Public Health Nutrition: 23(18), 3284–3294 doi:10.1017/S1368980020001615

The effect of time use and food cost on dietary quality

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Submitted 21 October 2019: Final revision received 17 February 2020: Accepted 27 April 2020: First published online 13 July 2020

Abstract

Objective: To develop a questionnaire to measure food nutrition, food expenditures and time spent in food-related activities; and to assess the association between diet quality, time spent in food-related activities and food expenditures using data from a pilot study.

Design: Cross-sectional study. Multiple linear regression models were used to analyse participants' survey response behaviours and the relationship between food nutritional quality and time and money expenditures.

Setting: Online survey using Qualtrics software in a public university located in West Texas, USA.

Participants: Faculty and staff aged 18 years and older from a public university located in West Texas, USA

Results: Combining questions from three survey instruments that collect data on food nutrition, food expenditures and time spent in food-related activities resulted in a thirty-page survey instrument. The median completion time of the survey instrument was about 30 min. Preliminary results suggest that time and money expenditures are associated with food quality but that their role is small relative to sociodemographic characteristics such as race and gender.

Conclusions: Time and money expenditures are associated with food quality but their role is small relative to sociodemographic characteristics such as race and gender.

Keywords
Diet quality
Time use
Food cost
Healthy Eating Index

According to the Centers for Disease Control and Prevention, more than half of American adults – six in ten adults in the USA – have one or more chronic diseases[1]. Many of these, including CVD, high blood pressure, type 2 diabetes, some cancers, and chronic lung and kidney disease, are related to poor diet quality[1]. Concurrent with these persistently high levels of obesity and chronic diseases, trends in food intake over time reflect poor eating choices[2]. Data from the National Health and Nutrition Examination Survey (NHANES) show that, in the 2015–2016 NHANES, Healthy Eating Index-2015 (HEI-2015) Scores, a measure of how food choices align with United States Department of Agriculture (USDA) Dietary Guidelines, have remained below fifty-nine out of 100 possible points[3]. In addition, too many energies, added sugars, and saturated fats and too few whole grains, fruits, and vegetables are consumed, according to the USDA[2].

Research has shown that food choices are influenced by many factors. These include prices and income, time constraints, environmental factors such as the proximity of grocery stores and restaurants, community characteristics, family structure, psychological factors, nutritional information and participation in Federal food and nutrition assistance programmes[4]. Current studies indicate that factors related to total food expenditures and time use are major determinants of diet quality[5–8].

Research papers in the nutritional sciences, economics and time use fields often tackle the same issues but do so independently of each other. Nutritional scientists focus on detailed dietary data to assess diet quality. Economists focus on the effects of prices and income on food purchases and consumption. Time use researchers examine how people spend their time on various activities, including time spent preparing and eating food.

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https://doi.org/10.1017/S1368980020001615 Published online by Cambridge University Press

From the best of the authors' knowledge, no previous study has explored the relationships between time and money expenditures and food nutritional quality jointly. Aguiar and Hurst estimated a household production function with time and money on the right-hand side of the equation as we did, but their dependent variable is food consumption rather than diet quality[9,10]. A few studies have analysed the relationship between money expenditures and food nutritional quality, without functioning time[5,6,11]. Rao *et al.*[11] summarises findings from ten studies reporting twenty-nine cost differences between more- and less-healthy diet patterns. Twenty-seven of the reported estimated differences showed that healthier dietary patterns were more expensive than less-healthy patterns. Money expenditures used in all these studies do not correspond to actual amounts spent on food but to an estimated cost of the diet. Food quality, on the other hand, is defined in a variety of ways. For example, Drewnowski *et al.*[12] defined food quality in terms of consumption of relevant food categories such as vegetables and fruits, while Waterlander *et al.*[13] considered the energy density, and others look at the HEI, a standard measure to assess compliance with the Dietary Guidelines for Americans[14,15].

In the economics literature, Carlson *et al.*[14] examined the relationship between food nutritional quality and diet cost in the USA using dietary recall (24 h) data from the NHANES 2003–2004 and a nationally representative food prices database for the same year. Diet quality was measured using the HEI-2005 calculated using dietary recall data. Because the NHANES does not report food expenditures, the study estimated the diet cost indirectly using data on quantities obtained in the NHANES and prices from the food prices database. In this study, diet cost was found to have a very low association with food nutritional quality (a $1/d increase in diet cost is found to be associated with a 1·9-point increase in the HEI-2005).

Several studies examining the relationship between the HEI and diet cost have also been carried out by public health and nutrition experts. For example, Beydoun *et al.*[16] analysed the association between the HEI-2010 and diet cost using the same approach and price database used by Carlson *et al.*[14] with data from a sample of individuals living in Baltimore, MD in 2004. Findings from this study suggested a small positive association between the HEI and food expenditures: a $1/d increase in food expenditures (about a 20 % increase in the average diet cost per day) was found to be associated with a 1·65 higher HEI-2000. Similar studies have also been conducted by Rehm *et al.*[17] and Rehm *et al.*[6] using the same price database as Carlson *et al.*[14] and Beydoun *et al.*[16] but corresponding to different years. A limitation of these studies is the fact that they only focus on the correlation between HEI and diet cost.

Few studies that have examined the relationship between time spent preparing food and diet quality have failed to factor in food expenditures[18,19]. These studies differ in terms of data sources as well as the measure of diet quality and time expenditures. Mancino and Gregory[18] used data from a survey of 400 women in the Chicago area in 2007. Diet nutritional quality was using the HEI-2005 calculated using a 24-h dietary recall, whereas that time expenditures were measured using the number of minutes a person spent in food preparation on the day the survey was conducted. The study found no evidence of a relationship between time spent cooking and diet quality. Monsivais *et al.*[19] used data from a survey of households conducted in Seattle in 2008–2009. Diet quality in this study was measured by frequency of consumption of six food groups reflecting healthier and less healthy intakes: fruit, green salad, vegetables other than salad or potatoes, fruit juice, sugar-sweetened beverages and sweetened grain-based snacks. Time expenditures included time spent preparing, cooking and cleaning up after meals. The study found that spending more on food preparation at home was associated with increased consumption of fruits and vegetables which resulted in higher diet quality.

Because the data that are collected and utilised in these three different fields capture different aspects of this production of diet quality, the household production function for diet quality in which time and money expenditures are inputs cannot be estimated with existing data. Therefore, there is a need to create a survey instrument that captures important pieces of information from all three disciplines. The purpose of this paper is to describe such a comprehensive survey instrument. Knowledge from the nutrition, economics and time use disciplines is incorporated into the design of this survey. The paper also describes the results of a pilot test of this survey on a sample of faculty and staff at an institution of higher education as well as some preliminary analyses exploring the role of time and money expenditures on dietary quality.

Methods

Questionnaire development

A comprehensive survey instrument was constructed by pulling already-tested questions from three nationally representative US surveys. These include the Consumer Expenditure Survey[20], the American Time Use Survey and its Eating and Health Time Use Module[21], and the University of Michigan Health and Retirement Study[22]. The first two surveys are collected by the U.S. Bureau of the Census for the U.S. Bureau of Labor Statistics. The last is supported by the National Institute on Aging and the Social Security Administration. Questions from the Consumer Expenditure Survey used in this study are related to expenditures on food at home, food away from home and alcoholic beverages. Questions from the Eating and Health Time Use Module are about time spent eating, time spent purchasing and preparing foods, secondary

https://doi.org/10.1017/S1368980020001615 Published online by Cambridge University Press

eating (i.e. eating while doing other activities), respondent's height and weight, self-reported health status, and food and nutrition assistance programme participation. Finally, FFQ and questions about food consumption and nutrition (including vitamins and other supplements) were obtained from the 2013 Health and Retirement Study: Health Care and Nutrition Study[22] which were originally obtained from the Harvard FFQ for adults[23]. In addition, standard questions about the sociodemographic characteristics of the individual and the household, including gender, family size, education, income, race and ethnicity, are included in this survey instrument.

To pre-test the survey instrument, all the researchers involved in the study were asked to complete the survey. Feedback from the pre-test was used to correct errors and to modify some questions to ensure consistent use of units and language.

Recruitment and data collection procedures

The target population for the pilot test of the survey were faculty and staff aged 18 years and older from a public university located in West Texas, USA. Participants were recruited through campus announcements sent via email from July 2017 to November 2017. The data collected are cross-sectional. The recruitment announcements were sent once per week and provided general information about the study such as the purpose of the study, the target population, the survey they needed to complete, the approximate time it would take to respond, the probability of receiving an incentive, the link to the survey and the contact information for the research assistant. All interested participants were invited to follow the survey link, which was provided through the campus announcement, to complete the questionnaire using Qualtrics software (Qualtrics), an online survey tool that allows researchers to develop, distribute and analyse online surveys in real time. All participants who completed the questionnaire were asked if they would like to participate in a drawing to win one of five gift cards.

Diet quality assessment

The FFQ was used to obtain usual intake of 171 food items over the past 12 months. It included food items from the following food groups: dairy foods; fruits and vegetables; eggs, meats and fish; cereals, breads and starches; beverages (sugar-free, not sugar-free and other beverages); and sweets, baked goods and miscellaneous. Each food item was assessed by using eight categories that ranged from never to ≥2 times/d or nine categories that ranged from never to ≥6 times/d for some beverage and food items. Additionally, each food item from the FFQ specified the serving size according to the USDA Food and Composition Database. According to Emmett *et al.*[24] and Kristal *et al.*[25], the average energy and nutrients intakes can be estimated over the time frame of the questionnaire. The procedure explained by the Women's Health Initiative[26] and by the General Nutrition Assessment[27] of calculating nutrient intakes from FFQ was followed in this study. The following steps were taken to calculate the daily nutrient intake:

1. Estimate annual servings of a food by multiplying the reported weekly frequency and portion size from the USDA Food Composition Databases.
2. Obtain daily servings by dividing annual servings by 365 d.
3. Obtain daily portion size by dividing the daily serving (in g, ounces or millilitres of the food item) by the standard grams, ounces or millilitres per serving size according to the USDA Food and Composition Database.

Once a daily portion size for all food items was calculated for each participant, energies (kcal), MUFA (g), PUFA (g), saturated fats (g), Na (mg) and added sugar (g) were calculated using the Food Processor Nutrition Analysis Software version 11.1 which uses the latest version of the USDA Food Composition Database.

Diet quality was then determined using the HEI-2015[15]. The HEI-2015 contains thirteen dietary components: total fruits, whole fruits, total vegetables, greens and beans, dairy, total protein foods, seafood and plant proteins, fatty acids, refined grains, Na, added sugar and saturated fats. The intake of the dietary components is scored based on its respective density in comparison with the standards from USDA's Healthy US-Style Eating Patterns[15]. Minimum and maximum scores are 0 and 100 points, respectively. A nutritionist calculated the scores for each component following the scoring standards of HEI-2015[15] shown in detail in Table 1.

Money inputs

Money input expenditures include expenditures on groceries for food-at-home consumption; expenditures on meals or snacks at restaurants, cafeterias, carry outs, etc.; the value of 'free' meals at work; and the value of or the expenditures on meals eaten at school. Money expenditures are weekly expenditures for all household members.

Time inputs

For the calculation of time-input expenditures, the following were included as food-at-home-related activities: grocery shopping (including travel time and time spent shopping), food preparation, eating and clean-up. For food-away-from-home activities, meals at fast-food chains, eating places and restaurants (including travel time and time spent shopping) were included. All time use variables are measured on a weekly basis although, in several instances, survey respondents were given the option to provide time use information on a daily or weekly basis (e.g. time spent preparing, eating and cleaning up at home). The time use section only gathered information

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Table 1 HEI-2015 components and scoring standards*

Component	Maximum points	Standard for maximum score	Standard for minimum score of zero
Total fruits†	5	≥0·8 cup eq. per 1000 kcal	No fruit
Whole fruits‡	5	≥0·4 cup eq. per 1000 kcal	No whole fruit
Total vegetables§	5	≥1·1 cup eq. per 1000 kcal	No vegetables
Greens and beans§	5	≥0·2 cup eq. per 1000 kcal	No dark green vegetables or legumes
Whole grains	10	≥1·5 oz. eq. per 1000 kcal	No whole grains
Dairy‖	10	≥1·3 cup eq. per 1000 kcal	No dairy
Total protein foods¶	5	≥2·5 oz. eq. per 1000 kcal	No protein foods
Seafood and plant protein**	5	≥0·8 oz. eq. per 1000 kcal	No seafood or plan proteins
Fatty acids††	10	(PUFA + MUFA)/SFA ≥ 2·5	(PUFA + MUFA)/SFA ≤ 1·2
Refined grains	10	≤1·8 oz. eq. per 1000 kcal	≥4·3 oz. eq. per 1000 kcal
Added sugars	10	≤6·5 % of energy	≥26 % energy
Na	10	≤1·1 g per 1000 kcal	≥2·0 g per 1000 kcal
Saturated fats	10	≤8 % of energy	≥16 % of energy

HEI, Healthy Eating Index; eq., equivalent; oz., ounce.
*Intakes between the minimum and maximum standards were scored proportionately.
†Includes 100 % fruit juice.
‡Includes all forms except juice.
§Includes legumes (beans and peas).
‖Includes all milk products, such as fluid milk, yogurt and cheese, and fortified soya beverages.
¶Includes legumes (beans and peas).
**Includes seafood, nuts, seeds, soya products (other than beverages) and legumes (beans and peas).
††Ratio of PUFA and MUFA to SFA.

about the time spent on food-related activities by the survey respondent, not the household.

Theoretical model

The household production model originally developed by Becker in 1965 provides a useful framework for the analysis of the relationships between the quality of food consumed by households and total food expenditures and total time spent on food-related activities[28–30]. The household is assumed to derive utility from both market and household-produced goods such as health. The framework takes into account individuals' time and budget constraints, market prices for all goods, the times used to produce/consume goods, the diet quality production process (using purchased food and household time) and the health production process (with diet quality as one of the inputs). Moreover, it is assumed that decision-making follows a multi-stage decision process. At a higher stage, they allocate money and time to broad groups of goods and activities (e.g. money and time devoted to food and recreation) and subsequently make decisions to allocate money and time in subgroups (e.g. money and time for food at home and away from home). Thus, as shown in the appendix, the following model can be used to explore the role of total expenditures on food (i.e. money expenditures) and total time spent on food production/consumption (i.e. time expenditures) on dietary quality:

$$DQ = \mathbf{g}(E_F, t_{DQ}, \mathbf{C}), \quad (1)$$

where DQ is the diet quality, E_F is the total food expenditures, t_{DQ} is the total time needed to produce diet quality, $\mathbf{C}$ are household characteristics and g(.) denotes a function.

Data analyses

Two types of analyses were conducted using the survey data. First, survey respondents' behaviour was evaluated. Second, the relationships between food nutritional quality and time and money expenditures were analysed. This second type of analyses was conducted to test the hypothesis that more time spent in food-related activities (grocery shopping, preparing, eating and cleaning) and higher food expenditures are associated with higher dietary quality among participants.

Survey respondents' behaviour was assessed using basic descriptive statistics on completion rates, survey duration and sociodemographic characteristics. Data obtained from completed surveys were subsequently used to analyse the relationships between food nutritional quality and time and money expenditures using empirical versions of equation (1) (main equation of interest). The models were specified as multiple linear regression models with the natural logarithm of the HEI as the dependent variable and the natural logarithm of total time spent on food-related activities by the respondent, the natural logarithm of total household expenditures and the respondent's and household's sociodemographic characteristics (household composition, education, gender, race, ethnicity and age of the respondent) as explanatory variables. Two versions of the model in equation (1) were considered, one including separate values of time and money expenditures related to food at home and food away from home (model 1), as well as a model where time and money expenditures were aggregated (model 2). Total household income and variables related to hours worked per week (employment status) were not included as explanatory variables in the initial specifications of equation (1) as they are assumed to affect only decisions at a higher stage in the multi-stage budgeting process.

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To complement the analysis, two additional models were considered with the natural logarithm of HEI as the dependent variable. Model 3 includes as explanatory variables the number of meals consumed away from home by the survey respondent (per week) and sociodemographic characteristics. This model aimed to analyse the process of transforming food consumed to diet quality. Finally, model 4 included as explanatory variables all the sociodemographic characteristics considered in the previous two models as well as variables affecting the highest stage in the multi-stage budgeting process: employment status and total household income. Hence, this model can be interpreted as a reduced form version of equation (1). These models also serve as robustness tests for the analyses of the effects of sociodemographic characteristics on the nutritional quality of food as well as to further explore the role of food-away-from-home consumption on the nutritional quality of food.

All models were estimated using ordinary least squares, although there are potential endogeneity issues with the time and money expenditures variables as well as with the variables related to the number of meals away from home.* Thus, estimated regression coefficients were not given a causal interpretation but rather an interpretation as measures of association between the variables. Preliminary efforts to estimate the models using instrumental variable approaches were also not successful (e.g. Davis & You[31]), likely due to the small sample size. Finally, to evaluate the heteroscedasticity of the residuals, the White heteroscedasticity test was implemented. Multicollinearity among explanatory variables was evaluated using the variance inflation factor[30].

Results

Survey response behaviour

A total of 217 respondents started the survey, but only 142 (65·44 %) answered all the questions. The average survey duration for respondents that completed the survey was 226·27 min (3·77 h); with a median duration of only 30 min and an interquartile range of 18·78 min. In addition, 85 % of households completed the survey in 1 h or less. The high value for the average time of survey duration was due to the presence of few participants that completed the questionnaire in very large times (five participants had a time duration value higher than 35 h).

Table 2 compares the descriptive statistics related to the sociodemographic characteristics of respondents who completed the survey and respondents who started but did not answer all the survey questions. The difference in means was significantly different than zero ($\alpha = 0{\cdot}05$) for only two variables: white race and full-employment status. The proportions of white and fully employed individuals were higher among the group of respondents who completed the survey.†

The average age of respondents who completed the survey was 34 years, and the average household size was 2·56 individuals. Average household income was about $69 000. Most of the respondents were white (86 %), female (74 %), employed full time (75 %) and had a college degree or above (75 %).

Regression analysis

Table 3 presents descriptive statistics related to the main variables of interest in the regression analyses: food nutritional quality and money and time expenditures. These statistics reflect an average HEI of 66·11 with a minimum of 36·54 and a maximum of 91·38. Average weekly household food expenditures were $132·36. A majority of these food expenses were for food-at-home, as the average weekly expenditures on food-at-home were $99·76. The average numbers of restaurant and fast-food meals per week were 1·40 and 2·48, respectively. The average time spent on food-related activities was 1176·05 min/week (19.60 hours). As with the case of money expenditures, the majority of the time devoted to food activities is composed of food-at-home activities, with the average time devoted to these activities at 961·45 min/week (16.02 hours). Most of the time spent on food activities at home is related to food preparation (328·88 min or 05.48 hours/week) and eating (360·23 min or 06.00 h).

In all the estimated regression models (Tables 4 and 5), White tests for heteroscedasticity failed to reject the null hypothesis that the residuals were homoscedastic ($\alpha = 0{\cdot}05$). Similarly, variance inflation factor values for all the variables in all models were below 3 (values above twenty are suggested as indicative of multicollinearity problems)[32]. Thus, both heteroscedasticity and multicollinearity were not found to be problematic in this data set. The R^2 of the models ranged from 0·115 to 0·170. When evaluating the overall significance of the regressions using *F*-tests, only two models were significant at the 5 % level (model 2 and model 4). Model 3 was significant at the 10 % level, and model 1 was very close to being significant. Overall, the models are appropriate given the exploratory nature of these analyses and the small sample size.

Tables 4 and 5 presents estimation results. Models 1 and 2 are the main models exploring the associations of time and money expenditures with the nutritional quality of food. When considering aggregate measures of time and money spent on food activities (model 1), only food expenditures are found to be associated with the HEI.

*Endogeneity might be a problem due to the presence of unobservable factors such as nutrition knowledge and habits which are likely to be associated with both money and time expenditures on food and the nutritional quality of food.

†Regression models to assess the associations of sociodemographic characteristics (all variables listed in Table 2) with the decision to complete the survey and survey duration times for those completing the survey were estimated. *P*-values for *F*-tests evaluating the overall significance of the regressions were above 0.25; thus, there is no evidence that the decision to complete the survey and survey time duration are associated with observed sociodemographic characteristics of survey participants.

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Table 2 Descriptive statistics of faculty and staff that participated in the survey

Variable	Completed survey			Did not complete survey			
Continuous variables	*n*	Mean	SD	*n*	Mean	SD	Difference in means
Age of the respondent	142	34·50	12·21	74	29·01	10·31	5·49
Household size	142	2·56	1·36	75	2·69	1·40	–0·14
Annual household income ($10 000)	141	6·89	5·80	71	9·81	29·45	–2·92
Dummy variables (yes = 1, no = 0)							
White	141	0·86	0·35	75	0·73	0·45	0·12**
Asian	141	0·06	0·23	75	0·11	0·31	–0·05
Black	141	0·02	0·14	75	0·07	0·25	–0·05
Hispanic	140	0·16	0·37	75	0·17	0·38	–0·01
College education or above	142	0·75	0·44	75	0·65	0·48	0·09
Presence of children under 18 years	142	0·28	0·45	75	0·24	0·43	0·04
Female	142	0·74	0·44	75	0·72	0·45	0·02
Employed full time	142	0·75	0·44	60	0·53	0·50	0·21***

**Indicates statistical significance at the 5 % level.
***Indicates statistical significance at the 1 % level.

Table 3 Descriptive statistics of healthy eating index, meals away from home, food expenditures and time use

Variable	*n*	Mean	SD	Minimum	Maximum
Heathy Eating Index	142	66·11	11·57	36·54	91·38
Number of restaurant meals (per week)	141	1·40	1·41	0	10·00
Number of fast-food meals (per week)	142	2·48	2·32	0	10·00
Total food expenditures ($/week)	139	132·36	72·57	15·00	350·00
Food at home expenditures ($/week)	140	99·76	60·23	10·00	350·00
Food away-from-home expenditures ($/week)	141	31·85	30·49	0	120·00
Time spent on food activities (min/week)	141	1176·05	510·93	269·00	3540·00
Time spent on food activities at home (min/week)	142	961·45	460·38	149·00	2940·00
Time spent on grocery shopping (min/week)	142	103·39	65·77	5·00	360·00
Time spent preparing meals at home (min/week)	142	328·88	232·52	14·00	2100·00
Time spent eating at home (min/week)	142	360·23	261·95	0	1680·00
Time spent cleaning after eating at home (min/week)	142	168·95	127·06	2·00	840·00
Time spent on food activities away from home (min/week)	141	215·33	201·43	0	1560·00
Time spent on restaurant meals (min/week)	141	99·74	96·35	0	600·00
Time spent on fast-food meals (min/week)	142	114·77	162·24	0	1440·00

Estimated coefficients indicate that a 1 % increase in food expenditures is estimated to be associated with a 0·06 % increase in the HEI. This would mean that, for the average household, an increase in weekly food expenditures of $13·24 (a 10 % increase) would be associated only with an increase of 0·40 points in the HEI (a 0·6 % increase). Results from the model that included separate variables for time and money expenditures including food-at-home and food-away-from-home activities (model 2) suggested that only food-at-home expenditures and time spent on food-away-from-home are associated with the HEI. A 1 % increase in food-at-home expenditures is estimated to be associated with a 0·09 % increase in the HEI. On the other hand, a 1 % increase in the time spent on food-away-from-home activities is estimated to be associated with a 0·03 % decrease in the HEI. It is important to highlight the fact that adding disaggregated measures of money and time expenditures has a large impact on the predictive power of the model, as the R^2 increases by about 50 % when going from model 1 to model 2. When considering the number of meals away from home as an explanatory variable in the HEI regression model (model 3) instead of food and money expenditures, only the number of fast-food meals is associated with a lower HEI. More specifically, each additional fast-food meal per week is found to be associated with a 1·6 % decrease in the HEI.

Results in model 4 suggest that the HEI index is associated with household income and respondents' race and gender. A 1 % increase in income is associated with a 0·04 % increase in the HEI. Asian respondents are found to have a HEI that is about 13 and 20 % higher than the HEI of white households and household of races other than white, respectively. Female respondents are found to have a HEI that is about 6·5 % higher than the HEI of male respondents. The estimated coefficients on the socio-demographic characteristics were very similar across all model specifications.

Table 6 presents the estimated associations between a 10 % increase in time and money expenditures at home and away from home and the scores of the components

https://doi.org/10.1017/S1368980020001615 Published online by Cambridge University Press

Table 4 Regression estimates, determinants of the natural logarithm of the healthy eating index including separated and aggregated values of time and money expenditures related to food at home and away from home among 135 faculty and staff

	Model 1		Model 2	
	Coefficient	SE	Coefficient	SE
Intercept	3·976***	0·285	3·833***	0·254
Ln (Total food expenditures)	0·058*	0·030		
Ln (Food at home expenditures)			0·085***	0·029
Ln (Food away-from-home expenditures)			–0·002	0·010
Ln (Time spent on food activities)	–0·019	0·042		
Ln (Time spent on food activities at home)			0·008	0·035
Ln (Time spent on food activities away from home)			–0·028***	0·014
Age of the respondent	0·000	0·001	–0·000	0·001
Household size	–0·021	0·016	–0·026	0·015
White	0·059	0·058	0·087	0·057
Asian	0·246***	0·093	0·263***	0·092
Hispanic	0·039	0·048	0·027	0·047
College education or above	–0·004	0·037	–0·013	0·036
Presence of children under 18 years	–0·036	0·045	–0·014	0·045
Female	0·061*	0·036	0·071**	0·036
F-statistic	1·61		2·08	
P-value	0·11		0·02	
R^2	0·115		0·170	
n	135		135	

Ln, natural log.
*Indicates statistical significance at the 10 % level.
**Indicates statistical significance at the 5 % level.
***Indicates statistical significance at the 1 % level.

Table 5 Regression estimates, determinants of the natural logarithm of the healthy eating index including number of meals consumed away from home per week and sociodemographic characteristics among faculty and staff

	Model 3		Model 4	
	Coefficient	SE	Coefficient	SE
Intercept	4·133***	0·093	4·086***	0·089
Number of restaurant meals	–0·01	0·011		
Number of fast food meals	–0·016***	0·007		
Age of the respondent	0·001	0·001	–0·001	0·002
Household size	–0·017	0·015	–0·021	0·015
White	0·075	0·057	0·052	0·057
Asian	0·224**	0·092	0·182**	0·088
Hispanic	0·004	0·046	0·026	0·045
College education or above	–0·011	0·036	–0·037	0·038
Presence of children under 18 years	–0·008	0·045	–0·041	0·045
Female	0·053	0·035	0·065*	0·035
Ln (Annual household income)			0·043**	0·021
Employment full time			0·053	0·047
F-statistic	1·90		1·95	
P-value	0·051		0·044	
R^2	0·130		0·132	
n	138		139	

Ln, natural log.
*Indicates statistical significance at the 10 % level.
**Indicates statistical significance at the 5 % level.
***Indicates statistical significance at the 1 % level.

of the HEI. These values were obtained using the coefficients of the auxiliary regression models for the individual components of the HEI (complete results available from the authors upon request). These results confirm those obtained using model 1. Increases in money expenditures are found to be positively associated with increases in the scores of the majority of the individual components of the HEI (eight out of thirteen effects are positive and significant). On the other hand, increases in time expenditures on food away from home are associated with decreases in a large number of the scores for the individual components (five out of thirteen effects are negative and

https://doi.org/10.1017/S1368980020001615 Published online by Cambridge University Press

Table 6 Association between a 10 % increase in time and money expenditures related to food at home (FAH) and away from home (FAFH) and the components of the healthy eating index among 135 faculty and staff†

Component	Money for FAH	Money for FAFH	Time for FAH	Time for FAFH
Total fruits (max = 5; avg. = 2·93)‡S§	0·12***	0·01	–0·01	–0·03***
Whole fruits (max = 5; avg. = 3·60) S	0·12***	0·00	0·03	–0·03**
Total vegetables (max = 5; avg. = 3·21) S	0·14***	0·01	–0·01	–0·05***
Greens and beans (max = 5; avg. = 3·63) S	0·08***	0·01	0·03	–0·03**
Whole grains (max = 10; avg. = 3·08) S	0·09*	0·02	–0·06	–0·01
Dairy (max = 10; avg. = 3·99) NS	0·09*	0·03	–0·01	–0·03
Total protein foods (max = 5; avg. = 3·57) NS	0·02	0·01	–0·03	–0·01
Seafood and plant proteins (max = 3·66;avg. = 3·66) S	0·17***	0·00	0·00	–0·05***
Fatty acids (max = 5·50; avg. = 5·50) NS	0·02	–0·01	0·01	0·01
Refined grains (max = 10; avg. = 9·43) S	0·04*	0·01	–0·15***	–0·02
Na (max = 10; avg. = 7·92) NS	0·01	–0·02	0·07	–0·02
Added sugars (max = 10; avg. = 9·71) NS	0·01	0·00	–0·03	–0·01
Saturated fats (max = 10; avg. = 5·87) NS	–0·02	–0·03**	0·06	0·04**

†Calculations at the average values of time and money expenditures and the index scores. Average money and time expenditures on food at home are $99·76 and 961·45 min/week. Average money and time expenditures on food away from home are $31·85 and 215·33 min/week.
‡Max denotes the maximum score value, and avg. the average value in the sample.
§S and NS indicates if the underlying regression model is statistically significant or NS, respectively (10 % level). The underlying regression models use the natural log of the score as the dependent variable and as explanatory variables money and time expenditures both at home and away from home as well as sociodemographic characteristics: age, gender, race (White and Asian, dummies), ethnicity (Hispanic, dummy), education (College education and above, dummy) of the household head; household size; and, presence of children under 18 years in the household (dummy).
*Indicates statistical significance at the 10 % level.
**Indicates statistical significance at the 5 % level.
***Indicates statistical significance at the 1 % level.

significant, and only one is positive and significant). The largest estimated effect of money spent on food at home corresponds to seafood and plant proteins, which indicates that a 10 % increase in money expenditures is associated with an increase of 0·17 points in the score of this HEI component. The largest effect (in absolute value) of time expenditures on food away from home was for total vegetables and seafood and plant proteins (–0·05); thus, a 10 % increase in time spent on food away from home is associated with a 0·05 decrease in the scores of these HEI components.

Discussion

Combining questions from three survey instruments that collect data on food nutrition, food expenditures and time spent in food-related activities resulted in a 30-page survey instrument. The median completion time of the survey instrument was about 30 min. A concern with the survey instrument is its length, thirty pages, which could have discouraged some survey respondents. However, about 45 % of respondents who did not finalise the survey stopped answering questions with 8 % of progress or less which suggests that, for a large proportion of survey participants, survey length was not the main factor for survey abandonment. Moreover, although the median survey length of 30 min is at the lower bound of what some authors consider as a 'long survey,' it may be worth reducing its length if possible[33]. This is important as previous studies have found negative associations between survey length and both survey completion and the quality of the responses[33]. Despite the length of the survey, the instrument has enabled us to test the hypothesis that more time spent in food-related activities and higher expenses in food increase dietary quality.

Regression analyses of the pilot survey data identified a small positive association between food expenditures and HEI. Such small association suggests that preferences and eating habits are more important than time and money when making food choices. Similar results were observed in studies carried out by Chrisinger *et al.*[34], Carlson *et al.*[14], Dubois *et al.*[35] and Beydoun *et al.*[16] For instance, the study conducted by Beydoun *et al.*[16] found that the estimated degree of association between food expenditures and diet quality was very small even after controlling for other factors.

Regression analyses using the data from the pilot study also revealed a positive association between food-at-home expenditures and the HEI score. This result runs contrary to a recent study carried out by Tiwari *et al.*[36], where frequent cooking at home was associated with lower food expenditures per capita but higher HEI scores. However, the findings of this pilot study reinforce the affirmation by multiple scientists in the area of nutrition, public health, economics and time use fields that foods prepared at home are associated with higher quality of diets[19,37,38]. On the other hand, the analyses of this study found that an increase in the time spent on food away from home is associated with a decrease in HEI scores. Similarly, the most recent 'America's Eating Habits: Food Away from Home Report' found that food away-from-home consumption is associated with lower HEI scores[39].

https://doi.org/10.1017/S1368980020001615 Published online by Cambridge University Press

Study results also identified a negative association between the number of fast-food meals per week and the HEI score. This result coincides with the findings from the 'Americas Eating Habits: Food Away from Home Report' that fast-food consumers tend to have the worst diets based on their HEI scores[40]. The negative association likely stems from the fact that fast food tends to be higher in energy (calories), empty calories, saturated fat, Na[36,40]; and lower in vegetables, whole grains, fibre, vitamins and minerals[40].

Regarding the relation between sociodemographic characteristics and the HEI score, pilot test data analyses results showed that Asians had higher HEI scores than other ethnicities. This finding is similar to a study conducted among South Asians Americans where it was found that their HEI score was 68 and significantly higher than the average HEI scores of American adults which was 53[41]. In contrast, other studies comparing HEI scores among different ethnicities have found higher HEI among Hispanics[34,42]. Pilot test data analyses results also found that females had higher HEI scores than males, and this result is consistent with other studies[42,43]. For instance, a previous study that analysed the HEI in the adult national representative population found a HEI score of 59 and 54 for females and males, respectively[42].

Analyses of the survey data identified several limitations of the current version of the survey as well as some considerations for further survey refinement. The first limitation is the aggregate nature of the HEI as a measure of food nutritional quality for both food at home and food away from home. The second limitation is a mismatch between time and household expenditures. Whereas the time use questions on food activities were asked at the individual level, most of the questions related to food expenditures were asked at the household level. The third limitation is that the survey did not include a question related to the number of meals consumed at home but prepared away from home (e.g. frozen meals, take-out or delivery foods) or the number of meals prepared at home but consumed away from home (e.g. prepared lunch or meal) and the time spent packing and eating these meals. Finally, the issue of what is a meal should be considered more carefully to appropriately incorporate, for example, time and money spent preparing, buying and eating snacks.

Conclusion and implications

The feasibility of developing and implementing a comprehensive survey instrument to analyse the relation between diet quality, time use and food costs has been demonstrated; however, pilot testing of the survey instrument revealed some limitations of the current version of the survey which would have to be considered in future research. Results of the analyses using data from the pilot test suggest that time and money expenditures are associated with diet quality, but their role is small relative to sociodemographic characteristics such as race and gender, but more work is needed with different and/or larger target populations. Moreover, a larger sample might allow the exploration of time use and food expenditures among population groups with high diet quality as well as potential interactions between time and money.

Acknowledgements

Acknowledgements: The authors would like to acknowledge the Community and International Nutrition Research (CINR) lab members: Ruhul Amin, Bong Nguyen, Hyun-Jung Lee and Theophilus Rufus. Ruhul Amin collaborated in the development of the questionnaire; and Bong Nguyen, Hyun-Jung Lee and Theophilus Rufus assisted in the dietary analysis. *Financial support:* This research received support from Texas Tech University's Transdisciplinary Research Academy (TTUTRA). *Conflict of interest:* None. *Authorship:* C.E.C., C.M.K. and M.M. conceptualised the research study and the questionnaire; C.E.C. and C.M.K. conducted the literature review; A.F.M.-C. oversaw data collection and dietary quality analyses; C.E.C. and C.M.K. conducted data analyses and provided statistical expertise; C.E.C., C.M.K., A.F.M.C. and M.M. wrote the manuscript, reviewed and commented on subsequent drafts. *Ethics of human subject participation:* This study was conducted according to the guidelines laid down in the Declaration of Helsinki, and all procedures involving study participants were approved by the Institutional Review Board (IRB) at Texas Tech University. A waiver for consent form was approved by the IRB TTU.

Supplementary material

For supplementary material accompanying this paper visit https://doi.org/10.1017/S1368980020001615

References

1. CDC (2019) About Chronic Diseases. https://www.cdc.gov/chronicdisease/about/index.htm (accessed August 2019).
2. Bentley J (2019) U.S. Trends in Food Availability and a Dietary Assessment of Loss-Adjusted Food Availability, 1970–2014. https://www.ers.usda.gov/webdocs/publications/82220/eib-166.pdf?v=42762 (accessed August 2019).
3. USDA (2019) HEI Scores for Americans. https://www.fns.usda.gov/hei-scores-americans (accessed August 2019).

https://doi.org/10.1017/S1368980020001615 Published online by Cambridge University Press

4. Kalenkoski C & Hamrick K (2013) How does time poverty affect behavior? A look at eating and physical activity. *Appl Econ Perspect Policy* **35**, 89–105.
5. Darmon N & Drewnowski A (2015) Contribution of food prices and diet cost to socioeconomic disparities in diet quality and health: a systematic review and analysis. *Nut Rev* **73**, 643–660.
6. Rehm CD, Monsivais P & Drewnowski A (2015) Relation between diet cost and healthy eating index 2010 scores among adults in the United States 2007–2010. *Prev Med* **73**, 70–75.
7. Devine CM, Connors MM, Sobal J *et al.* (2003) Sandwiching it in: spillover of work onto food choices and family roles in low- and moderate-income urban households. *Soc Sci Med* **56**, 617–630.
8. Venn D & Strazdins L (2017) Your money or your time? How both types of scarcity matter to physical activity and healthy eating. *Soc Sci Med* **172**, 98–106.
9. Aguiar M & Hurst E (2007) Life-cycle prices and production. *Am Econ Rev* **97**, 1533–1559.
10. Aguiar M & Hurst E (2005) Consumption versus expenditure. *J Polit Econ* **113**, 919–948.
11. Rao M, Afshin A, Singh G *et al.* (2013) Do healthier foods and diet patterns cost more than less healthy options? A systematic review, meta-analysis. *BMJ Open* **3**, 1–16.
12. Drewnowski A, Darmon N & Briend A (2004) Replacing fats and sweets with vegetables and fruits – a question of cost. *Am J Public Health* **94**, 1555.
13. Waterlander W, de Haas W, van Amstel I *et al.* (2010) Energy density, energy costs and income – how are they related? *Public Health Nutr* **13**, 1599–1608.
14. Carlson A, Dong D & Lino M (2014) Association between total diet cost and diet quality is limited. *J Agric Resour Econ* **39**, 47–68.
15. Krebs-Smith SM, Pannucci TE, Subar AF *et al.* (2018) Update of the Healthy Eating Index: HEI-2015. *J Acad Nutr Diet* **118**, 1591–1602.
16. Beydoun MA, Fanelli-Kuczmarski MT, Allen A *et al.* (2015) Monetary value of diet is associated with dietary quality, nutrient adequacy among urban adults, differentially by sex, race, poverty status. *PLoS ONE* **10**, e0140905.
17. Rehm CD, Monsivais P & Drewnowski A (2011) The quality and monetary value of diets consumed by adults in the United States. *Am J Clin Nutr* **94**, 1333.
18. Mancino L & Gregory C (2012) Does more cooking mean better eating? Estimating the relationship between time spent in food preparation and diet quality. IDEAS Working Paper Series from RePEc.
19. Monsivais P, Aggarwal A & Drewnowski A (2014) Time spent on home food preparation and indicators of healthy eating. *Am J Prev Med* **47**, 796–802.
20. U.S. Department of Commerce Economic and Statistics Administration (2015) Consumer Expenditure Survey: Quarterly Interview Survey Information Booklet. https://www.bls.gov/cex/2015_information_booklet_ce_305.pdf (accessed August 2016).
21. U.S. Department of Labor (2017) American Time Use Survey: Eating & Health Module 2014–16 Questionnaire. https://www.bls.gov/tus/ehmquestionnaire1416.pdf (accessed August 2016).
22. Survey Research Center the University of Michigan (2013) Health and Retirement Study Mail Survey: Health Care and Nutrition Study. http://hrsonline.isr.umich.edu/modules/meta/2013/hcns/qnaire/HRS_HCNS_Survey2013_Eng_final.pdf?_ga=2.149457654.1901575602.1570733182-1997524678.1570733182 (accessed August 2016).
23. Health and Retirement Study (2013) 2013 HRS Health Care and Nutrition Study (HCNS) Version 4.0. https://hrs.isr.umich.edu/news/2013-hrs-health-care-and-nutrition-study-hcns-version-40 (accessed January 2020).
24. Emmett P, Jones LR, Northstone K *et al.* (2019) Collection and management of dietary data. In *Analysis in Nutrition Research: Principles of Statistical Methodology and Interpretation of the Results*, 1st ed., pp. 54–58 [G Pounis, editor]. Cambridge: Academic Press.
25. Kristal AR, Shattuck AL & Williams AE (1992) Food frequency questionnaires for diet intervention research. In *Proceedings of the 17th National Nutrient Bank Conference*, 110–125. Washington, D.C.: International Life Sciences Institute Baltimore.
26. Neuhouse M (2009) Use of Dietary/Nutrient Data in the WHI: WHI Data Training Workshop. https://www.whi.org/researchers/data/Training/Forms/AllItems.aspx (accessed November 2017).
27. Fred Hurchinson Cancer Research Center (2010) FFQ Data Analysis – GNA/MNA. https://sharedresources.fredhutch.org/data-analysis/ffq-data-analysis-%E2 %80 %93-gnamna (accessed November 2017).
28. Becker GS (1965) A theory of the allocation of time. *Econ J* **75**, 493–517.
29. Rosenzweig MR & Schultz TP (1983) Estimating a household production function: heterogeneity, the demand for health inputs, and their effects on birth weight. *J Polit Econ* **91**, 723–746.
30. Variyam JN, Blaylock JR & Smallwood D (1998) *USDA's Healthy Eating Index and Nutrition Information*. Washington, D.C: U.S. Department of Agriculture, Economic Research Service.
31. Davis GC & You W (2013) Estimates of returns to scale, elasticity of substitution, and the thrifty food plan meal poverty rate from a direct household meal production function. *Food Policy* **43**, 204–212.
32. Greene WH (2000) *Econometric Analysis*, 4th ed. Upper Saddle River, NJ: Prentice Hall.
33. Galesic M & Bosnjak M (2009) Effects of questionnaire length on participation and indicators of response quality in a web survey. *Public Opin Q* **73**, 349–360.
34. Chrisinger BW, Kallan MJ, Whiteman ED *et al.* (2018) Where do U.S. households purchase healthy foods? An analysis of food-at-home purchases across different types of retailers in a nationally representative dataset. *Prev Med* **112**, 15–22.
35. Dubois P, Griffith R & Nevo A (2013) Do prices and attributes explain international differences in food purchases? National Bureau of Economic Research Working Paper No. 18750. https://www.nber.org/papers/w18750.pdf (accessed February 2020).
36. Tiwari A, Aggarwal A, Tang W *et al.* (2017) Cooking at home: a strategy to comply with U.S. dietary guidelines at no extra cost. *Am J Prev Med* **52**, 616–624.
37. Fulkerson JA, Farbakhsh K, Lytle L *et al.* (2011) Away-from-home family dinner sources and associations with weight status, body composition, and related biomarkers of chronic disease among adolescents and their parents. *J Am Diet Assoc* **111**, 1892–1897.
38. Seguin RA, Aggarwal A, Vermeylen F *et al.* (2016) Consumption frequency of foods away from home linked with higher body mass index and lower fruit and vegetable intake among adults: a cross-sectional study. *J Environ Public Health* **2016**, 1–12.
39. Saksena M, Okrent A, Anekwe T *et al.* (2018) America's Eating Habits: Food Away From Home. https://www.ers.usda.gov/webdocs/publications/90228/eib-196.pdf (accessed June 2019).
40. Barnes TL, French SA, Mitchell NR *et al.* (2016) Fast-food consumption, diet quality and body weight: cross-sectional

https://doi.org/10.1017/S1368980020001615 Published online by Cambridge University Press

and prospective associations in a community sample of working adults. *Public Health Nutr* **19**, 885.
41. Saira AK, Robert TJ & Bahram M (2016) The relationship between diet quality and acculturation of immigrated South Asian American adults and their association with metabolic syndrome. *PLoS ONE* **11**, e0156851.
42. Hiza HAB, Casavale KO, Guenther PM *et al.* (2013) Diet quality of Americans differs by age, sex, race/ethnicity, income, and education level. *J Acad Nutr Diet* **113**, 297–306.
43. Reedy J, Lerman JL, Krebs-Smith SM *et al.* (2018) Evaluation of the healthy eating index-2015. *J Acad Nutr Diet* **118**, 1622–1633.

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