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Small increments in diet cost can improve compliance with the Dietary Guidelines for Americans

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1. Introduction

Higher-quality diets are reported to lead to better health outcomes, but have also been associated with higher per calorie diet costs[1–10]. In particular, adherence to the Dietary Guidelines for Americans has been associated with higher estimated food expenditures.[11–13] Conversely, families with lower incomes are often forced to stretch their food budgets leading to the purchase of more cost effective options, which are often lower in nutrient quality.[5,14] The lack of affordable nutrition may be one reason why lower socio-economic groups do not adhere to dietary guidelines [15,16] and have higher rates of obesity, diabetes and other diet-related non-communicable diseases.

Non-compliance with the dietary guidelines, may be explained, at least in part, by the lower cost of energy-dense refined grains, added sugars, and fats.[2,16] Such palatable, energy-dense

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foods have been associated with over-eating in clinical and in laboratory studies.[17] Taste, cost, and convenience along with health and variety are among the recognized drivers of food choice.[18–22] Socio-demographic variables such as age, gender, race/ethnicity, and education also play a role. [14,23,24]

The monetary cost of adhering to the dietary guidelines needs to be explored in detailed analyses of diet quality in relation to food spending. There are several ways to assess per capita food expenditures and individual-level diet costs. Among measures of household food spending are self-reported food expenditures,[25–27] sometimes backed with food purchase receipts.[11,28,29] Studies have also estimated household food purchases using sales data from supermarkets and grocery stores.[30–33]

Joining dietary records with retail food prices to estimate diet costs at the individual level has become the preferred technique in nutritional epidemiology.[2,3,7,8,10,4] In effect, the monetary price of a food item, expressed per 100g, edible portion, is treated as a nutrient vector.[34] The total cost of a given diet is calculated in a manner that is exactly analogous to the calculations of the diet's content of vitamins or minerals. The method of joining dietary intakes with retail food prices has been used to calculate diet costs in the US[13] and in other countries – Malaysia, Japan, Spain, UK, and France.[6,31,35–37] The same method is used by the USDA to calculate food assistance benefits.[34]

Few studies have been able to compare self-reported per capita food expenditures with estimated individual-level diet costs in relation to diet quality across socio-demographic groups in the US. This study compared two measures of food spending (self-reported food expenditures and Food Frequency Questionnaire (FFQ)-estimated diet costs) in relation to Healthy Eating Index 2015 (HEI-2015) scores, a measure of compliance with the US 2015–2020 Dietary Guidelines for Americans (DGA). To our knowledge, this study is the first to examine the shape of the cost-quality curve to specifically determine the point at which a change in diet cost would be associated with the greatest increase in HEI-2015.

2. Methods

2.1 Sampling and recruitment

2.1 Study population—The Seattle Obesity Study (SOS) III was a two-year longitudinal study conducted in King, Pierce, and Yakima counties in WA State. Eligible participants were adults aged 21–59 y, not pregnant or breastfeeding, with no issues impacting mobility, and primary food shoppers of their household. The three counties differed in socio-demographic composition. Median incomes were $71,811 in King, $58,204 in Pierce, and $43,506 in Yakima.[38] Percent Hispanic ethnicity was 7.5% in King, 7.2% in Pierce and 37.5% in Yakima.[38] Participation in the Supplemental Nutrition Assistance Program (SNAP) was higher in Yakima as compared to King or Pierce.[39]

Study sites were University of Washington (King), MultiCare Institute for Research and Innovation (Pierce), and the Center for Community Health Promotion——a satellite office of the Fred Hutchinson Cancer Research Center (FHCRC)—(Yakima). Address-based sampling schemes tailored to each site were employed to achieve geographic and socioeconomic representation. To address challenges with traditional randomized telephone-based recruitment methods among hard-to-reach populations, community outreach was also employed at each site.

As with past SOS studies, the King County address-based sampling scheme used 3 residential property values strata ($199K; $200–299K; and $300K+).[40] Potential participants were sent pre-notification letters and then contacted by phone to screen for eligibility. Participants were also recruited from lower-income neighborhoods through community outreach to increase representation of low-income groups. The sample size for King County at baseline was 356. The Pierce County sampling scheme was a random ZCTA-based sample of MultiCare Health System members, sampling by census-level incomes (3 categories) and distance to MultiCare (≤5 miles or > 5 miles). Additional participants were recruited through community outreach. The Pierce County sample at baseline was 167. The Yakima County sampling frame included randomly selected individuals who participated in previous FHRC studies.[41,42] Pre-notification letters, followed by recruitment phone calls in both English and Spanish, were employed, as well as participants recruited via community outreach. No stratification by property values or income was used for the Yakima sampling frame since most individuals in the sampling frame had lower income. The sample size in Yakima at baseline was 349.

The final baseline sample for SOS III was 872; however, not all sociodemographic and dietary variables were available for all participants. The sample over-represented women but was otherwise broadly consistent with the socio-demographic composition of each county.[38,43]

Upon determining eligibility and receiving verbal consent to join the study, participants were invited to complete the first in-person visit at local study sites within each county. Written consent was provided in the in-person visit before completing the study protocols. Data collection was conducted in English and Spanish (in Yakima only). Spanish data collection was conducted by trained bilingual and bicultural staff members. Compensation was provided for completion of the first in-person visit. Recruitment and baseline data collection occurred from July 2016 to May 2017. All study protocols received the necessary approvals by the institutional IRBs at the respective sites.

2.2 Health behaviors survey

Self-reported data on socio-demographics, food shopping, and other behaviors were collected via a computer-assisted survey. Survey questions were adapted from the SOS I and II, the Behavioral Risk Factor Surveillance System and the National Health and Nutrition Examination Surveys (NHANES).[40,44,45] Socio-demographic variables assessed were age, gender, race/ethnicity, education, marital status, and food assistance use (food banks, the Special Supplemental Nutrition Program for Women, Infants, and Children (WIC), the Supplemental Nutrition Assistance Program (SNAP)). In SOS III, race and ethnicity were captured using NHANES questions.[44] For cultural sensitivity, “Hispanic” was added as a race, based on the site PI’s feedback that Hispanic participants in Yakima self-identified as Hispanic as both a race and ethnicity. Race/ethnicity were grouped into three categories for analyses: non-Hispanic White, Hispanic, and others (i.e. African American, Asian, American Indian or Alaska Native, Native Hawaiian or other Pacific Islander, or other).

Participants self-reported the name and location of their primary food store, which were categorized by cost using a coding scheme based on the method developed in SOS II.[20] In SOS II, market basket prices were collected for 13 food stores reported by participants. Prices were collected in-person or online. Cluster analysis was used to categorize stores into three categories based on store prices; low, medium, and high-cost stores. In SOS III, the same categories were used. Examples of high-cost stores included Puget Consumer Co-op (PCC), QFC, and Whole Foods. Medium-cost stores included Costco, Fred Meyer, Safeway. Examples of low-cost stores included Albertson's, Grocery Outlet, Walmart, and WinCo foods.

Participants also reported their monthly at-home household food expenditures based on NHANES questions,[44] defined as food purchased to be prepared at home, as well as their monthly away from home expenditures, defined as purchases on food that was prepared outside the home (i.e. restaurants, cafeterias, etc.). Monthly at-home and away from home expenditures were summed to create a monthly total food expenditures variable. Total food expenditures were then divided by household size to create monthly total food expenditures per capita.

2.3 Food frequency questionnaire and HEI-2015 scores

Dietary data was collected using the Fred Hutchinson Cancer Research Center (FHCRC) FFQ, a validated data collection tool for dietary intake assessment, available to participants in both English and Spanish. [46] On the FFQ, participants reported their average consumption of >100 foods during the past year.

FFQ data were used to calculate HEI-2015 scores, a diet quality measure of compliance with the 2015 DGA.[46–48] The HEI score is a 100-point scale, based on intakes of food groups to encourage: fruits (10 points), vegetables (10), grains (10), dairy (10), proteins (10), and fats (10) and foods to limit: refined grains (10), sodium (10), added sugars (10) and saturated fats (10). The USDA suggests interpreting the HEI scores on a graded scale, where a score of 100 represents the highest quality diet, a score of 99–90 represents an "A," 80–89 a "B", etc. [47] According to 2013–14 NHANES data, Adult Americans averaged an HEI score of 59, which would receive an F on the graded scale, representing diets with room for improvement.[49] Component food items from the FFQ were linked to food items from the MyPyramid Equivalents Database (MPED) in order to estimate the food group equivalents for each line item on the FFQ.[50] These food group equivalents along with a few items outputted by Nutrition Data System for Research software (developed by the University of Minnesota)[51] were used to calculate HEI-2015 and its components.

2.4 Method to estimate monthly diet costs

Market basket data were collected in-person and compared to web prices in Safeway stores in the three counties (King, Pierce, Yakima) using standard data collection protocols.[30] The lowest price for each component food in the FHCRC FFQ was collected in the three counties. Diet costs for each participant were calculated using the county-specific market basket prices, which were adjusted for food waste using the standard USDA reference to compute costs per 100 g edible portion.[52] The costs for each food reported were summed for each individual to create the total daily cost of their diet, with the exception of non-caloric beverages (i.e. water, unsweetened tea, unsweetened coffee). This total diet cost per day was then divided by calories and multiplied by 2,000 to create estimated daily diet cost per 2,000 kcal, as a way to denote the money spent on food if consuming 2,000 kcal per day, the FDA's reference value for daily caloric intake.[53] Daily diet cost was then multiplied by 30 to create the monthly diet cost variable.

2.4 Residential property values

The residential property value metric at the tax parcel level was developed using King, Pierce, and Yakima County 2016 tax assessor records, as has been used in previous.[40,54,55] If a parcel had multiple units, the mean value per unit was applied. Thus, property values were split into tertiles to be used for as a proxy for income (tertile 1: <129,401, tertile 2: 129,700–293,500, tertile 3: 295,000 −1,492,000). In past studies, residential property values were highly correlated with income and wealth.[56]

2.5 Statistical analyses

Only baseline data were used. The following outliers greater than 3 SD above the mean were removed: n=14 for total food expenditures and n=5 for estimated diet cost derived from the FFQ. Similarly, implausible values for FFQ intake data were removed (n=11 for greater than 5000 kcal/day and n=3 for less than 500kcal/day). After excluding participants with missing data for socio-demographics (n=40) or property values (n=31), the analytical sample was 768.

First, we characterized the socio-demographic distribution along with primary food store category of the study population. Mean and SD's of self-reported monthly total food expenditures per capita (food expenditures) and estimated monthly diet cost per 2,000 kcal (diet cost) were compared across each socio-demographic variable. Univariate linear regressions were conducted to test for unadjusted differences in mean food expenditures and diet costs across population subgroups.

Next, the relations between food expenditures, diet costs, and the HEI-2015 diet quality score were tested using a series of linear regressions. Food expenditures and diet cost were divided by 100 to standardize the regression models to estimate the mean HEI per $100 increase in monthly spending. Univariate regressions testing the unadjusted associations were followed by separate multiple linear regression models, controlling for age (21-<40y, 40–50y, >50y), gender, education (< High school or less, Some college or technical school, College graduate or more), race/ethnicity (non-Hispanic White, Hispanic, other), marital status (married, unmarried), use of food assistance (food banks, WIC, and/or SNAP vs. no food assistance use), property value tertiles, and county (King, Pierce, Yakima). Multiple curvilinear regression models were conducted to test the significance of the quadratic relationship of food expenditures and diet costs with HEI-2015, controlling for the same set of covariates. Scatterplots with quadratic regression lines were created to visualize the curvilinear relationship between the two measures of food spending and HEI-2015.

All regression models were conducted with robust standard errors through Generalized Linear Estimating Equations (GEE) to address non-normality distributions of the outcome (HEI). All data analyses were conducted in SAS 9.4 (SAS institute, Cary, NC).

3. Results

3.1 Study sample demographics

Table 1 summarizes the socio-demographic distribution for the SOS III sample. The majority of the sample were female (81.8%), and had a college degree or more (44.7%) but with 33.3% of the sample who had a high school education or less. The sample racial/ethnic composition was 49.2% non-Hispanic White, 39.9% Hispanic, and 10.9% other. Food assistance use (food banks, WIC, and/or SNAP) was reported by 33.7%. Most participants shopped at medium price stores (45.1%) followed by low price stores (36.4%) and high price stores (18.5%).

Table 2 shows the means (in $/month) for per capita self-reported food expenditures and FFQ-derived individual diet cost for the whole sample and by socio-demographic subgroup. Mean monthly per capita food expenditures were $225.39($132.46); mean monthly diet cost per 2000 kcal was $284.67($59.82).

Both food expenditures and diet costs showed significant univariate differences by all socio-demographic variables. Food expenditures were positively associated with age, education, and property values. Non-Hispanic Whites had higher mean food expenditures (mean (SD): $279.28($142.42)) as compared to Hispanic/others (mean (SD): $155.19($76.37)). Groups using food assistance had lower mean total food expenditures (mean (SD): $142.98($68.51)) than those not using food assistance (mean (SD): $267.09($137.42)). Shopping at a medium or high cost store was positively associated with food expenditures, where those shopping at high cost stores reported almost double the food expenditures as those shopping at low cost stores ($330.12 ($138.93) vs. $169.86 ($97.20) respectively).

Diet costs were also positively associated with age, education, and property values. Non-Hispanic Whites had higher diet costs (mean (SD): $302.18 ($59.10)) as compared to Hispanic/others (mean (SD): $260.57($51.65)) Groups using food assistance had lower mean total food expenditures (mean (SD): $256.54($45.87)) than those not using food assistance and (mean (SD): $298.90($61.04)). Shopping at medium or high cost stores was associated with higher diet costs than shopping at low cost stores, where those shopping at high cost stores had diet costs that were about $50 more per month than those shopping at low cost stores ($315.51($63.23) vs. $264.12($54.41) respectively).

Table 3 presents the results of the univariate and fully adjusted multiple linear regression models relating food expenditures and diet costs to HEI-2015 scores. Both food expenditures and diet costs were positively associated with HEI-2015 in the univariate models. After adjustment, only diet cost remained significant. Overall, each $100 increase in diet cost was associated with an increase of 5.33 points in HEI-2015.

Table 3 also shows the results of a fully adjusted multiple linear regression testing the significance of a quadratic effect of diet cost (diet cost squared) on HEI-2015. There was evidence of a curvilinear relationship between diet cost and HEI-2015 even after controlling for potential covariates. There was no evidence of a curvilinear relationship for total food expenditures and HEI-2015 (data not shown).

Figure 1 scatterplot depicts the quadratic relation between diet cost and HEI-2015 scores, with an asymptote reached as diet costs reach about $350/month. The greatest increase in HEI scores was obtained within the lower range of diet costs. Using the sample mean of $285 per month and an HEI of 80 (considered a “B” on the HEI scale) as reference points, the graph is split into four quadrants: Q1, Q2, Q3, and Q4. Most of the sample had HEI scores below 80 (Q2 and Q3), however, there was also large individual variation in HEI scores for a given diet cost.

Figure 2 illustrates the differential gains in HEI-2015 with increasing diet costs. An increase in diet cost from $150 per day to $250 per day was associated with a 20.6% increase in HEI-2015 (54.00 to 65.10), but the same increment increase of diet cost from $350 to $450 was associated with only a 2.8% increase in HEI-2015 (72.00 to 74.00).

4. Discussion

The present results showed that while healthier diets and higher HEI-2015 scores were associated with greater food spending, there was much variability at the individual level. At any level of spending, a wide range of HEI-2015 diet quality scores was observed, just as compliance with the DGA could be achieved with a highly variable diet cost.

For example, lower food expenditures and FFQ-estimated diet costs. Both variables were associated with socioeconomic status (SES), consistent with prior research. Lower food expenditures and lower diet costs were associated with being younger, unmarried, having less than a high school education, using food assistance[5,14,23,24] and having lower property values. Also in line with previous research, higher food expenditures and diet costs were associated with shopping at high cost stores, just as lower food expenditures and diet costs were associated with shopping at low cost stores.[20]

For the SOS III sample as a whole, the present results showed a strong positive association between compliance with DGA and estimated diet cost. These observations are consistent with past analyses of the nationally representative NHANES sample, based on 24-hour dietary recalls joined with the national USDA food prices database, which showed that higher estimated diet costs were linked to higher HEI-2010 scores.[13] Similarly, a meta-analysis of 27 studies from 10 countries found that compliance with the highly recommended Mediterranean diet pattern was associated with an average increase in diet cost of about $1.50 per day or about $45 per person per month as compared to a less healthy diet pattern consisting of processed foods and refined grains.[3]

For the most part, past studies have examined a linear relationship between diet cost and diet quality.[2–10,16] The present results show that the relation between dietary compliance and cost may include a quadratic term, which would indicate the potential for maximal returns in diet quality at the lower end of the food spending spectrum. To our knowledge, only one study has explored this issue in a youth population and using a different diet quality metric.[6] The present analyses showing a curvilinear relation between diet cost and HEI−2015 scores are the first to demonstrate that increases in diet cost ($100/month) for lower cost diets can assist compliance with the DGA. For diet costs above ~$350 per month, there were diminishing returns.

The present results parallel research in health economics and the "absolute income hypothesis," which states that income and health are positively associated but at a decreasing *curvilinear* rate.[57,58] In other words, the hypothesis suggests that there are maximal returns for health with increasing income at the lower end of the income spectrum, whereas at higher income levels the benefits begin to plateau. This has been examined in the context of mortality risk [57,58] and happiness.[59] Our results suggest that compliance with the DGA follows the same rules. Increasing monthly food spending may be prohibitive to those at the lower end food spending, as lower diet costs and expenditures were associated with lower education, lower residential property values, and shopping at lower cost stores. To increase the affordability of healthy diets that are compliant with the DGA, the cost of nutrient-dense foods must come down. Future research on the implementation of dietary advice could benefit from exploring further ways to improve diet quality among lower SES groups.

The present finding that the overall relation between diet cost and adherence to the DGA does not hold for every individual participant has implications for personalized nutrition. Considering the positive association between diet cost and HEI, one might expect most participants to fall in Q1 and Q2. However, as the scatterplot shows, there was great individual variation in the relation between diet cost and diet quality, with some participants showing high diet costs and low diet quality (Q3) and several with low diet costs and higher diet quality (Q4). The Q4 quadrant participants had been identified as showing *nutrition resilience*— described in past studies as being able to eat better for less. Previous work examining this idea of nutrition resilience has found that participants with high diet quality but low diet cost had lower BMI's, cooked more at home, and had diets characterized by more whole grains, dairy, total protein, seafood/plant protein and less saturated fat, sodium, and empty calories but did not differ by demographics or income.[60] These results suggest that there are groups who are able to achieve healthier diets despite having fewer resources. More work is needed to understand the underlying mechanisms that enable these nutrition resilient individuals to consume high quality diets despite economic constraints. Such work could inform targeted intervention designs.

The present results documenting lower food spending by recipients of food assistance were not surprising, given that food assistance is likely associated with lower diet costs for two reasons: 1) governmental food assistance programs have strict household income qualifications and 2) using food assistance allows families to re-budget food costs for other basic needs such as housing or healthcare. The $100 increases in diet cost as depicted in Figure 2 correspond to shifts between the four food plans created by the USDA to represent "healthy" diets at differing costs. These include the Thrifty plan, Low-cost plan, Moderate-cost plan, and Liberal plan. An increase from $150 to $250 is comparable to an increase from the Thrifty plan to the Low-cost plan, which according to current results, corresponded to a 20.6% increase in HEI (Figure 2). Whereas an increase from $350 to $450 was more comparable to an increase from the Moderate-cost plan to the Liberal plan, which corresponded to a much smaller increase in HEI (2.8%). These results make a case that increasing SNAP benefits may go a long way in improving adherence to the DGA, as the Thrifty plan is used as the basis for SNAP allotments.

4.1 Study limitations and strengths

The limitations of the current study should be considered. The estimated household food expenditures were based on standard questions from NHANES.[44] However, these types of self-reported questions on food expenditures can be subject to misreporting and rounding errors. For present purposes, the household food expenditures were divided by number of people per household, which may not be the most accurate way of capturing individual-level food expenditures. In addition to food expenditures, food shopping behaviors were also collected via self-report, which subject to social desirability and recall biases.[61,62] The FFQ used to collect the dietary data is a standard, validated tool that has been employed in several large-scale studies.[46] However, it is a self-report measure, used to estimated diet cost. Linking dietary intakes with retail prices has now become standard procedure. The county-specific pricing of the FFQ component foods was based on the lowest price for each item, with the same price being assigned to all participants. This technique measures the intrinsic monetary cost of the diet rather than actual food expenditures. The SOS III focused on studying food purchases made in retail outlets (i.e. supermarkets, bulk stores, convenience stores) without including questions about alternative food sources (e.g. community gardens), an area for future research. The SOS III study purposely oversampled low-income and minority populations as well as women (primary food shoppers), so the results may not be generalizable to other populations. Finally, the current findings were based on cross-sectional data, thus causality cannot be inferred.

The study had some notable strengths. First, the population sample was geographically and ethnically diverse, with a wide range of education and incomes. Our measure of residential property values minimized loss of data, often due to missing incomes. To our knowledge, this was the first study to compare self-reported food expenditures to FFQ-estimated diet costs. Both measures captured SES variation, suggesting that food expenditures can be useful in the evaluation of a population's food purchasing patterns. Diet costs were less subject to direct misreporting and bias though they do depend on the underlying quality of FFQ data. Importantly, this is the first study to explore a nonlinear relationship between diet cost and HEI-2015. Finally, multiple linear regressions using GEE allows for robust standard errors were run, which is a more rigorous method than traditional linear regression models.

4. 2 Conclusions

There was a positive and curvilinear relation between HEI-2015 scores, a measure of compliance with the DGA, and two measures of food spending—self-reported food expenditures and estimated diet cost. First, lower food spending was associated with younger age and lower SES. Second, increases in diet cost of $100/month in the lower diet cost range were associated with greater HEI-2015 gains; such increases in the higher range had diminishing returns. Present analyses show how compliance with the DGA may be promoted by targeted economic interventions to make healthy foods more affordable to lower SES groups.[63]

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Highlights

- Food expenditures and diet costs were linked to socioeconomics in the same way
- Costs and expenditures were lower when shopping at low cost vs. high cost stores
- Diet cost was positively associated with diet quality in a curvilinear manner
- Small diet cost increases had maximal returns for HEI-2015 for lower end diet costs

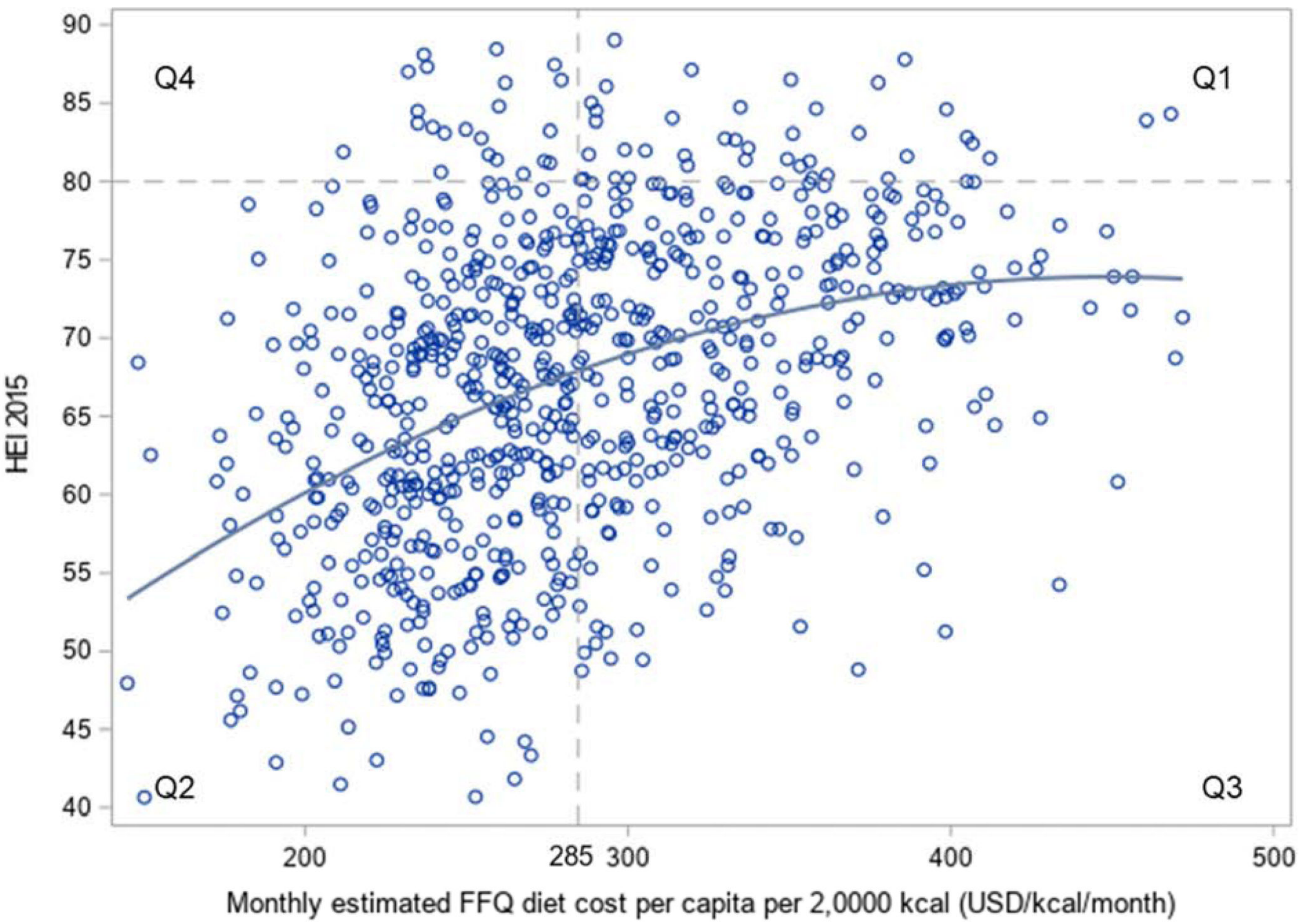

Figure 1:
Scatterplot depicting the quadratic relationship between diet cost (standardized per 2,000 kcal) ($/2,000kcal/month) and HEI-2015 diet quality scores derived from the FFQ (n=768). The graph is split into four quadrants (Q1-Q4) by using the sample mean was $285 per month and an HEI of 80 (considered a “B” on the HEI scale) as reference points.

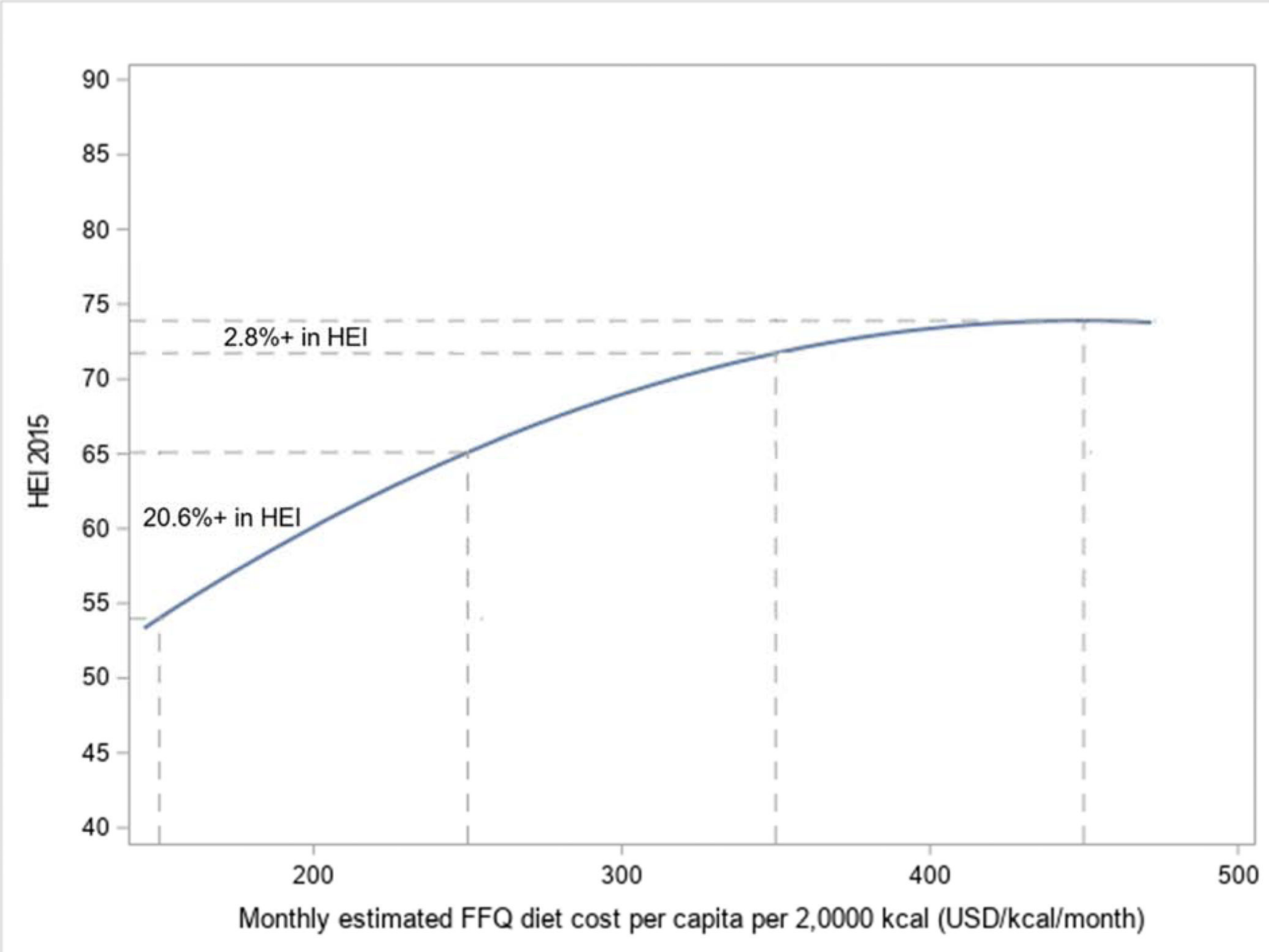

Figure 2:
Trend line for the quadratic relationship between estimated monthly diet cost (standardized per 2,000 kcal) and HEI-2015 diet quality scores derived from the FFQ, (n=768) depicting the maximal returns of diet cost for diet quality below ~$350/day. Shifts from $150 to $250 in estimated monthly diet cost were compared to shifts from $350 to $450 in estimated monthly diet cost.).

Table 1

Participant characteristics for total SOS III sample

	N	%
OVERALL	768	100
Gender		
Male	140	18.2
Female	628	81.8
Age		
21-<40y	257	33.4
40–50y	223	29.1
>50y	288	37.5
Race and Ethnicity		
Non-Hispanic White	378	49.2
Hispanic	306	39.9
Other	84	10.9
Marital Status		
Married	448	58.3
Unmarried	320	41.7
Education		
High school or less	255	33.3
Some college or technical school	169	22.0
College graduate or more	344	44.7
Property values (tertiles)		
Tertile 1: <129k	255	33.3
Tertile 2: 130–294k	256	33.2
Tertile 3: 295–1,492k	257	33.5
Food Assistance (Food bank, WIC, SNAP)		
Yes	258	33.6
No	510	66.4
Food store type		
Low cost	280	36.4
Medium cost	346	45.1
High cost	142	18.5

Notes: Hispanic includes those who reported Hispanic as ethnicity and race

SNAP: Supplemental Nutrition Assistance Program, WIC: Special

Supplemental Nutrition Program for Women, Infants, and Children

Table 2

Distribution of socio-demographics and mean values for food expenditures and diet cost

	Food expenditures per capita (USD/month)			Diet cost per 2,000 kcal (USD/2,000 kcal/month)		
	Mean	**SD**	**p-value**	**Mean**	**SD**	**p-value**
OVERALL (N=768)	225.39	132.46		284.67	59.82	
Gender						
Male	268.08	145.32	ref	282.70	55.05	ref
Female	215.88	127.61	**<0.0001**	285.11	60.86	0.65
Age						
21-<40y	188.30	107.11	ref	273.81	52.40	ref
40–50y	212.89	122.45	**0.02**	281.17	58.56	0.15
>50y	268.18	147.87	**<0.0001**	297.07	64.73	**<0.0001**
Race and Ethnicity						
Non-Hispanic White	279.28	142.42	ref	302.18	59.10	ref
Hispanic	155.19	76.37	**<0.0001**	260.57	51.65	**<0.0001**
Other	238.65	130.38	**0.01**	293.67	61.45	0.25
Marital Status						
Married	213.21	122.64	**0.004**	287.12	59.53	0.16
Unmarried	242.45	143.56	ref	281.24	60.15	ref
Education						
High school or less	149.31	76.04	**<0.0001**	257.55	46.91	**<0.0001**
Some college or technical school	227.40	127.56	**<0.0001**	286.84	60.83	**0.003**
College graduate or more	280.81	139.99	ref	303.71	60.39	ref
Property values (tertiles)						
Tertile 1: <129k	153.07	79.70	**<0.0001**	257.89	46.12	**<0.0001**
Tertile 2: 130–294k	237.04	139.32	**<0.0001**	287.53	57.99	**<0.0001**
Tertile 3: 295–1,492k	285.87	133.95	ref	308.51	63.10	ref
Food Assistance (Food bank, WIC, or SNAP)						
Yes	142.98	68.51	ref	256.54	45.87	ref
No	267.09	137.42	**<0.0001**	298.90	61.04	**<0.0001**
Food store type						
Low cost	169.86	97.20	ref	264.12	54.41	ref
Medium cost	227.35	128.28	**<0.0001**	288.65	56.36	**<0.0001**
High cost	330.12	138.93	**<0.0001**	315.51	63.23	**<0.0001**

Notes: Hispanic includes those who reported Hispanic as ethnicity and race; SNAP: Supplemental Nutrition Assistance Program, WIC: Special Supplemental Nutrition Program for Women, Infants, and Children; food expenditures per capita equal the sum of self-reported at-home and away from home food expenditures divided by household size; diet cost was estimated from FFQ intake data, divided by calories, multiplied by 30 to create a monthly diet cost variable, and adjusted to $/2,000kcal; unadjusted p-values

Table 3

Comparing multiple linear regression models with food expenditures and diet cost predicting HEI 2015 (n=768)

	Unadjusted models				Adjusted Models			
	Mean HEI per $100	**(95% CI)**		**p-value**	**Mean HEI per $100**	**(95% CI)**		**p-value**
Linear models								
Food expenditures per capita ($/month)	1.20	0.71	1.70	**<0.0001**	0.09	−0.49	0.67	0.77
Diet cost per 2,000 kcal ($/2,000 kcal/ month)	6.54	5.51	7.56	**<0.0001**	5.33	4.15	6.50	**<0.0001**
Curvilinear models								
Diet cost per 2,000kcal ($/2,000kcal/ month)	19.98	11.83	28.14	**<0.0001**	17.82	9.76	25.88	**<0.0001**
Diet cost per 2,000 kcal ($/2,000kcal/ month) squared	−2.23	−3.54	−0.91	**0.0009**	−2.06	−3.35	−0.78	**<0.002**

Notes: food expenditures per capita equal the sum of self-reported at-home and away from home food expenditures divided by household size; diet cost was estimated from FFQ intake data, divided by calories, multiplied by 30 to create a monthly diet cost variable, and adjusted to $/2,000kcal; both food expenditures and diet cost variables were then divided by $100 to estimate the mean HEI per $100 increase in monthly spending; unadjusted models: two separate unadjusted models were conducted- one with food expenditures per capita as the primary independent variable and another with diet cost as the independent variable; adjusted models: two separate generalized linear regressions with robust standard errors adjusting for age, gender, race/ethnicity, marital status, education, property values, food assistance, and county were conducted - one including food expenditures as the primary independent variable, another with diet cost as the primary independent variable.