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An economic analysis of community-level fast food prices and individual-level fast food intake: longitudinal effects

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Abstract

Background—While dietary intake is shaped by cost, there is minimal research on the association between community-level food prices and dietary intake.

Methods—We used nationally representative, longitudinal data to examine how community-level food price variation was associated with individual-level fast food intake by race/ethnicity and income across waves II (1996) and III (2001–02) of The National Longitudinal Study of Adolescent Health (n=11,088) from 158 baseline and 363 follow-up US counties.

Results—Negative binomial regression models predicting the number of fast food meals per week show strong relationships between fast food consumption and prices of fast food and soda that varied by gender and race/ethnicity. We found relatively stronger association between food prices and fast food intake for males and relatively greater price sensitivity for soda versus burgers. In the group with strongest associations (black males), a 20% increase in price of soda was associated with a decrease of a 0.25 visits to a fast food restaurant per week.

Conclusions—Economic incentives may be an effective mechanism to address fast food intake in an age group at high risk for obesity.

Keywords (MeSH*)

diet; * adolescent; * epidemiology; * United States; economic incentives; GIS

Introduction

Food prices are increasingly a topic of interest in terms of economic strategies or incentives for healthy dietary intake. Recently, several researchers have examined the association between food prices and obesity(Chou et al., 2004, Cawley, 2004, Lakdawalla and Philipson, 2002, Powell and Chaloupka, 2009), yet these studies are largely cross-sectional and ignore direct associations with dietary intake. Others have examined cross-sectional associations between regional food prices and consumption of select foods(Darmon et al., 2003, Drewnowski and Darmon, 2005c, Cox and Wohlgenant, 1986). One recent study

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examined fast food prices and obesity(Powell, 2009) and another recent study investigated the association between food prices with energy intake, weight, and diabetes risk over a 20-year period(Duffey et al., 2010).

Yet there has been minimal research linking community-level food prices to individual-level dietary behaviors and overall food consumption patterns. The earlier USDA surveys as well as the National Health and Nutrition Examination Survey do not allow food price data to be linked to individual level data at small geographic levels (e.g., many deal with state-level prices). Yet, data from experimental studies show that food price is one of the most influential factors in determining food choice, second only to taste(Shannon et al., 2002, Glanz et al., 1998, French, 2003, Epstein et al., 2006, Epstein et al., 2007).

Further, there is a large agricultural economics literature that addresses the association between food price data with dietary behavior, food production, and overall food expenditure and consumption, yet this work is focused on commodity- and brand-level demand(Frazao, 1999, Timmer et al., 1984). Of particular relevance is the differential association between food prices and dietary intake across income levels as individuals of low income are typically more sensitive to changes in food price(Chung and Myers, 1999a, MacDonald and Nelson Jr., 1991, Stewart et al., 2004, Stewart et al., 2003, Popkin, 2008a) and tend to have less varied, lower quality diets compared to higher income consumers(Hulshof et al., 2003). A range of small studies suggest that food expenditure patterns for high-priced healthier products is associated with reductions in fruit, vegetable, and dairy consumption among low income families(Chung and Myers, 1999b, Kirkpatrick and Tarasuk, 2003, Guo et al., 1999). However, there are still major gaps in the literature and a recent review called for studies estimating price effects and responsiveness among at risk populations, particularly low-income and ethnic minority populations.(Andreyeva et al., 2009)

This study capitalizes on data from a large, ethnically diverse and nationally representative longitudinal cohort across the age period between adolescence and young adulthood, a period of heightened risk for obesity incidence(Gordon-Larsen et al., 2004). Individual-level survey data were spatially and temporally linked to community food price data at the county level from the Council for Community and Economic Research, a resource widely used in studies of cigarette prices and tobacco consumption(Chaloupka et al., 2002, Grossman and Chaloupka, 1997, Liang et al., 2003, Grossman, 1989, Young and Bielinska-Kwapisz, 2003) and associations between community-level prices of select foods and related individual-level dietary consumption of fast foods were estimated with attention to variation by race/ethnicity and income.

Methods

Study Population

Data are from waves II (1996) and III (2001–02) of The National Longitudinal Study of Adolescent Health (Add Health), a cohort study of 20,745 adolescents representative of the U.S. school-based population in grades 7 to 12 (11–22 years of age) in 1994–95 followed into wave II (12–22 years) and wave III (18–28 years). Add Health included a core sample plus subsamples of selected minority and other groupings collected under protocols approved by the Institutional Review Board at the University of North Carolina at Chapel Hill. The survey design and sampling frame, which includes following the school-aged population at waves I and II and the full baseline sample at wave III have been discussed elsewhere(Gordon-Larsen et al., 1999, Miller et al., 2004). A Geographic Information System (GIS) was used to link time-varying community-level data at the county-level to Add Health respondent residential locations at each wave as reported elsewhere(Boone-

Heinonen et al., 2010a). Respondent residential locations were linked to attributes from time-matched price data (described below), which were merged with individual-level Add Health interview responses. We include measures from 18,405 unique individuals seen at one or both waves II and III (16,604 in wave II, 14,569 in wave III), with a total of 11,088 who were seen at both waves II and III. Data are available at the census tract level, which average approximately 4,000 inhabitants and are designed to be relatively homogeneous in terms of population characteristics. Data are also available at the county level, a county is a geographic subdivision of a state that is generally assigned governmental authority. In the US, the average number of counties per state is 62. These geographic coverage increases over time from baseline counties [N=158] and tracts [N=850] into follow up counties [N=363] and tracts [N=2714]. The average number of respondents per county was 131.3 at wave I and 133.3 at wave III.

County-Level Food prices

County-level food price data were compiled by, and downloaded from, the Council for Community and Economic Research (C2ER, formerly the American Chamber of Commerce Research Association). Conducted quarterly for approximately 300 US communities, this survey provides price levels for more than 60 consumer goods and services across participating metropolitan and nonmetropolitan areas. The C2ER data represent the most comprehensive national community-level food price data available and have been used widely in studies of tobacco pricing and smoking behavior(Chaloupka et al., 2002, Grossman and Chaloupka, 1997). Grocery items (i.e., specific foods, beverages), fast food items, cost of living and overall price indices, and cigarette prices have been collected as part of the Inter-City Cost of Living Index, published quarterly since 1968 for 300 US cities(Christian and Rashad, 2009). For cities across the country, prices are collected for a variety of goods and services, including grocery prices, average utility costs, health care, and miscellaneous items such as the price of a haircut or cost of dry cleaning. From the available price data, we used: soda (cost for a 2 Liter (L) bottle) and hamburger (1.4 pound (lb) burger, purchased away-from-home) since these foods are related to fast food intake. We also include the consumer price index (CPI) as a control measure. The CPI represents changes in prices of all goods and services purchased for consumption by urban households, including user fees and sales and excise taxes, but excluding income taxes(Gordon-Larsen et al., 2009). The overall CPI is typically preferred to food specific CPI values because it controls for total cost of living(Christian and Rashad, 2009, Duffey et al., 2008). The mean CPI across all analytical communities was 1.86 at baseline (1996) and 1.78 at follow-up (2001), which is interpreted in relative terms of a one-dollar purchase at the index base period (1982–84) versus at each study period: 1996: $1.86 and 2001: $1.78. Given that we follow individuals over time regardless of residential movement and a portion of the sample moves residences over time, some of the changes in prices simply reflect changes in community of residence over time, rather than true declines in prices (the number of countries represented more than doubled between wave II and wave III). However, there is evidence of variation in food prices over time, with disproportionate stability of specific types of foods, such as carbonated drinks, fats and oils, and sugar and sweets, while prices of fresh fruits and vegetables have had a steep increase over the past two decades in the US(Popkin, 2011) .

We also include a selection of prices of hypothesized complimentary and substitution (replacement) foods and beverages, which differ based on the food being examined, and include: whole milk (cost for one-half gallon), pizza (12–13 inch cheese, thin crust purchased away-fromhome), steak (cost of 1 lb., USDA choice), and fried chicken (cost of 2 pieces, thigh and drumstick, purchased away-from-home). We use these complimentary and substitution food price data as control variables in the models. In addition, we include the consumer price index as another price control in statistical models.

All prices were expressed in real terms using 2006, quarter 3 (index=100%) as the baseline. The C2ER price data were linked to Add Health respondents temporally (based on the year and quarter of Add Health exam dates) and spatially at the county level (based on the respondent's residential location at each time point). For respondents for whom there was not a direct match between residential location, C2ER county, and year in which food price data were collected, prices were imputed (6,344 observations, 30%) using food price data at larger aggregate level (county-averaged C2ER values in counties with more than one C2ER centroid) and adjacent quarter using a method that takes into account spatial and temporal missing data and has been published widely(Duffey et al., 2010, Chou et al., 2004, Grossman, 1989, Grossman and Chaloupka, 1997, Raper, 1999). For example, if a respondent's residential location had a single matching county indicator code and price data were available for the year and quarter in which the respondent was surveyed, prices from that matching county were assigned to the respondent. Model-based tests of statistical significance of imputed price data showed no statistical difference based on imputed versus non-imputed price data, thus both were retained in the final models.

Individual-level self-reported behaviors and sociodemographics

Consumption of fast food was quantified from participant responses to the following question at waves II and III: In the last seven days, on how many days did you eat at a fast food type place—McDonalds, Kentucky Fried Chicken, Pizza Hut, Taco Bell, or a local fast food restaurant? Response categories ranged from 0 to 7 times per week, calculated to reflect a per-week frequency.

Individual-level sociodemographic control variables included wave I self-identified race (white, black, Asian, Hispanic based on primary race/ethnicity reported by respondents and their parents), parent-reported annual household income and highest education attained (<high school, high school or GED, some college, ≥college degree), indicator variables representing the school sampled as part of the original Add Health sampling frame (145 indicator variables), and age at wave II and III interviews.

Statistical Methods

All analyses were done using Stata 10 (Stata Corp, College Station, TX). Descriptive statistics for food prices, and reported frequency of fast food meals consumed per week were compared across the two exam periods, with statistical significance set at the $p<0.05$ level (two-tailed test).

Add Health was a school-based sample, so the respondents' school at wave I is the most important source of clustering. After wave I, individuals can move to other communities but we retain original school level dummies in the models for subsequent waves. The hypothesis is that the school dummies capture long lasting unobservable influences on individual decisions even after the individual leaves their place of residence at wave I. The boundaries of the school catchment areas do not correspond with the county boundaries, so schools and county units do not provide a hierarchical structure (e.g., students nested within schools, schools nested within counties) required for multi-level models. Furthermore, since Add Health was a school-based sample (school catchment areas vary greatly across states) rather than sampled based on census units, counties contained few respondents on average (sparse data), with vastly different numbers of respondents across counties (unbalanced). For example, at both waves I and III, approximately 40% of counties had 5 or fewer respondents, whereras at wave I 29% of counties had 200 or more respondents and at wave

III 5% of counties had 200 or more respondents. For these reasons, we do not use multi-level models, but we do correct for school-level clustering using school-level indicator variables in the models.

Since the dependent variable in the regression model is a count of the number of individual-level fast food meals in a week, an extension of the Poisson model rather than ordinary least squares was used as an estimation method. It is well known that in the Poisson model is specifically designed to deal with dependent variables such as this. However, a shortcoming of the Poisson model is that the mean and variance of the outcome variable are assumed to be the same – this is the equidisperson property of the model. Since this assumption is quite restrictive, the negative binomial model, a continuous mixture model that extends the Poisson model by allowing unobserved heterogeneity so that the mean and variance are separate parameters to be estimated, was used. The negative binomial model assumes that the mixing distribution follows a gamma distribution with parameter α. When α is equal to zero, the negative binomial simplifies to the Poisson model. However, in this case the null was rejected at $\alpha=0$ for $p<0.05$.

In addition to testing for simplification to a Poisson model, there was the possibility that bias could be introduced if unobserved factors that affect fast food consumption were correlated with neighborhood choice and school choice. If this was true, community characteristics including prices in the community could be correlated with the error term. To correct for this bias, school level indicator variables were included in the model. A Hausman style test was used to test whether or not it was necessary to include the school dummies to correct for bias and the null hypothesis that they were not necessary was rejected at $p<0.05$.

We also tested whether having fast food restaurants in the community influenced the effect of community-level food prices on individual-level fast food consumption. To test this effect, we entered a variable representing the availability of fast food restaurants within 3 km of each respondent’s residential location. These data were obtained from a commercial dataset of U.S. businesses. Fast food restaurants include a wide range of quick service establishments providing generally premade food and little table service; they include traditional burger outlets as well as delicatessens and coffee shops. To capture a more homogenous, well-defined category, we examined only chain fast food restaurants (e.g., McDonald’s or Pizza Hut), classified according to the 8-digit Standard Industrial Classification (SIC) code 58120307 (fast-food restaurant, chain). We determined counts of fast food restaurants within 3km from each respondent’s residential address (network buffer), based on empirical rationale for similar neighborhood resource data.(Boone-Heinonen et al., 2010b, Boone-Heinonen et al., 2011) We found these additional community-level controls did not add to the explanatory power of the model and thus they were not included in final models.

We hypothesized differential price effects by race/ethnicity and by income. Sensitivity testing for the model with and without interaction terms yielded a chi-squared statistic of 155.95 with 36 degrees of freedom , $p<0.0001$, thus indicating that the interaction terms as a group were highly significant. Thus, the final model specification included interaction terms for food price by race/ethnicity and food price by income. Since the model with interaction terms was nonlinear and somewhat difficult to interpret, simulation methods were used to examine the estimated effects of price changes. The simulation provides illustration of variation in race and income group across estimated effects of price.

Results

This nationally representative and ethnically diverse sample provides substantial variation across parental income levels (Table 1). The mean number of individual-level reported fast food meals per week increased from wave II to III, while the community-level mean price of burgers and particularly sodas for the locations where our sample lived declined over time.

Negative binomial models predicting the number of fast food meals per week show statistically greater intake among males than females, and significantly lower intake for Asians, Hispanics and non-Hispanic blacks relative to whites (Table 2) even after controlling for wave, age, and community. Further there were differential relationships between community-level food prices of our key target foods, soda and burgers and individual-level fast food intake across race/ethnic groups and by income.

To aid interpretation of results for our key findings (burger and soda), Figure 1 shows predictions based on the model coefficients from Table 2. The relatively stronger association between community-level food prices and individual-level fast food intake for males relative to females is clearly evident. For example, in the group with strongest associations (black males), we found a 20% increase in price of soda was associated with a decrease of a 0.25 visits to a fast food restaurant per week.

Further, there is variation in the association by food type and across race/ethnicity, with greatest association between food prices and fast food intake observed for price of soda in black males.

Figure 2 shows another set of predictions based on the model coefficients for our key findings (burger and soda) from Table 2. Again there is race/ethnic variation in the association between community-level food prices and individual-level fast food intake that differ across food type. In addition, there was variation across income, with greater price sensitivity for community-level soda versus burger prices. Further, there was relatively greater inverse change in individual-level fast food intake with income, such that bigger changes in individual-level fast food intake were seen at low income level, with greatest association in blacks

DISCUSSION

Using nationally representative, longitudinal data, the association between community-level food price and individual-level fast food intake was estimated, with focus on variation by race/ethnicity and income. Increases in community-level prices of fast food and soda were associated with reductions in individual-level fast food consumption. Further, there were relatively stronger associations between community-level food prices and individual-level fast food intake for males and relatively greater price sensitivity for soda versus burgers. On average, our findings suggest that a 20% increase in soda price was associated with a reduction of approximately one-quarter visits to a fast food restaurant per week. This type of reduction could potentially have a substantial impact at the population level.

A recent review suggests that away-from-home foods and sodas are among the most responsive to price changes(Andreyeva et al., 2009), which is confirmed in the present study. In general, the current literature has largely included cross-sectional, descriptive analyses of ecological variations in income, energy-density of diet, and obesity(Maillot et al., 2007, Drewnowski and Darmon, 2005b, Drewnowski and Specter, 2004). Thus, few studies have examined food prices and how they might underlie health disparities. In fact, a recent review called for studies estimating price effects and responsiveness among at risk populations.(Andreyeva et al., 2009) The current research demonstrates variation in price sensitivity across race/ethnicity and income, with greater price sensitivity for soda versus burger prices and relatively higher change in individual-level fast food intake with community-level soda prices for blacks. A similar relationship was found among adults followed 20 years over the 20–34 to 40–54 age period(Duffey et al., 2010). Further, there seems to be greater price sensitivity for soda for individuals of low income and an intervention study suggests responsivity to soda price manipulation.(Block et al., 2010) In contrast, Powell(Powell, 2009, Powell et al., 2010) using longitudinal, self-reported height and weight data (but no data on fast food intake) found no such association between fast food prices and obesity.

Given higher prices of healthy foods (i.e. fresh fruits and vegetables)(Drewnowski and Darmon, 2005a, Drewnowski and Darmon, 2005d), public health professionals, politicians and others have suggested that foods high in calories, saturated fat, or added sugar be subject to added taxes and/or that healthier foods be subsidized(Cash et al., 2005, Chouinard et al., 2007, Jacobson and Brownell, 2000, Popkin, 2008a). Such manipulation of food prices, through subsidies and other methods, has been a mainstay of global agricultural and food policy(Popkin, 2008b, von Braun, 2008) employed as a means to increase availability of animal foods and basic commodities, but have not been readily employed as a mechanism to promote public health and chronic disease prevention efforts.(Popkin, 2008b, WHO, 2000, WHO/FAO, 2003) The current results suggest that increased soda prices may have associated decreases in fast food intake. While the size of the estimated impact of shifts in community-level prices on individual-level fast food consumption is relatively low, at the aggregate level, shifts in one or more meals eaten away from home at fast food establishments per week translates to significant impact on daily caloric intake as well as many important minerals(Guthrie et al., 2002, Paeratakul et al., 2003).

While other studies have examined the association between consumption of away-from-home foods, such as fast food intake, and adverse health outcomes(Duffey et al., 2007, Popkin et al., 2005, Prentice and Jebb, 2003, Burdette and Whitaker, 2004, Currie et al., 2009, Duffey et al., 2009), these studies generally ignore self-selection of fast food eating behaviors as well as consumption of other related food substitutions. In this study, we estimate the effect of community-level prices on individual-level fast food consumption. While, we face the issue of self-selection from the point of residential selection, we control for this with our use of indicator variables for school.

While major strengths of this study include our ability to address differential associations by race/ethnicity and income, the current analysis is limited by its focus on a small number of food and beverage groups – albeit the most important foods in terms of price sensitivity(Andreyeva et al., 2009). Additional and important substitution and complementary foods and beverages may exist and should be examined in future studies. The relationship between community-level price and individual-level consumption of "healthy" food items (i.e. raw fruits and vegetables) should also be examined; the C2ER price data do not include full detail on such foods. Ideally, the current research would benefit from inclusion of a full set of prices and food groups, as would the use of the demand approach frequently employed by economists, the Almost Ideal Demand System(Huang, 1997, Huang and Bouis, 1996, Wu et al., 1995). It is also possible that some of these paired changes, i.e. the price and consumption of soda, are parallel trends over time which are associated with other unobserved factors, and are not necessarily related. There are also limitations in the C2ER data. First, the C2ER price data are available at participating metropolitan and nonmetropolitan areas; these data sources provide the only current and historical price data available at the smallest geographic unit in the US. While these price data are only available for larger county-level units, it is possible that within-county price variations are important, however there are no national food price datasets at smaller than county level. Further, there is no way to obtain retrospective price data other than the C2ER data. Given that we follow individuals over time regardless of residential movement and a portion of the sample moves residences over time, some of the changes in prices may reflect changes in community of residence over time, rather than true decreases in prices (note that the number of counties where respondents lived doubled between waves II and III). As such, our analysis is individual-based in that we estimate the effect of community-level food prices on individual-level behavior, as opposed to following specific communities over time. There are simply no national, community-level, longitudinal samples with food price and individual-level behavior data. Our findings have clear implications for how food prices influence individual behavior. There is a clear need for longitudinal, national research in this area, and currently the C2ER data provide the only option. Yet even so, the datasets include some missing temporal and geographic data. In the current study this limitation was overcome by using imputation strategies widely used in the literature(Grossman and Chaloupka, 1997, Grossman, 1989, Chou et al., 2004, Duffey et al., 2010, Raper, 1999). We are also limited by the choice of data collected by the C2ER. Whereas the price of soda is reported per 2-liter size, this size is not the usual size to be purchased at fast food restaurants. Nonetheless, the pricing of soda will still impact the relative price of soda regardless of purchase size. It is also possible for some degree of county mismatch in individuals who moved residences shortly before measurement.

In sum, using national, longitudinal data including community-level food prices, observed increases in community-level prices of fast food and soda were associated with reductions in individual-level fast food consumption. Further, there was variation in these associations by race/ethnicity and income, with generally greater price sensitivity for soda versus burgers. The current findings contribute to the recent national discussion regarding economic incentives for reducing obesity(Brownell and Frieden, 2009).

Research Highlights

1. There are few longitudinal studies that link community-level food prices with dietary intake
2. Prices of fast food were inversely associated with fast food intake
3. Price sensitivity varied by gender and race/ethnicity
4. Economic incentives may be an effective mechanism to address fast food intake

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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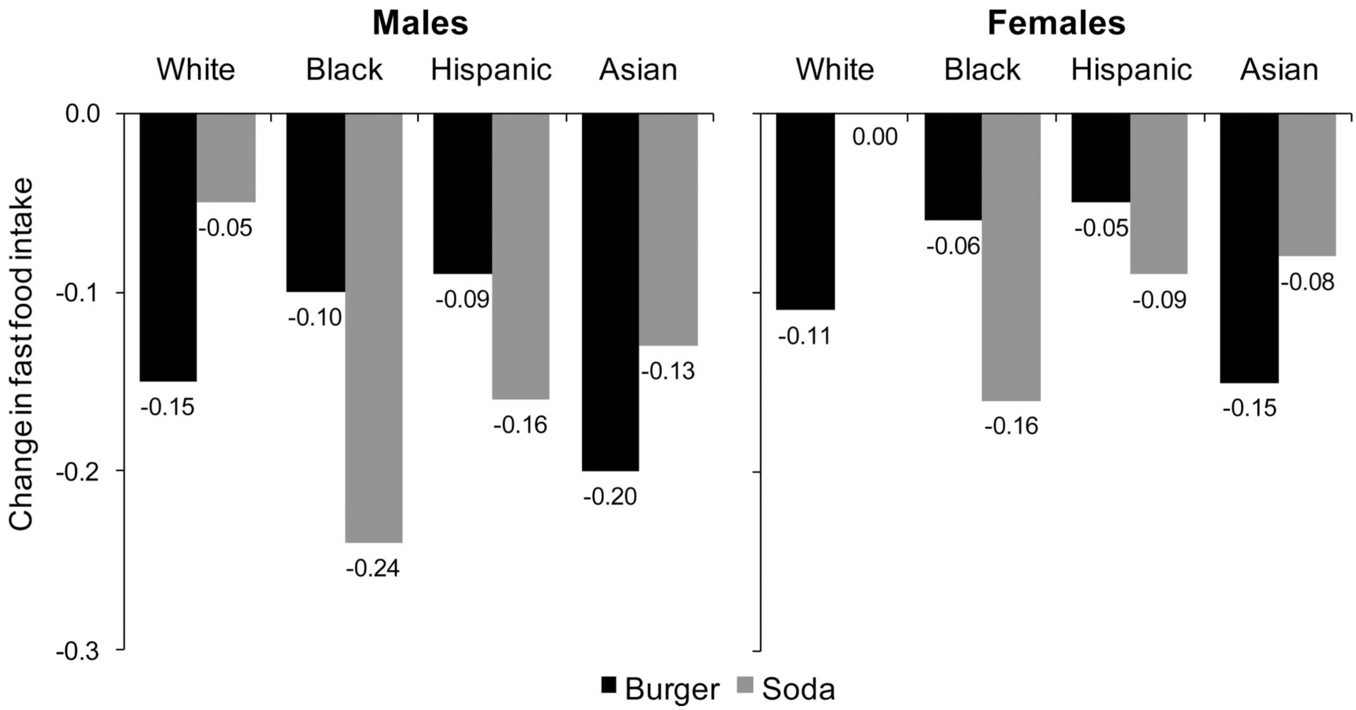

Figure 1.

Twenty percent increase in County-level prices of soda and burgers and associated decrease in number of individual-level fast food eating occasions by individual-level gender and race, The National Longitudinal Study of Adolescent Health waves II (1996, 12–22 years) and III (2001, 18–28 years)

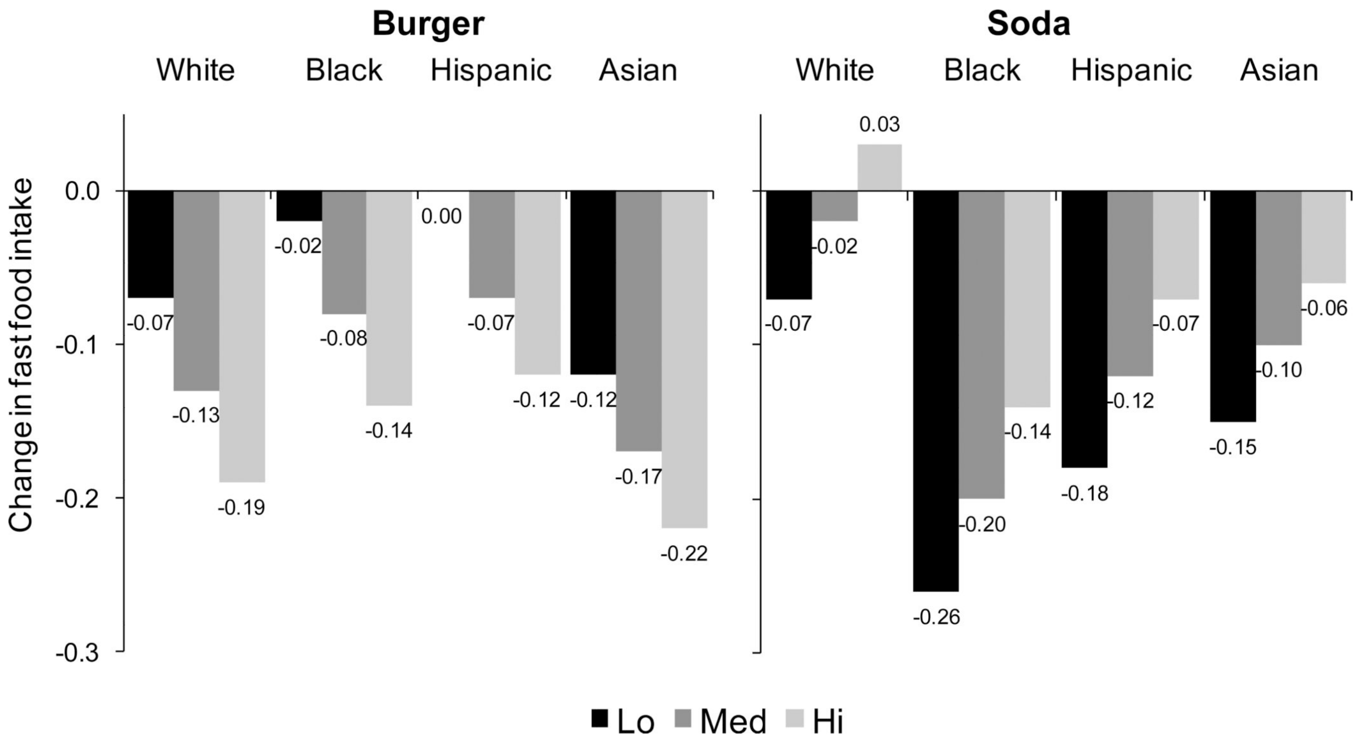

Figure 2.

Twenty percent increase in County-level prices of soda and burgers and associated decrease in number of individual-level fast food eating occasions by individual-level income and race, The National Longitudinal Study of Adolescent Health waves II (1996, 12–22 years) and III (2001, 18–28 years).

Table 1

Baseline and Follow up descriptive statistics, respondents enrolled in The National Longitudinal Study of Adolescent Health waves II (1996, 12–22 years) and III (2001, 18–28 years) and their community characteristics at each time point

	Wave II N=14,604		*Wave III N=14,569*	
Variable	**Mean**	**SD**	**Mean**	**SD**
Individual-level Sociodemographics				
Age	16.24	1.64	21.98	1.78
Female (%)	51.25	0.50	52.92	0.50
Black (%)	21.61	0.41	21.37	0.41
Hispanic (%)	16.65	0.37	16.23	0.37
Asian (%)	6.77	0.25	6.62	0.25
Parent HS (%)	29.79	0.46	29.40	0.46
Parent Some College (%)	26.99	0.44	27.02	0.44
Parent College (%)	26.64	0.44	26.87	0.44
Income, per $1,000	42.27	29.30	42.86	29.16
Individual-level outcome measure				
Fast food meals per week	2.21	1.79	2.47	2.09
Community-level exposures and control measures				
County	N=158		N=363	
Price - soda*	1.36	0.21	1.20	0.11
Price-burger*	2.33	0.28	2.28	0.20
Price-pizza*	8.34	0.82	9.51	0.74
Price-steak*	5.89	0.97	7.22	0.99
Price-milk*	1.45	0.18	1.88	0.28
Price-fried chicken*	2.23	0.21	2.58	0.26
Consumer Price Index*	1.86	0.06	1.78	0.07
Census Tract	N=850		N=2714	
Population Density†	1278.48	2082.98	1394.18	2099.00
Population <100% poverty (%)†	0.15	0.12	0.15	0.12
Population College Educated(%)†	0.23	0.13	0.22	0.16
Population White (%)†	0.73	0.29	0.68	0.29

*Council for Community and Economic Research. Price data are county-specific, real prices, in 2006 US dollars, for a 2-L bottle of soda ("soda"), a one-quarter pound hamburger purchased at a fast food restaurant ("burger"), a 13-in cheese pizza, regular crust, purchased away from home ("pizza"), a one-half gallon of whole milk ("whole milk"), 1 lb US Department of Agriculture choice steak ("steak"), and fried chicken pieces, thigh and drumstick, purchased away from home ("fried chicken").

†Census Tract Level (US Census)

Table 2

Longitudinal negative binomial results from a single multivariate model* predicting Fast Food meals/week, The National Longitudinal Study of Adolescent Health waves II (1996, 12–22 years) and III (2001, 18–28 years)

Variable	Coef	95% CI	95% CI	Z	P
Wave 2	0.2688	−0.1219	0.6595	1.35	0.177
Individual-level Baseline Age† < 13 years	−0.1794	−0.2978	−0.0610	−2.97	0.003
Individual-level Baseline Age 14 years	−0.1615	−0.2670	−0.0561	−3.00	0.003
Individual-level Baseline Age 15 years	−0.0884	−0.1874	0.0106	−1.75	0.080
Individual-level Baseline Age 16 years	0.0733	−0.0176	0.1642	1.58	0.114
Individual-level Baseline Age 17 years	0.1286	0.0400	0.2171	2.85	0.004
Individual-level Baseline Age 18 years	0.1895	0.1014	0.2776	4.22	0.0001
Individual-level Baseline Age 19 years	0.1470	0.0721	0.2218	3.85	0.0001
Individual-level Baseline Age 20 years	0.1588	0.0888	0.2287	4.45	0.0001
Individual-level Baseline Age 21 years	0.1553	0.0903	0.2203	4.68	0.0001
Individual-level Baseline Age 22 years	0.0946	0.0319	0.1573	2.96	0.003
Individual-level Baseline Age 23 years	0.0669	0.0045	0.1292	2.10	0.035
Individual-level Baseline Age 24 years	0.0438	−0.0197	0.1074	1.35	0.176
Individual-level gender (Female)	−0.1085	−0.4039	0.1869	−0.72	0.472
Individual-level race/ethnicity (Black)	−0.4774	−0.9373	−0.0175	−2.03	0.042
Individual-level race/ethnicity (Asian)	−1.7979	−2.4912	−1.1046	−5.08	0.0001
Individual-level race/ethnicity (Hispanic)	−0.5452	−1.0616	−0.0288	−2.07	0.039
Individual-level Household Income	0.0039	−0.0024	0.0103	1.21	0.225
Individual-level Parent Education (High School)	0.0239	−0.0080	0.0558	1.47	0.142
Individual-level Parent Education (Some College)	0.0295	−0.0041	0.0630	1.72	0.085
Individual-level Parent Education (College)	0.0102	−0.0270	0.0475	0.54	0.591
County-level Price-Soda‡	−0.2113	−0.3650	−0.0576	−2.69	0.007
County-level Price-Burger‡	−0.0342	−0.1777	0.1094	−0.47	0.641
CPI‡	1.1560	−0.3796	2.6916	1.48	0.140
Individual-level Race/ethnicity (Black)*	−0.2701	−0.4489	−0.0913	−2.96	0.003

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Variable	Coef	95% CI	95% CI	Z	P
County-level Price-Soda‡					
Individual-level Race/ethnicity (Black)* County-level Price-Burger‡	0.0450	−0.1171	0.2071	0.54	0.586
Individual-level Race/ethnicity (Hispanic)* County-level Price-SodaJ	−0.1293	−0.2988	0.0401	−1.5	0.135
Individual-level Race/ethnicity (Hispanic)* County-level Price-Burger‡	0.0366	−0.1089	0.1821	0.49	0.622
Individual-level Race/ethnicity (Asian)* County-level Price-Soda‡	−0.1626	−0.3692	0.0440	−1.54	0.123
Individual-level Race/ethnicity (Asian)* County-level Price-Burger‡	−0.1137	−0.3339	0.1066	−1.01	0.312
Individual-level Household Income* County-level Price-Soda‡	0.0028	0.0006	0.0049	2.55	0.011
Individual-level Household Income* County-level Price-Burger‡	−0.0019	−0.0038	0.0000	−1.92	0.055
Individual-level Gender* County-level Price-Soda‡	0.0652	−0.0449	0.1753	1.16	0.246
Individual-level Gender* County-level Price-Burger‡	0.0271	−0.0799	0.1342	0.5	0.619
Population Density§	0.0000	0.0000	0.0000	−4.12	0.0001
Population <100% poverty (%)§	−0.4216	−0.5422	−0.3010	−6.85	0.0001
Population College Educated (%)§	−0.3605	−0.4532	−0.2678	−7.62	0.0001
Population White (%)§	−0.1666	−0.2285	−0.1047	−5.27	0.0001
Alpha	0.2245	0.2141	0.2355		

*Longitudinal negative binomial model, includes all terms listed in table as well as indicator variables for school (not shown). Note that full set of coefficients for additional food price covariates and their interaction terms is shown in Appendix.

†The association between age and the outcome variable was not linear. The most appropriate specification was to use indicator variables for each age category.

‡Council for Community and Economic Research. Price data are County-specific (aggregated to the county-level), real prices, in 2006 US dollars, for a 2-L bottle of soda (“soda”), a one-quarter pound hamburger purchased at a fast food restaurant (“burger”), a 13-in cheese pizza, regular crust, purchased away from home (“pizza”), a one-half gallon of whole milk (“whole milk”), 1 lb US Department of Agriculture choice steak (“steak”), and fried chicken pieces, thigh and drumstick, purchased away from home (“fried chicken”).

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§Census Tract Level (US Census)