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Association Between County-Level Food Retail and Socioeconomic Environment and Nutritional Quality of Household Food Purchases, 2015

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Abstract

Background—About 40 million Americans do not have easy access to affordable nutritious foods. Healthier foods are less likely to be available to those living in rural and/or lower-income communities.

Objective—The objective of this study was to analyze the association between nutritional quality of household food purchases and county-level food retail environment; county-level demographic, health, and socioeconomic indicators; and household composition, demographic characteristics, and socioeconomic characteristics.

Design—This study is a secondary analysis of the 2015 Information Resources Inc Consumer Network panel; Purchase-to-Plate Crosswalk, which links US Department of Agriculture nutrition databases to Information Resources Inc scanner data; County Health Rankings; and the Food Environment Atlas data.

Participants and settings—A total of 63,285 households, representative of the contiguous US population, consistently provided food purchase scanner data from retail stores throughout 2015.

Main outcome measures—Nutritional quality of retail food purchases was assessed using the Healthy Eating Index 2015 (HEI-2015).

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AUTHOR CONTRIBUTIONS

Conceptualization: K. Roy and A. Carlson; methodology: A. Ghazaryan, A. Carlson, and K. Roy; software: A. Ghazaryan and A. Carlson; validation: A. Carlson; formal analysis: A. Ghazaryan and A. Carlson; resources: A. Carlson and A. Rhone; data curation: A. Ghazaryan, A. Carlson, and A. Rhone; writing—original draft preparation, A. Ghazaryan; writing—review and editing, K. Roy, A. Carlson, A. Rhone, and A. Ghazaryan; visualization: A. Ghazaryan, K. Roy, and A. Carlson; supervision, K. Roy and A. Carlson; project administration, K. Roy and A. Carlson. All authors reviewed and commented on subsequent drafts of the manuscript.

STATEMENT OF POTENTIAL CONFLICT OF INTEREST

No potential conflict of interest was reported by the authors

Statistical analysis—Multivariate linear regression analysis was used to simultaneously test the relationship between the main outcome and household-level demographic and socioeconomic characteristics as well as the county-level demographic, health, socio-economic, and retail food environment.

Results—Household heads who had higher education and households with higher incomes purchased food of better nutritional quality (ie, higher HEI-2015 scores). Also, the association between retail food purchase HEI-2015 scores and the food environment was weak. Higher density of convenience stores was associated with lower retail food purchase nutritional quality for higher-income households and households living in urban counties, whereas low-income households in counties with higher specialty (including ethnic) store density purchased higher nutritional quality food. Both in the full sample and when stratified by household income or county rural vs urban status, no association was found between grocery store, supercenters, fast-food outlets, and full-service restaurant densities and retail food purchase HEI-2015 scores. HEI-2015 scores were negatively correlated with the county average number of mental health days for higher income and urban households.

Conclusions—The study findings suggest that availability of healthier food alone may not improve healthfulness of retail food purchases. Future studies examining the influence of demand-side factors/interventions, such as habits, cultural preferences, nutrition education, and cost/affordability, on household purchasing patterns could provide complementary evidence to inform effective intervention strategies.

Keywords

Healthy Eating Index; Retail environment; IRI Consumer Network; Purchase to Plate Crosswalk; ERS Food Environment Atlas; County Health Rankings

Poor diet quality and nutrition are major preventable risk factors for leading chronic conditions, including obesity, diabetes, cardiovascular diseases, and some cancers.^{1–3} Dietary intake and quality is determined by individual and environmental factors, including cultural, political, physical, and socioeconomic determinants.⁴ In the United States, nearly 40 million individuals live in communities without easy access to affordable nutritious food; these are predominantly lower-income or rural communities with higher rates of diet-related chronic conditions.⁵ Many studies have analyzed disparities in access to stores and restaurants⁶ and interactions between built environments, such as availability of grocery stores, and health conditions, such as obesity and cardiovascular diseases.^{7,8}

Studies exploring the relationship between availability of stores/restaurants and diet quality report mixed evidence.⁹ Some report positive associations between availability of supermarkets/grocery stores and diet quality indexes, as well as meeting guidelines for specific dietary components such as intake of fruits and vegetables (F/V), or saturated fats,^{7,10–12} whereas other studies report null results.^{10,13,14} Similarly, access to fast-food outlets are shown to be negatively associated with diet quality in some studies,^{15,16} whereas no such association was found in others.^{12,14,17} Furthermore, lower-income, rural, and/or ethnic communities and neighborhoods report having access to fewer supermarkets but more convenience stores and fast-food restaurants than higher-income communities.^{18–22}

In response, federal, state, and local governments have funded programs to attract supermarkets in underserved areas.^{23,24}

Several previous studies analyzing the association between availability of stores/restaurants and diet quality focus on small geographic areas, such as a city or neighborhood,²⁵ and measure diet quality in terms of F/V intake.²⁶ In addition, most studies use distance to stores selling healthy food as proxy for access, although recent research suggests that households consider factors other than proximity when choosing where to shop.²⁴ In fact, about 90% of households usually shop at a supermarket/supercenter for groceries, often bypassing the closest option.²⁷

To summarize, there is an ongoing interest in making healthy foods more accessible and most of the previous studies measured access to healthy foods either in terms of neighborhood stores and/or in terms of specific products (eg, F/V). In this study, a multivariate linear regression analysis was used to simultaneously analyze the association between household-level store-bought food healthfulness (measured by the Healthy Eating Index 2015 [HEI-2015]) and county-level food retail environment; county-level demographic health and socioeconomic indicators; and household composition, demographic characteristics, and socioeconomic characteristics.

METHODS

Measures

To measure healthfulness of retail purchased food, the simple HEI-2015 scoring algorithm method was used, which summarizes how well a basket of foods conforms to the Dietary Guidelines for Americans 2015–2020.^{28,29} The index ranges from zero to 100, with 100 indicating conformance with the 13 dietary components: total vegetables, greens and beans, total fruits, whole fruits, whole grains, dairy, total protein foods, seafood and plant proteins, fatty acids, sodium, refined grains, saturated fats, and added sugars. The HEI-2015 is well suited for this study because it is density-based, capturing how well purchases meet recommended amounts of the dietary components (eg, per 1,000 kcal and ratio of fatty acids). Details on construction and applications of the HEI are discussed in the literature,^{29,30} and on the National Cancer Institute's HEI page.³¹

Data

The study used the 2015 Information Resources Incorporated (IRI) Consumer Network nationally representative household food purchase scanner data, which unlike data from dietary recall and food frequency questionnaires, covers food purchases by households from retail stores over an entire year. The data contained information on purchased products' quantities, prices, discounts, and coupons, household composition, and demographic and socioeconomic characteristics, as well as the household heads' education, age, and marital status. Types of stores covered included convenience, dollar, drug, grocery, liquor, and mass merchandiser/club stores, but did not include food away from home (eg, restaurants, fast-food outlets, or entertainment venues).

The primary survey respondent was either the only person in the household or one of the household heads, who was the self-selected primary shopper for the household. The presence of a second household head, as well as the sex of the household head(s) was identified by the primary respondent. Race and ethnicity, as reported by the primary shopper in the IRI data, was used in the analysis, which may represent characteristics of only the primary respondent, additional household members, or the entire household. The number of households included in the study was 63,285, which make up IRI's static panel of households that consistently reported purchases. IRI assigns projection factors (survey weights) to participating static panel households to make the panel nationally representative of the contiguous US household population.³²

Nutrition information was retrieved from the Purchase-to-Plate Crosswalk (PPC) data, which links US Department of Agriculture (USDA) nutrition databases to IRI scanner data.^{32–35} County-level food retail environment indicators were drawn from the Food Environment Atlas³⁶ dataset, which provides information on the density of grocery, convenience, and specialty stores (eg, ethnic stores, retail bakeries, meat and seafood markets, dairy stores, and produce markets), supercenters, fast-food and full-service restaurants, and farmers' markets. The densities of fast-food/full-service restaurants were included to capture potential dynamics between at-home and food-away-from-home purchase decisions (eg, households consuming less healthy food-away-from-home may purchase healthier products for at-home consumption). The data on density of stores/restaurants were from 2014, farmers' markets from 2016. Lastly, the County Health Rankings³⁷ data on county-level racial/ethnic composition (data year: 2015), rurality (data year: 2010), poor mental and physical health days (data year: 2015), and adult obesity prevalence (data year: 2013) was used. Rurality measures percentage of the county population living in census blocks classified as rural based on the 2010 Census Bureau's rural–urban classification, which was the last Census update applicable to data through 2020.³⁸

The study protocol did not require institutional review board review because of the use of secondary de-identified data not involving human subjects (as defined by federal regulations and guidance). In addition, the data used in the study have received clearance from IRI.

Statistical Analysis

Household HEI-2015 scores were calculated in several steps. First, household retail food purchase quantities (recorded in purchase weight grams) of each grocery item for a full year were merged with the USDA nutrition datasets using the PPC. Second, the purchase weight recorded in the IRI data were converted to edible weight using conversion factors in the PPC, and the USDA Food Pattern Equivalent Database³⁹ was used to calculate the food pattern equivalents. The HEI-2015 component and total scores were calculated at the household level using a Stata version 16.1⁴⁰ translation of the SAS programs on the National Cancer Institute's HEI page.³¹

To assess the association between healthfulness of food purchases and household characteristics and the county-level food environment and other indicators multivariate linear regressions were used. Regressions were performed using the household survey weights included in the Consumer Network data. Analyses were also conducted based on stratified

income categories (household income at or below 185% of the 2015 federal poverty level⁴¹ (FPL) and above 185%) and county rurality (rural [50% or more percent of the county population living in census blocks classified as rural] and urban). Income groupings were based on the eligibility requirements for USDA food assistance programs, such as Special Supplemental Program for Women, Infants, and Children⁴² and National School Lunch Program⁴³ (free or reduced-price meals). All specifications included binary indicators of households' residence state. Equality of coefficients between income groups and rural–urban stratifications was tested using the adjusted Wald test and a significance level of 0.05. Analysis was conducted using Stata version 16.1 software.⁴⁰

RESULTS

Descriptive Statistics

Table 1 presents the descriptive statistics (weighted means and 95% CIs, obtained using Stata's "svy: mean" command) summarizing household HEI-2015 and other characteristics of households and their counties of residence. The average weighted HEI-2015 score of retail food purchases was 51.55. About 24% of households were at or below 185% of the FPL. The average household size was almost three. The percentage of households where the primary shopper identified as non-Hispanic (NH) White, NH Black, NH Asian, NH Other, and Hispanic was 71%, 11%, 4%, 2%, and 12%, respectively. Household types included: 18% with younger children (younger than age 13 years), 15% with either only older children (aged 13 to 18 years) or both younger and older children, 5% young singles (aged 19 to 44 years, no children), 22% older singles (aged 45 year or older, no children), 9% young couples (aged 19 to 44 years, no children), and 32% older couples (no children, aged 45 years or older). About 62% of households had a married household head, about 38% of households had household heads who are single, widowed, or separated/divorced. Around 28% of households had only a female head (married or otherwise). For households with two heads (who were likely to make joint food purchase decisions even in the case that only one was the primary shopper), education represents the highest educational attainment amongst them, whereas age represents the average age of both household heads. Only 1% of households had at least one head with no diploma or less than a high school diploma, followed by 17% with a high school diploma. 28% of households had at least one head who attended some college, 35% had a college degree, and 19% had a postgraduate degree. Average age of household head was 52.4 years.

Average number of grocery stores per 10,000 county population was 2.0, supercenters was 0.17, convenience stores was 3.96, specialty stores was 0.7, fast-food restaurants was 7.18, full-service restaurants was 7.49, and farmers' markets was 0.27. The county-level average number of mentally and physically unhealthy days within a month (age-adjusted) was 3.71 and 3.68, respectively. The county-level average prevalence of self-reported adult obesity was 27.95%.

Household Characteristics

Table 2 presents regression results from the full sample and stratified by income. Table 3 includes results based on county rural–urban stratification. Findings showed that household

head's education had a positive association with food purchase quality. Household HEI-2015 score was 1.04 (95% CI 0.16 to 1.93), 2.24 (95% CI 1.36 to 3.12), 4.44 (95% CI 3.56 to 5.33), and 6.36 (95% CI 5.46 to 7.26) points higher for those with high school, some college, college, and postgraduate degrees, respectively, compared with those with less than a high school diploma. As indicated by the test of equality of coefficients, the coefficients were not statistically significantly different by income and urban–rural stratifications. Being above 185% of FPL (vs at/below) was associated with 1.70 (95% CI 1.44 to 1.96) points higher HEI-2015 score, with magnitudes not being statistically different for households in urban vs rural counties.

Relative to households with only younger children, households with only older children or both young and older children, on average, had 1.64 (95% CI –2.00 to –1.28) points lower HEI-2015 scores. The statistically significant difference held when stratified by income and rural–urban. The HEI-2015 score was lower by 0.70 points (95% CI –1.24 to –0.16) for young couples compared with households with young children. Although there was no statistically significant difference between HEI-2015 scores for young couples and households with younger children in rural counties, the HEI-2015 score in urban counties was 0.84 points (95% CI –1.41 to –0.26) lower for young couples compared with households with only younger children. Older couples (compared with households with only younger children), on average, had 0.93 points (95% CI –1.34 to –0.51) lower HEI-2015 scores. When stratified by income, HEI-2015 score for older couples at or below 185% of poverty was 1.65 points (95% CI –2.43 to –0.87) lower than for households with only younger children at or below 185% of FPL. Above 185% of FPL, the difference was only –0.75 (95% CI –1.23 to –0.26) but difference in the magnitude of coefficients across income groups were statistically significant.

Compared with NH White primary shoppers, HEI-2015 score was higher for NH Asian (1.20, 95% CI 0.60 to 1.80); Hispanic (1.17, 95% CI 0.74 to 1.59); and NH Black (0.89, 95% CI 0.56 to 1.21) primary shoppers. When stratified by income, these differences held for households with incomes above 185% of FPL. However, differences in HEI-2015 scores between NH White and NH Black, as well as NH White and NH Asian primary shoppers were not statistically significant for households at or below 185% of poverty. When stratified by county rurality, there was no statistically significant difference in HEI-2015 scores between different races and ethnicities in rural counties, but the difference remained in urban counties. The full sample results indicated that households where the household heads were married, on average, had higher HEI-2015 scores (0.55, 95% CI 0.17 to 0.92) than those where the household head was not married (ie, single, widowed, or separated/divorced). When stratified by household income, the difference was statistically significant only for those above 185% of FPL (0.59, 95% CI 0.13 to 1.04). When stratified by county rurality, the difference was only statistically significant for urban households (0.67, 95% CI 0.26 to 1.07). The HEI-2015 score was lower for households with only a female head (–0.82, 95% CI –1.16 to –0.48), compared with households with only a male or both male and female heads.

County Characteristics

Results from the full sample, as well as those stratified by household income and county rurality showed that the association between household-level retail food purchase quality and indicators on density of grocery stores, super-centers, fast-food restaurants, full-service restaurants, and farmers' markets were not statistically significant (Table 2). In contrast, number of convenience stores per 10,000 population was negatively associated with HEI-2015 scores based on the full sample (-0.22 , 95% CI -0.32 to -0.12), for households above 185% of FPL (-0.31 , 95% CI -0.42 to -0.19), and those in urban counties (-0.30 , 95% CI -0.44 to -0.16), but not for households at or below 185% of FPL and those in rural counties. The number of specialty stores per 10,000 population was positively associated with HEI-2015 scores based on the full sample (0.41 , 95% CI 0.07 to 0.74), and for households at or below 185% of FPL (0.97 , 95% CI 0.27 to 1.66), but not for households above 185% of FPL.

No statistically significant association between county racial/ethnic composition and HEI-2015 scores were found. The county-level average number of poor mental health days was negatively associated with HEI-2015 scores for the full sample (-0.89 , 95% CI -1.63 to -0.16), households above 185% of FPL (-1.12 , 95% CI -1.94 to -0.30), and households living in urban counties (-0.94 , 95% CI -1.72 to -0.16). The HEI-2015 score was, on average, 0.53 points (95% CI -0.91 to -0.15) lower for households in rural counties (relative to those in urban counties).

DISCUSSION

This study analyzed the association between nutritional quality of household food purchases from retail stores and household- and county-level characteristics, such as the food retail environment, socioeconomic and demographic characteristics, and physical/mental well-being. The contribution of this manuscript to the literature is threefold. First, county- and not neighborhood-level food retail environment indicators were used because counties are larger than neighborhoods, thereby capturing the possibility that households may shop at stores not in their neighborhoods. Studies have shown that most Americans do not shop at the nearest stores, considering aspects other than location when choosing where to shop.^{27,44} Second, household food scanner data were used, which unlike most other data sources (dietary recall or food frequency) used in the literature, collect purchase data over an entire year, thus providing a more realistic and comprehensive picture of what consumers purchase. Although store food purchases do not perfectly correlate with intake,⁴⁵ they shed light on at-home diet quality,⁴⁶ which, in turn, plays a role in shaping individual dietary intake.⁴⁷ Third, compared with previous studies that focus on one or several food groups and ingredients (eg, F/V consumption, added sugars, and sodium) to measure healthfulness of food purchases/consumption, the HEI-2015 was used to measure the healthfulness of food purchases, which incorporates 13 dietary components.

The findings suggested that most of the variation in healthfulness of at-home food purchases were explained by factors not included in the model, whereas most of the measured variation was explained by household characteristics rather than the food retail environment in the county of residence, county's demographic makeup, or rurality. Low R^2 values are

common in this type of analysis^{48–50} because factors influencing consumer decisions are varied and difficult to capture in large surveys. Household head's education level had a strong association with HEI-2015 scores: household heads with college degree had 3.78 (for households residing in rural counties) or 4.78 (for household above 185% of FPL) points higher HEI-2015 scores than those with less than a high school diploma. The association held regardless of household income or county's rural or urban status. The finding that education was positively related to food purchase quality is consistent with other studies.^{44,51,52} Another finding consistent with past studies^{47,52,53} is that household income was positively associated with food purchase/diet quality. Research has shown that lower income consumers tend to purchase/consume fewer fruits, vegetables, and fiber, and more sugary foods and beverages than higher-income consumers.^{54–56}

Among different types of retail stores and restaurants, only the numbers of convenience and specialty stores in a county were associated with household HEI-2015 scores. When stratified by household income or county rural or urban status, the positive association between specialty stores and HEI-2015 scores was statistically significant only for lower-income households. To our knowledge, this was the first study to separately analyze association between specialty stores and nutritional quality of retail food purchase. The negative coefficient on the number of convenience stores, although statistically significant in the full sample and for higher income and urban households, had a small magnitude. The negative association is consistent with other studies because convenience stores are mostly categorized as unhealthy store types, with a higher prevalence of processed and energy-dense foods.^{57–59} Overall, the study findings indicated that the food retail environment, even for geographic areas larger than neighborhoods, was mostly unrelated to the nutritional quality of retail food purchased.^{10,12–14,17,60} Although better access to different types of stores and restaurants was not associated with food purchase quality, a dietary intervention study based on data from Worcester County, MA, between June 2009 and January 2012 found that shorter distance to stores selling healthier products improves effectiveness of interventions (diet change aligning with the American Heart Association's Dietary Guidelines or increasing dietary fiber consumption), among adults with obesity.⁶¹ Another study suggested that prices may not only affect choice of products but also types of stores where consumers shop, especially for lower-income consumers who may choose stores offering lower prices.⁶² Better pricing for healthier foods compared to unhealthier alternatives might be another tool for promoting healthy eating than just improving availability of stores selling healthy products.⁶³ Some demand-side policies that have been effective in improving diet quality include nutrition education,⁶⁴ telehealth dietary interventions,⁶⁵ and tailored behavioral interventions.⁶⁶

Limitations

This study comes with several limitations. First, the data included only food-at-home purchases, which accounted for about 50% of food expenditures and 66% of total calories consumed⁶⁷ and excluded food-away-from-home purchases. Second, data reported were at the household level, whereas food intake is an individual-level activity. Third, food purchases are not equal to intake because some products may go unused. Fourth, the calculation of the HEI-2015 score did not include random weight products—items selected

by the consumer individually (eg, fresh meat, poultry, seafood, bakery, fruits, vegetables, cheese, cold cuts and lunch meat, prepared foods, coffee, and candy, nuts, and seeds), rather than sold in fixed-weight packages—because study participants did not report the quantity purchased for these items. Given that different random weight product categories affect the HEI-2015 differently, the direction of the potential bias in HEI-2015 calculation resulting from their exclusion is unknown. In the 2013 IRI Consumer Network, random weight produce accounted for 40% to 45% of produce expenditures, but this is likely not consistent across households.³³ It has been shown that compared with the Consumer Expenditure Survey, purchases in the Consumer Network Panel were underreported, with reporting rates varying between food types and demographic groups—expenditures on product categories containing a large share of random weight items (eg, fresh fruits, fresh vegetables, and meat) were particularly lower in the Consumer Network Panel.³³ For example, in 2012, Consumer Network expenditure as a percent of Consumer Expenditure Survey expenditure on fresh vegetables, fresh fruits, and beef was 47.2%, 49.7%, and 61.6%, respectively.³³ This study did not identify whether the expenditures were lower because of price sensitivity, underreporting, or both. Fifth, county-level densities of different store types, unlike proximity indicators (eg, distance or travel time, which have their own limitations⁶⁸), do not necessarily measure households' actual exposure and access to those stores. Because there are many factors influencing where households shop and because defining consistent and appropriate geographic boundaries is a challenging methodological issue,⁶⁸ county-level indicators add to the diversity of geographic areas used in the literature, such as buffer distances, neighborhoods, census tracts, and block groups, among others.¹²

CONCLUSION

The findings suggest that availability of healthier food alone may not improve the nutritional quality of retail food purchases. Future studies examining the influence of demand-side factors and interventions in influencing household purchasing patterns by addressing habits/cultural preferences, nutrition education, and cost/affordability barriers especially for lower income households may provide complementary evidence useful in informing effective intervention strategies.

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RESEARCH SNAPSHOT

Research Questions:

What are the associations between household-level store-bought food healthfulness and county-level food retail environments; county-level demographic, health, and socioeconomic indicators; and household composition, demographic characteristics, and socioeconomic factors? Do these associations vary by household income and county rurality?

Key Findings:

The association between retail food purchase Healthy Eating Index 2015 (HEI-2015) scores and food retail environment was weak. Higher density of convenience stores was associated with slightly lower retail food purchase HEI-2015 scores for higher-income households and households living in urban counties, whereas low-income households in counties with higher specialty (including ethnic) store density purchased higher nutritional quality food. Both in the full sample and when stratified by household income or county rural/urban status, no association was found between grocery store, supercenters, fast-food outlets, and full-service restaurant densities and retail food purchase HEI-2015 scores. The county-level average number of reported mental health days was also negatively associated with retail food purchase HEI-2015 scores for higher income and urban households. Differences in retail food purchase HEI-2015 scores were also observed based on household head(s) education level, household income, composition, and demographic characteristics.

Table 1.

Characteristics of households participating in the 2015 Information Resources Incorporated Consumer Network Panel and their counties of residence

Variable	Weighted mean (95% CI)
Healthy Eating Index 2015 ^a	51.55 (51.45–51.65)
At or below 185% of federal poverty level	0.24 (0.24–0.24)
Above 185% of federal poverty level	0.76 (0.76–0.76)
Household size	2.57 (2.55–2.58)
Race and ethnicity	
Non-Hispanic White	0.71 (0.71–0.72)
Non-Hispanic Black	0.11 (0.11–0.11)
Non-Hispanic Asian	0.04 (0.04–0.04)
Non-Hispanic Other	0.02 (0.02–0.03)
Hispanic	0.12 (0.11–0.12)
Household type	
Households with only younger children, younger than age 13 years	0.18 (0.18–0.19)
Households with only older children (aged 13–18 years) or both young and older children	0.15 (0.15–0.15)
Young singles, aged 19–44 years	0.05 (0.04–0.05)
Older singles, aged 45 years or older	0.22 (0.22–0.22)
Young couples, aged 19–44 years	0.09 (0.08–0.09)
Older couples, aged 45 years or older	0.32 (0.31–0.32)
Married household head	0.62 (0.61–0.62)
Female only head	0.28 (0.27–0.28)
Household head's education and age	
No diploma or less than high school	0.01 (0.01–0.02)
High school	0.17 (0.16–0.17)
Some college	0.28 (0.27–0.28)
College degree	0.35 (0.35–0.35)
Post-graduate	0.19 (0.19–0.20)
Household head age (y)	52.4 (52.3–52.6)
County retail food environment ^b	
Grocery stores per 10,000 population	2.00 (1.99–2.01)
Supercenters per 10,000 population	0.17 (0.17–0.17)
Convenience stores per 10,000 population	3.96 (3.94–3.97)
Specialty stores per 10,000 population	0.70 (0.69–0.70)
Fast-food restaurants per 10,000 population	7.18 (7.17–7.20)
Full-service restaurants per 10,000 population	7.49 (7.46–7.52)
Farmers markets per 10,000 population	0.27 (0.26–0.27)
County racial and ethnic composition ^c	
% Non-Hispanic White	64.01 (63.79–64.22)
% Non-Hispanic Black	12.22 (12.10–12.34)
% Asian	5.20 (5.14–5.26)

Variable	Weighted mean (95% CI)
% Hispanic	15.98 (15.81–16.15)
County health indicators and rurality	
Poor mental health days ^d	3.71 (3.70–3.71)
Poor physical health days	3.68 (3.68–3.69)
% Adult obesity	27.95 (27.90–28.00)
Rural	0.12 (0.12–0.13)
N (unweighted)	63,285

^aThe Healthy Eating Index 2015 score was calculated using the simple scoring algorithm method.

^bRetail food environment indicators were obtained from the Food Environment Atlas dataset.

^cCounty racial and ethnic composition, health indicators, and rurality are from the Country Health Rankings dataset.

^dPoor mental and physical health days are average numbers of mentally/physically unhealthy days reported in past 30 days. The values are age-adjusted.

Table 2.

Association between Healthy Eating Index 2015 (HEI-2015)^a and county-level food retail and socioeconomic environment: Results from multivariate linear regressions estimated using the full sample and stratified by household income

Variable	Full sample		At or below 185% of federal poverty level		Above 185% of federal poverty level		Test of equality of coefficients ^b	
	Coefficient ^c (95% CI)	P value	Coefficient ^c (95% CI)	P value	Coefficient (95% CI)	P value	P value	P value
County retail food environment ^d								
Grocery stores per 10,000 population	-0.05 (-0.20 to 0.10)	0.51	-0.17 (-0.48 to 0.14)	0.28	-0.01 (-0.18 to 0.16)	0.92	0.37	0.37
Supercenters per 10,000 population	-0.25 (-1.17 to 0.68)	0.60	0.16 (-1.62 to 1.93)	0.86	-0.47 (-1.54 to 0.61)	0.39	0.55	0.55
Convenience stores per 10,000 population	-0.22 (-0.32 to -0.12)	< 0.001	-0.04 (-0.24 to 0.16)	0.70	-0.31 (-0.42 to -0.19)	< 0.001	0.02	0.02
Specialty stores per 10,000 population	0.41 (0.07 to 0.74)	0.02	0.97 (0.27 to 1.66)	0.01	0.19 (-0.19 to 0.57)	0.33	0.05	0.05
Fast-food restaurants per 10,000 population	0.05 (-0.04 to 0.14)	0.25	-0.02 (-0.19 to 0.15)	0.81	0.08 (-0.02 to 0.18)	0.12	0.32	0.32
Full-service restaurants per 10,000 population	-0.05 (-0.11 to 0.01)	0.10	-0.05 (-0.16 to 0.07)	0.41	-0.04 (-0.10 to 0.03)	0.28	0.85	0.85
Farmers markets per 10,000 population	-0.06 (-0.47 to 0.35)	0.77	0.15 (-0.71 to 1.02)	0.73	-0.15 (-0.60 to 0.30)	0.52	0.55	0.55
Household income and size Above 185% of federal poverty level	1.70 (1.44 to 1.96)	< 0.001						
Household size	-0.50 (-0.62 to -0.38)	< 0.001	-0.42 (-0.63 to -0.21)	< 0.001	-0.54 (-0.69 to -0.40)	< 0.001	0.34	0.34
Race and ethnicity								
Non-Hispanic Black (reference: non-Hispanic White)	0.89 (0.56 to 1.21)	< 0.001	0.63 (-0.08 to 1.34)	0.08	0.94 (0.58 to 1.31)	< 0.001	0.44	0.44
Non-Hispanic Asian	1.20 (0.60 to 1.80)	< 0.001	1.48 (-0.06 to 3.02)	0.06	1.16 (0.51 to 1.82)	< 0.001	0.71	0.71
Non-Hispanic Other	0.16 (-0.48 to 0.79)	0.63	0.53 (-0.62 to 1.68)	0.37	0.06 (-0.71 to 0.82)	0.89	0.51	0.51
Hispanic (reference: non-Hispanic)	1.17 (0.74 to 1.59)	< 0.001	1.16 (0.26 to 2.06)	0.01	1.18 (0.69 to 1.66)	< 0.001	0.98	0.98
Household type								
Households with only older children or both young and older children (reference: households with only young children)	-1.64 (-2.00 to -1.28)	< 0.001	-1.73 (-2.40 to -1.06)	< 0.001	-1.60 (-2.03 to -1.18)	< 0.001	0.76	0.76
Young singles	0.21 (-0.61 to 1.02)	0.61	-0.01 (-1.72 to 1.70)	0.99	0.34 (-0.59 to 1.28)	0.47	0.73	0.73
Older singles	-0.16 (-0.72 to 0.40)	0.57	-0.74 (-1.73 to 0.25)	0.15	0.08 (-0.60 to 0.76)	0.82	0.18	0.18
Young couples	-0.70 (-1.24 to -0.16)	0.01	-1.44 (-2.59 to -0.29)	0.01	-0.51 (-1.12 to 0.10)	0.10	0.16	0.16
Older couples	-0.93 (-1.34 to -0.51)	< 0.001	-1.65 (-2.43 to -0.87)	< 0.001	-0.75 (-1.23 to -0.26)	< 0.001	0.05	0.05
Married (reference: single/widowed/separated/divorced)	0.55 (0.17 to 0.92)	< 0.001	0.48 (-0.20 to 1.17)	0.17	0.59 (0.13 to 1.04)	0.01	0.80	0.80

Variable	Full sample			At or below 185% of federal poverty level			Above 185% of federal poverty level			Test of equality of coefficients ^b	
	Coefficient ^c (95% CI)	P value	Coefficient ^c (95% CI)	P value	Coefficient (95% CI)	P value	Coefficient (95% CI)	P value	P value	P value	
Female only head (reference: male only or both female and male head)	-0.82 (-1.16 to -0.48)	< 0.001	-0.56 (-1.22 to 0.09)	0.09	-0.96 (-1.36 to -0.56)	< 0.001				0.31	
Household head's education and age											
High school (reference: no high school diploma)	1.04 (0.16 to 1.93)	0.02	0.95 (-0.15 to 2.04)	0.09	1.27 (-0.21 to 2.75)	0.09				0.73	
Some college	2.24 (1.36 to 3.12)	< 0.001	2.13 (1.03 to 3.22)	< 0.001	2.48 (1.01 to 3.94)	< 0.001				0.71	
College	4.44 (3.56 to 5.33)	< 0.001	4.04 (2.92 to 5.16)	< 0.001	4.78 (3.31 to 6.24)	< 0.001				0.43	
Post-graduate	6.36 (5.46 to 7.26)	< 0.001	6.26 (4.86 to 7.66)	< 0.001	6.62 (5.14 to 8.09)	< 0.001				0.73	
Household head age	0.05 (0.04 to 0.06)	< 0.001	0.05 (0.03 to 0.08)	< 0.001	0.05 (0.04 to 0.07)	< 0.001				1.00	
County racial and ethnic composition ^e											
% Non-Hispanic White	-0.02 (-0.06 to 0.02)	0.35	0.02 (-0.06 to 0.11)	0.60	-0.04 (-0.09 to 0.02)	0.17				0.24	
% Non-Hispanic Black	0.01 (-0.04 to 0.05)	0.68	0.05 (-0.03 to 0.14)	0.24	-0.01 (-0.06 to 0.05)	0.82				0.26	
% Asian	-0.04 (-0.10 to 0.02)	0.15	0.03 (-0.09 to 0.15)	0.63	-0.07 (-0.14 to -0.00)	0.04				0.15	
% Hispanic	-0.03 (-0.07 to 0.02)	0.24	0.00 (-0.08 to 0.09)	0.94	-0.04 (-0.09 to 0.01)	0.15				0.42	
County health indicators and rurality											
Poor mental health days ^f	-0.89 (-1.63 to -0.16)	0.02	-0.10 (-1.74 to 1.54)	0.91	-1.12 (-1.94 to -0.30)	0.01				0.27	
Poor physical health days	0.20 (-0.32 to 0.72)	0.45	-0.05 (-1.22 to 1.13)	0.94	0.24 (-0.34 to 0.82)	0.41				0.67	
% Adult obesity	-0.14 (-0.18 to -0.10)	< 0.001	-0.08 (-0.17 to 0.01)	0.07	-0.15 (-0.20 to -0.10)	< 0.001				0.21	
Rural (ref: urban)	-0.53 (-0.91 to -0.15)	0.01	-0.72 (-1.43 to -0.01)	0.05	-0.48 (-0.93 to -0.04)	0.03				0.58	
Intercept	54.40 (48.99 to 59.81)	< 0.001	46.59 (36.06 to 57.11)	< 0.001	58.21 (51.78 to 64.65)	< 0.001				0.06	
R ²	0.09		0.06		0.07						
N	63,285		11,659		51,626						

^aThe simple scoring algorithm method was used for the HEI-2015 calculation. The score is calculated based on the retail food purchases reported by the static-panel households of the national-representative Information Resources Incorporated Consumer Network Panel 2015.

^bEquality of coefficients between income groups were tested using the adjusted Wald test.

^cCoefficients on binary indicators of state of residence are omitted for brevity.

^dRetail food environment indicators were obtained from the Food Environment Atlas dataset.

^eCounty racial and ethnic composition, health indicators, and rurality are from the Country Health Rankings dataset.

^fPoor mental and physical health days are average numbers of mentally/physically unhealthy days reported in past 30 days. The values are age-adjusted.

Table 3.

Association between Healthy Eating Index 2015 (HEI-2015)^a and county-level food retail and socioeconomic environment: Results from multivariate linear regressions, stratified by county rural or urban status

Variable	Rural		Urban		Test of equality of coefficients ^b
	Coefficient ^c (95% CI)	P value	Coefficient (95% CI)	P value	
County retail food environment ^d					
Grocery stores per 10,000 population	-0.14 (-0.37 to 0.10)	0.25	-0.01 (-0.22 to 0.21)	0.94	0.43
Supercenters per 10,000 population	-0.52 (-1.81 to 0.77)	0.43	-0.15 (-1.52 to 1.23)	0.84	0.70
Convenience stores per 10,000 population	-0.03 (-0.18 to 0.11)	0.67	-0.30 (-0.44 to -0.16)	<0.001	0.01
Specialty stores per 10,000 population	0.39 (-0.07 to 0.85)	0.10	0.41 (-0.08 to 0.91)	0.10	0.95
Fast-food restaurants per 10,000 population	0.07 (-0.09 to 0.23)	0.37	0.03 (-0.08 to 0.14)	0.58	0.68
Full-service restaurants per 10,000 population	-0.07 (-0.16 to 0.02)	0.13	-0.03 (-0.11 to 0.04)	0.37	0.53
Farmers markets per 10,000 population	-0.19 (-0.73 to 0.35)	0.48	0.45 (-0.22 to 1.12)	0.19	0.14
Household income and size					
Above 185% of federal poverty level	1.48 (0.91 to 2.05)	<0.001	1.76 (1.46 to 2.05)	<0.001	0.40
Household size	-0.28 (-0.58 to 0.02)	0.07	-0.52 (-0.65 to -0.39)	<0.001	0.15
Race and ethnicity					
Non-Hispanic Black (reference: non-Hispanic White)	0.76 (-0.31 to 1.84)	0.16	0.90 (0.55 to 1.24)	<0.001	0.82
Non-Hispanic Asian	0.16 (-2.84 to 3.17)	0.91	1.21 (0.60 to 1.82)	<0.001	0.50
Non-Hispanic Other	-0.29 (-1.70 to 1.12)	0.68	0.19 (-0.51 to 0.89)	0.59	0.55
Hispanic (reference: non-Hispanic)	1.22 (-0.39 to 2.84)	0.14	1.15 (0.71 to 1.59)	<0.001	0.93
Household type					
Households with only older children or both young and older children (reference: households with only young children)	-1.00 (-1.89 to -0.12)	0.03	-1.73 (-2.12 to -1.34)	<0.001	0.14
Young singles	0.87 (-1.28 to 3.01)	0.43	0.11 (-0.76 to 0.98)	0.81	0.52
Older singles	0.14 (-1.28 to 1.56)	0.84	-0.19 (-0.79 to 0.42)	0.54	0.67
Young couples	0.47 (-0.96 to 1.90)	0.52	-0.84 (-1.41 to -0.26)	<0.001	0.10
Older couples	-0.90 (-1.97 to 0.18)	0.10	-0.91 (-1.35 to -0.46)	<0.001	0.99
Married (reference: single/widowed/separated/divorced)	-0.34 (-1.26 to 0.58)	0.47	0.67 (0.26 to 1.07)	<0.001	0.05
Female only head (reference: male only or both female and male heads)	-1.55 (-2.45 to -0.66)	<0.001	-0.73 (-1.09 to -0.36)	<0.001	0.09
Household head's education and age					

Variable	Rural		Urban		Test of equality of coefficients ^b	
	Coefficient ^c (95% CI)	P value	Coefficient (95% CI)	P value	P value	P value
High school (reference: no high school diploma)	1.03 (-0.94 to 3.00)	0.30	1.06 (0.08 to 2.04)	0.03	0.98	0.98
Some college	1.91 (-0.04 to 3.87)	0.05	2.34 (1.37 to 3.31)	<0.001	0.70	0.70
College	3.78 (1.82 to 5.73)	<0.001	4.57 (3.60 to 5.55)	<0.001	0.47	0.47
Postgraduate	5.86 (3.78 to 7.93)	<0.001	6.46 (5.47 to 7.45)	<0.001	0.61	0.61
Head age	0.08 (0.05 to 0.11)	<0.001	0.05 (0.04 to 0.06)	<0.001	0.04	0.04
County racial and ethnic composition ^e						
% Non-Hispanic White	0.00 (-0.07 to 0.06)	0.90	-0.03 (-0.12 to 0.06)	0.55	0.67	0.67
% Non-Hispanic Black	0.00 (-0.07 to 0.07)	0.94	0.00 (-0.09 to 0.10)	0.93	0.98	0.98
% Asian	-0.07 (-0.80 to 0.66)	0.85	-0.05 (-0.15 to 0.05)	0.32	0.96	0.96
% Hispanic	-0.06 (-0.14 to 0.02)	0.16	-0.03 (-0.12 to 0.06)	0.50	0.67	0.67
County health indicators						
Poor mental health days ^f	-1.86 (-4.78 to 1.05)	0.21	-0.94 (-1.72 to -0.16)	0.02	0.55	0.55
Poor physical health days	0.35 (-1.43 to 2.13)	0.70	0.24 (-0.33 to 0.80)	0.41	0.91	0.91
% Adult obesity	-0.08 (-0.19 to 0.03)	0.15	-0.13 (-0.18 to -0.09)	<0.001	0.41	0.41
Intercept	52.54 (40.53 to 64.55)	<0.001	55.39 (45.62 to 65.15)	<0.001	0.72	0.72
R	0.08		0.08			
N	8,359		54,926			

^aThe simple scoring algorithm method was used for the HEI-2015 calculation. The score is calculated based on the retail food purchases reported by the static-panel households of the national-representative Information Resources Incorporated Consumer Network Panel 2015.

^bEquality of coefficients between rural or urban stratifications were tested using the adjusted Wald test.

^cCoefficients on binary indicators of state of residence are omitted for brevity.

^dRetail food environment indicators were obtained from the Food Environment Atlas dataset.

^eCounty racial and ethnic composition, health indicators, and rurality are from the Country Health Rankings dataset.

^fPoor mental and physical health days are average numbers of mentally/physically unhealthy days reported in past 30 days. The values are age-adjusted.