EATING WELL AND PAYING LESS: A POSITIVE DEVIANCE STUDY

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ABSTRACT

Background/Objective: Past studies have shown that healthier diets tend to cost more. This study identified groups of positive deviants (PD) who are able to achieve healthier diets at lower cost, and characterize them by socio-demographics, dietary components, and food attitudes.

Subjects/Methods: The Seattle Obesity Study (SOS) was a cross-sectional study based on a representative sample of 1266 adults of King County, WA, conducted in 2008–09. Socio-demographic and attitudinal variables were obtained through telephone survey. Dietary intake data were obtained using a food frequency questionnaire (FFQ). Diet cost was calculated based on retail prices for FFQ component foods. Healthy Eating Index-2005 (HEI), mean adequacy ratio (MAR), and energy density (ED) were used as three measures of diet quality.

Results: Higher diet cost is associated with being female, aged 50-64, a college graduate or higher, and having annual household income $100,000 or more. 66 HEI positive deviants, 73 MAR positive deviants, and 33 ED positive deviants were identified who had higher diet quality at lower cost. Compared to other individuals, PD varied by gender, age, race, education, income, marital status and perceived importance of eating foods that are healthy, inexpensive and convenient. Regardless of cost, individuals with high diet quality had similar HEI component scores. However, PD were able to achieve the same high HEI at lower cost. Their diet was constituted by more fruits, vegetables, whole grains, and milk, and less saturated fats, solid fats, alcohol, and added sugars (SoFAAS).

Conclusions: One way to achieve high diet quality at low cost is by choosing less expensive forms of fruits and vegetables—such as apples and carrots instead of strawberries and kale. Increasing intake of healthful food components that are less expensive, such as whole grains, meats and beans is another way to achieve a healthier diet at lower cost. Strategies to improve diet quality at low cost should also include techniques to increase the perception that it is important that food be healthy, and to improve the accuracy of self-assessments of diet quality.

INTRODUCTION

Individuals who consume diets high in fruits, vegetables, whole grains, and low fat dairy products, and low in saturated fat, refined carbohydrates, and sodium typically experience beneficial health effects. These include lower blood pressure, higher insulin sensitivity, and a more favorable body fat percentage [1-3]. Unfortunately, adherence to such diets comes at a higher cost. Nutrient-dense diets, characterized by the dietary pattern noted above, typically cost more than energy-dense diets that are high in sugar, fat, and processed grains [4-7] Food price is a common barrier to healthy eating, especially among low-income consumers [8-11]. However, there are individuals who go against this norm and are able to eat well at a low cost [12,13]. Exploring the characteristics of individuals who are able to achieve high diet quality at low cost may shed light on which specific behaviors and practices enable them to do so.

Positive deviance is one way to approach this topic. Positive deviance is an inductive approach that seeks to pinpoint beneficial health behaviors in a population that allows some to thrive, while others with the same resources tend to fail [14]. It is a commonly used approach for overcoming barriers to behavior change, and is an alternative to needs-based approaches [15]. By studying the behaviors of successful people in a population, we can develop health promotion strategies that can then be disseminated to improve outcomes for less successful individuals [16]. It is more realistic to implement positive deviant behaviors that are already practiced by some individuals in a community, than to attempt to implement new behaviors that require outside resources [12].

The positive deviance approach has been used extensively in developing countries to improve maternal and child nutrition by studying the health behaviors of families with well-nourished children, despite living in generally malnourished regions. Positive deviant discoveries include findings such as: increasing consumption of meat and vegetables, daytime rest, and antenatal care improve pregnancy outcomes in Egypt [17]; greater birth interval, breastfeeding at least 8-9 times/day, and starting complementary foods at 6-8 months improve weight-for-age outcomes in children living in slums in India [18]; and positive verbalization during feeding improves food acceptance in children in Viet Nam [19]. More examples of positive deviant studies are available online [20].

Positive deviance has been used in developed countries, but to a much less extent than in developing countries. Positive deviance has been used to study health behaviors associated with positive health outcomes, including breast feeding in the United States [21], smoking cessation in New South Wales [22], and hospital management in Australia [23]. While some US-based studies have used positive deviance to study nutrition related behaviors such as diabetes care [24] and weight control [25], there has been no use, to our knowledge, of positive deviance to study the relationship between diet cost and diet quality.

The present project is based on the Seattle Obesity Study (SOS), a cross-sectional study of social disparities, diet quality and health using a representative sample of 2001 adults of King County, WA [26]. This project examined the utility of the positive deviance approach to overcome high cost as a barrier to healthy eating. Positive deviants were defined as those who had higher diet quality at low cost, in this sample. Three measures of diet quality were used to define these groups: Energy density, HEI-2005 and Mean adequacy ratio. The purpose of the present study was to identify positive deviant respondents in this sample and characterize them in terms of key socio-demographics, attitudinal and dietary components. This is one of the first studies, to our knowledge, to use positive deviance approach to identify ways to achieve healthier diets at lower cost in the US.

SPECIFIC AIMS

1. To develop a metric to identify positive deviant (PD) individuals—a subgroup of individuals with higher diet quality (i.e. higher HEI score, higher MAR or lower dietary energy density) at lower diet cost. Also, to identify two comparison subgroups of individuals demonstrating the expected relationship between diet cost and diet quality—a subgroup of individuals with lower diet quality at lower diet cost (Exp-Low) and a subgroup of individuals with higher diet quality at higher cost (Exp-High).

2. To characterize and compare the PD subpopulations to the expected outcome populations (Exp-High and Exp-Low), with respect to key socio-demographics (gender, age, race/ethnicity, education, income and marital status), dietary components (based on HEI component scores), and attitudinal factors (perceived importance of food cost, healthfulness and ease of preparation).

METHODS

Study Design

The present project was a secondary data analysis of Seattle Obesity Study (SOS), a population-based study of social disparities, diet quality, and health, conducted during 2008-2009 in King County, WA State. A stratified sampling scheme was used to ensure adequate representation of lower income and minorities. King County, WA zip codes with high percentages of households with incomes <$35,000, African-Americans, or Hispanics were oversampled. Randomly generated telephone numbers were matched with residential addresses using commercial databases. A pre-notification letter was mailed out to alert potential participants that their household was randomly selected for a study by the University of Washington (UW) School of Public Health. Once the household was contacted, an adult member of the household was randomly selected to be the survey respondent.

Exclusion criteria were age younger than 18 years, discordance between data obtained from the vendor and self-reported by the respondent, and cell phone numbers. The study sample consisted of 2,001 male and female adult residents of King County, WA. The study protocols were approved by the University of Washington Institutional Review Board [26,27].

Data Collection Instruments and Variables of Interest

Socio-demographic and attitudinal data: using a telephone survey

A 20-minute telephone survey, administered to 2001 participants, yielded self-reported data on socio-demographic and health measures. The protocols were modeled on the Behavioral Risk Factors Surveillance System (BRFSS) surveys for Washington State. The SOS sample was demographically comparable to the BRFSS data, and was representative of King County.

Socio-economic measures were income and education [26,27]. Income was collected as a categorical variable, with categories less than $10,000, $10,000 to less than $15,000, $15,000 to less than $20,000, $20,000 to less than $25,000, $25,000 to less than $35,000, $35,000 to less than $50,000, $50,000 to less than $75,000, $75,000 to less than $100,000, and greater than or equal to $100,000. For analytical purposes, income was condensed to three categories, less than $50,000, $50,000 to $99,999, and $100,000 or more. Education was collected as a categorical variable, with categories never attended school or only attended kindergarten, grades 1 through 8 (elementary), grades 9 through 11 (some high school), grade 12 or GED (high school graduate), college 1 year to 3 years (some college or technical school), college 4 years or more (college graduate). For this analysis, education was categorized as high school or less, some college, and college graduate or higher.

Demographic variables of interest were gender, age, race, and marital status. Gender was collected and analyzed as male or female. Age was collected as a continuous variable in years. For analytical purposes, age was redefined as 18-49 years, 50-64 years, and 65+ years. Race was collected as white, black or African American, Asian, native Hawaiian other Pacific Islander, American Indian, or Alaska native. Race was redefined as white or non-white for this analysis. Marital status was collected categorically as married, divorced, widowed, separated, never been married, or member of an unmarried couple. For analytical purposes, this variable was redefined as married or unmarried.

The food-related attitudes were also collected from each respondent as part of the telephone survey. Respondent were asked to state their agreement with three statements on attitudes. The statements were: “It is important to me that the foods I usually eat are inexpensive”; “It is important to me that the foods I usually eat are healthy”; “It is important to me that the foods I usually eat take little time to purchase, cook and clean up”. Responses were collected categorically as strongly agree, somewhat agree, neither agree nor disagree, somewhat disagree, or strongly disagree. For analytical purposes, responses were redefined as agree or neutral/disagree.

Self-reported diet quality was also captured using the question: How would you rate the quality of your diet? Responses were collected and analyzed categorically as not at all healthy, somewhat healthy, healthy, or very health.

Dietary data: using Food Frequency Questionnaire (FFQ)

Survey participants were asked if they would also complete a dietary intake assessment. The majority (*n*=1903 or 95%) agreed and food frequency questionnaire (FFQ) instruments and stamped addressed return envelopes were mailed. The FFQ used was the G-SEL version of the Fred Hutchinson Cancer Research Center (FHCRC), previously used in large-scale studies [28,29]. Participants recorded the frequency of consumption of ~150 foods and beverages listed in the FFQ along with portion size.

Completed surveys, returned to the investigators, were checked for errors, stripped of all identifiers and sent to Nutrition Shared Resource at the FHCRC for processing. Nutrient composition analyses of dietary intake data yielded dietary energy (kcal), the weight of foods, beverages, and drinking water (g) consumed and the estimated daily intakes of over 45 macro- and micronutrients, using well-established method in previous studies [30]. This data was used to compute three summary measures of diet quality. 69% of the telephone respondents completed the FFQ (*n*=1318).

52 questionnaires were excluded based on extreme energy intakes (<500Kcal >5000Kcal/day). After taking missing data into account for the variables of interest, the analytical sample for this project consisted of 1,110 adults.

Measures of diet quality.

Three summary measures of diet quality were derived from FFQ data: Healthy Eating Index-2005 (HEI), Mean adequacy ratio (MAR), and Energy density (ED).

The Healthy Eating Index (HEI) is a federal measure of diet quality based on the USDA Dietary Guidelines for Americans [31]. The measure is based on the consumption of 9 food groups (total fruit, whole fruit, total vegetables, dark green and orange vegetables and legumes, total grains, whole grains, milk, meat and beans, and oils), and three moderation components (saturated fat, sodium, and discretionary calories [calories from solid fats, alcoholic beverages, and added sugars]). HEI is expressed as a score from 0 to 100, with a score of 100 representing complete conformance to the Dietary Guidelines for Americans [31].

Mean adequacy ratio (MAR) is an index of the percent of recommended daily allowances (RDA) for key nutrients [32]. It is an average of the nutrient adequacy ratio for 11 key nutrients (vitamins A, C, D, E, B12, calcium, iron, magnesium, potassium, folate and fiber). Most of these nutrients were expressed as nutrients of concerns by 2005 Dietary Guidelines Advisory Committee [33]. Following past models, nutrients were not weighted and no attempt was made to adjust for bioavailability [32]. Nutrient adequacy ratio for each nutrient at the individual level was truncated at 1 to avoid a skewed overall MAR score due to overconsumption of one or more nutrients [32,34]. MAR was computed using foods and caloric beverages, as beverages are an important source of nutrients in a diet [35,36]. MAR is expressed as percent of adequacy per day, and a higher MAR is associated with higher diet quality.

A third indicator of diet quality was Energy density (ED), defined as ratio of total energy intake over daily weight of total foods consumed. A diet low in energy density has been recommended as a dietary approach to disease prevention by organizations including the joint American Institute for Cancer Research and Cancer Research Fund, the USDA, and the 2010 Dietary Guidelines for Americans [37,38]. Data for foods and calorie beverages were used. ED is expressed as kcal/g, and a lower energy density is associated with higher diet quality.

Measure of diet cost

The daily diet cost measure for each respondent was obtained using FHCRC FFQ. The methodology for measuring diet cost has been described in detail previously [30, 39]. The methods are discussed here briefly. Each FFQ component food was translated to a specific food item in purchasable form. Food prices were obtained from three supermarkets in Seattle (Safeway, Albertson's, QFC) between 2004-2006. The lowest available price for each food item was assigned, and these prices were used to calculate diet cost based on each respondent's FFQ responses. This monetary variable was then divided by the individual's reported mean energy intake in kcal, and multiplied by 2,000, resulting in an energy-adjusted diet cost variable in units $/2,000 kcal. These adjustments were done to take differences in calorie intake into account.

Statistical Analyses

The first aim was to identify sub-groups of positive deviant (PD) and non-positive deviant (non-PD) groups in the sample. Univariate analyses were used to summarize the distribution of key variables of interest—energy-adjusted diet cost and the three diet quality measures. Scatter plots were used to show the relation between diet cost and diet quality. These summary measures and graphs allowed us to visually identify PD, Exp-High and Exp-Low groups. Means and proportions were computed to examine the overall sample distribution. Bivariate associations of key socio-demographic variables with n-tiles of energy-adjusted diet cost, and each of the three diet quality measures were examined. Chi-square tests were conducted to test for statistical significance. The 2nd aim of the study was to characterize PD, Exp-High and Exp-low groups by key demographic and attitudinal variables. Bivariate associations were conducted along with chi2 tests to test for statistical significance. All analyses were conducted using StataSE 12 and an α-level of 0.05 was used to indicate statistical significance.

RESULTS

Sample distribution

The overall sample distribution by socio-demographic and cost variables is shown in **Table 1.** The majority of the sample was female (62.3%), and white (87.9%). Only one-third of the sample was under the age of 50 (32.5%). More than half of the respondents were college graduates (58.4%), and over one-quarter had income $100,000 or more (26.7%). More than half of the sample was married (53.8%). The mean (SD) energy-adjusted diet cost was $10.20 (2.37), and the median (IQR) diet cost was $9.90 (2.90).

Diet cost and diet quality distribution

The overall distributions of the energy adjusted diet cost, HEI, MAR and ED variables are shown in **Figures 1A-1D**. Energy-adjusted diet cost ranged from $4.80 to $21.72 per 2,000 kcal, with mean (SD) $10.20 (2.37) and median (IQR) $9.90 (2.90). HEI scores ranged from 37.3 to 95.1 with mean 69.7 (10.0) and median 71.6 (49.4). MAR ranged from 19.3% to 100% with mean 76.6% (16.3) and median 79.5 (23.0). Energy density ranged from 0.53 kcal/g to 3.03 kcal/g, with mean 1.14 (0.27) and median 1.12 (0.34).

Table 1. Distribution of the study sample by key socio-demographic and diet cost variables

Socio-demographics	**n**	**%**
Gender		
Male	418	37.7
Female	692	62.3
Age		
18-49	361	32.5
50-64	463	41.7
65+	286	25.8
Race/Ethnicity		
White	976	87.9
Non-white	134	12.1
Education		
High School or less	184	16.6
Some college	278	25.1
College graduate or higher	648	58.4
Income		
Less than $50,000	418	37.7
$50,000-99,999	396	35.7
$100,000 or more	296	26.7
Marital Status		
Married	597	53.8
Unmarried	513	46.2
Diet Cost	**Mean (SD)**	**Median (IQR)**
Energy-adjusted Diet Cost	$10.20 (2.37)	$9.90 (2.90)

Figure 1A. Distribution of energy-adjusted diet cost..

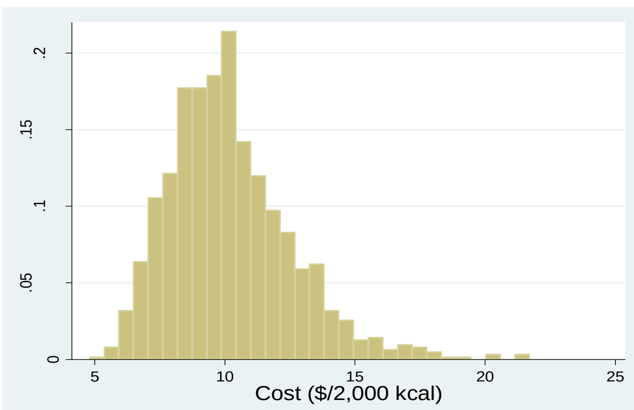


Figure 1B. Distribution of Healthy Eating Index 2005.

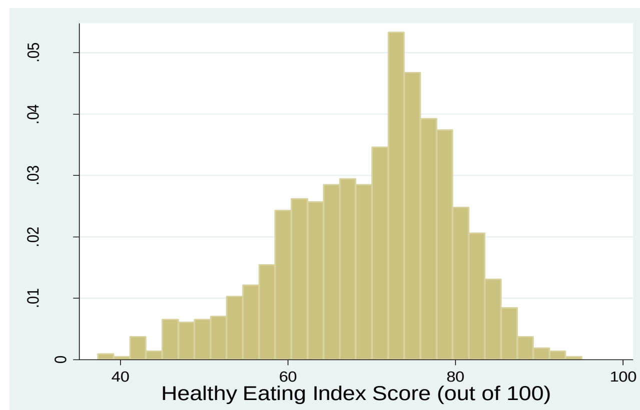


Figure 1C. Distribution of mean adequacy ratio.

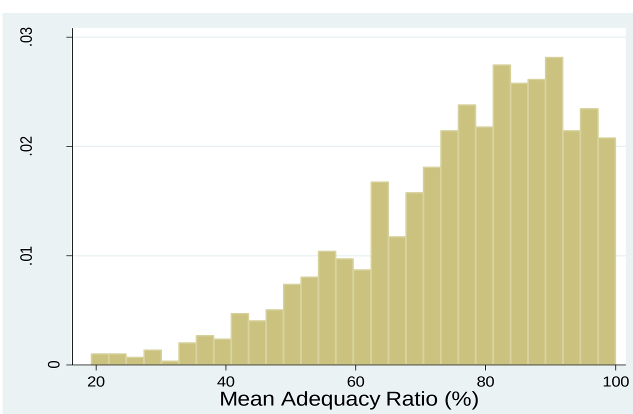
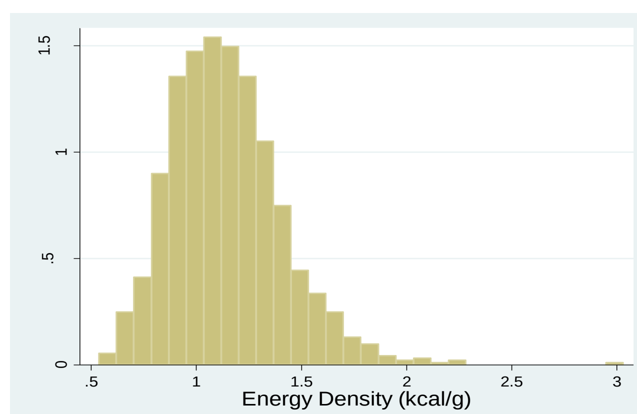


Figure 1D. Distribution of energy density.



Relation between diet cost and key socio-demographic variables

Distribution of tertiles of energy-adjusted diet cost by key socio-demographic variables is provided in **Table 2.** The energy-adjusted mean diet cost for cost tertile 1 was $7.88, and costs ranged from $4.80-9.02. Mean diet cost for cost tertile 2 was $9.88, and costs ranged from $9.02-10.75. Mean diet cost for cost tertile 3 was $12.83, and costs ranged from $10.76-21.72. Significant differences were observed in cost tertiles by gender, age, education and income. Women tend to have higher energy-adjusted diet cost, constituting for 73.5% of the highest cost tertile, and 53.0% of the lowest cost tertile. The highest tertile of cost has significantly higher proportion of individuals aged 50-64 (50.5%) compared to the lowest tertile of cost (37.0%), and a significantly lower proportion of individuals aged 65+ (18.9%) compared to the lowest tertile of cost (32.4%). Respondents with college degree or higher also tend to have higher diet cost, making up 34.3% of people in the highest cost tertile and 19.5% of people in the lowest diet cost tertile; individuals high school education or less tend to have lower diet cost, constituting 23.5% of the lowest cost tertile and 9.2% of the highest cost tertile. The highest tertile of diet cost has significantly lower proportion of people with income less than $50,000 (26.2%) compared to the lowest tertile of cost (50.0%); individuals with income of $100,000 or more tend to have higher diet cost, making up 34.3% of the highest cost tertile and 19.5% of the lowest cost tertile.

Table 2: Distribution of tertiles of energy adjusted diet cost by key socio-demographic variables

	Energy-adjusted Diet Cost Tertile 1			Energy-adjusted Diet Cost Tertile 2			Energy-adjusted Diet Cost Tertile 3			
n	n=370			n=370			n=370			
Mean (SD)	$7.88 (0.81)			$9.88 (0.49)			$12.83 (1.87)			
(Min, Max)	($4.80,9.02)			($9.02,10.75)			($10.76,21.72)			
Key Socio-demographics	**n**	**%**	**Mean (SD)**	**n**	**%**	**Mean (SD)**	**n**	**%**	**Mean (SD)**	**Chi-square**
Gender										
Male	174	47.0	7.81 (0.49)	146	39.5	9.88 (0.50)	98	26.5	12.82 (1.84)	p=0.000
Female	196	53.0	7.94 (0.78)	224	60.5	9.89 (0.48)	272	73.5	12.83 (1.88)	
Age										
18-49	113	30.5	7.89 (0.74)	135	36.5	9.86 (0.48)	113	30.5	12.60 (1.93)	p=0.000
50-64	137	37.0	7.91 (0.82)	139	37.6	9.94 (0.47)	187	50.5	12.95 (1.88)	
65+	120	32.4	7.85 (0.87)	96	26.0	9.85 (0.53)	70	18.9	12.88 (1.74)	
Race/Ethnicity										
White	324	87.6	7.88 (0.80)	325	87.8	9.88 (0.49)	327	88.4	12.83 (1.87)	p=0.942
Non-white	46	12.4	7.89 (0.89)	45	12.2	9.94 (0.49)	43	11.6	12.80 (1.92)	
Education										
High School or less	87	23.5	7.69 (0.93)	63	17.0	9.87 (0.46)	34	9.2	12.82 (1.56)	p=0.000
Some college	102	27.6	7.80 (0.82)	93	25.1	9.79 (0.50)	83	22.4	12.45 (1.75)	
College graduate or higher	181	48.9	8.02 (0.73)	214	57.8	9.93 (0.49)	253	68.4	12.95 (1.94)	
Income										
Less than $50,000	185	50.0	7.78 (0.85)	136	36.8	9.81 (0.51)	97	26.2	12.53 (1.51)	p=0.000
$50,000-99,999	113	30.5	7.90 (0.81)	137	37.0	9.94 (0.46)	146	39.5	12.67 (1.72)	
$100,000 or more	72	19.5	8.11 (0.68)	97	26.2	9.91 (0.49)	127	34.3	13.25 (2.19)	
Marital Status										
Married	184	49.7	7.99 (0.75)	201	54.3	9.85 (0.48)	212	57.3	12.85 (1.84)	p=0.115
Unmarried	186	50.3	7.78 (0.86)	169	45.7	9.93 (0.49)	158	42.7	12.81 (1.91)	

Relation between socio-demographic variables and quartiles of diet quality, for each measure of diet quality

Distributions of key socio-demographic variables by quartiles of each diet quality measure are presented in **Tables 3A-3C.**

Healthy Eating Index 2005

HEI scores ranged from 37.3 to 95.1, with quartile means of 56.0, 67.5, 74.2 and 81.2 **(Table 3A)**. Differences in HEI scores are observed by five of the seven socio-demographic variables of interest—gender, education, income, marital status and diet cost. Individuals in the highest quartile of HEI are more likely to be women (75.5%), compared to individuals in the lowest quartile of HEI (48.2% women). The highest HEI quartile has significantly more college graduates (62.8%) compared to those in the lowest HEI quartile (48.9%). Individuals having income $100,000 or more also tend to have higher HEI scores, constituting 24.2% of the highest HEI quartile, and 18.0% of the lowest HEI quartile. Being in the highest HEI quartile is also associated with being married (54.2%, compared to 46.8% in lowest HEI quartile), and being in the highest tertile of energy-adjusted diet cost (43.0% in highest cost tertile, compared to 21.2% in lowest HEI quartile).

Mean Adequacy Ratio

MAR scores ranged from 19.3% to 100%, with quartile means of 53.6, 73.9, 84.5 and 94.5 **(Table 3B).** MAR had the strongest overall association with demographics, as it was associated with six of the seven demographic variables. Differences in MAR scores are observed by gender, age, race, education, income, and diet cost. There was a significantly higher proportion of women in the highest HEI quartile (67.5%) compared to the lowest HEI quartile (55.4%). The highest quartile of MAR was also had a higher proportion of white persons (93.1%), compared to the lowest MAR quartile (83.1%). Individuals with college education or higher were tend to have higher MAR, constituting 66.1% of the highest MAR quartile, and

45.0% of the lowest MAR quartile. The proportion of individuals with income $100,000 or more is greater in the highest quartile of MAR (30.7%), compared to the lowest quartile of MAR (23.7%), Being in the highest MAR quartile is also associated with being in the highest tertile of energy-adjusted diet cost (38.9%, compared to 28.4% in the lowest MAR quartile).

Energy Density

ED ranged from 0.54 to 3.03 kcal/g, with quartile means of 0.83, 1.04, 1.21 and 1.50. ED **(Table 3C).** ED was associated with only 3 demographic variables—gender, age and diet cost. Individuals in the lowest ED quartile (highest diet quality) are more likely to be women (69.1%), than individuals in the highest quartile of ED (lowest diet quality) (55.6%). The proportion of individuals aged 18-49 was significantly lower in the lowest quartile of ED (22.3%) compared to the highest quartile of ED (34.6%). Individuals in the lowest ED quartile tend to have higher diet cost, with 64.0% in the highest diet cost tertile, compared to 6.5% in the highest cost tertile among those in the highest ED quartile.

Table 3A. Distribution of Healthy Eating Index-2005 (HEI 2005) quartiles by key socio-demographic variables.

	HEI Quartile 1		HEI Quartile 2		HEI Quartile 3		HEI Quartile 4		
n **Mean (SD)** **(Min, Max)**	n=278 56.0 (5.8) (37.3, 62.8)		n=277 67.5 (2.5) (62.9, 71.6)		n=278 74.2 (1.5) (71.6, 77.1)		n=277 81.2 (3.4) (77.1, 95.1)		
Key Socio-demographics	**n**	**%**	**n**	**%**	**n**	**%**	**n**	**%**	**Chi-square**
Gender									
Male	144	51.8	116	41.9	90	32.4	68	24.6	p=0.000
Female	134	48.2	161	58.1	188	67.6	209	75.5	
Age									
18-49	91	32.7	98	35.4	94	33.8	78	28.2	p=0.213
50-64	111	39.9	120	43.3	118	42.5	114	41.2	
65+	76	27.3	59	21.3	66	23.7	85	30.7	
Race/Ethnicity									
White	252	90.7	238	85.9	240	86.3	246	88.8	p=0.277
Other	26	9.4	39	14.1	38	13.7	31	11.2	
Education									
High School or less	59	21.2	53	19.1	36	13.0	36	13.0	p=0.002
Some college	83	29.9	69	24.9	59	21.2	67	24.2	
College graduate or higher	136	48.9	155	56.0	183	65.8	174	62.8	
Income									
Less than $50,000	123	44.2	102	36.8	90	32.4	103	37.2	p=0.001
$50,000-99,999	105	37.8	86	31.1	98	35.3	107	38.6	
$100,000 or more	50	18.0	89	32.1	90	32.4	67	24.2	
Marital Status									
Married	130	46.8	160	57.8	157	56.5	150	54.2	p=0.044
Unmarried	148	53.2	117	42.2	121	43.5	127	45.9	
Diet Cost ($/2000 kcal)									
Tertile 1	137	49.3	101	36.5	66	23.7	66	23.8	p=0.000
Tertile 2	82	29.5	97	35.0	99	35.6	92	33.2	
Tertile 3	59	21.2	79	28.5	113	40.7	119	43.0	

Table 3B. Distribution of mean adequacy ratios (MAR) quartiles by key socio-demographic variables.

	MAR Quartile 1		MAR Quartile 2		MAR Quartile 3		MAR Quartile 4		
n	n=278		n=277		n=278		n=277		
Mean (SD)	53.6 (10.5)		73.9 (3.6)		84.5 (2.8)		94.5 (3.3)		
(Min, Max)	(19.3, 66.3)		(66.5, 79.5)		(79.5, 89.3)		(89.4, 100)		
Key Socio-demographics	**n**	**%**	**n**	**%**	**n**	**%**	**n**	**%**	**Chi-square**
Gender									
Male	124	44.6	104	37.6	100	36.0	90	32.5	p=0.027
Female	154	55.4	173	62.5	178	64.0	187	67.5	
Age									
18-49	63	22.7	79	28.5	95	34.2	124	44.8	p=0.000
50-64	123	44.2	127	45.9	115	41.4	98	35.4	
65+	92	33.1	71	25.6	68	24.5	55	19.9	
Race/Ethnicity									
White	231	83.1	246	88.8	241	86.7	258	93.1	p=0.003
Other	47	16.9	31	11.2	37	13.3	19	6.9	
Education									
High School or less	69	24.8	49	17.7	32	11.5	34	12.3	p=0.000
Some college	84	30.2	74	26.7	60	21.6	60	21.7	
College graduate or higher	125	45.0	154	55.6	186	66.9	183	66.1	
Income									
Less than $50,000	127	45.7	98	35.4	98	35.3	95	34.3	p=0.049
$50,000-99,999	85	30.6	109	39.4	105	37.8	97	35.0	
$100,000 or more	66	23.7	70	25.3	75	27.0	85	30.7	
Marital Status									
Married	134	48.2	154	55.6	154	55.4	155	56.0	p=0.198
Unmarried	144	51.8	123	44.4	124	44.6	122	44.0	
Diet Cost ($/2000 kcal)									
Tertile 1	117	42.1	98	35.4	82	29.5	73	29.5	p=0.001
Tertile 2	82	29.5	99	35.7	88	31.7	101	31.7	
Tertile 3	79	28.4	80	28.9	108	38.9	103	38.9	

Table 3C. Distribution of energy density (ED) quartiles by key socio-demographic variables.

	ED Quartile 1		ED Quartile 2		ED Quartile 3		ED Quartile 4		
n **Mean (SD)** **(Min, Max)**	n=278 0.83 (0.09) (0.54, 0.96)		n=277 1.04 (0.05) (0.96, 1.12)		n=278 1.21 (0.05) (1.12, 1.30)		n=277 1.50 (0.20) (1.30, 3.03)		
Key Socio-demographics	**n**	**%**	**n**	**%**	**n**	**%**	**n**	**%**	**Chi-square**
Gender									
Male	86	30.9	104	37.6	105	37.8	123	44.4	p=0.013
Female	192	69.1	173	62.5	173	62.2	154	55.6	
Age									
18-49	62	22.3	111	40.1	92	33.1	96	34.7	p=0.000
50-64	135	48.6	111	40.1	102	36.7	115	41.5	
65+	81	29.1	55	19.9	84	30.2	66	23.8	
Race/Ethnicity									
White	239	86.0	251	90.6	247	88.9	239	86.3	p=0.282
Other	39	14.0	26	9.4	31	11.2	38	13.7	
Education									
High School or less	50	18.0	34	12.3	47	16.9	53	19.1	p=0.150
Some college	69	24.8	63	22.7	69	24.8	77	27.8	
College graduate or higher	159	57.2	180	65.0	162	58.3	147	53.1	
Income									
Less than $50,000	104	37.4	88	31.8	114	41.0	112	40.4	p=0.143
$50,000-99,999	104	37.4	102	36.8	101	36.3	89	32.1	
$100,000 or more	70	25.2	87	31.4	63	22.7	76	27.4	
Marital Status									
Married	132	47.5	152	54.9	155	55.8	158	57.0	p=0.103
Unmarried	146	42.5	125	45.1	123	44.2	119	43.0	
Diet Cost ($/2000 kcal)									
Tertile 1	33	11.9	58	20.9	100	36.0	179	64.6	p=0.000
Tertile 2	67	24.1	91	32.9	132	47.5	80	28.9	
Tertile 3	178	64.0	128	46.2	46	16.6	18	6.5	

I. Identifying positive deviants and comparison groups

Positive deviants (PD) were defined as individuals who had high diet quality at low diet cost. PD were identified using three separate measures of diet quality: HEI, MAR and ED.

Association between diet cost and each of the three diet quality measures

Bivariate association between energy-adjusted diet cost and each of the diet quality measures are presented in **Figures 2A-2C**. At every level of diet cost, there is a range of diet quality; at every level of diet quality, there is a range of diet cost. A positive correlation was observed between energy-adjusted diet cost and HEI-2005 score (r=0.23), MAR score (r=0.13), and a negative correlation was observed with energy density (r=-0.55).

Defining positive deviants

In accordance with previous studies, variable cutoffs were defined based on percentiles [12,14,40]. Based on the distribution of data obtained, low diet cost was defined as the lowest tertile of energy-adjusted diet cost (<$9.02/2,000 kcal). High diet quality was defined as the highest 25th percentile of HEI-2005 score (HEI>77.1), the highest 25th percentile of MAR (MAR >89.4%), and the lowest 25th percentile of ED (ED<0.96 kcal/g). Based on these criteria, there were 66 HEI positive deviants, 73 MAR positive deviants, and 33 ED positive deviants.

Two comparison groups were defined, which consisted of respondents who had lower diet quality at low diet cost (Exp-low) and high diet quality at high diet cost (Exp-high). The cut offs for percentiles were selected based on the distribution of data obtained. As described above, the lowest tertile of energy adjusted diet cost was treated as the low diet cost group. Low diet quality was defined as the lowest quartile of HEI (HEI<62.8) and MAR (MAR<66.3%), and the highest quartile of ED (ED>1.30 kcal/g). Based on these criteria, the Exp-low comparison group consisted of 137, 117, and 179 individuals for HEI, MAR and ED respectively. High diet cost was defined as the highest tertile of energy adjusted diet cost (>$10.76/2,000 kcal). Higher diet quality was defined above. Based on these criteria, the Exp-high comparison group consisted of 119, 103, and 178 respondents for HEI, MAR and ED. These groups are represented graphically in **Figures 3A-3C**.

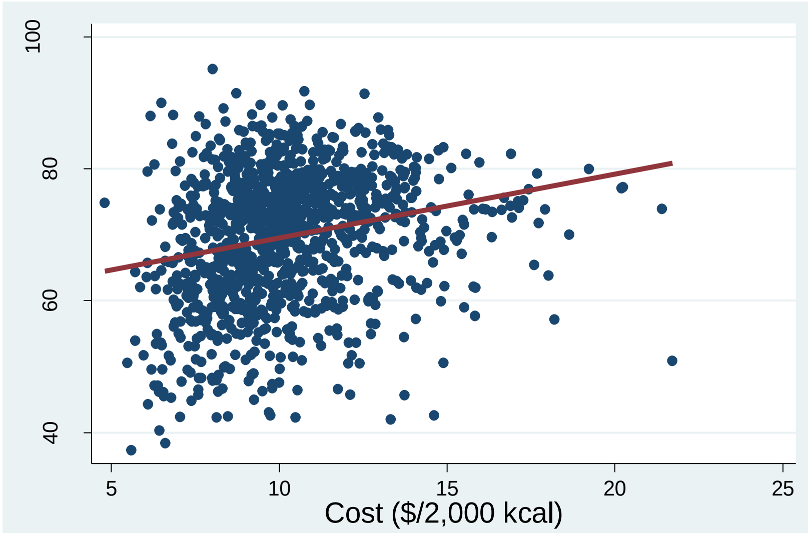


Figure 2A. Distribution of Healthy Eating Index-2005 (HEI) by energy adjusted diet cost with linear fit.

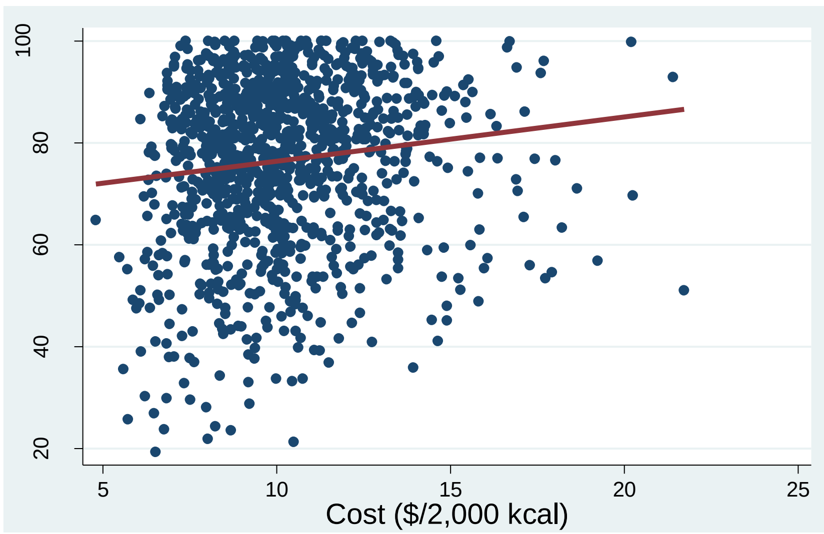


Figure 2B. Distribution of mean adequacy ratio (MAR) by energy adjusted diet cost with linear fit

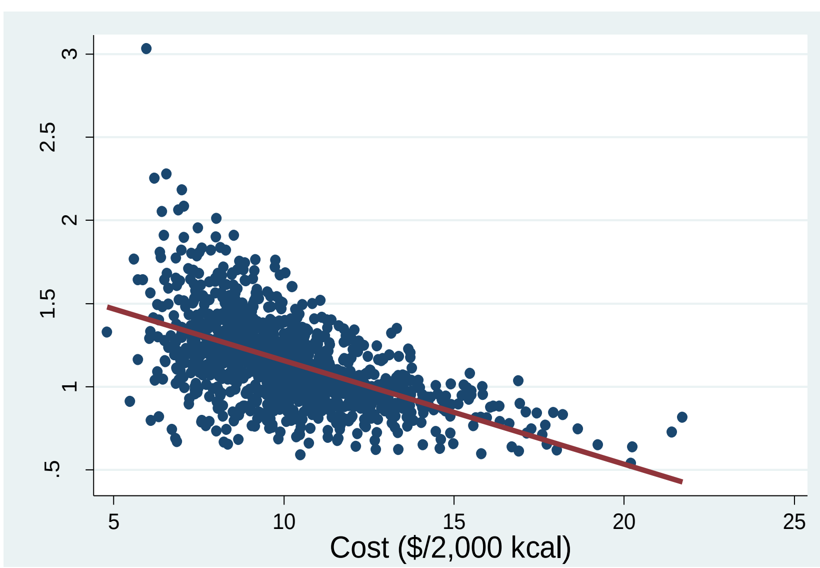


Figure 2C. Distribution of energy density (ED) by energy adjusted diet cost with linear fit

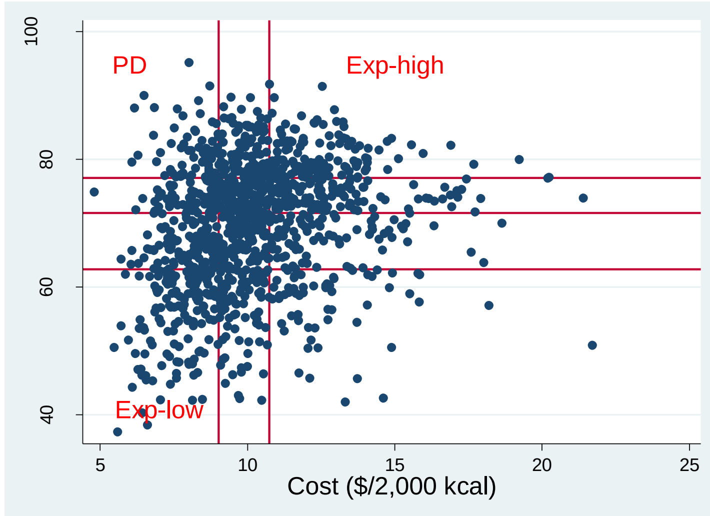


Figure 3A. Definition of positive deviant and comparison groups based on HEI quartiles and energy adjusted diet cost tertiles

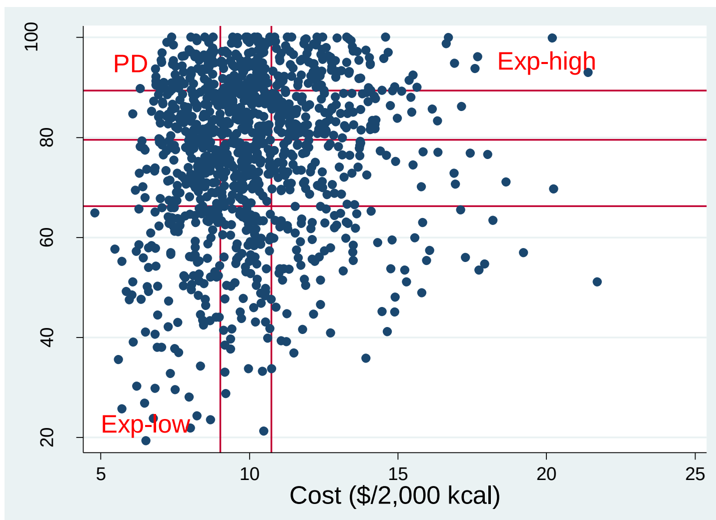


Figure 3B. Definition of positive deviant and comparison groups based on MAR quartiles and energy adjusted diet cost tertiles

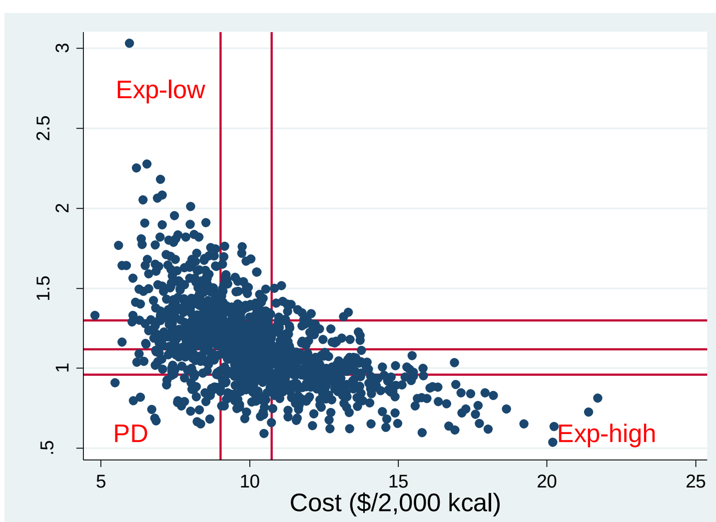


Figure 3C. Definition of positive deviant and comparison groups based on ED quartiles and energy adjusted diet cost tertiles

II. Characterizing positive deviants and comparison groups by key socio-demographics, dietary components, and food attitudes

Healthy Eating Index 2005

Table 4A shows the distribution of key socio-demographic variables for the PD, Exp-High, and Exp-Low groups based on HEI scores. Compared to the Exp-High group, PD were more likely to be male (36.4% compared to 16.0%), aged 65+ (39.4% compared to 22.7%), have high school education or less (18.2% compared to 6.7%), and have income less than $50,000 (47.0% compared to 28.6%). Compared to the Exp-Low group, PD were more likely to be female (63.6% compared to 46.0%), aged 65+ (39.4% compared to 33.6%), a college graduate or higher (56.1% compared to 43.8%), have income $100,000 or more (16.7% compared to 12.4%), and be married (54.6% compared to 47.5%).

Table 4A also shows the distribution of food attitudinal variables for PD, Exp-High, and Exp-Low groups based on HEI scores. Compared to the Exp-High group, PD were more likely to agree that it is important that foods are inexpensive (59.1% compared to 46.3%), but had similar rates of agreement that it is important for foods to be healthy (97.0% compared to 100.0%) and convenient (62.1% compared to 59.7%). Exp-High individuals were more likely to self-report "Very healthy" diet quality (35.3%) compared to PD (21.2%). Compared to the Exp-Low group, PD were slightly more likely to agree that it is important that foods are inexpensive (59.1% compared to 55.5%), more likely to agree that it is important that foods are healthy (97.0% compared to 81.7%), and equally likely to agree that it is important that foods be convenient (62.1% for both). Exp-Low individuals were more likely to self-report their diet quality as "Somewhat healthy" (54.7%) or "Not at all healthy" (13.1%) compared to PD (28.8% and 0%). 24.1% of individuals in the Exp-Low group self-reported a "Healthy" diet quality, and 8.0% self-reported "Very healthy".

Table 4A. Comparison of PD, Exp-High, and Exp-Low groups (based on HEI) by key socio-demographic and food attitude variables.

	High diet quality, low cost (Positive Deviants)		High diet quality, high cost (Expected-High)		Low diet quality, low cost (Expected-Low)	
n **Mean HEI (SD)** **(Min, Max)**	n=66 81.6 (3.9) (77.1, 95.1)		n=119 80.9 (3.1) (77.1, 91.8)		n=137 55.3 (6.1) (37.3, 62.8)	
Key Socio-demographics	**n**	**%**	**n**	**%**	**n**	**%**
Gender						
Male	24	36.4	19	16.0	74	54.0
Female	42	63.6	100	84.0	63	46.0
Age						
18-49	15	22.7	34	28.6	42	30.7
50-64	25	37.9	58	48.7	49	35.8
65+	26	39.4	27	22.7	46	33.6
Race/Ethnicity						
White	57	86.4	105	88.2	121	88.3
Other	9	13.6	14	11.8	16	11.7
Education						
High School or less	12	18.2	8	6.7	34	24.8
Some college	17	25.8	27	22.7	43	31.4
College graduate or higher	37	56.1	84	70.6	60	43.8
Income						
Less than $50,000	31	47.0	34	28.6	76	55.5
$50,000-99,999	24	36.4	45	37.8	44	32.1
$100,000 or more	11	16.7	40	33.6	17	12.4
Marital Status						
Married	36	54.6	65	54.6	65	47.5
Unmarried	30	45.5	54	45.4	72	52.6
Food Attitudes	**n**	**%**	**n**	**%**	**n**	**%**
Important that foods are inexpensive						
Agree	39	59.1	55	46.3	76	55.5
Neutral/disagree	27	40.9	64	53.8	61	44.5
Important that foods are healthy						
Agree	64	97.0	119	100.0	112	81.7
Neutral/disagree	2	3.0	0	0.0	25	18.3
Important that foods are convenient						
Agree	41	62.1	71	59.7	85	62.1
Neutral/disagree	25	37.9	48	40.3	52	38.0
Self-reported diet quality						
Not at all healthy	0	0.0	0	0.0	18	13.1
Somewhat healthy	19	28.8	18	15.1	75	54.7
Healthy	33	50.0	59	49.6	33	24.1
Very Healthy	14	21.2	42	35.3	11	8.0

Table 4B shows the HEI component scores for PD, Exp-High and Exp-Low groups based on HEI scores. Note that a higher score is generally associated with higher consumption, except for the 3 moderation components (saturated fat, sodium, and solid fats, alcohol, added sugar (SoFAAS)), where a higher score is associated with lower consumption. Compared to the Exp-High group, PD had lower total vegetable, dark green and orange vegetable, milk, and saturated fat scores, and higher total grains, whole grains, oils, and sodium scores. Compared to the Exp-Low group, PD had higher fruit, non-juice fruit, total vegetable, dark green and orange vegetable, whole grains, milk, oils, saturated fat, sodium and SoFAAS scores. PD did not have lower scores than Exp-Low for any components. These results are shown in graphical form in **Figure 4.**

Table 4B. Mean HEI component scores for PD, Exp-High and Exp-Low groups (based on HEI).

	High diet quality, low cost (Positive Deviants)	**High diet quality, high cost (Expected-High)**	**Low diet quality, low cost (Expected-Low)**
n **Mean HEI (SD)** **(Min, Max)**	n=66 81.6 (3.9) (77.1, 95.1)	n=119 80.9 (3.1) (77.1, 91.8)	n=137 55.3 (6.1) (37.3, 62.8)
HEI Component (Max score)	**Mean (SD)**	**Mean (SD)**	**Mean (SD)**
Total fruit (5)	4.60 (0.73)	4.86 (0.48)	2.51 (1.56)
Non-juice fruit (5)	4.76 (0.75)	4.97 (0.22)	2.80 (1.68)
Total vegetables (5)	4.12 (0.95)	4.89 (0.36)	3.30 (1.17)
Dark green/ orange vegetables (5)	3.65 (1.36)	4.65 (0.73)	1.91 (1.24)
Total grains (5)	4.38 (0.93)	3.80 (1.04)	4.09 (0.94)
Whole grains (5)	3.41 (1.45)	2.39 (1.45)	1.70 (1.34)
Milk including soy beverages (10)	7.08 (2.66)	8.09 (2.34)	6.16 (2.75)
Meat and beans (10)	9.47 (1.25)	9.64 (0.74)	9.06 (1.67)
Oils (10)	9.56 (1.05)	7.98 (2.09)	7.73 (2.33)
Saturated fat (10)	7.84 (1.62)	9.14 (1.00)	3.08 (2.92)
Sodium (10)	4.74 (1.96)	2.73 (2.07)	4.43 (2.43)
Solid fat, alcohol, added sugar (20)	18.0 (2.17)	17.8 (2.30)	8.54 (4.17)

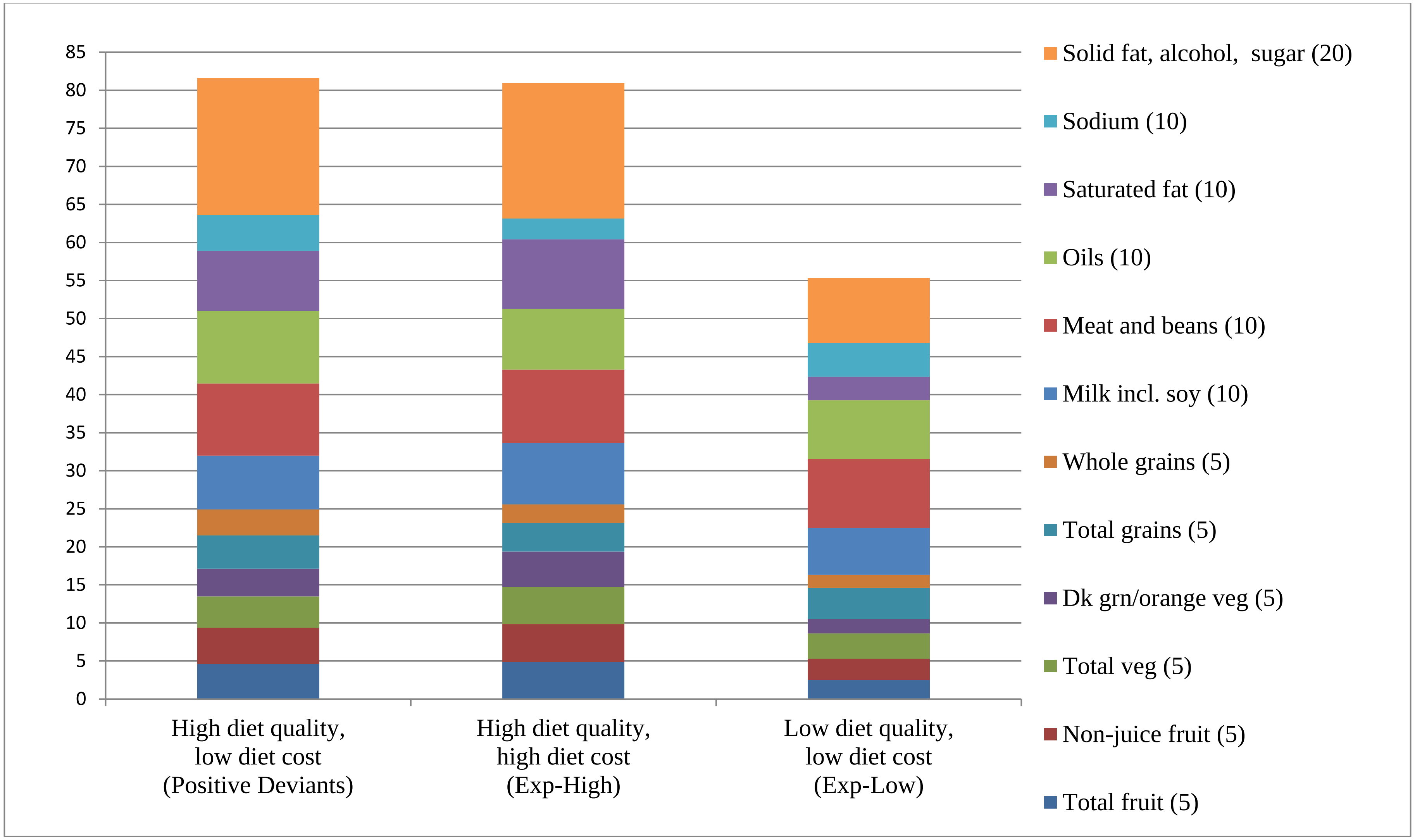
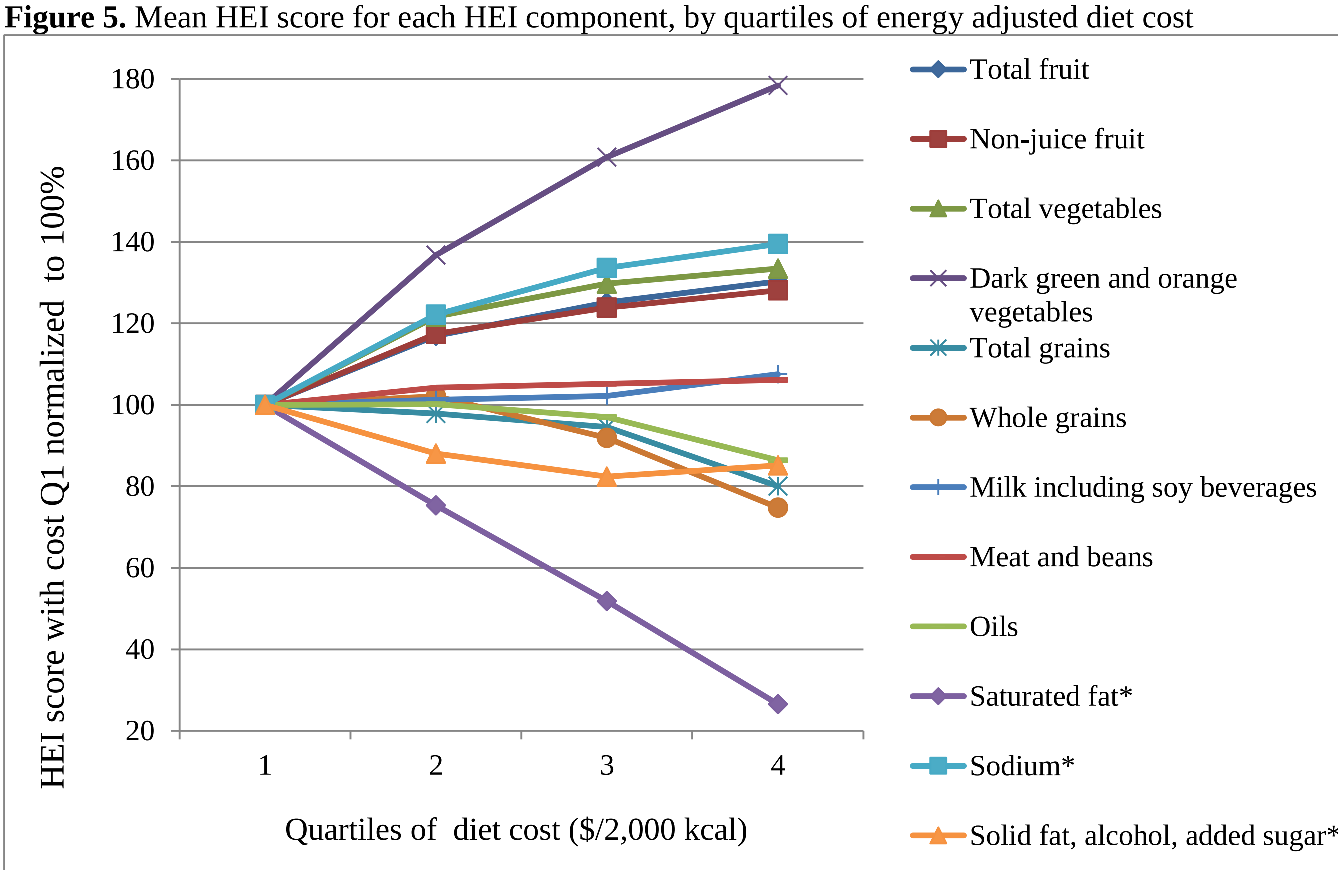


Figure 4. Mean HEI component scores for positive deviants and comparison groups (based on HEI).

Mean HEI component scores by diet cost quartiles, normalized to 100, are shown in **Figure 5.** Note that scores for saturated fats, sodium, and solid fat, alcohol, added sugar (SoFAAS) were reversed so the graph would better reflect consumption, as higher scores for these variables are associated with lower intake. The highest quartile of cost is associated with a significantly higher consumption of dark green and orange vegetables, and significantly lower consumption of saturated fats. The highest quartile of cost is associated with moderately higher consumption of sodium, total vegetables, total fruit, and non-juice fruit, and moderately lower consumption of oils, SoFAAS, total grains, and whole grains. Milk, meat and bean consumption increase only slightly with cost.

Figure 5. Mean HEI score for each HEI component, by quartiles of energy adjusted diet cost



*Scores for these moderation components were reversed, as higher scores are reflective of lower intake.

Mean Adequacy Ratio

Table 5A shows the distribution of key socio-demographic variables for the PD, Exp-High, and Exp-Low groups based on MAR. Compared to the Exp-High group, PD were more likely to be male (38.4% compared to 21.4%), aged 65+ (24.7% compared to 12.6%), have high school education or less (17.8% compared to 7.8%), and have income less than $50,000 (43.8% compared to 30.1%). Compared to the Exp-Low group, PD were more likely to be female (61.6% compared to 47.0%), aged 18-49 (43.8% compared to 21.4%), white (94.5% compared to 79.5%), a college graduate or higher (63.0% compared to 33.3%), have income $50,000-99.999 (34.3% compared to 22.2%), and be married (54.8% compared to 45.3%).

Table 5A also shows the distribution of food attitudinal variables for PD, Exp-High, and Exp-Low groups based on MAR. Compared to the Exp-High group, PD were more likely to agree it is important that foods are inexpensive (61.6% compared to 48.6%), equally likely to agree it is important that foods are healthy (97.2% compared to 99.0%), and more likely to agree it is important that foods be convenient (69.9% compared to 60.2%). Individuals in the Exp-High group were more likely to report "Very healthy" diet quality (34.0%) compared to PD (13.7%). Compared to the Exp-Low group, PD were equally likely to agree that it is important that foods are inexpensive (61.6% for both), more likely to agree that it is important that foods are healthy (97.2% compared to 86.3%), and equally likely to agree that it is important that foods are convenient (69.9% compared to 70.1%). Individuals in the Exp-Low group were more likely to self-report a "Somewhat healthy" (61.5%) or "Not at all healthy" (9.4%) diet quality, compared to PD (32.9% and 0.0%). 20.5% of individuals in the Exp-Low group self-reported a "Healthy" diet quality, and 8.6% self-reported "Very healthy".

Table 5A. Comparison of PD, Exp-High, and Exp-Low groups (based on MAR) by key sociodemographic and food attitude variables.

	High diet quality, low cost (Positive Deviants)		**High diet quality, high cost (Expected-High)**		**Low diet quality, low cost (Expected-Low)**	
n	n=73		n=103		n=117	
Mean MAR (SD)	94.2 (3.2)		95.0 (3.3)		52.1 (12.1)	
(Min, Max)	(50.7, 91.5)		(89.4, 100)		(19.3, 66.3)	
Key Socio-demographics	**n**	**%**	**n**	**%**	**n**	**%**
Gender						
Male	28	38.4	22	21.4	62	53.0
Female	45	61.6	81	78.6	55	47.0
Age						
18-49	32	43.8	42	40.8	25	21.4
50-64	23	31.5	48	46.6	41	35.0
65+	18	24.7	13	12.6	51	43.6
Race/Ethnicity						
White	69	94.5	94	91.3	93	79.5
Other	4	5.5	9	8.7	24	20.5
Education						
High School or less	13	17.8	8	7.8	37	31.6
Some college	14	19.2	23	22.3	41	35.0
College graduate or higher	46	63.0	72	69.9	39	33.3
Income						
Less than $50,000	32	43.8	31	30.1	73	62.4
$50,000-99,999	25	34.3	35	34.0	26	22.2
$100,000 or more	16	21.9	37	35.9	18	15.4
Marital Status						
Married	40	54.8	56	54.4	53	45.3
Unmarried	33	45.2	47	45.6	64	54.7
Food Attitude Variables	**n**	**%**	**n**	**%**	**n**	**%**
Important that foods are inexpensive						
Agree	45	61.6	50	48.6	72	61.5
Neutral/disagree	28	38.4	53	51.5	45	38.5
Important that foods are healthy						
Agree	71	97.2	102	99.0	101	86.3
Neutral/disagree	2	2.7	1	1.0	16	13.7
Important that foods are convenient						
Agree	51	69.9	62	60.2	82	70.1
Neutral/disagree	22	30.1	41	39.8	35	29.9
Self-reported diet quality						
Not at all healthy	0	0.0	0	0	11	9.4
Somewhat healthy	24	32.9	20	19.4	72	61.5
Healthy	39	53.4	48	46.6	24	20.5
Very Healthy	10	13.7	35	34.0	10	8.6

Table 5B shows the HEI component scores for PD, Exp-High and Exp-Low groups based on MAR. Note that a higher score is generally associated with higher consumption, except for the 3 moderation components (saturated fat, sodium, and solid fats, alcohol, added sugar (SoFAAS)), where a higher score is associated with lower consumption. Compared to the Exp-High group, PD had higher total grains, whole grains, oils, and sodium scores, and lower total vegetables, dark green and orange vegetables, and saturated fat scores. Compared to the Exp-Low group, PD had higher total fruit, non-juice fruit, milk, and SoFAAS scores, and no lower scores.

Table 5B. Mean HEI component scores for PD, Exp-High and Exp-Low groups (based on MAR).

	High diet quality, low cost (Positive Deviants)	**High diet quality, high cost (Expected-High)**	**Low diet quality, low cost (Expected-Low)**
n **Mean MAR (SD)** **(Min, Max)**	n=73 94.2 (3.2) (89.4, 100)	n=103 95.0 (3.3) (89.4, 100)	n=117 52.1 (12.1) (19.3, 66.3)
HEI Component (Max score)	**Mean (SD)**	**Mean (SD)**	**Mean (SD)**
Total fruit (5)	4.10 (1.20)	4.62 (0.80)	2.95 (1.69)
Non-juice fruit (5)	4.27 (1.09)	4.79 (0.68)	3.24 (1.74)
Total vegetables (5)	3.73 (1.04)	4.81 (0.45)	3.56 (1.25)
Dark green/orange vegetables (5)	2.91 (1.34)	4.41 (1.03)	2.29 (1.44)
Total grains (5)	4.21 (0.95)	3.54 (0.99)	4.41 (0.76)
Whole grains (5)	2.51 (1.55)	1.80 (1.26)	2.63 (1.65)
Milk including soy beverages (10)	7.89 (2.28)	8.24 (2.16)	5.33 (2.94)
Meat and beans (10)	9.24 (1.32)	9.66 (0.74)	9.21 (1.38)
Oils (10)	8.65 (1.73)	7.29 (2.25)	8.04 (2.29)
Saturated fat (10)	5.37 (3.14)	8.38 (1.91)	5.08 (3.24)
Sodium (10)	4.81 (1.73)	2.37 (1.87)	4.03 (2.46)
Solid fat, alcohol, added sugar (20)	14.1 (4.11)	15.7 (3.81)	11.7 (5.51)

Energy Density

Table 6A shows the distribution of key socio-demographic variables for the PD, Exp-High, and Exp-Low groups based on ED. Compared to the Exp-High group, PD were more likely to be male (39.4% compared to 29.2%), aged 65+ (36.4% compared to 23.0%), have high school education or less (42.4% compared to 9.6%), income less than $50,000 (63.6% compared to 27.5%), and be unmarried (66.7% compared to 48.3%). Compared to the Exp-Low group, PD were more likely to be female (60.6% compared to 55.3%), aged 50-64 (48.5% compared to 39.7%), have high-school education or less (42.4% compared to 21.2%), income less than $50,000 (63.6% compared to 46.4%), and be unmarried (66.7% compared to 45.8%).

Table 6A also shows the distribution of food attitudinal variables for PD, Exp-High, and Exp-Low groups based on ED. Compared to the Exp-High group, PD were equally likely to agree it is important that foods be inexpensive (48.5% compared to 47.2%), less likely to agree it is important for foods to be healthy (84.9% compared to 98.4%), and more likely to agree it is important that foods are convenient (72.7% compared to 50.6%). Exp-High individuals were more likely to self-report "Very healthy" diet quality (29.8%) compared to PD (12.1%). Compared to the Exp-Low group, PD are slightly less likely to agree it is important that foods are inexpensive (48.5% compared to 52.5%), less likely to agree it is important that foods are healthy (84.9% compared to 90.5%), and more likely to agree it is important that foods are convenient (72.7% compared to 59.2%). Exp-Low individuals are slightly more likely to report diet quality as "Somewhat healthy" (50.3%) compared to PD (48.5%), and slightly less likely to report diet quality as "Not at all healthy" (6.2%) compared to PD (9.1%). 29.6% of individuals in the Exp-Low group self-reported a "Healthy" diet quality, and 14.0% reported "Very healthy".

Table 6A. Comparison of PD, Exp-High, and Exp-Low groups (based on ED) by key socio-demographic and food attitude variables

	High diet quality, low cost (Positive Deviants)		High diet quality, high cost (Expected-High)		Low diet quality, low cost (Expected-Low)	
n	n=33		n=178		n=179	
Mean ED (SD)	0.82 (0.08)		0.84 (0.09)		1.54 (0.23)	
(Min, Max)	(0.65, 0.95)		(0.54, 0.96)		(1.30, 3.03)	
Key Socio-demographics	**n**	**%**	**n**	**%**	**n**	**%**
Gender						
Male	13	39.4	52	29.2	80	44.7
Female	20	60.6	126	70.8	99	55.3
Age						
18-49	5	15.2	42	23.6	53	29.6
50-64	16	48.5	95	53.4	71	39.7
65+	12	36.4	41	23.0	55	30.7
Race/Ethnicity						
White	28	84.9	156	87.6	154	86.0
Other	5	15.2	22	12.4	25	14.0
Education						
High School or less	14	42.4	17	9.6	38	21.2
Some college	6	18.2	48	27.0	53	29.6
College graduate or higher	13	39.4	113	63.5	88	49.2
Income						
Less than $50,000	21	63.6	49	27.5	83	46.4
$50,000-99,999	8	24.2	75	42.1	59	33.0
$100,000 or more	4	12.1	54	30.3	37	20.7
Marital Status						
Married	11	33.3	92	51.7	97	54.2
Unmarried	22	66.7	86	48.3	82	45.8
Food Attitudes	**n**	**%**	**n**	**%**	**n**	**%**
Important that foods are inexpensive						
Agree	16	48.5	84	47.2	94	52.5
Neutral/disagree	17	51.5	94	52.8	85	47.5
Important that foods are healthy						
Agree	28	84.9	175	98.4	162	90.5
Neutral/disagree	5	15.2	3	1.7	17	9.5
Important that foods are convenient						
Agree	24	72.7	90	50.6	106	59.2
Neutral/disagree	9	27.3	88	49.4	73	40.8
Self-reported diet quality						
Not at all healthy	3	9.1	0	0.0	11	6.2
Somewhat healthy	16	48.5	50	28.1	90	50.3
Healthy	10	30.3	75	42.1	53	29.6
Very Healthy	4	12.1	53	29.8	25	14.0

Table 6B shows the HEI component scores for PD, Exp-High and Exp-Low groups based on ED. Note that a higher score is generally associated with higher consumption, except for the 3 moderation components (saturated fat, sodium, and solid fats, alcohol, added sugar (SoFAAS)), where a higher score is associated with lower consumption. Compared to the Exp-High group, PD had lower fruit, non-juice fruit, total vegetables, dark green and orange vegetables, meat and beans, saturated fat, and SoFAAS scores, and higher milk and sodium scores. Compared to the Exp-Low group, PD had higher total fruit, milk, saturated fat, sodium and SoFAAS scores, and lower total grains, meat and beans, and oils scores.

Table 6B. Mean HEI component scores for PD, Exp-High and Exp-Low groups (based on ED).

	High diet quality, low cost (Positive Deviants)	**High diet quality, high cost (Expected-High)**	**Low diet quality, low cost (Expected-Low)**
n	n=33	n=178	n=179
Mean ED (SD)	0.82 (0.08)	0.84 (0.09)	1.54 (0.23)
(Min, Max)	(0.65, 0.95)	(0.54, 0.96)	(1.30, 3.03)
HEI Component (Max score)	**Mean (SD)**	**Mean (SD)**	**Mean (SD)**
Total fruit (5)	3.78 (1.60)	4.51 (1.06)	3.01 (1.52)
Non-juice fruit (5)	3.58 (1.70)	4.61 (1.01)	3.65 (1.54)
Total vegetables (5)	3.61 (1.25)	4.74 (0.70)	3.69 (1.10)
Dark green/orange vegetables (5)	2.73 (1.60)	4.43 (1.12)	2.57 (1.33)
Total grains (5)	3.25 (1.24)	3.25 (1.10)	4.45 (0.74)
Whole grains (5)	2.11 (1.70)	1.78 (1.34)	2.37 (1.56)
Milk including soy beverages (10)	8.16 (3.09)	7.52 (2.92)	5.36 (2.49)
Meat and beans (10)	8.20 (2.11)	9.36 (1.28)	9.46 (1.34)
Oils (10)	6.63 (2.51)	6.46 (2.46)	8.92 (1.82)
Saturated fat (10)	6.83 (3.29)	9.10 (1.31)	4.14 (3.05)
Sodium (10)	5.29 (2.41)	2.86 (2.46)	4.10 (2.25)
Solid fat, alcohol, added sugar (20)	13.2 (6.72)	14.5 (5.35)	12.5 (4.49)

DISCUSSION

This is the first study to our knowledge to apply the positive deviance model to identify ways to achieve a healthier diet at lower cost in the US. There were many significant findings.

Healthy Eating Index-2005

Significant differences in HEI score were seen across gender, education, income, marital status, and diet cost. Consistent with previous research findings, females and individuals who are married and have higher diet cost, income and education had higher HEI scores [26,41]. Contrary to previous research, age and race were not associated with HEI in this analysis [41].

Based on HEI scores, there were 66 positive deviants in this sample who were able to achieve higher diet quality at lower cost. There were also 119 individuals achieving higher diet quality but at higher cost, and 137 individuals with lower diet quality at lower cost. PD constituted only 5.9% of the population, indicating that while possible, it is uncommon to have a higher diet quality at lower cost.

Compared to people with lower diet quality and lower cost, PD were more likely to be female, aged 65+, have higher income and education, and be married. Positive food attitudes were also associated with diet quality, as PD were 15% more likely to place importance in the nutritive value of foods compared to persons with the same diet cost but low diet quality (Exp-Low). This suggests that there are behaviors associated with having a positive attitude toward the healthfulness of food that contribute to the ability of PD to achieve a higher diet quality at lower cost. These findings are similar to previous research, which has shown that positive food attitudes are associated with higher HEI scores [48].

Figure 4 shows that compared to the Exp-Low group, PD consumed a higher amount of total fruit, non-juice fruit, total vegetables, dark green/orange vegetables, whole grains, milk, and oils, and less saturated fat and SoFAAS. Following this dietary pattern allows PD to achieve higher diet quality without increasing diet cost. Based on this information, we can make food group based recommendations on how to eat well at lower cost.

Interestingly, despite differences in diet cost, the PD and Exp-High groups have similar HEI component scores. This indicates that there is some difference in dietary intake beyond food group choices that allow the positive deviants to eat a similar diet to the Exp-High group, but at significantly lower cost. Future research should analyze FFQ data in order to determine what specific foods each group is consuming. This would allow recommendations to be made on the substitution of specific foods within food groups in order to decrease diet cost while maintain high diet quality.

Figure 5 shows that there is a drastic increase in consumption of dark green and orange vegetables as cost increases, mirrored by a drastic decrease in saturated fat consumption. These findings are consistent with previous research [7,41,46]. Increasing intake of dark green and orange vegetables, and decreasing intake of saturated fats might be more expensive ways to increase HEI diet quality. However, the mean HEI component score for dark green and orange vegetables was nearly twice as high for PD compared to Exp-Low, even though they have the same diet cost. This suggests that one way to increase diet quality without increasing diet cost is to select lower priced foods within food groups (such as broccoli instead of kale, and carrots instead of butternut squash).

To a lesser extent, sodium, total vegetables, total fruit and non-juice fruit scores also increase with cost, while total grains, whole grains, oils, and SoFAAS decrease with cost. These findings are consistent with previous research [7,41,46]. This suggests that another way to increase HEI score without increasing diet cost is to increase consumption of healthy foods that are not associated with high cost, such as fruits and non-dark green and orange vegetables, and decreasing consumption of grains and SoFAAS may be more cost effective recommendations for increasing diet quality.

Mean Adequacy Ratio

Significant differences in MAR score were seen across gender, age, race, education, income, and diet cost. Previous studies have also found that females with higher education, higher income, and higher diet cost tend to have higher diet quality [26,45-47].

Based on MAR scores, there were 73 positive deviants in this sample who were able to achieve higher diet quality at lower cost. Again, the PD constituted a very small portion of the population (6.6%). There were 103 individuals achieving higher diet quality but at higher cost, and 117 individuals with lower diet quality at lower cost.

Compared to people with lower diet quality and lower cost, PD were more likely to be female, aged 18-49, white, have higher income and education, and be married. Positive food attitudes were also associated with diet quality, as PD were 11% more likely to place importance in the nutritive value of foods compared to persons with the same diet cost but low diet quality (Exp-Low). Again, the mindset that it is important for foods to be healthy likely contributed to PD being able to achieve higher diet quality without increasing cost. These findings are consistent with previous research [49].

Compared to the Exp-Low group, PD consumed a higher amount of total fruit, non-juice fruit, and milk, and less saturated fat and SoFAAS. PD also consumed slightly more total vegetables, dark green and orange vegetables, and oils, although the differences are not as great as seen in the groups defined by HEI scores. Contrary to the results of the HEI groups, MAR PD actually consume slightly less total grains and whole grains that Exp-Low individuals. By following these dietary patterns, it is possible to increase MAR without increasing cost.

Energy Density

Of the three measures of diet quality, socio-demographics showed the lowest association with ED. In this analysis, significant differences in ED were seen only by gender, age, and diet cost. These results were consistent with previous research which found that women typically consume diets of lower energy density [42] and that low energy density diets are associated with higher cost [43], but contrary to other research which has shown associations between ED and education, income, and race [26,43-46].

Based on ED, there were 33 positive deviants in this sample who were able to achieve higher diet quality at lower cost. The lower proportion of positive deviants (3.3%) indicates that it is even more difficult to achieve higher diet quality at lower cost when ED is the measure of diet quality. There were also 178 individuals achieving higher diet quality but at higher cost, and 179 individuals with lower diet quality at lower cost.

Compared to people with lower diet quality and lower cost, PD were more likely to be female (although the trend is not as strong as with HEI and MAR), and aged 50-64. Contrary to the groups defined by other measures of diet quality, ED PD were more likely to have lower education (high school or less), lower income (less than $50,000), and be unmarried. In designing future dietary interventions, it will be important to recognize that the target audience will be different depending on which measure of diet quality is being used as the health outcome.

Also contrary to the HEI and MAR results, ED PD were actually 6% less likely to place importance food being health, but were 13% more like to place importance on food being convenient. These findings were not in agreement with previous research, which found that positive food attitudes are associated with lower energy density [49].

Compared to the Exp-Low group, PD consumed more total fruit, milk, saturated fat, sodium and SoFAAS scores, and less total grains, meat and beans, and oils. Following this dietary pattern allows PD to achieve lower ED at lower diet cost. Based on this information, we can make food group based recommendations on how to eat well without paying more.

Assumptions and Limitations

The present study had limitations. The exclusion of cell phones numbers from the sampling scheme may introduce biases. Estimates of nutrient intakes and diet cost were each based on FFQs, which has known biases [50-52]. However, the FFQ is a useful tool to make comparisons across subjects and has been widely used in nutritional epidemiological studies. The present study was based on cross sectional data, so associations observed between socio-demographics, food attitudes, and diet quality intakes cannot be causally interpreted. Also, despite oversampling of low income and racially diverse areas, this sample population had a high proportion of individuals with higher income and higher education, as this is the socio-demographic make-up of Seattle. The relationships seen here between socio-demographics and diet quality and cost may have been even stronger had the sample been more representative of lower SES individuals. Further research should be conducted to identify positive deviants and their behaviors in more varied samples. Lastly, multivariate regression is needed to test for persistence of trends after adjusting for possible confounding variables.

However, this study also has several strengths. While many studies have looked at connections between demographics and diet quality, few if any have used multiple measures of diet quality for the same population. There are also relatively few studies that use the positive deviance model to study nutrition in developed countries, and none to our knowledge that use positive deviance to determine the relationship between diet cost, food attitudes and diet quality.

CONCLUSIONS

This study had several significant findings. First, gender and diet cost were the only variables that were associated with diet quality across all three measures of diet quality. Furthermore, the socio-demographic distribution of individuals with high diet quality at low cost (PD), high diet quality at high cost (Exp-High), and low diet quality at low cost (Exp-Low) varied depending on the measure of diet quality that is being observed (HEI, MAR or ED). This should be taken into consideration in planning future dietary interventions, as the target groups will change depending on the intervention aims.

Second, despite changes in diet cost there was little difference in HEI component scores among individuals with high diet quality. This indicates that it is possible to achieve a high HEI score at low cost by making substitutions within food groups—i.e. choosing less expensive options within food groups that are generally associated with higher cost (such as dark green and orange vegetables). Among people with low diet cost, individuals who were able to achieve high diet quality consumed more fruits, vegetables, and whole grains, and fewer saturated fats, and SoFAAS compared to those with low diet quality. This indicates that another way to increase diet quality without increasing diet cost is to alter dietary intake of foods that are not associated with high cost—such as increasing fruit, non-dark green and orange vegetables, whole grains, milk, meat and beans, and decreasing consumption of SoFAAS.

Third, among individuals with low diet cost, those with high diet quality place more importance on foods being healthy compared to those with low diet quality. This indicates that another important strategy for improving diet quality is providing nutrition education in order to increase the belief that it is important for foods to be healthy.

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