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Consumption of Fruits and Vegetables and the Role of the Food Environment

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Abstract

We use survey data to examine the relationship between food environment variables and the frequency of fruit and vegetable consumption in counties with high obesity rates in the Mississippi Delta. Results indicate that a lower vegetable, salad, and fruit consumption frequency is associated with longer distances traveled to a full-service grocery store, whereas access to public transportation is associated with a higher frequency of vegetable, fruit, and fruit juice consumption. The findings of this study can inform the development of localized interventions seeking to improve the food environment and increase fruit and vegetable consumption in rural communities.

Keywords: food access, food environment, fruit and vegetable consumption, obesity

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Introduction

Policy makers and health officials have long been concerned with poor-quality diets due to their association with diet-related chronic diseases, including obesity, cardiovascular disease, high blood pressure, and type 2 diabetes. The promotion of healthy diets is especially important given the growing trend in obesity rates in the United States over the past few decades. The rising prevalence of obesity is recognized as a national health epidemic with an immediate need for effective and sustainable interventions (Wang et al., 2020). A higher prevalence of obesity is often observed among African Americans, females, older adults, and individuals with a high school education or less (Hales et al., 2020).

In 2022, Mississippi had an obesity rate of 39.5% and was ranked fourth highest obesity prevalence in the United States (Americashealthrankings.org, 2024). Some counties in the Delta region of Mississippi have obesity rates of 40% and higher, representing some of the highest rates in the nation (countyhealthrankings.org, 2023). Additionally, Mississippi's poverty rate of 19.6% in 2023 was the highest in the country (Americashealthrankings.org, 2024), which suggests many households in this region lack the resources required to purchase the foods they need to live a healthy lifestyle. This relationship is supported by previous studies in Mississippi, which found evidence of poor dietary quality, a lower intake of key nutrients, and a higher intake of unhealthy foods, particularly among disadvantaged sociodemographic groups (Connell et al., 2007; McCabe-Sellers et al., 2007). Environmental disparities, and particularly the built food environment, may contribute to observed poor health outcomes, including higher rates of obesity in the Delta region.

The CDC (2021) defines the food environment as "the physical presence of food that affects a person's diet, a person's proximity to food store locations, a connected system that allows access to food, or the distribution of food stores, food service, and any physical entity by which food may be obtained." Previous studies examining the food environment and food availability found significantly higher levels of deprivation in grocery store access within low-income or otherwise socioeconomically disadvantaged communities (Morland et al., 2002; Connell et al., 2007; Powel et al., 2007; Larson, Stort, and Nelson, 2009; Ko et al., 2018). Similarly, studies found limited assortments of healthy food options in areas with low food access (Cheranides and Jeanicke, 2019). However, studies researching the influence of the food environment on obesity outcomes have predominantly found null and inverse associations between store availability and negative health outcomes, contrary to some expectations (Cobb et al., 2015).

Limited access to healthy and affordable food at the local level increases the likelihood that individuals must travel greater distances to access healthy food options (Kaiser, Carr, and Fontabella, 2017). Some studies suggest that lower levels of local food access directly affect the quality of residents' diets (Caspi et al., 2012), potentially increasing health risks associated with poor diet and nutrition (Hill-Briggs et al., 2021). However, there are unobservable or unmeasurable factors (e.g., preferences, perceptions) that affect diet quality and health outcomes but are not always controlled for in empirical studies due to the lack of individual data and measures. These factors create a potential for bias due to the use of causal inference methods or due to their unobservable and immeasurable nature (Cobb et al., 2015).

Multiple local, state, and federal initiatives have sought to improve the food environment, food choices, and associated health outcomes. The CDC's High Obesity Program (HOP) (CDC, 2023b) is one such federal initiative consisting of cooperative agreements with Cooperative Extension Services in counties with the nation's highest obesity rates (obesity rates of 40% or higher). Based on the premise that improvements to local food environments can lead to healthier consumer choices and health outcomes—including obesity rate reductions (Steeves, Martins, and Gittelsohn, 2014)—HOP's primary goal is to combat obesity through improved consumption of healthy foods and increased levels of physical activity.

Our study is part of the HOP-funded project titled, "Advancing, Inspiring, Motivating for Community Health through Extension" (AIM for CHangE), led by Mississippi State University. To identify potential strategies for improving the local food environment, the AIM for CHangE team conducted a community survey to assess the food environment of Mississippi Delta counties with the state's highest obesity rates. Specifically, the goal of this study is to examine the link between fruit and vegetable consumption frequency and food environment variables, such as distance traveled to the nearest full-service grocery store and access to healthy foods as measured by access to public transportation and whether respondents shop for food at convenience and/or dollar store formats. We found that, on average, residents in the target counties travel 13 miles to the nearest full-service grocery store. For comparison, the average U.S. household travels 2.19 miles to the nearest supermarket or large grocery store (Ver Ploeg et al., 2015). According to the USDA (2022), rural areas are considered low access if residents are within 10 to 20 miles of a grocery store or supermarket. Residents with limited access to grocery stores often resort to shopping at convenience and dollar store formats to meet their food needs. Our results suggest a lower frequency of vegetable and salad consumption associated with longer grocery store distance, but a higher consumption frequency when residents have access to public transportation. While our results are not novel in that they agree with previous findings in the literature, our study provides localized information that could be shared with community coalitions to commence discussions regarding the community and initiatives that could be implemented. Our assessment aims to provide insights for communities in these Delta counties and inform local strategies to address obesity from a food environment, food systems, and policy perspective.

Data and Methods

Survey Data

The data used in this study are from a community survey of seven Mississippi Delta counties (see Figure 1) with the state's highest obesity rates (obesity > 40.0%). The survey was administered by the AIM for CHangE team with the help of community coalitions using paper and online formats. Study participants were randomly recruited throughout the target counties using flyers advertising the survey and containing QR codes with links to the online survey. Flyers were posted in frequently visited locations in each of the counties. The team also administered in-person surveys to help solicit responses from individuals without internet access. Participants who completed the survey were entered into a raffle for a $25 gift card to a local retailer. The data collection took place between January 2020 and March 2020, with a total of 352 completed survey responses.

Given the approach used to recruit participants, it is difficult to calculate a response rate. Because we excluded observations with missing data, we only used 222 observations in our analysis. The survey included questions pertaining to respondents' demographic characteristics, diet and nutrition, and physical activity.

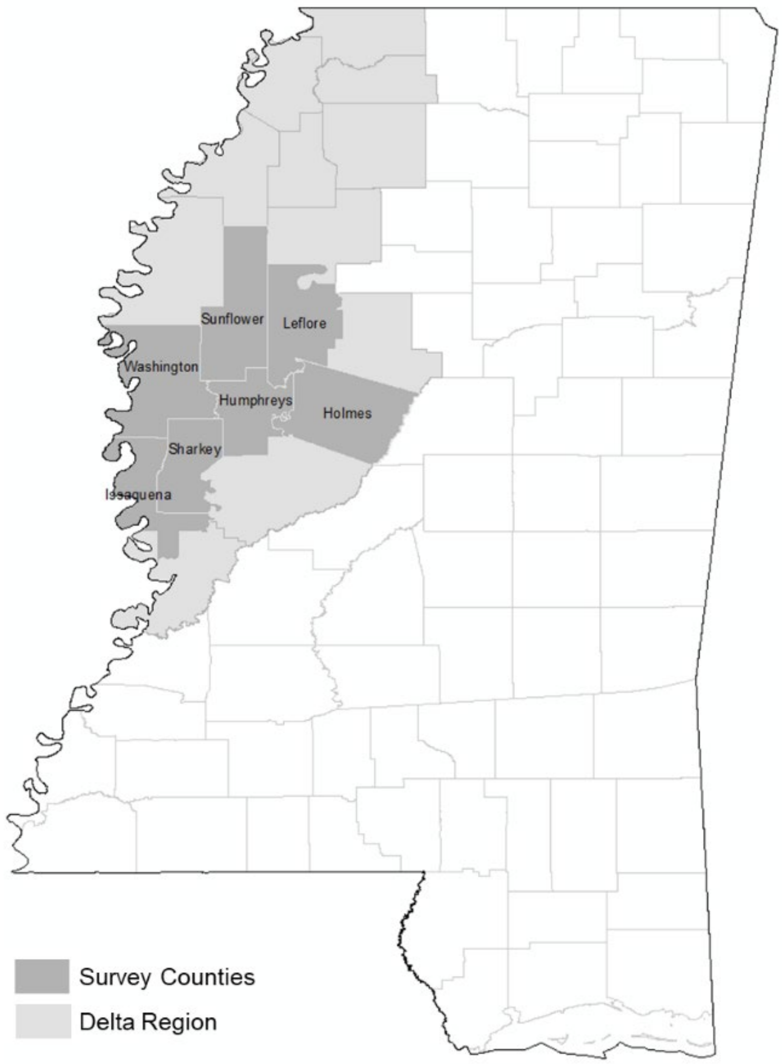

Figure 1. Map of the Mississippi Delta Region Highlighting the Targeted Counties Used for HOP Survey. Targeted Counties Include Holmes, Humphreys, Issaquena, Leflore, Sharkey, Sunflower, and Washington.

To measure the frequency of fruit and vegetable consumption, the survey included a simplified version of the National Cancer Institute's (NCI) Eating at America's Table Study (EATS) food frequency questionnaire, which is based on a 30-day dietary recall period (Thompson et al., 2011). We assess the consumption of specific food categories by asking respondents how often they ate or drank specific foods or beverages within the last 30 days. Foods and beverages include 100% fruit juice, fruits (fresh, frozen, and canned), lettuce salad consumed with or without other vegetables, and all other vegetables (raw, cooked, canned, and frozen, excluding lettuce salads and potatoes). The original survey responses had seven frequency categories, including “never,” “1–3 times last month,” “1–2 times a week,” “3–4 times a week,” “5–6 times a week,” “once a day,” and “more than once a day.” These categories were then grouped into three categories, including *Monthly* (respondents reporting “never” or “1–3 times last month”), *Weekly* (“1–2 times a week” or “3–4 times a week”), and *Daily* (“5–6 times a week,” “once a day,” or “more than once a day”). While five to six times a week does not perfectly equate daily consumption, it was classified as *Daily* for the purpose of our analysis given its proximity. Changes in the original variable categories were made because of the limited number of responses within the “never” and “more than once a day” response categories for some of the fruit and vegetable groups.

The key independent variables of interest are measures of the respondent’s local food environment. The survey included questions to gauge self-reported food accessibility in terms of public transportation and distance traveled to the nearest full-service grocery store. The variables included are the distance traveled to the nearest full-service grocery store (*Store Distance*) and an indicator of whether the community where the respondents live has any form of public transportation, such as bus routes (*Transportation*). To assess *Store Distance,* we specifically asked respondents, “How many miles do you have to travel to the nearest full-service grocery store, like Walmart or Sunflower, where you can get most of your groceries.” Access to public transportation is included to control for accessibility of full-service grocery stores. A longer distance traveled to a grocery store is expected to be negatively correlated with fruit and vegetable consumption frequency (Connell et al., 2007; Michimi and Wimberly, 2010). While availability of public transportation is not a direct measure of transportation access, it helps control for individuals’ ability to access grocery stores in cases where they may not have access to a personal vehicle. On average, Mississippi residents have limited access to personal vehicles, particularly among individuals with low grocery store access (USDA-ERS, 2020). We also include zip-code level population from the American Community Survey (U.S. Census Bureau, 2022) as a measure of rurality to account for the size of the location where residents live and control for food environment differences not captured by the variables in our survey.

Other food environment variables include indicators of where individuals report shopping for food. We include indicators for whether respondents shop for food at convenience stores (*Shop Conv Store*) or dollar store formats (*Shop Doll Store*). To obtain this information, we asked respondents, “Where do you get food in your county?” Respondents were able to select multiple responses from a list of options, including different store formats, farmers’ markets, food banks and other assistance programs, home gardens, full-service restaurants, fast food restaurants, and other. Shopping at either a convenience store or a dollar store format is expected to be correlated with lower consumption frequencies of fruits and vegetables, as these store formats generally offer a less healthy and less varied assortment of food options (Larson, Stort, and Nelson, 2009; Canales et al., 2021). In addition to food environment variables, we included variables capturing what respondents believed to be barriers preventing higher fruit and vegetable consumption. The survey asked respondents if they would consume more fruits and vegetables if the prices were cheaper (*Price*), or if they tasted better (*Taste*). These variables control for respondent preferences as well as affordability.

We report summary statistics in Table 2. The original sample in our study had a larger proportion of women, older respondents, and respondents with a college degree when compared to the population in the study area (see Table 2), which is consistent with the profile of individuals who are generally more likely to respond to surveys (Curtin, Presser, and Singer, 2000). African Americans make up 71.2% of the Delta region but represented 81.8% of the survey sample. Given that our sample was not representative of the overall characteristics of the Delta region, we applied poststratification weighting using iterative proportional fitting or ranking in STATA v.18 (Bergmann, 2011). Poststratification weights were estimated based on the following distribution of demographic (U.S. Census) variables in our target region: age (18–60 years 71%, above 60 years 29%), gender (male 48%, female 52%), race (African American 71%, other races 29%), college degree (college 14%, no college 86%), and employment (employed 42%, other 58%). In Tables 1 and 2 we report both weighted and unweighted sample summary statistics. Because there is no means of verifying the representativeness of the findings against the general population of the area, any general extrapolations of the findings should be done with this caveat in mind.

Table 1. Summary Statistics for Categorical Dependent Variables

	Unweighted Sample				**Weighted Sample**			
Consumption Frequency	**Vegetables**	**Salad**	**Fruit**	**Fruit Juice**	**Vegetables**	**Salad**	**Fruit**	**Fruit Juice**
Monthly	28.8%	36.9%	18.0%	32.9%	29.4%	46.2%	18.3%	34.7%
Weekly	53.2%	50.9%	55.9%	45.5%	52.6%	39.0%	52.8%	43.2%
Daily	18.0%	12.2%	26.1%	21.6%	18.1%	14.8%	29.0%	22.2%

Table 2. Summary Statistics for Independent Variables

		Unweighted Sample		**Weighted Sample**	
Variable	**Description**	**Mean**	**St. Dev.**	**Mean**	**St. Dev.**
Age	Respondent's age in years	51.77	15.42	49.91	1.75
Gender	= 1 if Male	0.20	0.40	0.48	0.50
Race	= 1 if African American	0.82	0.38	0.71	0.45
College degree	= 1 if respondent has college education	0.42	0.49	0.14	0.35
Employed full time	= 1 if respondent is employed full time	0.58	0.49	0.42	0.49
Taste	= 1 if respondent would eat more vegetables if they tasted better	0.35	0.48	0.38	0.48
Price	= 1 if respondent would eat more vegetables if they were cheaper	0.51	0.50	0.44	0.50
Zip code population	Total population in zip code of residence	6,077	6,386	5,229	460
Store distance	Distance to a full-service grocery store from residence location	12.94	13.16	13.04	1.28

Table 2 (cont.)

Variable	Description	Unweighted Sample Mean	Unweighted Sample St. Dev.	Weighted Sample Mean	Weighted Sample St. Dev.
Shop conv store	= 1 if respondent shops at a convenience store	0.41	0.49	0.47	0.50
Shop dollar store	= 1 if respondent shops at a dollar store format	0.74	0.44	0.77	0.42
Transportation	= 1 public transportation is available in community	0.16	0.37	0.17	0.38
No. observations	222				

Note: The standard deviation of binary variables was calculated as $\sqrt{\rho(1-\rho)}$, where ρ is the mean value of the binary variable.

Regression Analysis

We used regression analysis to examine the associations among respondents' fruit and vegetable consumption patterns and their local food environment, demographic characteristics, socioeconomic status, and perceived barriers to fruit and vegetable consumption. Specifically, we used an ordered logit regression model to account for the discrete and ordered nature of the dependent variable. The dependent variable of interest, *y*, is the consumption frequency of vegetables, fruits, salad, and fruit juice. The frequency of consumption is a discrete categorical variable, with ordered potential responses of *Monthly*, *Weekly*, and *Daily*. We focus on fruit and vegetable consumption as a proxy for overall dietary quality, as the existing literature often finds a positive correlation between fruit and vegetable consumption and a healthier diet (Thompson et al., 2011; Aune et al., 2017; Schlesinger et al., 2019; Wallace et al., 2019).

In the order logit model, the unobserved latent dependent variable, y^*, is related to the observed dependent variable y (frequency of consumption) as follows:

$$y_i = \begin{cases} = Monthly & if \quad y_i^* \leq 0 \\ = Weekly & if \quad 0 < y_i^* \leq \tau_1 \\ = Daily & if \quad \tau_1 < y_i^* \leq \tau_2 \end{cases} \qquad (1)$$

where τ_1 and τ_2 are unknown threshold parameters to be estimated. The regression model of y^* is specified such that:

$$y_i^* = \boldsymbol{\beta}'\boldsymbol{x_i} + \varepsilon_i \qquad (2)$$

where $\boldsymbol{x_i}$ is a set of explanatory variables for individual *i* that includes food environment measures, demographic variables (race, age, gender, employment, and education), barriers to frequent fruit and vegetable consumption, and whether respondents shop at a dollar store or convenience store.

The error term ε has a standard logistic distribution. The model was estimated via maximum likelihood estimation in STATA V.18 (StataCorp, 2021).

Results and Discussion

Table 1 and Table 2 present summary statistics for the dependent and independent variables in our study, respectively. Our analysis will focus on the weighted sample. Based on survey responses, the average distance respondents travel to the nearest full-service grocery store where they can meet all their grocery needs is 13.0 miles (see Table 2). However, some respondents reported traveling significantly longer distances than the average, as depicted in Figure 2. For example, several respondents reported traveling between 20 miles and 55 miles to reach a grocery store. Extended distances to a full-service grocery store may partially account for the high percentage of survey respondents who report shopping at convenience (46.5%) and dollar stores (76.6%) for their grocery needs. Limited proximity to a full-service grocery store may prompt some individuals to supplement their grocery purchases with purchases at dollar store formats or convenience stores, which are often more accessible (i.e., higher store density) than supermarkets and full-service grocery stores in the Mississippi Delta region (Canales et al., 2021).

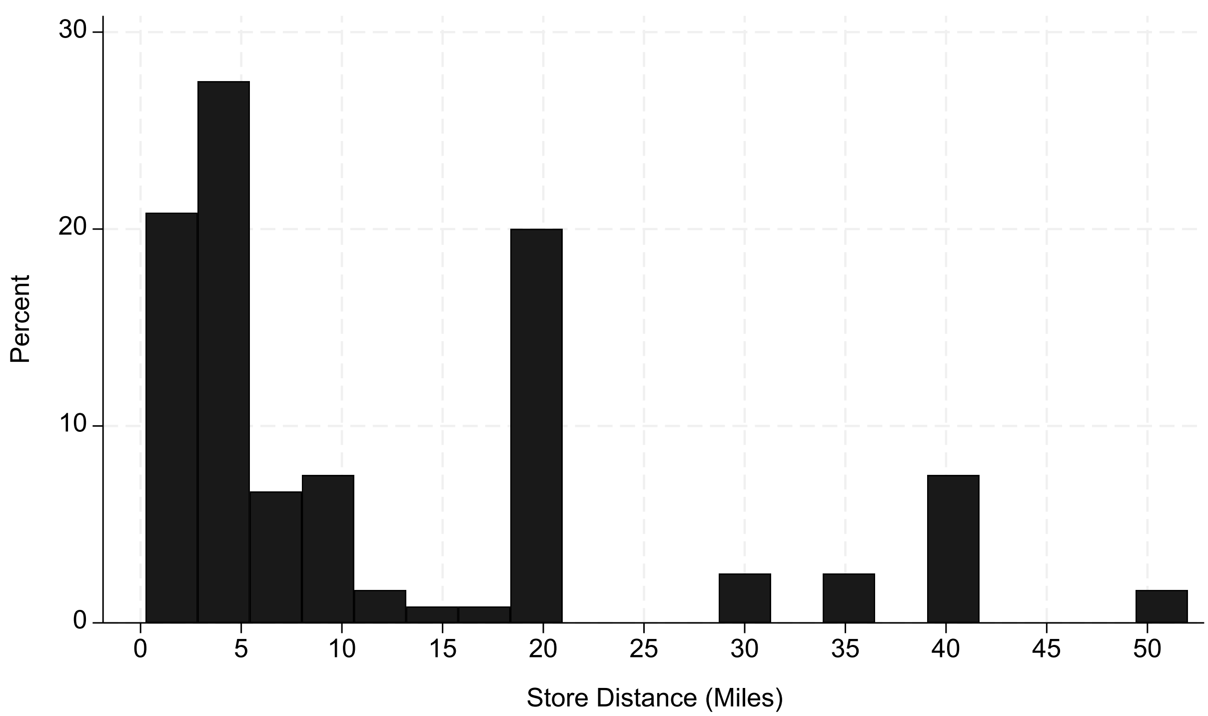

Figure 2. Distribution of Distances Traveled to the Nearest Full-Service Grocery Store by Survey Respondent, Weighted Sample

After being asked what respondents believed would help them eat healthier, we found that less than half of the sample view the taste of the food (37.7%) as a potential factor that would help them improve their vegetable intake (see Table 2). Our results also suggest that 44.2% of respondents saw price as a barrier to consuming more vegetables (i.e., they indicate they would eat more vegetables if they were cheaper), creating an area of concern surrounding the choice to eat less healthy options due to food prices. A previous study by Sharkey at al. (2010) found price to be a recurring barrier to healthy food consumption in rural areas.

Using a 30-day food recall method, we found that many respondents in our sample are not consuming fruits and vegetables daily as recommended by the Dietary Guideline of America (Dietaryguideline.gov). Figure 3 shows the percentage of respondents reporting Daily, Weekly, and Monthly for our fruit and vegetable consumption categories. Most individuals report weekly consumption of fruits (52.8%) and vegetables (52.6%). Only 18.1% of individuals in our sample consume vegetables daily, and only 14.8% consume salad daily. Although these respondents report consuming fruit and vegetables daily, they do not necessarily consume the recommended nutritional intake of 1.5 cups per day for fruits and 2−3 cups per day for vegetables (USDA and USDHHS, 2020). These findings are consistent with those of a previous study conducted in the Mississippi Delta. McCabe-Seller et al. (2007) found an overall lower diet quality in the lower Mississippi Delta area, when compared to white and African American adults in the National Health and Nutrition Examination Survey (NHANES) of 1999–2000. Based on a 24-hour recall method, the authors found that less than 25% and 16% of adults meet the vegetable and fruit intake recommendation, respectively.

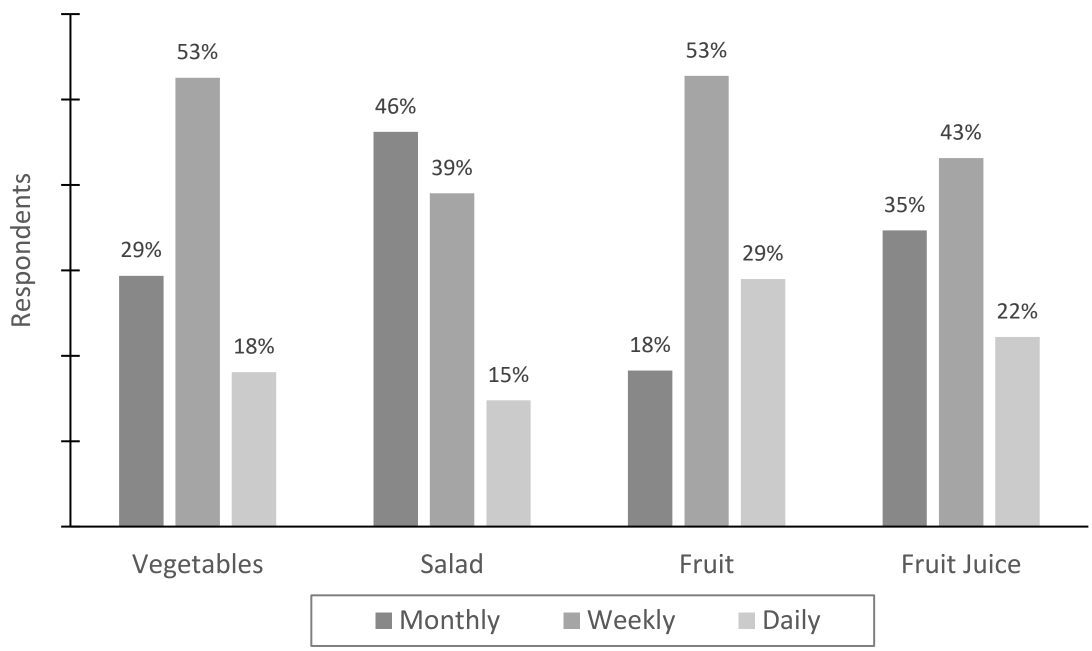

Figure 3. Frequency of Consumption of Fruits and Vegetables from Survey Respondents for Weighted Sample

The results of the ordered logit model are reported in Table 3. We present results for the weighted sample in the main text, whereas results for the unweighted sample are reported in Appendix A1.

When applying weights, the results are similar to results using the unweighted sample. To increase the number of observations, we also imputed missing responses while applying weights. Imputation resulted in a sample of 250, and the results of the ordered logit for this sample are reported in Appendix A2. The results on the imputed and weighted sample are similar to the results reported in Table 3. Given the nonlinear functional form of the ordered logit model, the magnitudes of the coefficients are not directly interpretable, and the signs of the coefficients only show whether the dependent variable (frequency of consumption) increases or decreases given a change in each explanatory variable. To aid in effective interpretation, we report the average marginal effects from the ordered logit estimates (see Table 3) in Table 4. The marginal effects can be interpreted as the average change in the probability of each consumption frequency (i.e., daily, weekly, monthly consumption), given a 1-unit change in the explanatory variables.

We find a significant negative association between store distance and frequent consumption of vegetables, salads, and fruits. Average marginal effects for store distance indicate that for each additional mile that an individual must travel to a full-service grocery store, they are 0.3 percentage points less likely to consume vegetables (p-value < 0.10) and salads daily (p-value < 0.05), and 0.6 percentage points less likely to consume fruits daily (p-value < 0.10). For each additional mile, respondents were also 0.5, 0.7, and 0.4 percentage points more likely to consume vegetables (p-value < 0.05), salads (p-value < 0.05), and fruit (p-value < 0.10) less frequently only on a monthly basis, respectively. In previous studies, farther commute distances to a full-service grocery store are associated with decreased fruit and vegetable intake (Rose and Richards, 2004; Michimi and Wimberly, 2010; Sharkey, Johnson, and Dean, 2010). For example, Sharkey, Johnson, and Dean (2010) found a 1.2 percentage point decrease in fruit consumption for each additional mile to a store with a good selection of food. Other studies in the literature also found that longer distances are correlated with eating less healthy food options, which has a disproportionate negative effect on disadvantaged groups (Connell et al., 2007; Jilcott et al., 2010; Michimi and Wimberly, 2010).

Table 3. Regression Results for Logit Model on the Frequency of Consumption for Vegetables, Salads, Fruits, and Fruit Juice, Weighted Sample

	Vegetables		**Salad**		**Fruit**		**Fruit Juice**	
	Coeff.	**Std. Error**	**Coeff.**	**Std. Error**	**Coeff.**	**Std. Error**	**Coeff.**	**Std. Error**
Age	-0.003	(0.013)	0.018	(0.017)	0.002	(0.013)	-0.020	(0.017)
Gender (male = 1)	-0.135	(0.426)	-0.356	(0.441)	0.202	(0.452)	0.044	(0.432)
Race (African American = 1)	-0.890**	(0.365)	0.724	(0.475)	0.087	(0.450)	1.231**	(0.573)
College degree	0.150	(0.325)	0.217	(0.345)	-0.116	(0.449)	0.370	(0.387)
Employed full time	-0.329	(0.429)	0.657	(0.502)	-0.726*	(0.375)	-1.434***	(0.463)
Taste	0.500	(0.404)	0.360	(0.445)	-0.183	(0.506)	0.013	(0.520)
Price	0.744	(0.457)	0.357	(0.430)	0.141	(0.434)	-0.360	(0.460)
Zip code population	-0.000	(0.000)	-0.000	(0.000)	-0.000	(0.000)	0.000	(0.000)
Store distance	-0.025*	(0.013)	-0.032**	(0.013)	-0.032*	(0.019)	-0.017	(0.012)
Shop conv store	0.039	(0.443)	-0.043	(0.480)	0.279	(0.464)	-0.582	(0.563)
Shop dollar store	-0.237	(0.486)	0.337	(0.448)	0.229	(0.424)	0.439	(0.647)
Transportation	0.819*	(0.484)	1.019**	(0.401)	0.431	(0.569)	0.876**	(0.407)
τ_1	-1.852**	(0.754)	1.653	(1.047)	-2.024**	(0.796)	-1.450	(1.165)
τ_2	0.836	(0.803)	3.803***	(1.184)	0.589	(0.838)	0.829	(1.120)
No. observations	222		222		222		222	

Note: ***, **, and * indicate statistical significance at the 1%, 5%, and 10% levels, respectively

Table 4. Estimated Marginal Effects of the Independent Variables on the Frequency of Consumption

	Vegetables		Salad		Fruit		Fruit juice	
	Marginal Effect	**St. Error**	**Marginal Effect**	**St. Error**	**Marginal Effect**	**St. Error**	**Marginal Effect**	**St. Error**
Age								
Monthly	0.001	(0.002)	-0.004	(0.004)	0.000	(0.002)	0.004	(0.003)
Weekly	0.000	(0.001)	0.002	(0.002)	0.000	(0.001)	-0.001	(0.001)
Daily	0.000	(0.002)	0.002	(0.002)	0.000	(0.002)	-0.003	(0.002)
Gender								
Monthly	0.025	(0.080)	0.076	(0.095)	-0.028	(0.061)	-0.008	(0.080)
Weekly	-0.007	(0.023)	-0.036	(0.050)	-0.011	(0.028)	0.002	(0.016)
Daily	-0.018	(0.057)	-0.040	(0.047)	0.039	(0.089)	0.007	(0.064)
Race								
Monthly	0.154**	(0.062)	-0.157	(0.101)	-0.012	(0.064)	-0.251**	(0.117)
Weekly	-0.021	(0.029)	0.082	(0.065)	-0.004	(0.021)	0.091	(0.073)
Daily	-0.134**	(0.056)	0.075*	(0.040)	0.017	(0.085)	0.160***	(0.057)
College								
Monthly	-0.028	(0.061)	-0.046	(0.074)	0.016	(0.062)	-0.069	(0.070)
Weekly	0.007	(0.018)	0.022	(0.036)	0.006	(0.025)	0.014	(0.019)
Daily	0.020	(0.044)	0.025	(0.038)	-0.022	(0.087)	0.055	(0.055)
Employed								
Monthly	0.061	(0.079)	-0.142	(0.107)	0.104*	(0.055)	0.277***	(0.079)
Weekly	-0.017	(0.022)	0.065	(0.056)	0.033	(0.030)	-0.073*	(0.037)
Daily	-0.044	(0.059)	0.077	(0.056)	-0.137*	(0.073)	-0.204***	(0.072)
Taste								
Monthly	-0.092	(0.074)	-0.077	(0.095)	0.025	(0.071)	-0.002	(0.097)
Weekly	0.024	(0.026)	0.036	(0.043)	0.010	(0.025)	0.000	(0.019)
Daily	0.068	(0.054)	0.041	(0.053)	-0.035	(0.095)	0.002	(0.077)
Price								
Monthly	-0.137*	(0.078)	-0.076	(0.092)	-0.020	(0.060)	0.067	(0.084)
Weekly	0.036	(0.023)	0.036	(0.040)	-0.007	(0.023)	-0.013	(0.019)
Daily	0.102	(0.069)	0.041	(0.053)	0.027	(0.083)	-0.053	(0.068)
Zip code population								
Monthly	0.000	(0.000)	0.000	(0.000)	0.000	(0.000)	0.000	(0.000)
Weekly	0.000	(0.000)	0.000	(0.000)	0.000	(0.000)	0.000	(0.000)
Daily	0.000	(0.000)	0.000	(0.000)	0.000	(0.000)	0.000	(0.000)
Store distance								
Monthly	0.005**	(0.002)	0.007**	(0.003)	0.004*	(0.003)	0.003	(0.002)
Weekly	-0.001	(0.001)	-0.003***	(0.001)	0.002	(0.001)	-0.001	(0.001)
Daily	-0.003*	(0.002)	-0.004**	(0.002)	-0.006*	(0.003)	-0.002	(0.002)
Shop conv store								
Monthly	-0.007	(0.082)	0.009	(0.103)	-0.039	(0.064)	0.108	(0.104)
Weekly	0.002	(0.022)	-0.004	(0.048)	-0.015	(0.026)	-0.022	(0.028)
Daily	0.005	(0.060)	-0.005	(0.055)	0.053	(0.088)	-0.086	(0.082)

Table 4 (cont.)

	Vegetables		Salad		Fruit		Fruit juice	
	Marginal Effect	St. Error	Marginal Effect	St. Error	Marginal Effect	St. Error	Marginal Effect	St. Error
Shop dollar store								
Monthly	0.044	(0.090)	-0.072	(0.095)	-0.032	(0.059)	-0.082	(0.121)
Weekly	-0.011	(0.027)	0.034	(0.042)	-0.012	(0.024)	0.016	(0.027)
Daily	-0.032	(0.065)	0.039	(0.054)	0.044	(0.082)	0.065	(0.097)
Transportation								
Monthly	-0.151*	(0.087)	-0.218***	(0.081)	-0.060	(0.078)	-0.163**	(0.073)
Weekly	0.040	(0.035)	0.102**	(0.048)	-0.023	(0.032)	0.033	(0.031)
Daily	0.112*	(0.066)	0.117**	(0.046)	0.083	(0.108)	0.130**	(0.054)

Note: ***, **, and * indicate statistical significance at the 1%, 5%, and 10% levels, respectively.

A low density of full-service grocery stores and supermarkets has been shown to decrease healthy food access among rural, low-income, and elderly residents (Morland et al., 2002; Hendrickson, Smith, and Eikenberry, 2006; McGee et al., 2011). The lack of local access to full-service grocery stores forces residents to travel longer distances to meet their food needs. Consequently, individuals with limited access resort to purchasing foods at alternative store formats, including convenience and dollar stores. While we expected the store format would influence frequency of fruit and vegetable consumption due to differences in the assortment of fresh fruit and vegetables, we did not find any statistically significant difference in fruit and vegetable consumption between individuals who shop at convenience and dollar stores and those who do not. In a similar vein, a systematic review of studies examining the effect of the food environment on obesity found limited statistical evidence that store availability affects obesity (Cobb et al., 2015).

Limited access to transportation can further exacerbate the negative association between longer store distances and the consumption of healthy foods, as it may constrain individuals' ability to reach well-assorted stores, such as supermarkets and grocery stores. Our results suggest that respondents living in areas with access to some form of public transportation are 11.2 percentage points more likely to consume vegetables (p-value < 0.10), 11.7 percentage points more likely to consume salad (p-value < 0.05), and 13.0 percentage points more likely to consume fruit juice daily (p-value < 0.05). Similarly, in areas where respondents indicated having access to transportation, they were 15.1, 21.8, and 16.3 percentage points less likely to consume vegetables, salad, and fruit juice only monthly, respectively. These findings are consistent with previous studies that demonstrate the adverse impact of unreliable transportation on food access, particularly among low-income households (Connell et al., 2007; Kaiser et al., 2017). The observed marginal effects of public transportation underscore the potential need for interventions that facilitate ease of access to healthy food in disadvantaged communities through improved public transportation systems. There is a need to implement more accessible public transportation to bridge the gap between the lack of personal transportation and spatial access to supermarkets in the Mississippi Delta region. Facilitating access to bus routes or rideshare programs in rural areas could be one strategy worth examining, as increasing the presence of large food retail stores in rural areas is challenging due to the high entry and operation costs, supply chain issues, and limited demand, which make the retail market in low-income and rural areas unattractive to larger food retail outlets (Paddison and Calderwood, 2007; Cheranides and Jeanicke, 2019).

With regard to perceived barriers, individuals who perceive price as a barrier to consuming more vegetables were 13.7 percentage points (*p*-value < 0.05) less likely to consume vegetables monthly compared to individuals who do not perceive price as a barrier. Price is commonly identified as a barrier to the consumption of healthier and more expensive food options. Prior studies found that price barriers decrease the probability of eating healthier (French, 2003; Kaiser et al., 2017), which is sometimes explained by the higher cost per serving of fruits and vegetables in rural areas. One study conducted in the Mississippi Delta found that the price per serving of fruits and vegetables is higher in the Delta relative to the national average price per serving (Connell et al., 2012). Another study also found that prices of healthier foods—such as fruits and vegetables–are higher in counties in Mississippi with high obesity rates when compared to prices in counties with lower obesity rates (Fan et al., 2021). Overall, however, findings by Carlson and Frazao (2012) indicate that healthy foods are not always more expensive than less healthy foods. The decrease in infrequent consumption despite price being perceived as a barrier in our study may indicate that individuals who acknowledge price as a barrier may also want to eat vegetables and consume them more frequently. It can be inferred that individuals allocate spending toward different food items based on factors other than healthy eating and meeting dietary recommendations.

According to McGee et al. (2011), while residents may perceive price barriers to purchasing healthy foods, personal preferences and individual family members' preferences tend to have a greater influence on food purchasing behaviors. For individuals with lower fruit and vegetable consumption in our sample, the consumption of healthier food options might be due to preferences and other behavioral components rather than factors that are generally expected to prevent more frequent fruit and vegetable consumption like price. A limitation of our study is that we were not able to capture the effects of preferences. To do this, we would need to collect data on respondents' preferences over different types of food, as well as data on how prices, availability, and accessibility affect their choices to consume one food item compared to other food items.

An implication of our findings regarding respondents' perceived barriers can be the implementation of behavioral interventions in the Mississippi Delta region to address high obesity rates, as direct solutions targeting price barriers may not prove effective among individuals who consume fruits and vegetables infrequently. Several existing policies have focused on decreasing healthier food prices in efforts to increase healthier food consumption. While this approach may prove effective, it may miss the target audience of those consuming fruit and vegetables less frequently and whether they do not perceive price as a barrier to consumption. Initiatives should identify strategies that target individuals who do not view food price as a barrier to consuming more fruits and vegetables and whose low consumption may be due instead to dietary preferences. This alternative approach could improve the potential effectiveness of policies designed to improve consumption frequency and reduce the occurrence of obesity and noncommunicative weight-related health risks. In our study, we did not find a statistically significant association between the taste of food as a barrier and the frequency of fruit and vegetable consumption.

We included full-time employment and college education in our regression as a proxy measure of respondents' socioeconomic status. Socioeconomic status partially helps to shape individual food consumption choices as well as the consumption frequency of certain foods based on cost, accessibility, and other related factors. While we did not find that attending college has a significant effect on consumption frequency, we found that individuals with full employment were less likely to consume fruit and fruit juice daily but more likely to consume them monthly. While we had expected fruit consumption to be more frequent among the employed, it is important to note that the fruit category in the survey included the consumption of canned products, which are affordable and more widely available at various store formats compared to fresh fruits.

With regard to differences in the frequency of consumption across demographic groups, we found that African Americans were 13.4 percentage points (p-value < 0.05) less likely to consume vegetables daily and were 15.4 percentage points (p-value < 0.05) more likely to consume vegetables on a less frequent monthly basis. African Americans, on the other hand, were more likely (16.0 percentages points) to consume fruit juice daily (p-value < 0.01). As differences in health outcomes are observed, it is important to understand differences in consumption frequency across demographic groups.

Conclusion

The goal of our study was to examine the relationship between local food environment factors and the consumption of fruits and vegetables among individuals living in the Mississippi Delta, a region with one of the nation's highest obesity rates. Specifically, we studied how consumption patterns of healthy foods are affected by proximity to full-service grocery stores, healthy food accessibility as measured by access to public transportation, and whether respondents shop for food at convenience or dollar store formats. We also examined differences in fruit and vegetable consumption frequencies across groups based on demographic characteristics, such as reported age, gender, race, employment, and educational attainment. Results from our study provide insights for communities in the Mississippi Delta and may inform local strategies to address obesity from a food environment, food systems, and policy perspective. These findings are particularly important for policy makers seeking to address issues within food systems in the Mississippi Delta region.

The food environment measures were statistically significant across the various food groups considered. We found that individuals who travel longer distances to the nearest full-service grocery store were less likely to consume vegetables frequently (i.e., daily). This finding is informative, particularly when considering the effects of proximity and store density within rural Mississippi Delta communities. On average, individuals in our sample reported traveling 13 miles from their residence to a full-service grocery store, with several survey respondents traveling between 20 miles and 55 miles. The longer travel distances required to access full-service stores could explain why many respondents (76.6%) shop for groceries at dollar store formats, which are more accessible (i.e., higher store density) when compared to supermarkets and full-service grocery stores. Understanding this aspect of the local food environment is particularly insightful for initiatives geared toward improving healthy consumption via increasing access to the different food shopping options that are available to individuals. In many cases, supermarket or grocery store operators do not find it economically viable to locate in certain areas. In such cases, it is important to identify strategies that promote healthier food assortments in existing stores and improve physical access to healthy food through channels like transportation infrastructure. Such strategies could include increasing access to public transportation. The availability of public transportation, as a measure of accessibility, is another statistically significant food environment variable in our study. Our results suggest that public transportation access increases the likelihood that individuals consume vegetables and salad more frequently, highlighting the potential importance of transportation service availability, particularly in areas with low store access, like the Mississippi Delta.

The data used in our study have some important limitations. The first limitation worth acknowledging is the relatively small sample size and representativeness of the sample. To address this issue, we used poststratification weights and imputation of missing data and found consistent results. Because we cannot verify the representativeness of the findings against the general population of the area, any general extrapolations of the findings should be done with this data limitation in mind. Second, because the data collection took place between January and March of 2020, our reported frequency of fruit and vegetable consumption would likely be lower when compared to the average annual consumption, due to lower availability of fresh produce during the winter months. Because the availability of fresh produce during the winter is lower across all store formats and that other explanatory factors are not likely to change seasonally, we do not expect the association between the explanatory variables and consumption frequency to be affected. It is also important to note that the consumption frequency questions in the survey asked for consumption in all forms (fresh, canned, and frozen). In the case that overall fruit and vegetable availability was more restrictive during the winter in convenience and dollar stores relative to supermarkets, we would expect to see lower consumption frequency associated with shopping at these store formats. However, we did not find any statistical differences in consumption associated with store format. Another possible issue with the timing of the survey is COVID-19, which was officially declared a pandemic on March 11, 2020, with the implementation of shutdowns beginning March 15, 2020 (CDC, 2023a). While most of the data had been collected at that point, it was foreseeable that the pandemic altered shopping and consumption patterns (e.g., less frequent visits to crowded stores and greater consumption of canned and frozen products). Given all of these potential dynamics, it is difficult to assess how the pandemic could have affected the direction of the effect of the explanatory variables in our study on consumption frequency. Third, we did not explore the role of food away from home and access to retail food service establishments on the frequency of fruit and vegetable consumption, highlighting an area for possible future research. If consumption away from home is negatively correlated to fruit and vegetable consumption and negatively (positively) correlated to the likelihood of purchasing foods at dollar or convenience stores, it is possible that we are overestimating (underestimating) the effect of shopping at convenience or dollar stores. As seen in our results, we did not find any statistical difference in consumption when respondents shopped at dollar or convenience stores. Lastly, the HOP Community Survey did not include some key variables of interest, such as income, a major determinant of socioeconomic status that could play a role in an individual’s ability to afford a healthy diet. It is also possible that unobserved factors, such as preferences, play a large role in consumption decisions. Understanding consumer preferences for fruit and vegetables could inform behavior-based interventions related to the food environment of the Mississippi Delta.

Notwithstanding the limitations of the data used in our study, we believe the results provide useful insights regarding the food environment in the Mississippi Delta region and how food environment factors may play a role in fruit and vegetable consumption frequency. These insights can be used to inform further research and outreach and provide a starting point for conversations about initiatives to improve the food environment based on the unique conditions and characteristics of the population examined.

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Appendix A1. Regression Results for Logit Model on the Frequency of Consumption for Vegetables. Salads, Fruits, and Fruit Juice, Unweighted Sample

	Vegetables		**Salad**		**Fruit**		**Fruit Juice**	
	Coeff.	**Std. Error**	**Coeff.**	**Std. Error**	**Coeff.**	**Std. Error**	**Coeff.**	**Std. Error**
Age	0.007	(0.010)	0.017	(0.010)	0.008	(0.010)	-0.003	(0.010)
Gender (male = 1)	-0.053	(0.345)	-0.418	(0.351)	-0.064	(0.344)	0.311	(0.332)
Race (African American = 1)	-0.609*	(0.352)	0.298	(0.362)	0.541	(0.351)	1.544***	(0.372)
College degree	0.091	(0.274)	0.046	(0.274)	-0.014	(0.275)	0.155	(0.272)
Employed full time	-0.238	(0.309)	0.708**	(0.317)	-0.361	(0.308)	-0.597*	(0.315)
Taste	-0.056	(0.287)	0.059	(0.291)	-0.281	(0.291)	0.247	(0.288)
Price	1.053***	(0.300)	0.088	(0.289)	0.278	(0.287)	0.068	(0.286)
Zip code population	-0.000	(0.000)	-0.000	(0.000)	-0.000	(0.000)	0.000	(0.000)
Store distance	-0.023**	(0.011)	-0.028**	(0.011)	-0.020*	(0.011)	-0.011	(0.010)
Shop conv store	-0.128	(0.292)	0.037	(0.295)	0.090	(0.295)	-0.047	(0.290)
Shop dollar store	-0.584*	(0.331)	-0.028	(0.334)	-0.325	(0.328)	-0.324	(0.330)
Transportation	0.715*	(0.369)	0.605	(0.381)	0.227	(0.368)	0.625*	(0.374)
τ_1	-1.540*	(0.831)	0.500	(0.840)	-1.440*	(0.813)	0.014	(0.823)
τ_2	1.117	(0.826)	3.151***	(0.868)	1.238	(0.810)	2.245***	(0.835)
No. observations	222		222		222		222	
AIC	446.9		440.5		452.5		463.2	
Log likelihood	-209.4		-206.2		-212.2		-217.6	

Note: ***, **, and * indicate statistical significance at the 1%, 5%, and 10% levels, respectively.

Appendix A2. Regression Results for Logit Model on the Frequency of Consumption for Vegetables. Salads, Fruits, and Fruit Juice, Imputed and Sample Using Weights

	Vegetables			**Salad**			**Fruit**			**Fruit juice**		
	Coeff.		**Std. Error**	**Coeff.**		**Std. Error**	**Coeff.**		**Std. Error**	**Coeff.**		**Std. Error**
Age	0.003		(0.013)	0.023		(0.016)	0.004		(0.012)	-0.018		(0.016)
Gender (male =1)	-0.021		(0.412)	-0.390		(0.420)	0.321		(0.446)	0.163		(0.419)
Race (African American =1)	-0.632	*	(0.339)	0.695		(0.483)	0.196		(0.454)	1.307	**	(0.531)
College degree	0.105		(0.319)	0.087		(0.344)	-0.092		(0.448)	0.334		(0.387)
Employed full time	-0.404		(0.400)	0.636		(0.502)	-0.701	*	(0.371)	-1.530	***	(0.451)
Taste	0.105		(0.390)	0.356		(0.436)	-0.339		(0.482)	-0.118		(0.493)
Price	0.934	**	(0.441)	0.317		(0.413)	0.307		(0.412)	-0.310		(0.452)
Zip code population	0.000		(0.000)	0.000		(0.000)	0.000		(0.000)	0.000		(0.000)
Store distance	-0.026	**	(0.013)	-0.032	**	(0.013)	-0.034	*	(0.019)	-0.019		(0.012)
Shop conv store	0.064		(0.431)	-0.063		(0.476)	0.404		(0.444)	-0.421		(0.528)
Shop dollar store	-0.165		(0.437)	0.328		(0.435)	0.178		(0.384)	0.393		(0.627)
Transportation	0.641		(0.446)	0.986	**	(0.383)	0.334		(0.546)	0.936	**	(0.400)
τ_1	-1.491		(0.717)	1.646		(1.048)	-1.799		(0.740)	-1.388		(1.117)
τ_2	1.061		(0.739)	3.890		(1.189)	0.756		(0.774)	0.870		(1.054)
No. observations	250			250			250			250		

Note: ***, **, and * indicate statistical significance at the 1%, 5%, and 10% levels, respectively.