.3	(60.3, 62.3)	59.3 ^{a,b,c}	(58.1, 60.4)	<.001

Note. Model adjusted for education, area, socioeconomic status, *Prospera* beneficiary, indigenism, and BMI category.

FI, food insecurity; HEI, Healthy Eating Index.

^aSignificantly different compared to food security status (Bonferroni-corrected, $p < .05$).

^bStatistically significant compared to mild FI (Bonferroni-corrected, $p < .05$).

^cStatistically significant compared to moderate FI (Bonferroni-corrected, $p < .05$).

^dMaximum score: 5.

^eMaximum score: 10.

^fMaximum score: 20.

^gMaximum score: 100.

TABLE 4 Score means of HEI-2010 components, expressed as absolute scores (Preschool)

Component	Food security		Food insecurity						p-Value for trend
			Mild		Moderate		Severe		
	Mean	CI 95%	Mean	CI 95%	Mean	CI 95%	Mean	CI 95%	
Total fruit ^d	4.4	(4.2, 4.6)	4.1	(3.9, 4.3)	3.7 ^a	(3.4, 4.0)	3.3 ^{a,b}	(2.8, 3.8)	<.001
Whole fruit ^d	4.7	(4.6, 4.9)	4.7	(4.6, 4.8)	4.5	(4.4, 4.7)	4.0 ^{a,b}	(3.6, 4.4)	.01
Total vegetables ^d	3.1	(2.8, 3.5)	3.0	(2.8, 3.2)	2.6	(2.2, 2.9)	2.9	(2.5, 3.3)	.18
Greens and beans ^d	0.7	(0.4, 1.1)	1.2	(0.9, 1.5)	0.9	(0.5, 1.2)	1.7 ^a	(1.1, 2.3)	.02
Whole grains ^e	2.9	(2.3, 3.6)	3.4	(2.9, 3.8)	3.1	(2.3, 3.9)	2.7	(1.8, 3.6)	.55
Dairy ^e	8.7	(8.3, 9.1)	8.3	(7.9, 8.6)	7.9	(7.2, 8.6)	8.1	(7.5, 8.7)	.08
Total protein foods ^d	2.9	(2.7, 3.2)	3.1	(2.9, 3.3)	3.0	(2.7, 3.4)	3.4	(3.0, 3.7)	.05
Seafood and plant proteins ^d	3.1	(2.8, 3.5)	3.3	(3.0, 3.5)	2.8	(2.4, 3.2)	3.6	(3.1, 4.1)	.36
Fatty acids ^e	1.4	(1.1, 1.9)	1.5	(1.2, 1.7)	1.3	(0.9, 1.7)	1.9	(1.3, 2.4)	.28
Refined grains ^e	7.0	(6.2, 7.7)	6.1	(5.5, 6.7)	5.1 ^a	(4.4, 5.9)	5.7	(4.8, 6.6)	.01
Sodium ^e	9.4	(9.2, 9.6)	9.0	(8.8, 9.2)	9.3	(9.1, 9.6)	8.3 ^a	(7.5, 9.1)	.02
Empty calories ^f	18.2	(17.6, 18.8)	18.5	(18.2, 18.8)	17.9	(17.1, 18.7)	18.4	(17.8, 18.9)	.97
HEI-2010 score ^g	66.8	(65.5, 68.1)	66.2	(65.0, 67.3)	62.3 ^{a,b}	(59.9, 64.6)	64.1	(61.9, 66.3)	.01

Note. Model adjusted for education, area, socioeconomic status, *Prospera* beneficiary, indigenism, and BMI category.

FI, food insecurity; HEI, Healthy Eating Index.

^aSignificantly different compared to food security status (Bonferroni-corrected, $p < .05$).

^bStatistically significant compared to mild FI (Bonferroni-corrected, $p < .05$).

^cThere were no significant differences compared to moderate FI.

^dMaximum score: 5.

^eMaximum score: 10.

^fMaximum score: 20.

^gMaximum score: 100.

TABLE 5 Score means of HEI-2010 components, expressed as absolute scores (school-aged)

Component	Food security		Food insecurity						p-Value for trend
			Mild		Moderate		Severe		
	Mean	CI 95%	Mean	CI 95%	Mean	CI 95%	Mean	CI 95%	
Total fruit ^d	3.7	(3.4, 4.0)	3.7	(3.6, 3.9)	3.5	(3.3, 3.8)	3.2	(2.8, 3.6)	0.02
Whole fruit ^d	4.4	(4.1, 4.6)	4.4	(4.3, 4.5)	4.3	(4.1, 4.5)	4.0	(3.6, 4.4)	0.12
Total vegetables ^d	3.1	(2.9, 3.4)	3.0	(2.8, 3.2)	3.1	(2.9, 3.4)	2.7	(2.4, 3.0)	0.14
Greens and beans ^d	0.6	(0.4, 0.8)	0.7	(0.5, 0.9)	0.7	(0.4, 1.0)	0.7	(0.4, 1.1)	0.66
Whole grains ^e	3.2	(2.7, 3.8)	3.1	(2.7, 3.4)	3.6	(3.1, 4.2)	3.3	(2.5, 4.1)	0.65
Dairy ^e	6.7	(6.2, 7.3)	7.3	(7.1, 7.7)	6.6	(6.2, 7.1)	5.5 ^{a,b,c}	(4.8, 6.2)	0.01
Total protein foods ^d	3.1	(2.9, 3.3)	3.0	(2.9, 3.2)	3.0	(2.8, 3.3)	2.9	(2.6, 3.2)	0.37
Seafood and plant proteins ^d	2.9	(2.7, 3.2)	3.3	(3.1, 3.5)	3.4	(3.1, 3.7)	3.2	(2.8, 3.5)	0.25
Fatty acids ^e	2.3	(1.8, 2.7)	2.1	(1.8, 2.3)	2.1	(1.8, 2.5)	3.0	(2.3, 3.6)	0.12
Refined grains ^e	4.3	(3.7, 4.9)	4.3	(3.9, 4.7)	4.6	(4.0, 5.2)	4.1	(3.2, 4.9)	0.90
Sodium ^e	8.8	(8.5, 9.0)	8.9	(8.8, 9.2)	8.9	(8.7, 9.2)	8.9	(8.5, 9.2)	0.86
Empty calories ^f	18.5	(18.0, 19.0)	18.1	(17.8, 18.4)	18.1	(17.6, 18.6)	17.5	(16.7, 18.2)	0.03
HEI-2010 score ^g	61.8	(60.2, 63.4)	62.3	(61.2, 63.4)	62.3	(60.7, 63.8)	59.0	(56.7, 61.3)	0.05

Models adjusted for education, area, socioeconomic status, *Prospera* beneficiary, indigenism, age, and BMI category.

FI, food insecurity; HEI, Healthy Eating Index.

^aSignificantly different compared to food security status (Bonferroni-corrected, $p < .05$).

^bStatistically significant compared to mild FI (Bonferroni-corrected, $p < .05$).

^cStatistically significant compared to moderate FI (Bonferroni-corrected, $p < .05$).

^dMaximum score: 5.

^eMaximum score: 10.

^fMaximum score: 20.

^gMaximum score: 100.

TABLE 6 Score means of HEI-2010 components, expressed as absolute scores (adolescents)

Component	Food security		Food insecurity						p-Value for trend
	Mean	CI 95%	Mean	Mild CI 95%	Mean	Moderate CI 95%	Mean	Severe CI 95%	
Total fruit ^d	3.4	(3.1, 3.7)	3.3	(3.1, 3.5)	3.4	(3.2, 3.7)	3.3	(3.0, 3.6)	0.77
Whole fruit ^d	4.1	(3.9, 4.4)	4.0	(3.9, 4.2)	4.1	(3.9, 4.4)	4.0	(3.8, 4.2)	0.65
Total vegetables ^d	3.0	(2.8, 3.2)	3.0	(2.8, 3.1)	3.0	(2.8, 3.2)	2.9	(2.6, 3.1)	0.55
Greens and beans ^d	0.9	(0.6, 1.2)	0.9	(0.7, 1.1)	0.8	(0.5, 1.1)	0.6	(0.3, 0.9)	0.07
Whole grains ^e	3.8	(3.3, 4.4)	3.6	(3.2, 3.9)	3.6	(3.2, 4.2)	3.1	(2.5, 3.7)	0.08
Dairy ^e	5.9	(5.4, 6.4)	5.3	(5.1, 5.6)	4.5 ^{a,b}	(4.1, 4.9)	5.0	(4.5, 5.6)	0.01
Total protein foods ^d	3.4	(3.2, 3.6)	3.5	(3.3, 3.6)	3.5	(3.3, 3.7)	2.9 ^{a,b,c}	(2.6, 3.2)	0.01
Seafood and plant proteins ^d	3.1	(2.8, 3.4)	3.2	(2.9, 3.4)	3.4	(3.1, 3.6)	3.2	(2.9, 3.6)	0.47
Fatty acids ^e	2.8	(2.5, 3.3)	3.0	(2.8, 3.3)	3.6	(3.2, 3.9)	3.3	(2.8, 3.8)	0.06
Refined grains ^e	4.3	(3.8, 4.8)	3.8	(3.4, 4.2)	4.2	(3.7, 4.7)	3.4	(2.7, 4.1)	0.09
Sodium ^e	8.5	(8.2, 8.8)	8.2	(7.9, 8.5)	8.3	(7.9, 8.6)	8.3	(7.9, 8.8)	0.63
Empty calories ^f	17.5	(16.9, 18.1)	17.5	(17.0, 17.9)	17.9	(17.4, 18.4)	17.9	(17.2, 18.5)	0.31
HEI-2010 score ^g	61.0	(59.5, 62.7)	59.4	(58.3, 60.5)	60.4	(58.9, 61.8)	58.0 ^a	(56.4, 59.5)	0.03

Model adjusted for education, area, socioeconomic status, *Prospera* beneficiary, indigenism, and BMI category.

FI, food insecurity; HEI, Healthy Eating Index.

^aSignificantly different compared to food security status (Bonferroni-corrected, $p < .05$).

^bStatistically significant compared to mild FI (Bonferroni-corrected, $p < .05$).

^cStatistically significant compared to moderate FI (Bonferroni-corrected, $p < .05$).

^dMaximum score: 5.

^eMaximum score: 10.

^fMaximum score: 20.

^gMaximum score: 100.

lower mean score for dairy of 5.5p (95% CI 4.8–6.2) compared to 6.7p (95% CI 6.2–7.3) in those with FS. Among adolescents, it was those living with moderate FI who had a reduced mean score for dairy of 4.5p (95% CI 4.1–4.9) compared to 5.9p (95% CI 5.4–6.4) in those with FS. Finally, also among adolescents, those with severe FI had a reduced mean score for total protein foods of 2.9p (95% CI 2.6–3.2) compared to 3.4p (95% CI 3.2–3.6) in those living with FS. It is noteworthy to add that added sugars contributed an average of 15.0% of the total daily energy intake per capita in children and adolescents 2–19 years, yet added sugar intake was not associated with FI.

5 | DISCUSSION

Our analyses utilized the HEI-2010 to quantify the dietary quality of Mexican children and adolescents and how it relates to FI. According to the results, dietary quality was lower with worsening FI and was the lowest among those living in households with severe FI. The food groups' intakes that were most negatively associated with FI were total fruit, whole fruit, total vegetables, dairy, and total protein foods. This result is consistent with prior findings from studies in Mexico, which have documented that FI is closely linked with low household income (Villagómez et al., 2013). It has been hypothesized that the high price of nutrient dense healthy foods, particularly fruit, lean meats, milk, and dairy products, may limit the ability of the poorer segments of the

population to consume them (Rivera-Dommarco, Hernández-Avila, Aguilar-Salinas, Vadillo-Ortega, & Murayama-Rendón, 2013).

When comparing associations between individual HEI food components and FI level, we found that the trends were similar across age groups for total vegetables, whole grains, seafood and plant proteins, and fatty acids. In contrast, even though total fruit and whole fruit intake was higher among preschool children, we found these food groups to be more negatively associated with worsening FI among preschoolers compared with older children and adolescents. Likewise, consumption of refined grains and sodium was lower among preschool children; however, we also found these food groups to be more positively associated with worsening FI among preschoolers compared with older children and adolescents. Thus, our findings confirm a higher dietary quality among young children, perhaps because they consume more of their foods and beverages at home, compared to older children (Afeiche, Taillie, Eldridge, & Popkin, 2016). However, this age-related protective effect seems to disappear with worsening FI as dietary quality was not different across age groups for these food groups among those living under severe FI conditions.

Interestingly, among pre-school children, dairy intake was independent of FI. Because dairy products are indispensable among this age group and provide significantly greater percentage of total calories compared to older children (Pedraza, Aburto, Sánchez, & Rivera, 2014), mothers may adjust their own intake to buffer their children against food shortages (Ghattas, 2014), particularly for dairy products among young children. Furthermore, low-income children may receive them through food assistance programs. Lastly,

pre-school children living in households with severe FI had the highest bean intake, which increased their overall HEI score and masked the otherwise downward HEI score trend associated with severe FI across older age groups. In addition, because beans are first counted towards the total protein foods and seafood and plant proteins, they contributed a significant amount to these two food groups and consequently prevented the decline of their scores as FI became more severe. This finding suggests that as FI severity worsens, the population tends to depend more on bean consumption for their protein needs versus animal source proteins, particularly in households with young children.

Consistent with our findings, a study of Mexican households published in 2014 by Valencia and Ortiz found that among households with FI, there was high availability of corn, and legumes, as well as a reduction in fresh fruit, animal proteins, including seafood, and dairy products (Valencia-Valero & Ortiz-Hernández, 2014). Also, prior studies in Mexico have shown that household income is inversely associated with energy consumption from foods such as bread, tortilla, cereals, and positively associated with consumption of oils, and vegetable fats increase perhaps because they supply a greater energy content at a lower cost (Rivera-Dommarco et al., 2013; Villagómez et al., 2013).

Another key point is that in spite of having a lower education attainment and SES status, indigenous populations and those living in rural areas had a higher dietary quality regardless of age group, compared to their non-indigenous and urban counterparts, respectively. This may be related to the stronger influence of the nutrition transition in urban areas and the higher likelihood that subsistence food production is probably higher in indigenous areas than in urban areas, which is not captured by traditional SES measures. Rural and indigenous communities may still follow more traditional dietary patterns based on consumption of traditional staple foods including beans, whole corn tortillas, vegetables, and hot peppers. Nevertheless, their overall dietary mean scores still fall within the “needs improvement” category.

Consistent with our findings, a study by Kranz and McCabe found that dietary quality in US children ages 2–18 years declined with age (Kranz & McCabe, 2013). Similarly, a study by Banfield, Liu, Davis, Chang, and Frazier-Wood (2016) examined dietary quality of a nationally representative sample of US children and adolescents ages 4–18 years participating in National Health and Nutrition Examination Survey from 2005 to 2010 using the HEI-2010. They found that the youngest group ages 4–8 years had the highest score of 52.1p, followed by the 9–13 years olds with a score of 46.9p, and the adolescent group ages 14–18 years with a score of 43.6p. In our study, dietary quality was also found to worsen significantly with increasing age. However, the overall mean HEI score differences were quite different between these two populations, with the US pediatric population falling in the “poor” diet category, and the Mexican pediatric population falling in the “needs improvement” category.

It is important to note that the HEI-2010 does not take into account total caloric or individual nutrient intake, rather specific food components per 1,000 kcal. Nevertheless, in our study, we found a statistically significant inverse association between total caloric intake and FI severity (data not shown in tables). Even though the percentage of the total calories that came from added sugars did not differ across

FI categories, it is noteworthy that it was substantially above the upper limit across FI categories and age groups. This finding indicates that excessive added sugar intake affects the entire population regardless of their FI status. By contrast, a study by Sharkey, Nalty, Johnson, and Dean (2012) conducted in a Mexican-origin population with high rates of poverty in the US southwest showed that children's very low FS (equivalent to severe FI in our study) was associated with greater intakes of added sugar, energy, and fat. This difference may be attributed to environmental factors such as lower cost and easier access to foods and beverages that supply added sugars, fats, and more calories in the USA, and social factors such as increased stress. Further analyses are warranted to understand this binational difference on the relationship between sugar intake and FI.

5.1 | Limitations

Our study has some limitations. First is the cross-sectional design, because exposure and outcome are simultaneously assessed; the temporal sequence of events cannot be disentangled. In addition, because more than one point in time is needed, we are unable to assess if FI was episodic, persistent, or chronic as it has been done in previous longitudinal studies (Garcia et al., 2013). Second, the HEI-2010 was designed to measure dietary quality of Americans following the federal Dietary Guidelines, which may not be fully applicable to the Mexican population (Fomento de Nutrición y Salud A.C., 2014). Also, it is important to note that the HEI was updated in 2010 to reflect the new federal Dietary Guidelines for Americans, as such, it is possible that some of the studies that used the prior versions of the HEI may have found different associations between dietary quality and reported health outcomes. Third, FI was assessed at the household level and therefore cannot be used to understand if and how the experience of FI varies among individuals living in the same household. Fourth, because of variations in how corn tortillas are prepared, some misclassification of tortillas could have occurred with regard to the whole grains and refined grains categories. Fifth, among adolescents, the score for “empty calories” incorporated solid fats and added sugars but excluded alcohol due to low-reported intake. The maximum average intake reported by any individual was well below the threshold for counting alcohol towards this component. However, among children and adolescents aged 10–19 years, the reported prevalence of alcohol consumption in the same group was 28.8% among males and 21.2% among females (Gutiérrez et al., 2012). We therefore speculate that if alcohol intake would have been accurately captured on the FFQ, the total HEI-2010 score for this sample may have decreased among pre-adolescent and adolescents. Lastly, our dietary information was collected from an FFQ. It is unknown how much the different approaches to collect dietary intake data may influence measurement error in dietary intake assessment. The closed list of foods that although designed to capture most frequent foods and beverages consumed among the Mexican population can miss certain food and beverage patterns that can contribute to substantial dietary quality differences among different levels of FI. In particular, this may be important when comparing mean HEI scores between the Mexican and American pediatric populations, given that in the Mexican survey, diet was measured using an FFQ and in the American survey using 24-

hr dietary recalls. Despite this limitation, prior studies on pediatric populations have found that FFQs have been useful for ranking children according to food groups intake (Saeedi, Skeaff, Wong, & Skidmore, 2016) as well as provide reproducible estimates of food group intakes (Huybrechts, De Backer, De Bacquer, Maes, & De Henauw, 2009). In addition, the FFQ is an instrument that captured usual food consumption of our nationally representative population, and it helped us obtain information from a greater number of participants as it takes relatively less time to complete and has been found to be well accepted across diverse populations (Satija, Yu, Willett, & Hu, 2015). It has been documented that dietary pattern analyses allow us to understand the role of the total diet in disease onset (Slattery, 2010), because the effects of simultaneous intake of several foods or nutrients are taken into account (Moeller et al., 2007). In Mexico, this FFQ has shown a reasonable validity defining three dietary patterns through a factor analysis against a 24-hr dietary recall (Denova-Gutiérrez, Tucker, Salmerón, Flores, & Barquera, 2016).

6 | CONCLUSIONS

This work revealed that there is an association between FI and a reduced consumption of nutrient dense foods among pediatric populations. A poor dietary quality coupled with adverse environmental conditions can trigger nutritional deficiencies, obesity, and other health problems later in life (Arimond & Ruel, 2004; Ruel, 2003; World Health Organization, UNICEF, 2003). Therefore, it is important to evaluate the condition of FI in order to focus interventions and social programs to improve the nutrition and health of children. In particular, nationwide or local programs designed to improve household FI may help improve dietary quality of children and adolescent populations by helping increase consumption of plain dairy products (without added sugars), whole fruits, vegetables, and protein foods, including beans and legumes, and reducing refined grain products. In this sample, we did not observe differences in added sugars as a function of FI status, suggesting that the current excessive added sugar intake is affecting the entire pediatric population. This excessive intake underscores the importance of implementing policies and regulations to help decrease added sugar intake across the population.

The HEI-2010 is a tool that can be used to assess dietary quality and capture changes over time (Guenther et al., 2013a); thus, dietary quality scores from the Ensanut 2012 can serve as a reference to assess possible dietary quality changes in future Mexican National Health and Nutrition Surveys. Lastly, our study confirms the value of ELCSA as an instrument useful for FS policy making as it clearly identified key dietary quality findings that went above and beyond what is captured by standard poverty indicators (Pérez-Escamilla, 2012).

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CONFLICTS OF INTEREST

The authors declare that they have no conflict of interest.

AUTHOR CONTRIBUTIONS

LAR and RPE conceptualized the manuscript; LAR cleaned all data, conducted all analyses, and drafted the manuscript; IMGH substantially contributed to the statistical modeling and analyses; VMR, RPE, and TSL substantially contributed to the interpretation of the results. All authors have read and approved the final manuscript.

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