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ORIGINAL ARTICLE

Changes in diet quality over 10 years of nutrition transition in Colombia: analysis of the 2005 and 2015 nationally representative cross-sectional surveys

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Abstract

Objectives To describe the changes in diet quality in Colombians using nationally representative samples from the 2005 and 2015 nutrition surveys.

Methods Repeated cross-sectional analyses of the National Nutrition Surveys from 2005 and 2015. Children (4–17 y.o.) and adults (≥ 18 y.o.) were included. The Alternative Healthy-Eating Index (AHEI) was derived from 24-h recall questionnaires and used to examine diet quality.

Results A total of 33,971 participants (20,122 children, 13,849 adults) were included in 2005, and 26,445 participants (15,304 children, 11,141 adults) in 2015. Over the ten-year period, the AHEI decreased from 46.3 to 44.3 in children (Cohen's $d = 0.19$) and from 49.0 to 46.2 in adults. (Cohen's $d = 0.25$). On average, those in the highest socioeconomic level had the worst diet quality; however, the difference between the less and most affluent groups shrank by 4.0% over the observation period.

Conclusions Between 2005 and 2015, there was a worsening in the diet quality of Colombian children and adults. Less affluent individuals had a greater worsening of diet quality compared to groups from higher socioeconomic levels.

Keywords Diet quality · AHEI score · Nutrition transition · Nationally representative nutrition survey · ENSIN · Colombia · Latin America

Abbreviations

AHEI	Alternative healthy-eating index
DHS	National demographic and health survey
ENSIN (Encuesta Nacional de la Situación Nutricional)	National Nutrition Survey
PUFA	Polyunsaturated fatty acids
SSB	Sugar-sweetened beverages

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Introduction

Over the past 20 years, the Colombian population has been undergoing a nutrition transition (Lamus-Lemus et al. 2012; Parra et al. 2015). As with other low- and middle-income countries, this transition has been associated with a double burden of disease and with an increase in the morbidity and mortality of non-communicable diseases (NCDs) (Parra et al. 2015).

Nationwide changes in food preferences have led to an increase in the consumption of energy high-dense preparations (Cornwell et al. 2018). These changes suggest that diet quality has worsened, but most of the epidemiological evidence in Colombia has been limited to studies that investigated changes in consumption of single food items or nutrients, which limit our capacity to interpret the overall quality of the diet (Cornwell et al. 2018). Studying diet using more integrative approaches (Leech et al. 2015) that include foods and nutrients known to be associated with health outcomes, might provide a more realistic view of the role of diet on disease modulation (Miller et al. 2019).

At least 81 metrics or indexes have been developed to provide standard measurements of diet quality (Trijsburg et al. 2019). Some of these indices have been associated with NCD risk and used in the study of nutrition transition in developing countries, suggesting a potential use in identifying deleterious changes in dietary patterns (Lopez-Olmedo et al. 2019; Wang et al. 2018).

Despite the high burden associated with some of the harmful consequences of nutrition transition, few of the available indices have been used to study diet quality in nationally representative surveys in Latin America (Miller et al. 2019). In Colombia, diet quality has been poorly described and little is known about its trend over the past two decades. Considering that the National Nutrition Survey (*Encuesta Nacional de la Situación Nutricional* –ENSIN-) has brought consistent quinquennial reports since 2005, the analysis of dietary data collected as part of these repeated surveys can contribute to the understanding of the nutrition transition at national and regional level. Thus, the current study aimed to describe the changes in diet quality in a nationally representative sample of children and adults who participated in the 2005 and 2015 ENSIN Surveys.

Methods

Study sample

ENSIN is a survey with national and sub-national representativeness. Details of the methods used in the 2005 and 2015 ENSIN surveys have been published elsewhere (Instituto Colombiano del Bienestar Familiar 2006; Ministerio de Salud y Protección Social 2016). Briefly, the ENSIN survey is administered jointly with the Demographic and Health Survey (DHS), collecting cross-sectional data on dietary intake using a 24-h recall questionnaire. Through a multistage random cluster sampling, household and individual data for children and adults are collected in rural and urban areas from all 32 Colombian Territorial Departments. For the current analyses, data from the ENSIN 2010 were not included as it used a different sampling frame and a 32-food item food frequency questionnaire instead of the 24-hour recall used in 2005 and 2015 (Fonseca Centeno et al. 2011).

In 2005, from a sampling frame of 116,359 individuals, 39,413 were randomly selected to participate in the ENSIN survey. Data from 34 665 individuals were available for further analyses (supplemental Figure 1).

In the 2015 Survey, 34,122 were eligible for the nutrition survey, of whom 34,101 individuals were included in the analyses (supplemental Figure 1). Subjects with missing data on socio-demographic variables (e.g., age, sex, socioeconomic status, geographic localization) were excluded from the current analyses. For the children group, only those aged $\geq$ 4 years old were included, since Latin American preschool children usually follow specific dietary patterns aimed at addressing nutrition-related deficiencies through the intake of food supplements (Bernal and Fernández 2013).

Demographic, socioeconomic, and dietary data

Demographic and socioeconomic data were collected using a validated questionnaire developed by the DHS. Information was collected on each household's cumulative living standard using easy-to-collect data (e.g., water access, television, type of vehicles, material used for housing construction). A wealth index was built by DHS developers using principal component analysis (PCA), deriving negative (unfavorable conditions), and positive scores (improved conditions). The PCA component score matrix calculated for Colombia is available in the following link https://www.dhsprogram.com/programming/wealth%20index/Colombia%20DHS%202015/Colombia%202015.pdf. Following the protocol recommended by the DHS, all participants were categorized into one of five quintiles of wealth index.

In both surveys, dietary data were collected using a single 24-h recall questionnaire applying previously validated methods (Instituto Colombiano del Bienestar Familiar 2006). Serving sizes were registered using visual references with a set of 60 geometric figures. Foods, preparations, and ingredients were recorded using the Nutritional Guidelines Based on Foods for the Colombian Population (*Guías Alimentarias Basadas en Alimentos*

para la Población Colombiana Mayor de 2 Años) as reference (Instituto Colombiano de Bienestar Familiar 2015a, b); those ingredients not included in the national guidelines were weighted by the interviewers and the data were added to the ENSIN database by a designated researcher (Instituto Colombiano del Bienestar Familiar 2006). Macro- and micronutrient estimates were derived using the 2015 national food composition table (Instituto Colombiano de Bienestar Familiar 2015a, b).

Participants with implausible total energy intakes (< 1st or > 99th percentiles) were excluded (Welch et al. 2005).

Assessment of diet quality

The Alternative Healthy-eating Index (AHEI) 2010 was calculated to estimate diet quality for all participants. Considering that this index includes alcohol consumption, which is legally forbidden in Colombia for children (under 18 years old), a modified AHEI 2010 without the scoring of alcohol drinking was used in those under-18-year-old.

The AHEI 2010 is an a priori score developed to assess the adherence to the 2005 Dietary Guidelines for Americans, where the daily consumption of 11 different food groups or components is evaluated. The total score ranges from 0 (lowest diet quality) to 110 (highest diet quality), with 0–10 points for each component. Six of these components are considered to be ideal; therefore, higher consumptions are assigned higher scores: (1) vegetables (excluding potatoes), (2) fruits, (3) nuts and legumes, (4) whole grains, (5) omega-3 fatty acids, and (6) polyunsaturated fatty acids (PUFA) expressed as % of total energy. The remaining five are focused on moderation, that is, their lower or null consumption is assigned higher scores: (1) sugar-sweetened beverages (SSB) and juices, (2) red and processed meat, (3) trans-fatty acids (as % of total energy), (4) sodium, and (5) alcohol (Chiuve et al. 2012).

Statistical analyses

Demographic, socioeconomic, and nutrition data at baseline (2005) and 10 years later (2015) were described using main tendency and frequency values (weighted data), when appropriate. A geographic information system was developed to describe sub-national distribution of diet quality. These procedures were performed using Stata/MP 15.0 (StataCorp 2017) and ArcGIS desktop 10.5 (Environmental Systems Research Institute 2011).

The differences in the frequencies of categorical variables between both study periods were examined using Rao-Scott Chi-squared test, adjusting by the multistage sampling design. Continuous variables (e.g., dietary consumption, and AHEI score) were compared using Mann–Whitney or Student' test. The Cohen's *d* value was used to quantify the effect size.

A linear multivariable regression analysis was performed to compare the period of interview (independent variable, 2005 as reference category) between scores of AHEI adjusted by sex, age, and other confounders as sociodemographic and lifestyle variables. All *P* values were two-tailed ($\alpha = 0.05$). Coefficients were adjusted using the sampling weights (derived from the multistage random sampling stratification) provided by the ENSIN database for effect size determination. To assess the changes over time in the differences for the AHEI score within population groups, a linear regression models including interaction terms between the time variable (i.e., 2005 and 2015) and age ranges, sex, wealth index quintiles, living area, and geographic region were performed. Additionally, a sensitivity analysis was conducted to identify which food groups were responsible for the highest proportional differences in the AHEI score: The mean differences including only the healthy food groups in the score (i.e., fruits, vegetables, whole grains, nuts and legumes, PUFA, and omega-3–6) and only unhealthy food groups (i.e., SSB, red and processed meats, trans-fatty acids, sodium and alcohol—for adults—) were separately estimated through a linear regression model using the logarithmic transformation of AHEI as the outcome.

Ethics

The PROFAMILIA Ethics Committee approved the ENSIN survey prior to data collection (Resolución 8430 de 1993; Ministerio de Salud de Colombia). All adult participants provided written informed consent, while children and adolescents provided an informed assent form, in accordance with the guidelines stated in the Declaration of Helsinki. The data for the current analyses are publicly available, and The Ministry of Health of Colombia authorized their use for this secondary analysis.

Results

The final sample for 2005 was comprised of 34,665 individuals. When exclusion due to age and unreliable total energy intake was applied, the study sample was reduced to 33,971 participants (20,122 children; 13,849 adults). In ENSIN 2015, 26,445 participants (15,304 children; 11,141 adults) with valid and complete data were included (supplemental Figure 1).

A description of demographic and socioeconomic characteristics is presented in Table 1. Amongst children, females represented half of the sample at both survey points, with average ages of 10.8 and 11 years for 2005 and

2015, respectively. Approximately two-thirds of participants reported living in urban areas in 2005 and 2015.

Amongst adults, women represented 53.5% and 59.0% of ENSIN 2005 and 2015 study samples, respectively. The proportion of participants living in urban areas also decreased slightly, from 78% in 2005 to 75% in 2015.

Dietary intake and diet quality assessment

Children

The median total energy intake for children in 2005 was 2261 kcal/day, and the median sodium intake was 647.8 mg/day. Daily intake of vegetables and fruits was 125 g and 35.6 g, respectively. As expected, high intragroup variation in the consumption of sugar-sweetened beverages, red and processed meat was observed (Table 2). The consumption of whole grains was relatively infrequent, with only 9.5% (n = 1920) of the participants reporting some intake.

In 2015, the median total energy intake was 2210.8 kcal/day, whilst sodium intake was 708 mg/day. The intake of fruits and vegetables was below 30 g/day for both food groups (Table 2). Only 2.4% (n = 363) of the children reported consumption of whole grains.

The mean AHEI score in 2005 was 46.3 (Table 3), with the highest average contribution coming from the moderation components, mainly trans-fatty acids (9.5 points), red and processed meat (7.1 points), and sugar-sweetened beverages (6.3 points). Whole grains, vegetables, and fruits had the lowest average score (0.3, 1.2, and 1.9 points, respectively).

In 2015, the mean AHEI score was 44.3 points (Table 3). On average, within the moderation components the trans-fatty acids showed the highest score (9.7 points), while the PUFAs were the component considered to be ideal with the highest mean contribution (9.1 points). The lowest average scores were found in whole grains (0.1 points), vegetables (0.9 points), and fruits (0.9 points).

Figure 1 illustrates the variations observed in diet quality across country Departments (provinces). AHEI score decreased in all 32 Colombian Departments in 2015 compared to 2005, with the largest proportional worsening being observed in Tolima (center), Santander (northeast), and Arauca (northeast), and the shortest proportional reduction in San Andres Islands (insular northwest), Amazonas (south), and La Guajira (North).

Adults

In 2005, the median total energy intake in adults was 2443.1 kcal/day, whilst the median intake of sodium was 624.6 mg/day. Consumption of fruits, vegetables, legumes, whole grains, SSB and juices, and alcohol is summarized in Table 2. PUFA and trans-fatty acids represented 18.9% and 0.35% of total daily energy intake, respectively.

In 2015, the median total energy intake was 2444.3 kcal/day, while sodium intake was 807.2 mg/day. The median consumption of fruits and vegetables was lower than in 2005 (Table 2). PUFA and trans-fatty acids represented 18.8% and 0.15% of total daily energy intake, respectively.

In 2005, the overall AHEI score was 49.0 points on average. Amongst healthy foods, the consumption of PUFAs had the highest average contribution to the final score (9.2 points), and whole grains represented the category with the lowest contribution (0.4 points). Within the moderation food groups, trans-fatty acids gave the highest mean contribution (9.5 points) and the alcoholic beverages the lowest (2.7 points).

AHEI score was lower in 2015 by 2.8 points in average when compared with 2005 data (Table 3). The highest contribution to the score was attributed to trans-fatty acids (9.7 points) and PUFA (9.1 points), while the lowest came from whole grains (0.2 points), fruits (1.0), and vegetables (1.1 points).

Diet quality by demographic and socioeconomic conditions

Amongst children, those aged 4–6 years old had the highest diet quality both in 2005 and 2015. In contrast, the oldest children (i.e., adolescents 11–17 years old) had the worst diet quality in both study periods. Amongst adults, the highest AHEI score was observed in those aged $>$ 60 years old and the lowest in the youngest group (i.e., 30 years old or less) (Table 3).

In children and adults, diet quality decreased as wealth index increased, a correlation that was observed in both study periods. Regardless of the survey year or age group studied, those living in rural areas had higher mean AHEI scores than those living in urban areas (Table 3).

Changes in diet quality between 2005 and 2015

A general reduction in diet quality between 2005 and 2015 was found in both children and adults (Table 3 and Figure 1). From its baseline value in 2005, the AHEI score decreased by 4.3% and 5.7% among children and adults, respectively. These observations were confirmed in the regression models where a mean decrease equivalent to 1.6 and 3.5 AHEI points was found among children and adults, respectively (Table 4).

The adjusted regression model showed that mean AHEI score decreased over the 10-year period. Children living in the northern Caribbean Region had the largest proportional impairment of diet quality (− 9.7%), while those

Table 1 Demographic and socioeconomic characteristics of Colombian participants included in the National Nutrition Surveys (ENSIN) 2005 and 2015. Colombia, 2005–2015

	Children			Adults		
	ENSIN 2005	ENSIN 2015	*p* value	ENSIN 2005	ENSIN 2015	*p* value
Sample size	20,122	15,304		13,849	11,141	
Sex % (n)						
Women	49.6 (9980)	49.8 (7627)		53.5 (7412)	59.0 (6582)	
Men	50.4 (10,142)	50.2 (7677)	0.003	46.5 (6437)	40.9 (4559)	0.018
Age mean ± SD	10.8 ± 3.6	11.0 ± 4.4	< 0.001	33.4 ± 13.2	37.6 ± 13.3	< 0.001
Wealth index mean ± SD	− 0.1 ± 1.0	− 1.6 ± 3.6	< 0.001	0.2 ± 0.9	− 0.9 ± 3.4	< 0.001
Area % (n)						
Urban	74.1 (14 916)	73.3 (11,220)		78.6 (10,886)	75.2 (8378)	
Rural	25.9 (5206)	26.7 (4084)	< 0.001	21.4 (2963)	24.8 (2763)	< 0.001
Geographic region % (n)						
Caribbean (Northern)	27.7 (5578)	18.5 (2844)		26.5 (3676)	18.6 (2844)	
Eastern	11.9 (2397)	17.5 (2680)		11.8 (1628)	17.5 (2680)	
Central-Andean	22.7 (4575)	30.3 (4642)		24.3 (3363)	30.3 (4642)	
Pacific (Western)	12.5 (2521)	12.7 (1955)		13.2 (1817)	12.8 (1955)	
South-eastern	25.1 (5051)	20.8 (3183)	0.051	24.3 (3365)	20.8 (3183)	0.006
Education (highest level achieved) % (n)						
None	1.3 (254)	0.1 (17)		0.7 (91)	0.1 (13)	
Pre-school	5.7 (1152)	6.7 (1032)		0.1 (7)	0.1 (16)	
Elementary	49.9 (10,042)	32.2 (4934)		30.8 (4267)	26.5 (2953)	
High school	33.5 (6735)	40.2 (6153)		46.6 (6450)	49.5 (5510)	
Technical/technological	0.1 (24)	0.1 (11)		5.8 (809)	10.4 (1155)	
University	0.2 (47)	–		10.4 (1441)	5.6 (623)	
Graduate (specialization. Master. Doctorate or higher)	0.0 (0)	–		0.9 (119)	1.6 (179)	
Unknown	9.3 (1868)	20.6 (3157)	< 0.001	4.8 (665)	6.2 (692)	< 0.001
Occupation % (n)						
Employed	3.9 (778)	2.5 (388)		57.7 (7985)	55.4 (6169)	
Unemployed	4.7 (944)	6.8 (1045)		29.8 (4133)	36.4 (4055)	
Student	34.8 (7009)	43.6 (6677)		9.1 (1259)	5.0 (553)	
Retired	NA (NA)	–		1.0 (132)	0.9 (104)	
Other/unknown	56.6 (11,391)	47.0 (7 194)	< 0.001	2.5 (340)	2.3 (260)	< 0.001

individuals belonging to the highest socioeconomic level had any improvement in their diet quality (Table 3).

Among adults, those without formal education (i.e., education received as a student in schools or similar organizations) showed the most severe decrease in AHEI score (− 15.3%). A decreasing trend of AHEI score with wealth index increasing was observed (Table 4). Participants who had achieved higher education (i.e., master, doctorate, or higher level) and those in retirement were the only two exceptions for population groups with improvement in their diet quality (Table 3).

The interaction of time on the associations between diet quality and demographic and socioeconomic variables is presented in Table 5. A statistically significant improvement in AHEI score among the most affluent economic groups was observed. Those living in rural areas also showed an increment in diet quality in reference to their urban peers.

The sensitivity analysis showed that the largest reductions in AHEI were due to the intake of unhealthy foods (i.e., SSB, red and processed meat, trans-fatty acids, and sodium). Also, the consumption of unhealthy foods was responsible for the largest proportional differences between

Table 2 Median and interquartile ranges (Q3–Q1) for daily dietary intake and total energy intake for the Colombian population according to the National Nutrition Survey (ENSIN) 2005 and 2015. Colombia, 2005–2015

Dietary items	Children			Adults		
	ENSIN 2005	ENSIN 2015	*p* value	ENSIN 2005	ENSIN 2015	*p* value
Total energy (kcal/day)	2261 (1439.1)	2210.8 (1570.8)	0.0027	2443.1 (1626.5)	2444.3 (1761.2)	0.6269
Vegetables (g/day)	125(239.5)	17.2(123.4)	0.0001	131.3 (249.5)	15.5 (135.1)	0.0001
Fruits (g/day)	35.6 (92)	25.9 (74.7)	0.0001	56.1 (119)	41.2 (105.7)	0.0001
Whole grains (g/day)	0 (0)	0 (0)	0.0001	0 (0)	0 (0)	0.0001
Nuts and legumes (g/day)	0 (103)	0 (25)	0.0001	0 (103)	0 (16.7)	0.0001
Sugar-sweetened beverages and fruit juices (ml/day)	0 (186)	205.6 (457.4)	0.0001	0 (206)	186.8 (459.1)	0.0001
Red meat (g/day)	30 (51)	27.7 (90.4)	0.0001	33 (63.8)	45.2 (118.3)	0.0001
Processed meat (g/day)	0 (0)	0 (18.4)	0.0001	0 (0)	0 (0)	0.0001
Omega 3 fatty acids (g/day)	0 (0)	456 (94.9)	0.0001	0 (0)	34.6 (103.3)	0.0001
Poly-unsaturated fatty acids (g/day)	9.7 (10.7)	46.3 (46.9)	0.0001	8.95 (10.2)	50.3 (50.4)	0.0001
Trans fat (mg/day)	1007.8 (1575.6)	469.4 (1226.6)	0.0001	969.3 (1614.1)	427.7 (1159.4)	0.0001
Sodium (mg/day)	647.8 (806.2)	708 (635.8)	0.0001	624.6 (772.5)	807.2 (754.6)	0.0001
Alcohol (g/day)	NA	NA	NA	0 (0)	0 (0)	0.0246

the youngest and the oldest adults (supplemental Tables 1 and 2).

Discussion

In this nationally representative study of the Colombian population, we found that the diet quality of children and adults decreased over ten years. A reduction in the consumption of foods considered to be healthy (i.e., fruits, vegetables and legumes), and an increase in the consumption of SSB, red meat and sodium were the main drivers of the worsening of diet.

The changes in dietary patterns i Colombia and in other middle-income countries have been influenced by the increase in availability of ultra-processed, hyper-caloric, inexpensive, and easy-to-prepare products (Baker and Friel 2016; Parra et al. 2018). Such shift in dietary patterns has been referred to as a nutrition transition and has been associated with the increasing rates of NCDs (e.g., obesity, type 2 diabetes mellitus and high blood pressure) (Popkin et al. 2012). Our findings suggest that diet quality decreased despite the steady economic growth of the country in the last two decades, and the implementation of several public policies to prevent obesity and improve healthy dietary habits (Alarcón Urrutia 2017).

Diet quality was negatively associated with socioeconomic status. This is a common consequence of economic growth in low- and middle-income countries (Mondini and Monteiro 1997; Wentzel-Viljoen et al. 2018), and partly explains the current stage of nutrition transition (i.e., receding famine and degenerative diseases) (Popkin 1999). Although a nutrition transition is a heterogeneous process, the changes observed in diet quality suggest that the Colombian population is adopting patterns of eating that are characterized by energy-dense and ultra-processed foods. The wealthiest groups showed the less severe impairment of diet quality between 2005 and 2015, which is compatible with behavioral changes toward healthier nutrition commonly found in the fifth stage of transition (Mayen et al. 2014; Popkin 1999).

Our results are in line with previous studies showing that the prevalence of obesity increased at higher rate among people from lower socioeconomic levels, despite the fact that the highest prevalence is still found in high-income communities across the Colombia (Kasper et al. 2014). A recent study of diet quality in eight Latin American countries (Argentina, Brazil, Chile, Colombia, Costa Rica, Ecuador, Peru, and Venezuela) based on data from two non-consecutive 24-h recall collected between 2014 and 2015, concluded that a more privileged socioeconomic status was associated with a better diet quality and higher dietary diversity. However, the specific results for the Colombian sample (n = 1230) showed a different behavior, with the lowest score in the middle socioeconomic level, and little differences observed between the highest and lowest levels. In contrast, the observations from Chile, a country with higher *per capita* income and a more advanced nutrition

Table 3 Alternative Healthy-Eating Index (AHEI) 2010 mean scores (± SD) in the Colombian population based on the National Nutrition Survey (ENSIN) 2005 and 2015. Colombia, 2005–2015

	Children				Adults			
	ENSIN 2005	ENSIN 2015	*p* value	Cohen's d	ENSIN 2005	ENSIN 2015	*p* value	Cohen's d
Total sample	46.3 ± 10.5	44.3 ± 11.0	< 0.001	0.19	49.0 ± 10.7	46.2 ± 11.5	< 0.001	0.24
Sex								
Women	46.2 ± 10.7	44.5 ± 10.9	< 0.001	0.17	49.4 ± 10.4	47.6 ± 11.5	< 0.001	0.13
Men	46.4 ± 10.4	44.1 ± 11.0	< 0.001	0.20	48.5 ± 11.1	44.4 ± 11.2	< 0.001	0.34
Age (years)								
4–6	47.1 ± 9.9	46.7 ± 10.5	0.2195	0.03	–	–	–	–
6–10	46.8 ± 10.3	46.4 ± 10.7	0.0383	0.04	–	–	–	–
11–17	45.8 ± 10.7	42.7 ± 10.9	< 0.001	0.28	–	–	–	–
18–20	–	–	–	–	47.9 ± 10.8	44.3 ± 11.5	< 0.001	0.32
21–30	–	–	–	–	48.1 ± 11.1	45.0 ± 11.5	< 0.001	0.26
31–40	–	–	–	–	49.4 ± 10.7	45.8 ± 11.4	< 0.001	0.32
41–50	–	–	–	–	49.8 ± 10.5	46.9 ± 11.1	< 0.001	0.26
51–60	–	–	–	–	51.2 ± 10.3	48.6 ± 11.5	< 0.001	0.23
61 or more	–	–	–	–	51.4 ± 9.7	48.9 ± 11.5	< 0.001	0.23
Wealth index								
Q1	51.8 ± 9.2	48.3 ± 10.6	< 0.001	0.30	54.0 ± 9.9	49.3 ± 10.7	< 0.001	0.45
Q2	47.9 ± 9.5	45.1 ± 10.8	< 0.001	0.28	50.5 ± 10.2	47.1 ± 11.3	< 0.001	0.31
Q3	45.9 ± 10.1	43.1 ± 11.0	< 0.001	0.22	48.6 ± 10.1	45.5 ± 11.6	< 0.001	0.28
Q4	43.6 ± 10.2	42.8 ± 10.7	< 0.001	0.04	47.5 ± 10.8	45.4 ± 11.7	< 0.001	0.18
Q5	41 ± 10.4	41.7 ± 10.6	0.005	− 0.12	46.1 ± 11.0	44.9 ± 11.6	< 0.001	0.10
Area								
Urban	45 ± 10.5	43.4 ± 44.2	< 0.001	0.12	48.1 ± 10.7	45.5 ± 11.4	< 0.001	0.23
Rural	50.3 ± 9.7	46.9 ± 47.2	< 0.001	0.28	52.4 ± 10.3	48.5 ± 11.4	< 0.001	0.35
Geographic region								
Caribbean (Northern)	46.5 ± 10.4	42 ± 10.7	< 0.001	0.38	49.1 ± 10.7	44.7 ± 11.0	< 0.001	0.40
Eastern	44.9 ± 10.5	43.1 ± 10.7	< 0.001	0.12	47.7 ± 11.2	45.2 ± 11.5	< 0.001	0.22
Central-Andean	45.3 ± 10.5	44.5 ± 11.0	< 0.001	0.04	48.2 ± 10.8	46.8 ± 11.6	< 0.001	0.12
Pacific (Western)	48.4 ± 10.7	46.7 ± 11.1	< 0.001	0.21	50.7 ± 10.3	48.8 ± 11.6	< 0.001	0.17
South-eastern	46.7 ± 10.4	45.8 ± 11.0	< 0.001	0.04	49.3 ± 10.7	46.6 ± 11.4	< 0.001	0.22
Education (highest level)								
None	49.7 ± 9.9	48.0 ± 9.7	0.503	− 0.32	52.2 ± 10.1	44.2 ± 10.9	0.009	0.78
Pre-school	47.8 ± 10.3	46.9 ± 10.5	0.041	0.08	50.9 ± 10.0	48.7 ± 11.1	0.654	− 0.68
Elementary	47.2 ± 10.5	45.3 ± 11.0	< 0.001	0.14	51.3 ± 10.1	48.1 ± 11.2	< 0.001	0.30
High school	44.5 ± 10.7	41.9 ± 10.9	< 0.001	0.20	48.2 ± 10.7	45.3 ± 11.6	< 0.001	0.25
Technical/technological	39.5 ± 9.8	42.2 ± 12.8	0.504	− 0.95	46.5 ± 11.0	44.9 ± 11.5	0.001	0.14
University	41.4 ± 12.0	NA	NA	NA	45.8 ± 11.0	45.1 ± 11.5	0.197	0.06
Graduate	NA	NA		NA	45.3 ± 11.7	45.7 ± 12.0	0.763	− 0.03
Unknown	47.5 ± 10.0	46.6 ± 10.6	0.002	− 0.57	49.7 ± 13.1	49.9 ± 10.8	0.896	− 0.01
Occupation								
Employed (or worker)	47.2 ± 10.8	43.8 ± 11.3	< 0.001	0.39	48.5 ± 11.1	44.9 ± 11.4	< 0.001	0.31
Unemployed	47.4 ± 10.5	43.8 ± 11.3	< 0.001	0.33	50.5 ± 10.0	48.6 ± 11.3	< 0.001	0.17
Student	45.3 ± 10.7	42.2 ± 10.9	< 0.001	0.29	46.6 ± 10.9	43.1 ± 11.3	< 0.001	0.31
Retired	–	–	–	–	49.6 ± 10.7	49.9 ± 11.6	0.843	− 0.02
Other/unknown	46.8 ± 10.4	43.1 ± 11.1	< 0.001	0.34	50.5 ± 9.8	46.6 ± 9.1	< 0.001	0.37

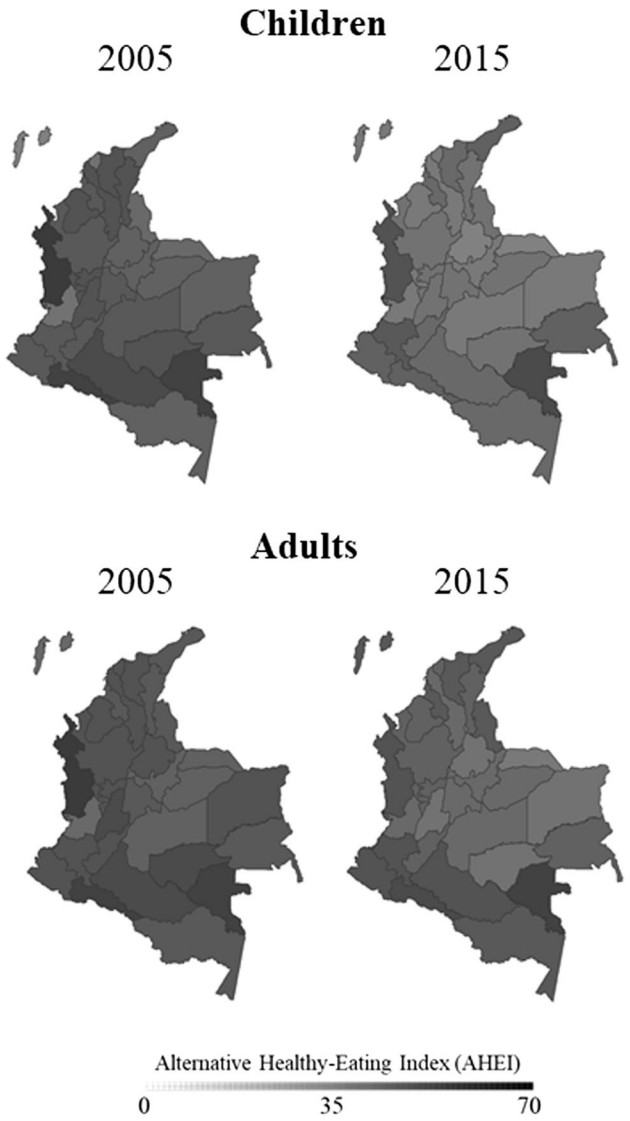

Fig. 1 Representation of changes in diet quality in Colombia between 2005 and 2015. Sub-national distribution of diet quality assessed through the Alternative Healthy-eating Index (AHEI) 2010. Representations are based on the National Nutrition Survey (ENSIN) data for 2005 and 2015. A worsening in diet quality for both children (upper panel) and adults (lower panel) across the country was observed over the inter-surveys period

transition showed that diet quality improved with wealthier status (Gómez et al. 2019). As poorest populations are more susceptible to the harmful effects of unhealthy nutrition (Albala et al. 2006), public attention should prioritize on the prevention of the spreading of obesogenic environments among low- and middle-income groups.

Our study also showed that adolescents (11–17 years old) and young adults (18–40 years old) had the worst diet quality. Comparing both study periods, diet quality had the greatest impairment in these age groups. Similar results have been found in population-based surveys from other developing countries (Brazil, and Iran) where diet quality was worst among young people, and it improved with age (Fernandes et al. 2018; Mello et al. 2018). The Latin American Study of Nutrition and Health (ELANS) found a slight improvement in diet quality associated with older age (Gómez et al. 2019). Such findings might be related to a higher frequency of social-eating pattern among adolescents and young adults, which increase the intake of food from restaurants and ready-to-eat products among these age groups (Cruwys et al. 2015; Haghighian Roudsari et al. 2017).

To date, most of the national nutrition policies in Colombia have been implemented to protect early childhood and school-age children, while the regulation on young adults nutrition is scarce and a minor focus of public attention (Alarcón Urrutia 2017). Our findings suggest that innovative strategies to increase healthy food preferences in the youth are needed.

When we examined the geographical distribution of diet quality across the country, we observed that, with few exceptions, individuals with the best diet reside in the departments with the lowest *per capita* gross domestic product (GDP) (e.g., Chocó and Vaupés). This interpretation supports the hypothesis that income level would be inversely correlated with diet quality in the Colombian population, but this association is changing. Similar trends linking diet quality and income were not observed when the economic growth in the 2005–2015 period was analyzed, using data from the National Department of Statistics (Departamento Administrativo Nacional de Estadística 2018). We consider that new studies analyzing the plausible effects of socioeconomic inequalities on nutrition-related health are warranted.

Participants living in urban environments had worse diet quality than those living in rural areas. This is probably unsurprising given that urbanization has been widely identified as a driving factor of nutrition transition, and is closely linked to population expansion and economic growth in low- and middle-income countries (Delisle et al. 2012; Popkin 1998). Differences in urban and rural dietary patterns are not consistent in lower income countries. In Benin, the highest consumption of fruits, vegetables and legumes have been found in rural communities (Delisle et al. 2012); meanwhile, in Kenya the highest intake of fruits and vegetables has been found in the urban population and among rural–urban migrants (Peters et al. 2019). The findings from other low- and middle income countries suggest that specific analyses on nutrition-related risks attributable to urbanization and rural migration would be helpful in South America.

To the best of our knowledge, this is the first study to examine diet quality in the Colombian population using two large cross-sectional samples from a nationally representative nutrition survey. Our study has several strengths.

Table 4 Linear regression model where the AHEI score was included as the dependent variable. Colombia, 2005–2015

	Children					Adults				
	Coefficient*	Coefficient	(SE)	[95% CI]	*p* value	Coefficient*	Coefficient	(SE)	[95% CI]	*p* value
Age range (in years)										
4–6	Ref	Ref	Ref	Ref	Ref	–	–	–	–	–
6–10	− 0.186	− 1.017	(0.339)	[− 1.68, − 0.34]	0.003	–	–	–	–	–
11–17	− 2.480	− 4.136	(0.302)	[− 4.73, − 3.54]	< 0.001	–	–	–	–	–
18–20	–	–	–	–	–	Ref	Ref	Ref	Ref	Ref
21–30	–	–	–	–	–	− 0.477	0.778	(0.463)	[− 0.14, 1.69]	0.095
31–40	–	–	–	–	–	0.619	1.946	(0.472)	[1.13, 2.75]	< 0.001
41–50	–	–	–	–	–	1.364	2.776	(0.545)	[1.70, 3.84]	< 0.001
51–60	–	–	–	–	–	2.641	4.068	(0.522)	[3.03, 5.10]	< 0.001
60 or more	–	–	–	–	–	2.894	4.208	(0.616)	[2.99, 5.42]	< 0.001
Sex										
Women	Ref	Ref	Ref	Ref	Ref	Ref	Ref	Ref	Ref	Ref
Men	− 0.323	− 0.626	(0.238)	[− 1.10, − 0.16]	0.009	− 1.773	− 3.191	(0.266)	[− 3.72, − 2.67]	< 0.001
Wealth index quintiles										
First	Ref	Ref	Ref	Ref	Ref	Ref	Ref	Ref	Ref	Ref
Second	− 3.676	− 1.605	(0.450)	[− 2.49, − 0.71]	< 0.001	− 2.850	− 1.775	(0.566)	[− 2.89, − 0.66]	0.002
Third	− 5.680	− 2.682	(0.660)	[− 3.98, − 1.38]	< 0.001	− 4.584	− 2.367	(0.645)	[− 3.64, − 1.10]	< 0.001
Fourth	− 7.112	− 3.378	(0.749)	[− 4.85, − 1.90]	< 0.001	− 5.295	− 3.846	(0.712)	[− 5.25, − 2.44]	< 0.001
Fifth	− 9.084	− 4.546	(0.799)	[− 6.12, − 2.97]	< 0.001	− 6.304	− 4.362	(0.754)	[− 5.85, − 2.88]	< 0.001
Area										
Urban	Ref	Ref	Ref	Ref	Ref	Ref	Ref	Ref	Ref	Ref
Rural	4.47	2.082	(0.624)	[0.85, 3.31]	0.001	3.582	1.032	(0.571)	[− 0.09, 2.16]	0.072
Geographic region										
Caribbean (Northern)	Ref	Ref	Ref	Ref	Ref	Ref	Ref	Ref	Ref	Ref
Eastern	− 1.025	0.094	(0.546)	[− 0.98, 1.17]	0.863	− 1.024	− 0.136	(0.504)	[− 1.13, 0.87]	0.787
Central-Andean	− 0.115	2.670	(0.511)	[1.66, 3.67]	< 0.001	0.183	1.577	(0.446)	[0.70, 2.46]	< 0.001
Pacific (Western)	2.712	4.097	(0.817)	[2.48, 5.71]	< 0.001	2.613	3.479	(0.643)	[2.21, 4.75]	< 0.001
Southeastern	1.366	3.913	(0.708)	[2.52, 5.30]	< 0.001	1.247	2.080	(0.801)	[0.50, 3.65]	0.010
Year										
2005	Ref	Ref	Ref	Ref	Ref	Ref	Ref	Ref	Ref	Ref
2015	− 2.049	− 1.621	(0.380)	[− 2.36, − 0.87]	< 0.001	− 2.727	− 2.588	(0.360)	[− 3.29, − 1.88]	< 0.001

Table 5 Assessment of the interactions between time (i.e., years of cross-sectional observations) and population variables. Colombia, 2005–2015

	Children					Adults				
	Coefficient[¥]	Coefficient	(SE)	[95% CI]	*p* value	Coefficient[¥]	Coefficient	(SE)	[95% CI]	*p* value
*Age ranges*year*										
6–10	− 0.039	− 0.402	(0.381)	[− 1.15, 0.34]	0.290	–	–	–	–	–
11–17	− 2.751	− 3.055	(0.351)	[− 3.74, − 2.37]	0.000	–	–	–	–	–
21–30	–	–	–	–	–	0.579	0.407	(0.460)	[− 0.49, 1.31]	0.375
31–40	–	–	–	–	–	0.064	− 0.029	(0.480)	[− 0.97, 0.91]	0.952
41–50	–	–	–	–	–	0.748	0.682	(0.497)	[− 0.29, 1.66]	0.170
51–60	–	–	–	–	–	0.980	0.751	(0.528)	[− 0.28, 1.79]	0.155
61 or more	–	–	–	–	–	1.079	0.597	(0.792)	[− 0.96, 2.15]	0.452
*Sex*year*										
Men	− 0.281	0.270	(0.217)	[− 0.16, 0.70]	0.214	− 2.273	− 2.288	(0.276)	[− 2.83, − 1.75]	0.000
*Wealth index quintiles*year*										
Second	0.624	0.772	(0.349)	[0.09, 1.46]	0.027	1.281	1.253	(0.480)	[0.31, 2.20]	0.009
Third	0.655	1.138	(0.384)	[0.39, 1.89]	0.003	1.576	1.924	(0.521)	[0.90, 2.95]	0.000
Fourth	2.531	2.989	(0.415)	[2.17, 3.80]	0.000	2.599	2.792	(0.549)	[1.71, 3.87]	0.000
Fifth	4.234	4.772	(0.433)	[3.92, 5.62]	0.000	3.459	3.542	(0.556)	[2.45, 4.63]	0.000
*Area*year*										
Rural	− 1.805	0.508	(0.337)	[− 0.15, 1.17]	0.132	− 1.285	0.246	(0.443)	[− 0.62, 1.12]	0.578
*Region*year*										
Eastern	2.604	1.728	(0.374)	[1.00, 2.46]	0.000	1.849	1.532	(0.457)	[0.64, 2.43]	0.001
Central-Andean	3.637	2.621	(0.323)	[1.99, 3.26]	0.000	2.968	2.117	(0.388)	[1.36, 2.88]	0.000
Pacific (Western)	2.789	1.517	(0.386)	[0.76, 2.28]	0.000	2.425	1.293	(0.472)	[0.37, 2.22]	0.006
Southeastern	3.531	2.219	(0.345)	[1.54, 2.90]	0.000	1.901	1.326	(0.437)	[0.47, 2.18]	0.002

The model is a linear regression adjusted by age, sex and socio-economic variables, in which the AHEI score is the dependent variable; the coefficients for the interaction terms between time and age ranges, sex, wealth index, living area, and geographic region are displayed. (The coefficients for the adjustment variables were omitted since they correspond to those represented in the Table 4)

AHEI Alternative Healthy-Eating Index, *SE* Standard error, *95% CI* 95% Confidence interval

[¥]Crude or unadjusted coefficient

Firstly, we describe the changes in the diet quality between 2005 and 2015, providing insight in the ongoing nutrition transition in Colombia. Secondly, both surveys used the same instrument to ascertain dietary intake, and food portions were derived with the use of illustrations to guide the participants.

We acknowledge that our study has some limitations. As we used two repeated cross-sectional surveys, the analyses do not allow interpretations of causal inferences; thus, the conclusions derived from this study are limited to describing changes in the AHEI score over a ten-year period and the main determinants of such variations. The use of a single 24-h recall questionnaire might not be representative of an individual's usual diet and is prone to recall bias and measurement error. In ENSIN 2015, there was no data on total energy and nutrient intakes. We therefore estimated nutrient content for the relevant food groups using data from the 2015 food composition table of Colombia. The same approach was used in both ENSIN surveys to harmonize the nutrient estimates. These methods can introduce bias and might have over- or under-estimated the final value of the AHEI score. Finally, the survey

questions used to ascertain education in children differed between 2005 and 2015, which might have led to misclassification of educational attainment level.

The worsening of diet quality could intensify the negative impact of the nutrition transition. This is particularly relevant in light of the epidemiological situation of other low–middle-income nations where the general adoption of unhealthy eating patterns was associated with an acceleration of the double burden of under- and over-nutrition (Wentzel-Viljoen et al. 2018).

In conclusion, the results from these repeated population-based cross-sectional surveys in Colombia suggest that diet quality worsened in 2015 compared to 10 years earlier, both in children and adults. The less affluent socioeconomic groups are rapidly adopting unhealthy dietary habits, whilst the wealthiest groups appear to be introducing behavioral changes toward healthy diets. Adolescents and young adults were identified as the population groups with the largest reduction in diet quality; therefore, the youth seems to be more vulnerable to the negative effects of nutrition transition in Colombia. Since the double burden of disease is already a nationwide threat for public health, efforts to promote healthy food preferences should be increased. Further studies focusing on the study of inequities over the nutrition transition are warranted.

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Authors' contributions GMG and VGL conceptualized the analysis plan; VGL had overall responsibility for the development of the manuscript, and supervised the data analyzes; GMG and RV analyzed the data, and MRD and VGL contributed to the interpretation of results; GMG wrote the first draft of the manuscript. All authors contributed and approved the final manuscript.

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Data availability Data described in the manuscript is available to the public upon request to the Ministry of Health of Colombia (http://www.ensin.gov.co/). Codebook and analytic code will be made available upon request to the corresponding author.

Compliance with ethical standards

Conflict of interest The authors declare that they have no conflicts of interests.

Ethical approval The PROFAMILIA Ethics Committee approved the ENSIN survey prior to data collection (Resolución 8430 de 1993; Ministerio de Salud de Colombia).

Informed consent All adult participants provided written informed consent, while children and adolescents provided an informed assent form, in accordance with the guidelines stated in the Declaration of Helsinki. The data for the current analyses are publicly available, and The Ministry of Health of Colombia authorized the use of the dataset for this secondary analysis.

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