Published in final edited form as:

J Epidemiol Community Health. 2012 June ; 66(6): 530–535. doi:10.1136/jech.2010.122333.

Are socioeconomic disparities in diet quality explained by diet cost?

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Abstract

Background—Socioeconomic disparities in nutrition are well documented. This study tested the hypothesis that socioeconomic differences in nutrient intakes can be accounted for, in part, by diet cost.

Methods—A representative sample of 1,295 adults in King County (WA) was surveyed in 2008–2009 and usual dietary intakes were assessed based on a food frequency questionnaire (FFQ). Monetary value of individual diets was estimated using local retail supermarket prices for 384 foods. Nutrients of concern as identified by the 2005 Dietary Guidelines Advisory Committee were fiber, vitamins A, C and E, calcium, magnesium and potassium. A nutrient density score based on all seven nutrients was another dependent measure. General linear models and linear regressions were used to examine associations among education and income, nutrient density measure and diet cost. Analyses were conducted in 2009–2010.

Results—Controlling for energy and other covariates, higher-cost diets were significantly higher in all seven nutrients and in overall nutrient density. Higher education and income were positively and significantly associated with the nutrient density measure, but these effects were greatly attenuated with the inclusion of the cost variable in the model.

Conclusions—Socioeconomic differences in nutrient intake can be substantially explained by the monetary cost of the diet. The higher cost of more nutritious diets may contribute to socioeconomic disparities in health and should be taken into account in the formulation of nutrition and public health policy.

Key words or phrases

food prices; diet cost; nutrient density; diet quality; inequalities

INTRODUCTION

Socioeconomic disparities in health are well documented [1, 2]. Studies have shown consistent associations between low education and income levels and higher rates of obesity, type II diabetes, and coronary heart disease [2, 3]. These health inequalities may be explained, in part, by differences in lifestyle habits and in the nutritional quality of the diet [4, 5]. In several studies, higher socioeconomic position (SEP) was associated with higher

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Competing Interests: None declared

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consumption of fruits and vegetables [6–10] and whole grains [10] and higher intakes of micronutrients [10, 11] and dietary fiber [10, 11]. In a multi-year, nationally representative sample of adults in the US, higher education and incomes were associated with diets that were lower in energy density with higher in vitamin A, calcium and potassium [7].

Vitamin A, calcium and potassium were among seven nutrients of public health concern identified by the 2005 Dietary Guidelines Advisory Committee (DGAC). Along with vitamins C, E, magnesium and fiber, these nutrients were each linked to indicators of nutrient adequacy or disease prevalence and were consumed in inadequate amounts by the general public [12]. The 2005 DGAC Report recommended efforts to increase intakes of these nutrients, emphasizing the importance of obtaining nutrients from foods rather than supplements. However, the DGAC also recognized that a number of factors, including economic constraints might limit access to the best food sources of these nutrients, such as fruits and vegetables [12].

Understanding individual and community level barriers to adopting healthy diets is essential to reducing socioeconomic disparities in diet quality [13–15]. Poverty has been associated with greater distances to supermarkets and other food outlets that offer nutritious foods [14, 16, 17]. Within the supermarket, the lack of money may impose further barriers. Studies have shown that nutrient rich foods cost more per calorie than do energy dense foods of minimal nutritional value [18]. Furthermore, the relative prices of healthy foods, notably vegetables and fruit, have increased to a greater extent over time than prices for refined grains, added sugars and fats [19, 20].

If the relatively high cost of nutritious foods contributes to observed socioeconomic disparities in nutrition then the associations of SEP with dietary nutrient intake would be attenuated once diet costs are taken into account. The present focus was socioeconomic differences in the intake of seven nutrients of concern in the American diet and the importance of the monetary value of food in explaining these differences.

METHODS

Participant sample

Analyses were based on data from the Seattle Obesity Study (S.O.S.), a population-based study of food access, diet quality, and health among adults in King County, WA, USA. The sampling and survey methods were similar to those used in the Behavioral Risk Factor Surveillance System (BRFSS) for WA state. Telephone survey respondents were contacted using a sampling scheme stratified by income range and race/ethnicity. Sampling was geographically based among five strata defined in terms of household income and percent African American and Hispanic. Strata with lower income and higher proportion of African Americans and Hispanics were over-sampled. Randomly selected telephone numbers were matched with household addresses using commercial databases. Once a household was contacted, an adult (>18y) member of the household was randomly selected to be the survey respondent. A 20 min telephone survey was administered by trained and computer assisted interviewers to respondents. The S.O.S sample of 2001 adults was demographically comparable to the 2007 BRFSS data for King County and was representative of the county population as compared to data from the 2000 US Census. Like the nationwide BRFSS sample, the present sample was disproportionately composed of women (1235/2001, 61.7%). Of the 2,001 men and women who completed the telephone survey, 1,909 were sent FFQs.

Of these, 1,318 completed the FFQs, a response rate of 69.2%. Twenty-three completed FFQs were excluded based on extreme energy intakes (<2.1 MJ/day, > 20.9 MJ/day) leaving

a final analytic sample of 1295 (825 women and 470 men). Those who completed the study received remuneration for their participation. All recruitment and study procedures were approved by the Human Subjects Division, the institutional review board for the University of Washington.

Demographic and socioeconomic measures

Self reported data on gender, age, race/ethnicity, and household size were obtained during the phone interview. Race was recoded into four categories (white, black, Asian and all others) for analysis. Highest level of education attained was grouped into 3 strata (see results) and household incomes, reported in 12 categories (<\$15,000 to >\$175,000), were regrouped into 5 strata (see results). Strata were selected prior to analyses to have a substantial spread in the variables of interest (education and income) and still provide sufficient sample size within each stratum. Household size was a continuous variable and included all adults and children residing in the respondent's household.

Dietary intake assessment

The FFQ used in this study has been used previously in a number of large studies of population health and disease risk [21–24]. Participants recorded the frequency of consumption of 152 line-item foods and beverages and indicated portion size. Respondents returned the completed FFQs to the investigators by mail. The completed FFQs were reviewed, checked for errors and processed using the nutrient database at the Nutrition Coordinating Center at the University of Minnesota [23]. Nutrient composition analyses of dietary intake data yielded dietary energy (MJ, kcal), the weight of foods, beverages, and drinking water (g), and the estimated daily intakes of over 45 macro- and micronutrients. Energy density and nutrient content of the diet were estimated based on all foods and beverages, caloric and non-caloric, but excluding drinking water. Aside from analyses of vitamins A, C, E, calcium, magnesium, potassium and fiber, a nutrient density variable based on these seven nutrients was computed. The nutrient density was defined as the mean percent daily value for all seven nutrients in 8.4 MJ (2000 kcal) of dietary energy. The following formula was used to compute this variable:

$$\text{Nutrient Density} = \frac{\sum_{i=1}^7 \text{ratio}_i}{7} * 100$$

Where, for nutrient i :

$$\text{ratio}_i = \left\{ \frac{\text{intake}_i}{\text{DV}_i} \right\}$$

Ratio _{i} is the intake of nutrient i in adjusted for 8.4 MJ of dietary energy divided by the daily value for that nutrient (DV _{i}), based on 8.4 MJ (see Table 2 for DVs)[25].

Monetary value of diets

The monetary value of the reported diets was estimated by attaching a food price vector to the nutrient composition database as described previously [26, 27]. Retail prices for each of the 384 component food items in the FFQ were obtained using standardized and published price collection methods [19]. The prices were collected from three supermarket chains in Seattle contemporaneously with the dietary survey. All food prices were adjusted for preparation and waste using a standard USDA reference [28], and were expressed in dollars

per 100g, edible portion. The variable associated with each individual's diet was the monetary value per day (\$/d).

Statistical analysis

Descriptive statistics were used to characterize the energy and nutrient characteristics of dietary intakes among demographic strata. General linear models (GLM) were used to provide covariate-adjusted means of nutrient intakes among strata of diet cost. Covariates in these models were dietary energy and the respondent's age and gender. GLM was also used to provide covariate-adjusted means of diet cost and nutrient intakes among strata of educational attainment and household income. Covariates for these analyses were dietary energy, age, gender, and race. Analyses of income also adjusted for household size. In the analyses of nutrient intakes, these covariates were included in one model. A second GLM also included the diet cost variable as a continuous covariate. A comparison of models with and without diet cost adjustment provided evidence regarding the role of this variable in mediating socioeconomic differences in nutrient intake. All analyses were conducted using SPSS 18.0 for Mac (IBM, Chicago, IL).

RESULTS

Mean age was 56.8 y for women and 56.5 y for men. Eighty-five percent of men and women identified themselves as white. The rest were Asian (7.2% of women, 6.7% of men); black (4.5% of women, 4.3% of men). All other races made up 1.4% of the sample. Most women and men had completed a bachelor's degree or higher (56.5 and 58.4%, respectively). Household incomes corresponded to median incomes of King County (62.3% reported incomes above \$50,000/year). Demographic and socioeconomic characteristics data are summarized in Table 1.

Energy and nutrient intakes

Mean intakes of dietary energy and seven nutrient of concern are summarized in Table 2. Women consumed fewer calories than men, 7.1 MJ/d (1700 kcal) versus 8.3 MJ/d (1,982 kcal). Men generally had higher crude nutrient intakes but, with the exception of vitamin C, intakes for both men and women fell short of the daily values for a 8.4 MJ diet. Gender-specific means of a nutrient density variable were computed to summarize the average attainment of recommended intakes for all seven nutrients. Although men had higher crude intakes for most of the individual nutrients, women had more nutrient-dense diets overall than did men. Table 2 also shows the estimated mean monetary diet cost (\$/day) for women and men. The monetary value of the diet was higher for men than women, corresponding in part to the higher quantity of food consumed.

Nutrient intakes and monetary value of the diet

Table 3 shows covariate-adjusted mean and 95% confidence intervals for nutrient levels across quintiles of diet cost. Nutrient levels were adjusted for dietary energy and respondents' age and gender. Diets in the top quintile of diet cost were higher in all seven nutrients. This relation was significant for all seven nutrients tested and for the composite measure of nutrient density

Socioeconomic position, dietary nutrient density and monetary value

The relations of diet cost with indicators of SEP were explored using GLM to control for total energy intake and other covariates. Figure 1 shows the association between diet cost and education (a) and income (b). Mean diet cost was higher in persons with higher educational attainment and higher household income. Persons with the lowest educational

attainment had a mean diet cost that was \$1.09/day lower than that of persons in the highest group (\$8.19 versus \$9.28, p trend < 0.001). Differences in diet cost were slightly larger across household income groups. The mean diet cost of the lowest income group was \$1.37 lower than the diet cost in the highest income group (\$8.36 versus \$9.73, p trend < 0.001).

The hypothesis that diet cost could explain some of the observed socioeconomic gradients in dietary nutrient density was evaluated using GLM. Figure 2 shows the covariate-adjusted means in dietary nutrient density among levels of education (**a**) and household income (**b**). Data points in black indicate nutrient density of diets adjusted for dietary energy intake, age, gender and other covariates. Persons with the highest educational attainment reported diets that were 11.5 percentage points higher in nutrient density than diets reported by the lowest group (Mean of 95.7 versus 84.2%, p trend < 0.001). Differences by household income also were evident. Persons in the highest income group had diets that were 9.3 points higher in nutrient density than the diets of those in the lowest group (96.6 versus 87.3%, p trend = 0.003). Introducing the diet cost variable into the models reduced these differences for both SEP variables (gray data points). The difference in dietary nutrient density between highest and lowest education levels was 5.3 percentage points (94.3 versus 89.0%, p trend = 0.012). Adjusting for diet cost attenuated the income trend more strongly. The difference between highest and lowest income groups was 1.4 percentage points (93.0 versus 91.6%, p trend = 0.618).

DISCUSSION

Socioeconomic disparities in health have an established dietary component [4, 29]. Moreover, diet quality, whether defined by nutrient intake or particular patterns of food consumption, has been shown to follow socioeconomic gradients [7, 30, 31]. The present findings indicate that such gradients can be substantially explained by diet cost, defined here as the monetary value of the diet.

Despite a long-term concern over social disparities in nutrition and health, studies on the relation between diet quality and cost are still outside the mainstream research in public health nutrition. A lack of available data has been a barrier to this line of research. On one hand, labor and agricultural economists have studied food prices and food expenditures, typically collecting data at the household level [32, 33]. On the other hand, public health professionals have collected data on diet quality and health outcomes at the individual level. Whereas economists lack data on foods consumed, nutrition scientists lack information on the monetary cost of foods consumed.

Without data on food expenditures, nutrition scientists have estimated dietary cost by applying retail food prices to diet records, diet history questionnaires and food frequency questionnaires. Studies from Japan [34, 35] and Europe [36–39] have shown that higher-cost diets are higher in nutritional quality [34, 36, 38, 39] and are associated with lower body mass index [34, 36, 40]. Fewer studies have examined food prices and diet cost in the context of socioeconomic disparities in nutrition.

For persons with a low income or low level of educational attainment, food prices and limited budgets can constrain the purchase and consumption of nutritious foods [9, 41–43]. Those observations, together with the findings reported here lead to the suggestion that diet cost is a mediating variable between SEP and diet quality. A mediating variable, by definition, explains at least some of the observed association between an exposure (e.g., indicators of SEP) and an outcome (e.g., nutrient density of the diet) [44], and when controlled for statistically through adjustment (shown in Fig 2), biases the main exposure-outcome association toward the null [45].

Limitations

Several design and methodological factors limited this study. First, the major purpose of this study was to explore diet cost as part of a causal pathway to diet quality. However, conclusions of causality or determinants of health behaviors are limited in cross-sectional studies [44]. Second, while the present sample of adults was representative of King County, WA, USA, it was not representative the US population overall. The sample was mostly white and non-Hispanic, more highly educated and with higher household incomes than the US population generally. Third, nutrient and monetary estimates were derived from a FFQ, an instrument that is subject to known biases [46–48], and monetary estimates were limited by the validity of the prices that were used in the database. As described previously [19, 27], the database was composed of 384 retail prices from three local, supermarket chains in the Seattle metropolitan area.

While these food prices may not have reflected those actually paid by respondents in this study, 65% of respondents did shop at the three supermarket chains as their primary or secondary food source. It should also be noted that convenience stores, corner stores and other specialty stores, which may have had higher food prices [49, 50], were not a major source of food in the present sample. Most respondents (93%) reported shopping at large supermarket and grocery store chains as their primary and/or secondary food sources. Nevertheless, the cost variable used in the present study should not be viewed as an estimate of food expenditure, but rather an estimate of the intrinsic monetary value of the diet, based on retail food prices.

Conclusions

If socioeconomic differences in diet quality and nutrient intake are related to the cost of food, then food prices should be viewed as a critical component of the greater economic environment, which is a recognized determinant of health [51]. Public health initiatives to promote the consumption of shortfall nutrients and address disparities in nutrition should be mindful of the economic hierarchy the food supply, in which calories are inexpensive but vitamins and minerals are costly [19, 52, 53]. At the same time, more research is needed to better understand how cost constraints affect food choices and diet quality in different demographic and socioeconomic strata.

Acknowledgments

The authors thank Theresa Hastert and Colin Rehm for their comments on earlier versions of this manuscript.

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What is already known?

Socioeconomic disparities in diet patterns and nutrient intake are well documented. However, little is known about the extent to which those disparities are driven by the higher monetary cost of nutritious foods.

What this study adds

This study found that the more nutritious diets were associated with higher diet cost. Moreover, socioeconomic disparities in diet quality were attenuated when the cost of the diet was taken into account. If diet costs can explain disparities in diet quality, then public health efforts to improve diet quality in vulnerable populations must move beyond simply emphasizing education and motivation. Economic and food systems interventions may be needed as well.

Figure 1.

Covariate-adjusted mean and 95% confidence intervals of diet cost in \$/day among persons of different educational attainment (**a**) and household income (**b**). For both analyses, means were adjusted for dietary energy and respondent's age, gender and race. For the analysis of household income, means are also adjusted for household size. Asterisks indicates significant test for linear trend across groups ($p < 0.001$).

Figure 2.

Covariate-adjusted mean and 95% confidence intervals of nutrient density of dietary intakes among persons of different educational attainment (**a**) and household income (**b**). Means adjusted for dietary energy and respondent's age, race, gender and household size. Nutrient density is the mean percent daily value for seven nutrients: vitamins A, C, E, calcium, magnesium, potassium and fiber. Shown are means adjusted for standard covariates (black points) and means adjusted for standard covariates and diet cost (gray points). Significance for linear trend across groups indicated by *** ($p < 0.001$); ** ($p = 0.003$); * ($p = 0.012$).

Table 1

Demographic and socioeconomic characteristics of sample

	Women	Men	Total
n =	825	470	1295
Age (years)	56.8 ± 0.5	56.5 ± 0.6	56.7 ± 0.4
% non-Hispanic white	85.1	85.1	85.1
% earning \$50,000/y	60.3	65.6	62.3
% with college (4 yr) degree	58.5	57.2	57.7

Table 2

Crude means and standard errors of dietary attributes by gender

n =	Women 825	Men 470	Total 1295	DV^a
Energy (MJ)	7.1 ± 0.1	8.3 ± 0.2	7.5 ± 0.1	8.4
Vitamin A (µg, RAE)	989 ± 22	894 ± 29	955 ± 17	1500
Vitamin C (mg)	111 ± 3	107 ± 3	110 ± 2	60
Vitamin E (mg)	13.8 ± 0.3	14.4 ± 0.4	14.0 ± 0.2	30
Calcium (mg)	905 ± 17	907 ± 24	906 ± 14	1000
Magnesium (mg)	296 ± 4	314 ± 6	303 ± 4	400
Potassium (mg)	2781 ± 41	2914 ± 56	2829 ± 33	3500
Dietary Fiber (g)	19.3 ± 0.3	18.9 ± 0.4	19.2 ± 0.3	25
Nutrient Density 7 (mean % DV) ^b	99.8 ± 1.1	84.9 ± 1.2	94.4 ± 0.8	
Monetary value of diet (\$/day)	8.75 ± 0.13	9.45 ± 0.19	9.01 ± 0.11	

Dietary attributes include all foods and beverages except drinking water.

^aDV, Daily Values for each nutrient, based on 8.4 MJ (2000 kcal) for adults and children 4y (from reference [25]).^bNutrient density computed as mean percent of daily values for vitamins A, C E, calcium, magnesium, potassium and fiber, based on 8.4 MJ of dietary energy.

Table 3
Adjusted means and 95% confidence intervals of nutrient intakes by quintile of diet cost. All subjects (n=1295)

n =	I		II		III		IV		V		P trend
	Mean	95% CI	Mean	95% CI	Mean	95% CI	Mean	95% CI	Mean	95% CI	
Diet cost (\$/day)	5.7	5.5, 5.9	7.42	7.2, 7.6	8.6	8.4, 8.8	10.08	9.9, 10.2	13.43	13.2, 13.7	<0.001
Vitamin A (µg, RAE)	650	567, 733	780	712, 849	901	836, 965	1064	995, 1132	1281	1191, 1370	<0.001
Vitamin C (mg)	63	53, 73	91	82, 99	104	96, 112	126	118, 135	162	152, 173	<0.001
Vitamin E (mg)	7.9	7.2, 8.6	8.3	7.7, 9	9.6	9.1, 10.2	9.6	9, 10.2	11	10.2, 11.8	<0.001
Calcium (mg)	824	768, 881	863	816, 909	873	829, 918	896	849, 943	984	923, 1045	0.002
Magnesium (mg)	247	237, 257	276	268, 285	293	285, 301	314	306, 323	372	361, 384	<0.001
Potassium (mg)	2196	2102, 2289	2531	2454, 2608	2754	2681, 2827	3000	2922, 3077	3576	3475, 3677	<0.001
Dietary Fiber (g)	14.4	13.4, 15.3	16.9	16.2, 17.7	18.4	17.6, 19.1	20.2	19.4, 21.0	24.4	23.4, 25.4	<0.001
Nutrient Density ^a (mean % daily value) ^a	68.5	65.6, 71.4	76.9	74.5, 79.3	82.4	80.1, 84.7	86.3	83.9, 88.7	99.4	96.2, 102.6	<0.001

Means adjusted in separate general linear models containing dietary energy and respondent's age and gender as covariates.

^a Nutrient density based on vitamins A, C, E, calcium, magnesium, potassium and fiber.