# Relation between diet cost and Healthy Eating Index 2010 scores among adults in the United States 2007-2010

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## Abstract

**Background**—Food prices may be one reason for the growing socioeconomic disparities in diet quality.

**Objective**—To evaluate the association between diet costs and the Healthy Eating Index-2010 (HEI-2010).

**Methods**—Cross-sectional study based on 11,181 adults from the 2007-2010 National Health and Nutrition Examination Survey, analyzed in spring 2014. Diet cost was estimated by linking dietary data with a national food price database. The HEI-2010, a measure of adherence to the Dietary Guidelines, was the outcome. The population ratio method was used to estimate the average HEI-2010 scores by quintile of energy-adjusted diet cost. Additional analyses evaluated the association between cost and HEI-2010 components.

**Results**—There was a strong positive association between lower energy-adjusted diet costs and lower HEI-2010 scores. The association was stronger among women (p-interaction=0.003). Lower diet costs were associated with lower consumption of vegetables, fruit, whole grains, and seafood, and higher consumption of refined grains and solid fat, alcohol and added sugars.

**Conclusions**—Lower energy-adjusted diet costs were associated with lower-quality diets. Future efforts to improve the nutritional status of the US public should take food prices and diet costs into account.

## Keywords

diet/economics; diet quality; nutrition surveys; cross-sectional studies; nutrition policy; dietary guidelines

## Introduction

Food prices are a major determinant of food choice, especially for lower-income groups (Darmon and Drewnowski, 2008; Drewnowski and Specter, 2004; Lee et al., 2011; Rao et al., 2013). The strong relation between diet cost and dietary quality may be one factor contributing to the observed socioeconomic gradient in diets and health (Aggarwal et al., 2011; Monsivais et al., 2012). The fact that some groups, such as Mexican-Americans achieve higher quality diets at lower cost than do other groups (Monsivais et al., 2013) suggests that healthy eating patterns can be achieved at times without major increases in food expenditures.

In previous studies, higher scores on such dietary quality measures as the Healthy Eating Index-2005 (HEI 2005), the Alternative Healthy Eating Index (AHEI), the DASH (Dietary Approaches to Stopping Hypertension) dietary pattern and a Mediterranean pattern were all linked to higher diet costs at the individual level (Bernstein et al., 2010; Lopez et al., 2009; Monsivais et al., 2013; Rehm et al., 2011). The recently developed Healthy Eating Index-2010 (HEI- 2010) (Guenther et al., 2013; Guenther et al., 2014), a measure of adherence to the 2010 Dietary Guidelines for Americans, provides a new opportunity to update and expand this work on social disparities in diet quality and health.

The HEI-2010 score captures all dietary components rather than a selected list of nutrients/ food groups and also reflects the most up-to-date evidence on the components of a healthy diet. Along with the AHEI (Bernstein et al., 2010), it is the ideal measure for evaluating the cost of healthy eating in a representative sample of US adults. The present analyses represents the first assessment of the relation between diet cost and HEI-2010 components and total scores, based on the most current 2007-2008 and 2009-2010 National Health and Nutrition Examination Survey (NHANES 2007-10) and an updated USDA national food prices database, building upon prior work which documented a strong relationship between diet cost and the HEI-2005 (Rehm et al., 2011). Based on prior observations, we hypothesized that more costly diets would tend to have higher HEI-2010 scores.

## Methods

### Study population and dietary assessment

This cross-sectional study was based on data from participants ages 20y from the 2007-2008 and 2009-2010 cycles of NHANES. NHANES is a large nationally representative population-based study of risk factors, dietary status and health conducted continuously in the United States. The NHANES 24-h dietary recall utilized a multi-pass method, where respondents reported the types and amounts of all food and beverages consumed in the preceding 24-hours, from midnight to midnight (Centers for Disease Control and Prevention and National Center for Health Statistics). The NHANES database contained two dietary recalls for most participants. The first was completed in-person at the Mobile Examination Center with a trained interviewer. The second was completed over the telephone some days later and tends to result in lower estimated energy intakes than the in-person recall. Given the availability of methods to estimate the population average of the HEI-2010 score by population sub-group using the first recall alone (National Cancer Institute, 2014), the

second recall was not used in the present analysis. Of 12,153 adults (age 20y) participating in 2007-2010 NHANES, 11,181 participants completed a valid 24-hour dietary recall and were included in this analyses (see **Table 1**). The results are representative of the US adult population from 2007-2010.

### The National Food Prices Database

The USDA Center for Nutrition Policy and Promotion (CNPP) national food prices database, provided the cost per 100g of edible portion for all foods and beverages reported in the 2001-2002 and 2003-2004 NHANES, excluding alcoholic beverages and water (Carlson et al., 2008). As described previously, the prices were based on retail prices paid by members of the Nielsen Homescan Consumer Panel during the same period of 2003–2004 NHANES data collection and reflected the average prices paid by US households. In creating the database CNPP made the assumption that all foods and beverages were purchased at retail and prepared and eaten at home. Although food prices do not permit estimations of actual food expenditures, the merging of the CNPP food prices with the NHANES dietary intakes data permitted the estimation of the intrinsic monetary cost of different diets, in line with USDA goals. This database has been used in previous investigations of the association between diet cost and diet quality (Bernstein et al., 2010; Monsivais et al., 2013; Rehm et al., 2011).

Since no national food prices of this scale have been released for more recent NHANES cycles, we updated the CNPP database for inflation in a multi-step process described here. First, all foods from the 2007-2010 NHANES that did not have a 2003-2004 price were identified. For these foods, a 2003-2004 price was estimated based on the prices of similar foods. We then developed a protocol to adjust the 2003-2004 prices for inflation and price increases. Since food prices have not changed uniformly over time across foods (Christian and Rashad, 2009; Monsivais et al., 2010), adjustment factors specific to food groups were used to update the prices database.

The food categorization scheme used in analyses of sodium intake using NHANES data by the Centers for Disease Control was used to define food groups/categories (Centers for Disease Control and Prevention (CDC), 2012). This food group database included 104 food groupings (exclusive of human milk) and is available online. This database was merged with the USDA Quarterly Food At-Home Prices Database (QFAHPD), which includes quarterly prices for 54 food groups from 2004-2010 (United States Department of Agriculture and Economic Research Service). For example: from the USDA food group database's "milk, lowfat and nonfat" was linked with "low fat milk" from the QFAHPD. For some food groups there were multiple matches within the QFAHPD (e.g., for meats or produce). For example, for "apples" from the USDA food groups database we used the prices for "fresh/frozen fruit" and "canned fruit", but weighted them 0.915 and 0.085 respectively, based on the relative frequency of consumption of fresh/frozen apples (e.g., raw apples) and canned apples (e.g., apple sauce). Because the QFAHPD is based on a weighted sample we accounted for the survey weights so the food group specific adjustment factors represent the change in price at the national level. This approach also weighted the quarterly prices equally, not accounting for the seasonal availability of some items.

The monetary value of the diet was computed by multiplying gram amounts of foods consumed by each NHANES participant by the price per gram. These values were then summed for each participant as described in previous publications (Rehm et al., 2011). Because the monetary value of the diet was highly correlated with the amount of energy consumed (r = 0.76), the energy-adjusted diet cost was computed and expressed per 2000 kcal using the density method of energy adjustment to be consistent with the approach used in estimating the HEI-2010. For analyses the energy-adjusted diet cost variable was categorized into survey-weighted quintiles, such that each group corresponds to 20% of the US adult population. Quintiles were calculated for each survey cycle separately and then combined for primary analyses. Therefore the range of diet cost values for each quintile differs by survey cycle. The diet cost ranges within each quintile are described in the footnote to **Table 2**.

### The Healthy Eating Index-2010

The development and calculation of the HEI-2010 is described in detail elsewhere (Guenther et al., 2013; Guenther et al., 2014). The HEI 2010 adequacy scores (with higher scores reflecting higher consumption) were for total vegetables (5 points), greens and beans (5 points), total fruit (5 points), whole fruit (5 points), whole grains (10 points), dairy (10 points), total protein foods (5 points), seafood and plant proteins (5 points) and the ratio of polyunsaturated and monounsaturated fatty acids to saturated fatty acids (10 points). Moderation scores (higher scores indicating lower consumption) included refined grains (10 points), sodium (10 points) and energy from solid fat, alcohol and added sugars (SoFAAS) (20 points). Energy from SoFAAS is a summary measure of "empty calories". The HEI-2010 scores were adjusted for energy. Calculation of the HEI-2010 score used code and methods made available by the USDA (National Cancer Institute, 2014).

### Analysis approach

Descriptive analyses calculated mean HEI-2010 scores and diet cost estimates overall and by population sub-group. Population subgroups were defined based on gender, age group (20-29y, 30-44y, 45-64y, 65-74y and 75y), race/ethnicity (non-Hispanic white, non-Hispanic black, Mexican-American, other Hispanic and other/mixed race), family income-to-poverty ratio (<1.0, 1.0-1.99, 2.0-2.99, 3.0-3.99 and 4.0); and education (<high school, high school graduate/equivalent, some college and college graduate). Survey-weighted t-tests were used to evaluate whether mean HEI-2010 scores and diet costs varied by socio-demographic groups, with the following groups used as the reference category: age 45-64, women, non-Hispanic white, higher income individuals (income-to-poverty ratio 4.0) and those with a college education.

The primary analyses focused on the relation between diet cost quintiles and HEI-2010 scores. Because naïve analyses of a single 24-hour recall do not accurately reflect intake of episodically consumed food groups (e.g., whole grains and dark green vegetables) the population ratio method was used to estimate average HEI-2010 scores and 95% confidence intervals by energy-adjusted diet cost quintile (Freedman et al., 2008; Guenther et al., 2013). The statistical test for determining significant differences across diet cost quintiles was a *t*-test with unequal variances between the two extreme quintiles. Additional hypothesis testing

evaluated the difference of pairwise differences in HEI-2010 scores with the lower diet cost quintile as the reference group. The association between diet cost and HEI-2010 scores was evaluated by gender and by race/ethnicity, given prior evidence for differences in the effect of diet cost on diet quality by gender (Rehm et al., 2011) and presence of significant interactions in the association between diet cost and diet quality by gender (p-interaction=0.003) and race/ethnicity (p-interaction=0.039).

Secondary analyses evaluated the association between diet cost and HEI-2010 components. This analysis was done to see whether some components of a healthy diet were more or less sensitive to cost. The population ratio yields an unbiased estimate of the mean HEI-2010 levels for populations, though this method does not permit for covariate-adjustment, akin to adjustment for covariates in regression models. Sensitivity analyses examined whether the association between the naïve HEI-2010 score (estimated directly from the 24-hour recall data) and diet cost could be explained by socio-demographic covariates, such as age, gender, race/ethnicity or socioeconomic status. The results of this sensitivity analyses are presented in **Supplemental Figure 1** and **Supplemental Table 1**. The secondary analyses adjusting for covariates used a complete case approach, with the age, race/ethnicity and gender adjusted analyses including all respondents. The model with education (n=16 missing) and family income-to-poverty ratio (n=1,019 missing) included 91% of all subjects (n=10,151).

Use of publicly available NHANES data are considered exempt from the Human Subjects review per University of Washington policies. The population ratio HEI-2010 scores were estimated in SAS (SAS Institute; Cary, NC) using macros and code provided by the USDA (National Cancer Institute, 2014). Additional analyses used Stata 13.1 (StataCorp; College Station, TX). A two-sided α-level of 0.05 was used and all analyses accounted for the complex sample design of NHANES data.

## Results

### Diet cost and HEI-2010 by socio-demographic strata

The relation between diet cost and overall diet quality across population strata is shown in **Table 1**.

The mean HEI-2010 score among US adults was 55.9 (95% confidence interval [CI] 54.4, 57.3) out of a potential 100 points and the mean energy-adjusted diet cost was $5.79 (95% CI 5.69, 5.89). Both diet costs and HEI-2010 scores generally increased with age, though those age 75y had lower cost diets than those 65-74 years-old. Men had lower HEI-2010 scores than women (p<0.001). Mexican-American, other Hispanics and non-Hispanic black adults consumed lower-cost diets when compared to non-Hispanic white adults (p<0.001 for all). Compared to non-Hispanic whites, HEI-2010 scores for non-Hispanic black adults were significantly lower (p<0.001). Lower family income-to-poverty ratio and educational attainment were associated with lower diet cost and lower HEI-2010 scores (p<0.001).

### The relation between diet cost and HEI-2010

Among US adults, there was a significant and positive association between higher diet cost and higher HEI-2010 scores (see **Table 2**).

Persons in the highest-diet-cost quintile had HEI-2010 scores that were 22.4 points (95% CI 20.4, 24.5) higher than those consuming the lowest-cost diets. As expected, the association was stronger among women (p-interaction=0.003). The difference in HEI-2010 scores between highest and lowest quintiles of diet cost was 23.7 points (95% CI 21.8, 26.8) for women and 19.8 points (95% CI 16.7, 22.9) for men.

Sensitivity analyses evaluated whether the association between diet cost and HEI-2010 could be explained by lack of control for key confounders (e.g., age, gender, race/ethnicity). Sensitivity analyses evaluating the impact of covariates are presented in **Supplemental Table 1** and **Supplemental Figure 1**, showing that the association between diet cost and HEI-2010 remained highly statistically significant despite adjustment for key covariates (p-trend<0.001 in all cases). Higher diet costs were associated with significantly higher HEI-2010 scores in a linear fashion among all race/ethnicity groups as shown in **Figure 1** (p-trend<0.001 for all race/ethnicity groups). The association between extreme diet cost quintiles and HEI-2010 scores was attenuated by 14% upon adjustment for age, gender, race/ethnicity, education and family income-to-poverty ratio (see **Supplemental Figure 1**).

### The relation between diet cost and HEI-2010 components

As shown in **Table 3**, higher-cost diets were associated higher HEI-2010 component scores for total vegetables, greens and beans, total and whole fruit, whole grains, and seafood and plant proteins (p-trend<0.001 for all components). Higher cost diets were associated with lower consumption of SoFAAS and refined grains (p-trend<0.001 for both components).

HEI-2010 component scores for total protein foods and dairy were both cost neutral. The maximum score for total protein was achieved for all other diet cost quintiles. The ratio of monounsaturated and polyunsaturated fatty acids to saturated fatty acids was also cost neutral. The only dietary component where higher diet cost was associated with a less favorable HEI-2010 component score was sodium. **Supplemental Figures 2 and 3** provide the HEI-2010 component scores by diet cost quintile stratified by gender.

## Discussion

This is the first report, based on the new HEI-2010 and the most current NHANES dietary data (2007-2010), showing that lower energy-adjusted diet costs were associated with lower-quality diets . A significant association between cost and quality was observed for both men and women and for the entire US population. The difference in HEI-2010 scores comparing the highest/lowest cost quintiles (+22 points) was considerably larger than differences by age, income, education, or race/ethnicity (Ervin, 2008; Hiza et al., 2013). From these data, it would appear that the disparities in dietary quality among adults in the US are strongly determined by food prices and by diet costs.

This is the first study to evaluate the likely cost of complying with the 2010 Dietary Guidelines for Americans using updated food prices. The results complement prior findings that healthier diets generally cost more and less healthy diets generally cost less (Bernstein et al., 2010; Lopez et al., 2009; Monsivais et al., 2013; Rehm et al., 2011). The observed difference of HEI-2010 scores between the highest and lowest cost quintiles was 50.7%

(e.g., 66.6 vs. 44.2). Previously, the difference between the lowest/highest HEI 2005 quintiles was 25.6% (Rehm et al., 2011), whereas a comparison of medians from highest/ lowest AHEI quintiles showed a difference of approximately 36% (Bernstein et al., 2010). Both of these studies were based on the 2001-2002 USDA national food prices database.

The observed differences in the strength of the association between diet cost and diet quality can be attributed to a number of factors. First, there is evidence that increases in the cost of healthful foods from 2001 to 2010 may have outpaced the cost of less healthful foods (Christian and Rashad, 2009; Monsivais et al., 2010). However, the estimated diet costs based on 2003-2004 prices and on 2007-2010 prices were highly correlated (r=0.99), suggesting the relative ranking of individuals based on diet costs would be generally unchanged. Changes in the underlying components of different diet quality scores may provide a better explanation. It is important to note that some, but not all components of the HEI-2010 score were associated with diet cost. However, the newer HEI components appear to have become more sensitive to cost. Whereas the HEI-2005 components included total grains (largely relatively low-cost refined grains) as a component to encourage, the HEI-2010 included refined grains as a food group to be consumed in moderation, which further strengthened the association between diet cost and HEI-2010 score. Whereas there was no relation between total protein and diet cost here or in previous analyses of HEI-2005, the inclusion of seafood and plant protein, which is positively associated with diet cost, in the new HEI-2010, virtually insures that higher-scoring diets will be more costly. The bottom line is that the presence and strength of association between diet cost and diet quality depends largely on the components of the diet quality metric. While the HEI-2010 may better reflect current understandings of the components of a healthful diet, it is not surprising that this more sensitive diet quality score was also more sensitive to diet cost.

However, diet costs are not positively associated with more healthful diets. Notably, those consuming higher-cost diets consumed considerably more sodium than those consuming lower-cost diets, consistent with prior NHANES-based diet cost studies (Drewnowski et al., 2015). The reasons for this observation merit further study, as sodium is currently a nutrient of much public health concern. The most important sources of sodium in the US include processed chicken and beef dishes, pizza, and also yeast breads, processed meat, and pasta dishes (Drewnowski and Rehm, 2013). While yeast breads are quite inexpensive, mixed meat dishes, pizza and processed meat are relatively costly items. In addition, it is important to note, that even those consuming the most costly diets still had diets that were, on average, sub optimal. Given that the maximum HEI score is 100, the observed means of 64.0 and 68.3 in the highest diet cost quintiles for men and women respectively, suggest that there is still much improvement to be made, among all strata of diet cost.

Whether high-quality diets can be obtained at low cost, subject to the adoption of different eating habits (e.g., widespread replacement of refined grains with whole grains, or replacements in meat foods with plant foods) by the US public is a compelling notion, best addressed by diet optimization modeling or linear programming, which can generate high-quality food patterns, subject to different nutritional, consumption and economic constraints (Maillot and Drewnowski, 2011; Maillot et al., 2008). Some of those patterns may already exist in the US population, given that a range of diet quality measures can be obtained at any

given level of diet cost. Identifying "positive deviants", or individuals or groups who consume high quality diets at low cost, is a promising avenue for future research. Mexican Americans and other Hispanics, as shown in **Figure 1** and prior studies, may be one such group (Aggarwal et al., 2014; Monsivais et al., 2013).

### Methodological Considerations and Limitations

This study had a number of limitations. First, the use of a food price database to estimate diet costs assumes a constant price for all foods/beverages and that all items were purchased at stores. An additional limitation is the absence of geographic specificity of food prices and diet costs. Variation may occur at the regional level (i.e., differences in prices between regions) or local level (i.e., difference in food prices between types or location of retailers within a city or region) (United States Department of Agriculture and Economic Research Service). In addition, the dietary data were based on a 24-hour recall, which may result in systematic under-reporting of foods thought to be less healthful (Lafay et al., 2000), particularly among heavier or obese individuals (Heitmann and Lissner, 1995; Subar et al., 2003). Such under-reporting would tend to obscure any association between diet cost and HEI-2010. Despite these limitations, we observed a profound difference in diet quality based on the HEI-2010 score between lower cost and higher cost diets.

### Conclusion

Attaching national prices to NHANES dietary intakes data allows for the study of diet quality in relation to cost in a nationally-representative sample of adults. There was a strong association between energy-adjusted diet cost and HEI-2010 scores, one that was not explained by race/ethnicity or measures of socioeconomic status. Given individual variation, future studies can identify those groups that have high-quality diets at unexpectedly low cost. Further studies along these lines are required to determine how to best implement and communicate the 2015 Dietary Guidelines to diverse population groups, whose food choices may be limited by economic constraints.

## Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

## Acknowledgements

## Abbreviations

**HEI-2010**      Healthy Eating Index-2010

| NHANES | National Health and Nutrition Examination Survey |
|--------|--------------------------------------------------|
| **USDA** | United States Department of Agriculture |
| **SoFAAS** | Solid fat, Alcohol and Added Sugars |
| **HEI 2005** | Healthy Eating Index-2005 |
| **AHEI** | Alternative Healthy Eating Index |
| **DASH** | Dietary Approaches to Stopping Hypertension |
| **CNPP** | Center for Nutrition Policy and Promotion |
| **QFAHPD** | Quarterly Food At-Home Prices Database |

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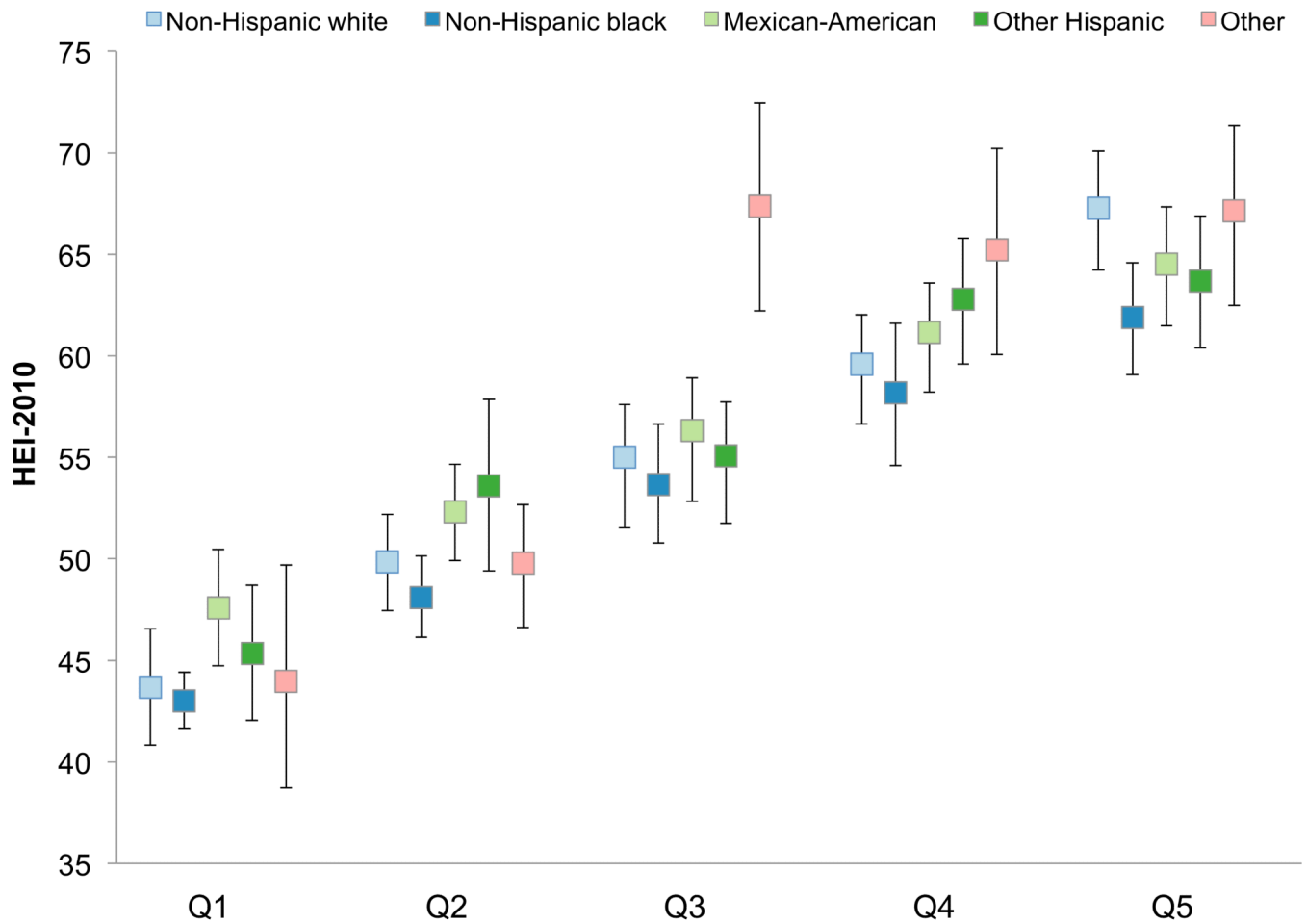
**Figure 1.**

Mean HEI-2010[a] values by energy-adjusted diet cost quintiles[b] and race/ethnicity[c] among adults (age 20) in NHANES 2007-2010

[a] HEI-2010 was estimated using population ratio method.

[b] Q1<$3.98 (2007-2008) & <$4.21 (2009-2010); Q2 $3.98-4.75 (2007-2008) & $4.21-5.03 (2009-2010); Q3 $4.76-5.59 (2007-2008) & $5.04-6.02 (2009-2010); Q4 $5.60-6.91 (2007-2008) & $6.03-7.58 (2009-2010); Q5 $6.92 (2007-2008) & $7.58 (2009-2010).

[c] The association between diet cost and HEI-2010 scores varied by race/ethnicity, p-interaction=0.0039.

**Table 1**

Population characteristics and average Healthy Eating Index-2010 (HEI-2010) values among adults (age 20) in NHANES 2007-2010

| | n | Weighted proportion (%) | $/2000 kcal (95% CI) | HEI-2010 (95% CI)[a] |
|---|---|---|---|---|
| Total | 11,181 | - | 5.79 (5.69, 5.89) | 55.9 (54.4, 57.3) |
| Age group | | | | |
| 20-29 | 1,792 | 19.3 | 5.40 (5.24, 5.56)*** | 48.8 (47.2, 50.5)*** |
| 30-44 | 2,841 | 27.6 | 5.77 (5.63, 5.92)* | 53.8 (51.6, 56.0)*** |
| 45-64 [ref] | 3,773 | 36.1 | 5.99 (5.85, 6.13) | 58.1 (56.3, 59.9) |
| 65-74 | 1,489 | 9.5 | 5.93 (5.76, 6.11) | 63.5 (61.7, 65.2)*** |
| 75 | 1,286 | 7.5 | 5.77 (5.58, 5.95)* | 63.3 (61.3, 65.1)*** |
| Gender | | | | |
| Female [ref] | 5,731 | 52.4 | 5.86 (5.75, 5.97) | 58.8 (57.2, 60.4) |
| Male | 5,450 | 47.7 | 5.72 (5.62, 5.83)** | 53.5 (52.1, 55.0)*** |
| Race/ethnicity | | | | |
| Mexican-American | 1,992 | 8.4 | 5.27 (5.13, 5.42)*** | 55.8 (54.3, 57.2) |
| Other Hispanic | 1,180 | 5.0 | 5.53 (5.38, 5.67)*** | 55.8 (54.5, 57.2) |
| Non-Hispanic white [ref] | 5,333 | 69.4 | 5.94 (5.81, 6.07) | 56.2 (54.4, 58.1) |
| Non-Hispanic black | 2,161 | 11.3 | 5.27 (5.15, 5.40)*** | 51.0 (49.8, 52.2)*** |
| Other/mixed race | 513 | 5.8 | 6.04 (5.73, 6.35) | 60.7 (58.5, 63.0)*** |
| Family poverty-to-income ratio[b] | | | | |
| <1.0 | 2,172 | 15.0 | 5.42 (5.26, 5.58)*** | 51.0 (49.2, 52.7)*** |
| 1.0-1.99 | 2,798 | 20.7 | 5.45 (5.32, 5.59)*** | 53.7 (51.5, 55.9)*** |
| 2.0-2.99 | 1,583 | 14.8 | 5.59 (5.41, 5.78)*** | 54.5 (52.2, 56.9)*** |
| 3.0-3.99 | 1,078 | 12.6 | 5.76 (5.53, 5.99)*** | 53.8 (51.6, 56.1)*** |
| 4.00 [ref] | 2,531 | 37.0 | 6.24 (6.08, 6.39) | 59.6 (57.8, 61.2) |
| Education (age 25)[b] | | | | |
| <High school | 3,299 | 19.4 | 5.42 (5.26, 5.58)*** | 52.2 (50.5, 54.0)*** |
| High school/equivalent | 2,656 | 24.1 | 5.56 (5.44, 5.68)*** | 51.8 (50.1, 53.7)*** |
| Some college | 3,022 | 30.3 | 5.79 (5.66, 5.91)*** | 56.0 (54.6, 57.4)*** |
| College graduate [ref] | 2,187 | 26.1 | 6.30 (6.18, 6.42) | 63.2 (61.7, 64.7) |

Significance of pairwise comparisons are indicated by asterisk as follows:

The reference was the lowest diet cost quintile.

[a] Mean HEI-2010 estimated using the population ratio method

[b] values may not add to some due to missing data (1,019 for poverty and 17 for education among those age 25)

* 0.05 > p-value > 0.01;

**

0.01 > p-value > 0.001;

***

p-value < 0.001.

**Table 2**

Mean HEI-2010[a] by energy-adjusted diet cost quintile among adults (age 20), overall and by gender[b] in NHANES 2007-2010

| | Overall (n=11,181) | Men (n=5,450) | Women (n=5,731) |
|---|---|---|---|
| | Mean (95% CI) | Mean (95% CI) | Mean (95% CI) |
| Cost per 2,000 kcal[c] | | | |
| Q1 (n=2,545) [ref] | 44.2 (42.7, 45.7) | 44.2 (42.4, 46.0) | 44.0 (42.1, 45.9) |
| Q2 (n=2,348) | 50.1 (48.7, 51.5)*** | 48.2 (46.3, 50.2)** | 52.7 (50.9, 54.6)*** |
| Q3 (n=2,231) | 55.8 (54.1, 57.6)*** | 54.0 (51.6, 56.4)*** | 58.2 (56.4, 59.8)*** |
| Q4 (n=2,073) | 60.2 (58.2, 62.1)*** | 57.0 (54.8, 59.1)*** | 63.6 (60.6, 66.5)*** |
| Q5 (n=1,984) | 66.6 (65.3, 67.9)*** | 64.0 (61.5, 66.5)*** | 68.3 (66.7, 69.9)*** |
| p-trend | <0.001 | <0.001 | <0.001 |

CI is confidence interval

Significance of pairwise comparisons are indicated by asterisk as follows:

* 0.05 > p-value > 0.01;

The reference was the lowest diet cost quintile.

[a] HEI-2010 estimated using the population ratio method

[b] The association between diet cost and HEI-2010 scores varied by gender, p-interaction=0.003

[c] Q1<$3.98 (2007-2008) & <$4.21 (2009-2010); Q2 $3.98-4.75 (2007-2008) & $4.21-5.03 (2009-2010); Q3 $4.76-5.59 (2007-2008) & $5.04-6.02 (2009-2010); Q4 $5.60-6.91 (2007-2008) & $6.03-7.58 (2009-2010); Q5 $6.92 (2007-2008) & $7.58 (2009-2010)

** 0.01 > p-value > 0.001;

*** p-value < 0.001.

**Table 3**

Estimated mean HEI-2010 components (and 95% CI) by survey-weighted energy-adjusted diet cost quintiles among adults (age ≥ 20) in NHANES 2007–2010

| HEI-2010 component | Diet cost ($/2000 kcal) quintile[a] | | | | | |
| | Q1 (n=2,545) | Q2 (n=2,348) | Q3 (n=2,231) | Q4 (n=2,073) | Q5 (n=1,984) | p-trend |
|---|---|---|---|---|---|---|
| Total vegetables [5] | 2.4 (2.3, 2.6) | 3.1 (3.0, 3.3) | 3.6 (3.4, 3.8) | 4.1 (3.9, 4.3) | 4.9 (4.7, 5.0) | <0.001 |
| Greens and beans [5] | 0.4 (0.3, 0.8) | 1.9 (1.6, 2.2) | 2.3 (2.1, 2.5) | 2.8 (2.4, 3.1) | 4.7 (4.1, 5.0) | <0.001 |
| Total fruit [5] | 1.9 (1.7, 2.1) | 2.8 (2.5, 3.0) | 3.4 (3.1, 3.7) | 3.7 (3.4, 4.0) | 4.3 (3.9, 4.8) | <0.001 |
| Whole fruit [5] | 2.0 (1.7, 2.2) | 3.3 (3.0, 3.6) | 4.5 (4.2, 4.9) | 5.0 (5.0, 5.0) | 5.0 (5.0, 5.0) | <0.001 |
| Whole grains [10] | 1.9 (1.7, 2.1) | 2.0 (1.8, 2.2) | 2.4 (2.2, 2.6) | 2.6 (2.3, 2.8) | 2.7 (2.5, 3.0) | <0.001 |
| Dairy [10] | 5.1 (4.8, 5.4) | 5.9 (5.5, 6.2) | 5.9 (5.6, 6.2) | 5.8 (5.4, 6.1) | 5.2 (4.8, 5.6) | 0.61 |
| Total protein foods [5] | 4.9 (4.7, 5.0) | 5.0 (5.0, 5.0) | 5.0 (5.0, 5.0) | 5.0 (5.0, 5.0) | 5.0 (5.0, 5.0) | 0.32 |
| Seafood and plant proteins [5] | 3.9 (3.5, 4.3) | 2.9 (2.5, 3.2) | 3.5 (3.1, 3.8) | 4.3 (3.8, 4.8) | 5.0 (5.0, 5.0) | <0.001 |
| Fatty acid ratio [10] | 4.5 (4.2, 4.8) | 4.4 (4.1, 4.7) | 4.0 (3.7, 4.3) | 4.2 (3.9, 4.6) | 4.8 (4.4, 5.2) | 0.22 |
| Sodium [10][b] | 5.3 (5.1, 5.6) | 4.0 (3.7, 4.3) | 3.8 (3.5, 4.1) | 3.3 (3.0, 3.6) | 2.7 (2.2, 3.2) | <0.001 |
| Refined grains [10][b] | 4.4 (4.1, 4.8) | 5.2 (5.0, 5.5) | 5.9 (5.5, 6.2) | 6.8 (6.5, 7.1) | 8.7 (8.4, 9.0) | <0.001 |
| Energy from SOFAAS [20][b] | 7.4 (6.7, 8.1) | 9.7 (9.1, 10.3) | 11.6 (11.1, 12.1) | 12.6 (12, 13.2) | 13.5 (13, 14.1) | <0.001 |

CI is confidence interval; SOFAAS are energy from solid fat, alcohol and added sugars; maximum score for each HEI-2010 component is provided in [brackets]

[a] Q1<$3.98 (2007-2008) & <$4.21 (2009-2010); Q2 $3.98-4.75 (2007-2008) & $4.21-5.03 (2009-2010); Q3 $4.76-5.59 (2007-2008) & $5.04-6.02 (2009-2010); Q4 $5.60-6.91 (2007-2008) & $6.03-7.58 (2009-2010); Q5 ≥$6.92 (2007-2008) & ≥$7.58 (2009-2010)

[b] these three dietary constituents to consume in moderation are reverse coded so that higher intakes are related to lower scores and lower intakes are related to higher scores.