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Consumption of fruits and vegetables in the Mississippi Delta and the role of the food environment

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Differences in the prevalence of obesity are generally associated with disparities in the food environment which partially determine diet quality. In this research, I examine the relationship between the local food environment and the consumption of fruit and vegetables among individuals living in the Mississippi Delta region using survey and store availability data for individuals living in seven counties with the highest obesity rates in the state. An ordered probit model with an endogenous covariate is used to assess the marginal effect of food environment variables on the frequency of fruit or vegetable consumption. I find that longer distance traveled to the nearest full-service grocery store is associated with lower frequency of vegetable consumption, while access to public transportation is generally associated with a higher frequency of consumption. Insights from this study could prove helpful for health officials and policymakers tasked with designing and implementing localized interventions that improve the food environment and increase healthy food access.

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CHAPTER I

INTRODUCTION

Policymakers and health officials have long been concerned with poor diets as they are often associated with diet-related diseases such as obesity, cardiovascular disease, high blood pressure, and type 2 diabetes. Promoting healthy diets is especially important given the growing trend in the incidence of obesity in the U.S. over the past decades which led to the Center for Disease Control and Prevention (CDC) identifying obesity as a national health pandemic in 2017 (CDC, 2020). A higher prevalence of obesity is often observed among Blacks, females, older adults (age 65+), and individuals with high school education or less (Hales et al., 2020).

Mississippi has been ranked as the least healthy state in the U.S. as of 2019 (Americashealthranking.org, 2021), with some counties in the Delta region having the highest obesity rates in the nation. Disparities in the built environment, particularly the food environment, may contribute to observed health outcomes such as the elevated obesity rates in Mississippi. These disparities in health outcomes are more severe in counties located in the Delta Region which experience the highest rates of poverty, obesity, and high blood pressure (United States Department of Agriculture-Economic Research Service, 2019; CDC-Behavior Risk Factor Surveillance System, 2019). The high poverty rate and low-income level present in the Delta suggest that many households may lack the resources required to purchase the foods they need to live a healthy life. This relationship is supported by studies in the region which have found evidence of poor dietary quality, a lower intake of key nutrients, and a higher intake of unhealthy foods, particularly among disadvantaged sociodemographic groups. Compared to national averages, the consumption of fruits and vegetables in the Mississippi Delta is significantly lower (Connell et al., 2006).

Diet-related health outcomes are repercussions of socioeconomic, demographic, and environmental factors (Lee et al., 2019). Food availability, access to transportation, the built environment, and the rural-urban divide are environmental factors that potentially contribute to the increase in the prevalence of poor diet related health outcomes (Papas et al., 2007). Studies in the existing literature have found poor food environments to be highly correlated with poor diet-related health outcomes (Grimm, Moore, and Scanlon, 2013; McCabe Sellers et al., 2007; Larson et al., 2009; Sharkey, Johnson, and Dean 2010). The food environment is also commonly known as the community, nutritional, or local food environment and takes on a multi-dimensional definition that includes availability, access, and affordability of food. The CDC (2014) 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."

The food environment may affect individuals' diets by shaping their food consumption choices. Other contributing factors include food prices, uses of food, access to transportation, culture, and rural/urban residence. A considerable number of studies on food access have found lower levels of obesity where residents have greater access to full-service grocery stores as opposed to convenience stores, introducing the theme of health risks associated with poor food environments (Larson et al., 2009; Morland et al., 2006; Chen et al., 2016). Limitations to either of these factors are thought to be more conducive to obesity and other negative health outcomes.

Food environment studies have examined not only access to food but the availability of food (Ko et al., 2018; Powel et al., 2007). A greater level of deprivation in food store access is observed in low-income and otherwise socioeconomically disadvantaged neighborhoods (Morland et al., 2002; Larson et al., 2009; Connell et al., 2007). The limited access to local healthy food increases the likelihood that individuals must travel greater distances to access healthy food options. If neighborhoods with poor food environments rely solely on what is available within their own communities, low levels of local access directly impact the quality of residents' diets, potentially increasing health risks associated with limited diets and poor nutrition.

There have been multiple local, state, and federal initiatives that have set goals to address poor food environments and associated negative health outcomes such as obesity rates. Initiatives such as the Smart Snacks in School initiative and Nutrition Standards in School programs are geared towards tackling issues related to the food environment, focusing on food accessibility, food marketing, food prices, and nutrition education (USDA, 2013; USDA, 2019). Other policies such as food labeling and taxes on sugary drinks seek to shape consumers decisions and dietary behaviors (Falbe, 2019). The CDC's High Obesity Program (HOP) is a federal initiative consisting of cooperative agreements with Cooperative Extension Services in counties with the highest obesity rates (obesity rates 40% or higher) to combat obesity through improved consumption of healthy foods and physical activity. Improvements in the food environment have been shown to have direct positive impacts on healthier consumer choices and improved health outcomes such as reduction in obesity rates (CDC, retrieved 2021; Steeves et al., 2014).

This study is a part of The Advancing, Inspiring, Motivating for Community Health through Extension (AIM for CHangE) project led by Mississippi State University and funded by the HOP. To identify strategies for improving the food environment, AIM for CHangE conducted a community survey to assess the food environment in counties with high obesity rates in the Mississippi Delta. My study is part of this assessment, and it seeks to provide insights for communities in the Delta and inform local strategies to address obesity from a food environment, food systems, and policy perspective.

The goal of my study is to examine the relationship between local food environment factors and the consumption of fruits and vegetables among individuals living in the region with the nation's highest obesity rates, the Mississippi Delta. I examined the effect of convenience store density, household proximity to supermarkets, and access to transportation on consumption frequency. I also studied differences in the frequency of fruit and vegetable consumption across different demographic groups to identify vulnerable groups that could serve as targets for future programmatic interventions. I find that factors thought to be associated with poor food environment factors—such as higher cost for healthier foods—tend to be correlated with more frequent consumption patterns. Additionally, access as a function of the food environment has a significant impact on consumption frequency of certain healthy food groups. Specifically, having public transportation available within Mississippi Delta communities increases the likelihood that individuals will consume more vegetables and fruit juice.

CHAPTER II

LITERATURE REVIEW

There is a considerable amount of evidence supporting the relationship between poor food environments and both the inadequate diets and higher obesity rates among residents of affected areas (Larson, Story, and Nelson, 2009). In Mississippi, studies have provided evidence of poor diets, particularly in the Delta Region. McCabe-Sellers et al. (2007) used the Healthy Eating Index (HEI)-2005— a measurement tool that assesses the overall diet quality of individuals based on the Dietary Guideline for Americans (Thompson et al., 2011a; Thompson et al., 2011b; McCabe-Sellers et al., 2007)— to analyze the adequacy of diets among adults in the Lower Mississippi Delta (LMD). Their study found that less than 50% of the adults in the region met dietary recommendations. Young adults between the ages of 18 and 59 had a less ideal diet compared to adults 60 years and older who had a significantly higher HEI score. The authors found that African American adults were less likely to conform to dietary recommendations compared to Whites and the general adult population. Their study also suggested that only 5.4% of African American adults and 7.6% of White adults in the Mississippi Delta consume a healthy diet, contrasted to 28% and 22.2% of respective adults who consume a poor diet, highlighting the need for dietary interventions

The steady increase in obesity rates and other negative health outcomes has been directly connected to the food environment. The ability to consume a quality diet is dependent on elements of the food environment such as the availability and access to quality food (Caswell and Yaktine, 2013; Downs et al., 2020). Access to larger retail stores and supermarkets allows for the consumption of healthier food items as these outlets provide a better assortment of healthier products (Larson et al., 2009). In a study of supermarket accessibility and the association between obesity and fruit and vegetable consumption, Michimi and Wimberly (2010) found that access to supermarkets, access to transportation, and the distance to the nearest supermarket are associated with both obesity and the consumption of fruits and vegetables. In low access areas, residents generally need to travel additional distances and shop at numerous outlets to purchase adequate healthful food options such as fruits and vegetables (Kaiser et al., 2017).

The presence of supermarkets and grocery stores in an area is a function of demand and supply factors (Burchi and de Muro, 2016). Having suitable demand (i.e., market size) to support the profitability of grocery stores in low access areas is important for the long-term viability of these businesses (Cleary et al., 2018). Grocery stores and supermarkets locate in areas where they are most accessible to potential customers (Aguirregabiria and Suzuki, 2015) and potential profits are maximized (Mendes and Themido, 2004). High entry and operation costs, supply chain problems, and limited demand are factors that make the retail market in low income and rural areas unattractive to larger retail outlets, further limiting food access in these areas (Paddison and Calderwood, 2007; Cheranides and Jeanicke, 2019). Residents of the Mississippi Delta have limited access to large food retailers which may be due to the low-income and socioeconomic conditions present in the area (Connell et al., 2006) which make the region unattractive for grocery stores. These factors may partially explain the spike in non-traditional outlets such as dollar stores and convenience stores which have become increasingly prevalent in low-income, rural communities. Yet, the lack of large food retailers offering a greater variety of foods can in turn reduce the ability of residents to obtain an adequate supply of healthy food.

Because of limited access to supermarkets in the Mississippi Delta region, many individuals are constrained to shopping at convenience stores which are often closer to home (Thompson et al., 2011a). The reliance on convenience stores limits access to healthy food options, preventing individuals from meeting national dietary recommendations[1] (McCabe-Sellers et al., 2007). Restrictions to shopping at the nearest available store are often owed to limited access to transportation in low-income and socioeconomically disadvantaged areas. Particularly among lower-income households, it is difficult to travel farther distances to shop at supermarkets which offer a wider variety of food options (Connel et al., 2006). Cheranides et al. (2019) and Rose et al. (2004) emphasize that limited access and low consumption of fruit and vegetable are prominent in socioeconomically deprived neighborhoods experiencing poor food access. Non-metropolitan rural areas tend to have a higher rate of obesity (Grimm et al., 2013) which may be partially explained by their lower access to healthy foods, including fruits and vegetables (Lundeen et al., 2016).

Being socioeconomically disadvantaged may be a major contributing factor associated with longer distance traveled to the nearest food store and having full access supermarkets, particularly in rural and low-income areas (Alwitt and Donley, 1997; Zenk et al., 2005). A study by Horel and Sharkey (2008) conducted in the Texas Brazos Valley region found low spatial access to food stores for residents in poverty and without a vehicle. The number of households

[1] Per the US Department of Agriculture and the US Department of Health and Human Services, the recommended nutritional intake is 1.5 cups per day for fruits and 2 to 3 cups per day for vegetables.

without available vehicle also tends to increase with greater neighborhood deprivation and a greater percentage of minority residents.

In most cases, there is a negative correlation between the distance a resident must travel to the nearest supermarket and their consumption of healthy foods, including fruits and vegetables. Hendrickson et al. (2006) conducted a comparative study of four communities in Minnesota and found that ease of access —e.g., reliable transportation and closer proximity to supermarkets— is more common in urban areas or areas with a higher economic status. A study by Jilcott et al. (2010) found that counties with higher percentages of rural residents were associated with longer commute times and residents' shopping outside of their own county. Similarly, Michimi and Wimberly (2010) found that residents of non-metropolitan rural areas had farther distances to travel to supermarkets coupled with increasing obesity prevalence and decreasing fruit and vegetable consumption as the distance to supermarkets increased. A study by Sharkey et al. (2010) estimated that the daily intake of fruits decreased for each mile that individuals had to travel to the nearest supermarket or store offering a broad selection of fruits.

Having better access to a full-service supermarket as opposed to a convenience store has been associated with a reduction in the risk of obesity (Larson et al., 2009) by increasing the intake of healthier food options (Bodor et al., 2008; Kaiser et al., 2017). The general lack of full-service grocery stores in socially disadvantaged areas suggests the inaccessibility of healthier food options (Kaiser et al., 2017). A study by Hendrickson et al. (2006) showed that a larger quantity and greater variety of fresh fruits and vegetables and other pre-packaged food items are found in urban stores relative to rural stores. In the lower Mississippi Delta, which has a large density of convenience stores (Canales et al., 2021), food retail stores have been found to stock more fats and sweets relative to fruits and vegetables (McGee et al., 2011). This finding is consistent with the results of other studies suggesting that convenience stores stock less healthy food items (Liese et al., 2007; Connell et al., 2006). Connell et al. (2007) found that small and medium sized food stores only carry 50% of the foods included in the USDA Thrifty Food Plan (TFP)[2], with convenience stores only carrying 28% in the lower Mississippi Delta. A cross-sectional study done by Kaiser et al. (2017) assessed a major corridor and an adjacent rural area where they find that all TFP food items and MyPlate Basket[3] food items were more likely to be available in supermarkets. However, more people shopped at convenience stores with less TFP and MyPlate food items.

Affordability is another dimension of the food environment and an important economic factor in consumer decisions. Healthier food items tend to cost more than less healthy alternatives (Liese et al., 2007), leading to a lower quality diet in neighborhoods with disadvantaged food environments and poor socioeconomic backgrounds (Hosler et al, 2006). In lower-income neighborhoods especially, residents usually pay an additional cost for food in comparison to higher-income neighborhoods (Rose et al., 2004). Added to affordability concerns is a lack of variety and lower assortment of foods in low-income areas (Hendrickson et al, 2006). A significant percentage of individuals in low-income households, like those in the Lower Mississippi Delta, use Supplemental Nutrition Assistance Program (SNAP) to expand the food supply in their households (Hendrickson et al., 2006; McCabe-Sellers et al., 2007). Individuals of a low-socioeconomic background are more likely to live in neighborhoods with a greater share of small grocery stores and convenience stores as opposed to large grocery stores and supermarkets

[2] Thrifty food plan is food plan developed by the USDA to "estimate the cost of a healthy diet across various price points—the Thrifty, Low-Cost, Moderate-Cost and Liberal Food Plans. The thrifty food plan is the lowest cost of the four". The TFP is re-evaluated every 5 years (USDA-Food and Nutrition Service, 2022).
[3] MyPlate Basket is a tool by USDA that is used to help select healthy foods for our meals. The MyPlate food are grouped into fruits, vegetables, grains, protein foods, and dairy (USDA-MyPlate, 2022).

(Wang, 2007; Connell, 2006), and in some instances need to travel to neighboring counties to redeem SNAP benefits and purchase food. In Mississippi's Issaquena County for example, 95% of residents redeem SNAP benefits in another county (Hossfield and Mendez, 2018; Liese et al., 2007; Mccabe-Sellers et al., 2007). In other instances, residents may possibly spend their benefits in both their county of residence and neighboring counties.

Due to economies of scale, full-service supermarkets often offer lower food prices which can help alleviate poor food access (Cleary et al., 2018). Consumers face a trade-off when deciding what items will be part of their food basket. If highly processed/high caloric foods are cheaper than healthy foods and consumers are income-constrained, then they may decide to purchase cheaper unhealthy foods. Another key economic factor behind consumption decisions is the economy of agglomeration, which explains the mechanism behind the clustering of firms in a certain geographic area (Bolter and Robey, 2020). Hillier et al. (2015) assessed behavioral models of healthy food access and found that there is often a "bundling" effect associated with the perceived efficiency around shopping trips, destination, and purchase. The authors found that 86.2% of participants preferred to shop at national chain supermarkets. Even though physical proximity proved to be a choice factor in participant decisions, participants frequently shopped where store traffic was heaviest despite location.

The price of food is more important to individuals who are food insecure (Kaiser et al., 2017) and have limited access to supermarkets, making price a major barrier to food access. In a study of food access and perceptions, Sharkey et al. (2010) show that price was a major concern for 45% of survey respondents, followed by freshness of fruits and vegetables and variety of assortment. A study by Kaiser (2017) found that a significant percentage (27%) of food-insecure households in their study faced difficulties in finding fresh produce in their neighborhood.

Similarly, 26% of food-insecure households were dissatisfied with food access in their neighborhoods as they needed to travel out of town to purchase healthy foods.

Previous models of consumption choice present in the literature have been able to account for specific factors and how they affect consumption. Demographic factors such as age, race, gender, education, income, and rural-urban location are prominent socioeconomic and demographic characteristics used to assess differences in consumption patterns among various groups (Sharkey et al., 2010; Bonanno and Li, 2014; Lin and Morrison, 2002; Sharkey and Horel, 2008). Mccabe-Sellers et al. (2007) found that households with incomes below $15,000 have lower vegetable consumption than households with incomes of $30,000 or above as measured by the HEI. Adults and individuals with higher education levels are more likely to consume a nutritious diet, potentially due to increased knowledge regarding what a nutritious diet should consist of (Mccabe-Seller et al., 2007). In the LMD, low-quality diet has been associated with younger age, with seniors consuming more fruits and vegetables than their younger counterparts (Thompson et al., 2011b; McCabe-Sellers et al., 2007). Generally, women and older individuals tend to be more interested in information regarding health (Deeks et al., 2009), which could also impact consumption decisions.

Assessing the adequacy of diets is important for ascertaining nutrition insufficiency and potentially improving underlying issues (Thompson et al., 2011a). Limited access to quality foods in the Delta region may partially explain the inadequate intake of important nutrients, particularly among African Americans. While energy intake in the Delta region does not differ from the general U.S. population (Champagne et al., 2004), nutritional intake among children and adults in socioeconomically disadvantaged areas tends to be lower than the national average (Connell et al., 2006) for both adults and children. Specifically, in the LMD, only half of the adult population meets the national dietary recommendations, and a smaller percentage meets the recommended fruits and vegetable daily intake (Mccabe-Sellers et al., 2007). Champagne et al. (2004) also reported that the intake of protein, dairy products, and fruits and vegetables are much lower in the Delta region when compared to the rest of the U.S. population.

The existing literature suggests that having an inadequate food environment is not without consequences. The reality that low-income households consume fewer fruits and vegetables than higher-income households is associated with various negative health outcomes (McCabe-Sellers et al., 2007). Increasing the consumption of healthy foods―such as fruits and vegetables― has been associated with decreases in the body mass index of both adults and children as well as decreases in the probability of being overweight (Lin and Morrison, 2002; McCabe-Sellers et al., 2007). In Mississippi, a study by Thompson et al., (2011b) found that a combination of fat intake reduction and an increase in fruit and vegetable intake resulted in a one-year weight loss between 4.3kg and 7.9kg among middle-aged women who were overweight and obese. Previous studies have conducted community-level research on the food environment and the risk of increased nutritionally related diseases. I contribute to this line of research by providing individual-level insights into the food environment of the Mississippi Delta. Previous research has focused on fruit and vegetable access and consumption based on a 3-day dietary recall. In my research, consumption frequency is based on a 30-day dietary recall which provides more information than the 24-hour or 3-day dietary recall period employed in previous studies. This approach provides a fuller look into the fruit and vegetable consumption of Mississippi Delta residents over a longer period and provides an update on the effects of the frequency of consumption of healthy foods in the region. Shorter recall periods may under-report an individual's usual intake as they may not account for variability in individuals' daily diet intake.

The food environment variables I looked at includes the availability of public transportation to residents and how it affects consumption, and I find that the availability increases the likelihood that individuals will consume healthier foods. I also assess the impact of store distance from individual residence and food shopping store types to see how they affect individual consumption of fruits and vegetables.

CHAPTER III

METHODS AND DATA

Survey and Data

The data used in my study come from the first round of the High Obesity Program (HOP) Community Survey collected between January 2020 and March 2020 with 352 completed responses. The AIM for CHangE team surveyed individuals living in 7 counties in the Mississippi Delta which are home to some of the state's highest obesity rates (obesity >40%). The target counties are Holmes, Humphreys, Issaquena, Leflore, Sharkey, Sunflower, and Washington which are shown in phase 1 counties of Figure 3.1. Phase 2 counties are adjacent counties that AIM for CHangE intends to expand to in the subsequent years. The survey was completed using both paper-based and online-based (via Qualtrics) methods to assess the consumption of healthy foods and levels of physical activity. The survey had question categories pertaining to demographics, diet and nutrition, and physical activity. Diet and nutrition questions included questions regarding respondents' body mass index (BMI), consumption frequency of different food groups, what would help them to eat healthier foods more frequently, and where individuals shop for their food.

To gauge the consumption frequency of fruits and vegetables, the survey includes a simplified version of the National Cancer Institute Eating at America's Table Study (EATS) food frequency questionnaire (Thompson et al., 2002). Respondents were asked to provide their frequency of consumption of different fruit and vegetable categories based on a 30-day dietary recall. For my research, I assess the different food categories which include 100% fruit juice, fruits (fresh, frozen, and canned), lettuce salad consumed with or without other vegetables, and all other vegetables (raw, cooked, canned, frozen) excluding lettuce salads and potatoes. The survey also included questions to gauge food accessibility in terms of transportation and distance traveled to the nearest full-service food store. Information on individuals' self-reported behaviors and barriers was also collected to help understand what consumers believe are factors that could influence their fruit and vegetable consumption.

I use stores and their addresses as well as their specific latitude and longitude using geolocated data from the USDA Food and Nutrition Service SNAP retailer database to assess the location and density of SNAP-participating stores in the zip code of survey respondents. Using store location data, I build different food environment measures following previous studies. Measuring the distance to stores and the density of stores using the centroid of a census tract or zip code is common among studies that assess different accessibility measures (Apparicio et al., 2017). For this study, I measure the distance to SNAP-authorized stores from a zip code centroid to evaluate the density of stores around respondents as well as the average distances that individual must travel to access different store formats. The software used to measure distances is ArcMap 10.8.1, using roads and highways to measure the distance between each store and the centroid of the 27 zip code areas where the survey respondents live. These data are combined with the geolocations from the geospatial database of the U.S. Census Bureau and Federal Highway Administration which contained roads and highways and their distances.

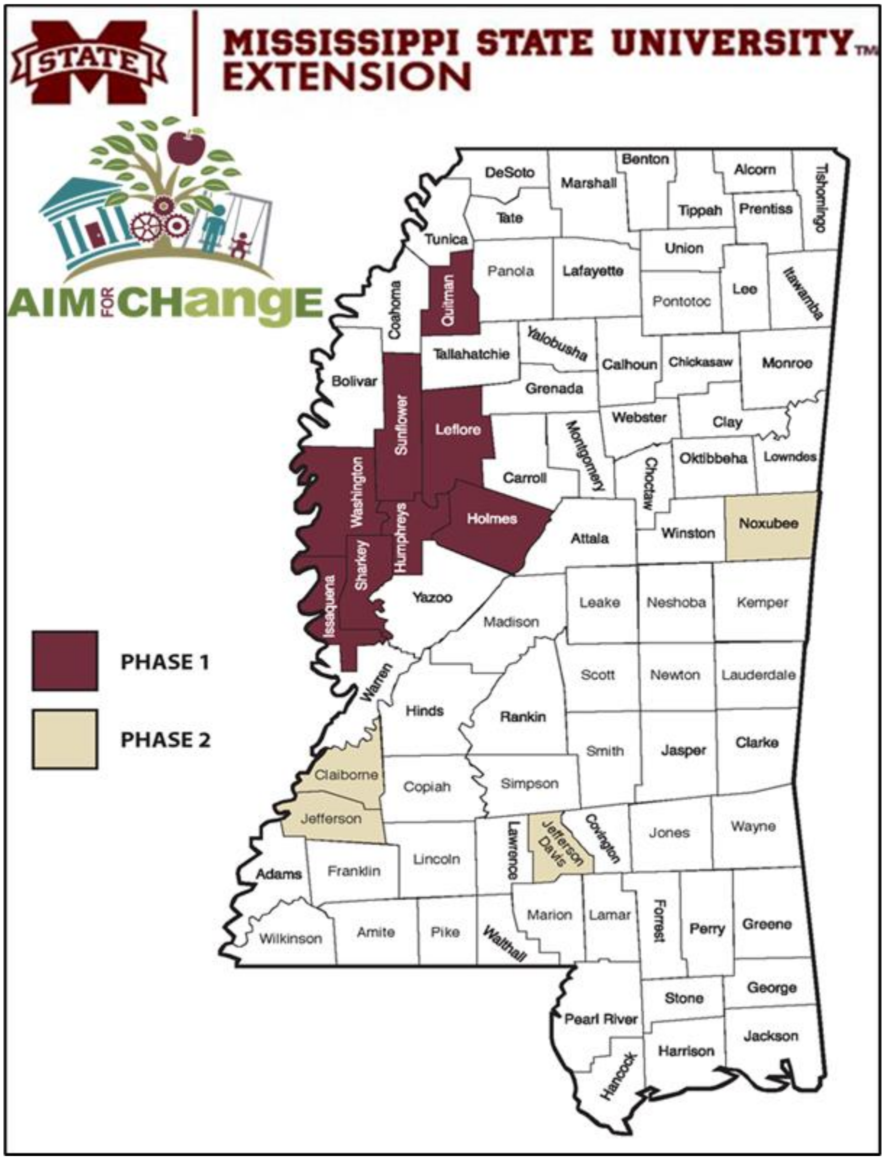

Figure 3.1 HOP target counties in the Mississippi Delta region

Regression Analysis

I examine the effects of an individual's food environment and sociodemographic factors, socioeconomic status, and their perceived barriers to consumption on their fruit and vegetable consumption patterns using an ordered probit regression model with an endogenous covariate to account for the discrete and ordered nature of the dependent variable and accommodate for endogenous variables. The frequency of consumption is a discrete categorical variable with ordered outcomes of *Monthly*, *Weekly*, and *Daily*. The unobserved latent dependent variable, y^*, is related to the observed dependent variable *y* (frequency of consumption) as follows:

$$\text{y} = \begin{cases} 1 = Monthly,\ \ if\ \ y^* \ < \tau_1 \\ 2 = Weekly,\ \ if\ \tau_1 < \ y^* \ < \tau_2 \\ 3 = Daily,\ \ if\ \tau_2 < y^* \end{cases} \qquad (1.1)$$

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

$$y_{ij}^* = \boldsymbol{\beta x_{ij}} + \gamma w_i + \epsilon_{ij} \qquad (1.2)$$

where $\boldsymbol{x_{ij}}$ is a vector of explanatory variables for individual *i* living in county *j*, and w_i is an endogenous binary indicator variable of SNAP participation status for individual *i*. Endogenous SNAP participation status is modeled such that:

$$w_i = \boldsymbol{\delta z_i} + \varepsilon_i \qquad (1.3)$$

where $\boldsymbol{z_i}$ contains the demographic variables in $\boldsymbol{x_{ij}}$ (i.e., age, gender, race, education) and full-time employment status.

The $\boldsymbol{x_{ij}}$ vector of explanatory variables includes food environment measures, demographic variables (race, age, gender, and education), respondent perception of barriers to frequently consuming vegetables, and whether respondents shop at a dollar store or convenience store. SNAP participation is included to control for socioeconomic conditions and is thought to be endogenous as there may be unobservable factors that could affect the decision to participate in the SNAP program and while also being correlated with frequency of fruit and vegetable consumption. Socioeconomic conditions (employment and income brackets) determine individuals' eligibility to participate in the SNAP program, but ultimately individuals decide whether to participate in the program, making SNAP participation nonrandom. SNAP participation is modeled based on demographic variables as well as employment, providing a predicted value of SNAP for the main regression that only depends on covariation with observable characteristics.

Because of the difficulty in interpreting coefficients from the ordered probit regression, I compute average marginal effects to assess the average changes in frequency of consumption probability given a one-unit change in the explanatory variables. The model is estimated via maximum likelihood estimation in STATA.

Variables and Model Specification

Dependent Variables

The dependent variable of interest is frequency of consumption of fruits, fruit juice, salad and vegetables. The existing literature often finds correlation between fruit and vegetable consumption and a healthier diet. For example, Thompson et al. (2011a), Wallace et al. (2019), Anune et al. (2017), and Schlesinger et al. (2019) have shown that maintaining a diet high in fruits and vegetables is essential to protect against relevant diseases such as diabetes, some cardiovascular diseases, and several types of cancer. In this study, the concept of diet quality is measured by the frequency of consumption of fruits and vegetables. Questions within the survey that asked how often respondents consumed fruit and vegetable items during the past month were used to measure fruit, fruit juice, vegetable, and salad consumption frequency. The frequency measures identified individuals as having daily, weekly, or monthly vegetable and fruit consumption.

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 grouped into *Monthly* which indicated that respondents consumed "never" or "1-3 times last month," *Weekly* which indicated that respondents consumed "1-2 times a week" or "3-4 times a week," and *Daily* which indicated that respondents consumed "5-6 times a week," "once a day," or "more than once a day." 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 category for some of the fruit and vegetable groups.

Explanatory Variables and Model Specification

Explanatory variables in the regressions to model consumption patterns include food environment factors, socioeconomic variables, demographic variables, where individuals shop for food, and perceived barrier to consumption. Understanding the food environment is critical in understanding health outcomes and food choices. Different food environment and socioeconomic factors have been known to have strong associations with diet quality, food choices, and health outcomes. Understanding these relationships is especially important to health officials and policymakers who need information about interventions that could improve the food environment and increase access to healthier foods.

In the main model of this study (Table 4.2), the key independent variables of interest include measures of the food environment from the HOP Community Survey. These variables include the distance traveled to the nearest full-service grocery store in miles (*Store Distance*) and whether communities where respondents live have any form of public transportation (*TransportComm*) such as bus routes which help to control for accessibility. *Store Distance* is expected to be negatively correlated with the frequency of consumption of fruits and vegetables (Connell et al., 2006; Michimi and Wimberly, 2010). While availability of public transportation is not a direct measure of transportation access, it helps to control for individuals' ability to access food stores given they may not have access to personal transportation. Mississippi residents have low access to personal vehicles, particularly individuals with low access to food stores (US Department of Agriculture Economic Research Service, 2020). Other food environment variables include where individuals shop for food within their county. Specifically, I am interested in whether individuals shopped at convenience stores (*Shop Conv Store*) or dollar store formats (*Shop Doll Store*). 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 are associated with less healthful assortments of food options (Larson et al., 2006).

In addition to the food environment variables, I included variables that explain what respondents believe to be barriers to consuming fruits and vegetables more frequently. The survey questions asked respondents if they would consume more vegetables if their family ate more (*Family*), if the prices were cheaper (*Price*), or if they tasted better (*Taste*). These barriers to consumption variables control for access to healthy foods, as well as the preference of respondents as it relates to consumption patterns. For each of these barriers, I expect that they will be correlated with lower frequencies of vegetable consumption. An advertisement variable (*Advertisement*) is included as a measure of behavioral factors that may help to determine consumption decisions. Using a 30-day recall, respondents were asked if they were exposed to advertisements via TV, radio, newspaper, or online which was promoting the consumption of healthy foods or drinks. Exposure to healthy eating advertisement helps to control for the respondents' behavioral component that may affect their consumption pattern (Halford et al., 2004), and is a measure of other contributing factors of the built food environment.

Other independent variables of interest capture sociodemographic characteristics including age and whether respondents are male, African Americans, and college educated. As discussed in my literature review, existing research has shown that diet quality and diet-related health outcomes usually vary across demographic groups. I expect African Americans, young adults, and males to have lower consumption frequencies, consistent with the findings of previous research (Hales et al., 2020; Larson et al., 2009; McCabe Sellers et al., 2007; and Rose et al., 2004). The inclusion of socioeconomic and demographic variables is used to control for individual-level variability in fruit and vegetable consumption not accounted for in the food environment, such as affordability which may be captured by income and or education. While being a good proxy for income level, the *College Educated* variable provides an indirect measure of literacy, household economic conditions, as well as a control for nutrition knowledge. Age, race, and gender help to capture differences in the frequency of consumption across groups within the region of study.

SNAP participation is included to control for socioeconomic conditions within households that I was unable to identify directly. Income is the main determinant of SNAP eligibility, but this information was unavailable. Instead, employment status is used in the SNAP equation. Employment status does not necessarily determine a household's ability to afford fruits and vegetables, as a full-time job does not equate to a livable income. While employment status is a known determinant of SNAP participation (Mississippi Department of Human Service, 2022) it is less likely to be correlated with fruit and vegetable consumption (Wolfson and Bleich 2015).

I estimate alternative model specifications where the food environment measures are derived from the published store availability data instead of the food environment measures from the HOP community survey responses. This alternative specification allows the model to capture different objective measures of the food environment that are not prone to common survey errors. For the first alternative model specification (Table 4.3), I use food environment measures based on store density and store distance at the zip code level. These variables include the minimum distance to the nearest supermarket (*Supemin1*) and the count of convenience stores within a 30-mile radius of the zip code centroid (*Convcount30*) to capture the availability and density of full-service stores from the respondents' zip code centroid. The demographics, barriers, and socioeconomic variables were the same as those included in my primary specification.

For the second alternative model specification (Table 4.4), I estimate the distance-weighted index of the five closest convenience stores (*ConvIndex*) and the five closest supermarkets (*SupeIndex*) from each zip code centroid. The reason for selecting the five closest stores to calculate these indices is that there were only five supermarkets available for any given zip code used for the count of store formats from the centroid. The calculation of these indices follows the definition of a concentration index of a particular store format by Kuang (2017) such that:

$$I_{zs} = \sum_{s=1}^{5} \frac{1}{d_{zs}^{\theta}} \tag{1.3}$$

where *I* is the distance-weighted concentration index of the different food store types, and d_{zs} is the roads and highways distance from a zip code centroid *z* to the store *s*. According to Kuang (2017), the optimal baseline value for θ is 1/2[4], which I also assumed for this calculation. The measure of store concentration allows for more weight to be given to stores within closer locations. Geographic food environment measures help to identify the impact of being within a specified distance to the different store types. These additional food environment variables are calculated to help evaluate alternative estimation methods of a food environment measure. They help to measure the food environment at a zip code level and may better explain built environment factors that affect consumption patterns.

[4] The value of θ was found to be robust to other values such as 1/3, 1/4, 1/5, and 0 in a study by Kuang, (2017).

Store distances from a zip code centroid are calculated using network analyst extension in ArcMap V.10.8.1 (ArcGIS, Redlands, CA). All other data manipulation, data cleaning, and model estimations is conducted using STATA V.17.1 (StataCorp LLC, College Station, TX).

CHAPTER IV

RESULTS

Data and Survey Demographics

There are 325 initial responses from round 1 of the HOP community survey, however, some observations were dropped because they lacked responses for the variables that I used for my analysis. I use US Census Bureau (2021) population demographic data (age, employment, education, race, and gender) from the seven target counties in the Delta region for comparison purposes. Both the survey and regional demographics are reported in the summary statistics table (Table 4.1). There is a relatively small survey sample size of 205 respondents after some variables and observations are dropped, and most of the survey's demographic variables proved to not be representative of the region of study. The survey respondents are predominantly African American (81.46%) with a 10.28 percentage point difference from the regional average (71.18%) which is also predominantly African American. Whites and other races make up 28.82% of the regional average but only 18.54% of the survey sample. Most survey respondents are employed full-time (57.10%). Regional full-time employment is less than half the weighted population (42.40%), and the survey mean is 57.10%. Most survey respondents were also female (80.66%), which is distinct from the regional average of 51.73%. The SNAP participation variable was representative, however, with 22% of the survey respondents reporting SNAP participation compared to the regional SNAP participation rate of 18.01% (USDA-ERS, 2020).

Table 4.1 Summary Statistics

Variable Group	Variable	Description	No. Obs.	Mean	Std. Dev.	Regional Weighted Mean
Food Environment Measure	Store Distance[a]	Distance to a full-service grocery store from residence location	205	13.276	13.472	
	Shop Conv Store[a]	Respondent shops at a convenience store	205	0.400	0.491	
	Shop Doll Store[a]	Respondent shops at a dollar store format	205	0.756	0.430	
	ConvIndex[b]	Distance weighted index of 5 closest convenience stores	201	3.704	2.952	
	SupeIndex[b]	Distance weighted index of 5 closest supermarkets	201	0.961	0.308	
	Supemin1[b]	Minimum distance to a supermarket from a zip code centroid	201	23.877	14.898	
	ConvCount30[b]	The count of convenience stores within a 30-mile range	201	52.950	29.889	
	TransportComm	Has public transportation available in community	205	0.141	0.349	
Perceived Barriers and Exposure to Advertisement	Family	Respondent would eat more vegetables if family ate more	205	0.420	0.495	
	Taste	Respondent would eat more vegetables if it tasted better	205	0.356	0.480	
	Price	Respondent would eat more vegetables if they were cheaper	205	0.522	0.501	
	Advertisement	Respondent was exposed to healthy eating advert. In the past 30 days. 1=Yes	205	0.580	0.495	
Socioeconomic Conditions	SNAP	SNAP assistance program participant	205	0.220	0.415	0.180
Demographics	Age	18-60	205	60.62	15.694	53.18
		> 60		39.38		21.09
	Gender	Dummy Variable 1=Male	205	0.195	0.397	0.483
	Race	Dummy Variable 1= African American	205	0.815	0.390	0.712
	Education	Dummy Variable 1= College education	205	0.405	0.492	0.144
	Employment	Dummy Variable 1=Full-Time Employed	205	0.571	0.496	0.424

[a]Source of food environment measure data is from the HOP Community Survey. [b]Source of food environment measure data is from published store availability data. Note that N=201 because zip codes that lack store data caused these variables to drop.

As shown in Table 4.1, the average distance to a full-service grocery store where respondent stated they could find all their grocery needs is 13.28 miles from their residence, with the minimum being less than 1 mile. As shown in Figure 4.2, the distance that residents must travel to the nearest full-service grocery store is positively skewed with some survey respondents traveling notably longer distances. Based on survey responses, 75% of respondents travel under 20 miles to a full-service grocery store and 50% travel under 8 miles. Less than 25% of respondents travel between 20 and 65 miles to access a full-service grocery store for all their grocery needs. Longer distances to a full-service store may partially explain why a large percentage of survey respondents (75.6%) indicate that they shop at dollar stores for grocery needs. The inability to access a full-service food store as easily may cause individuals to supplement their grocery needs at dollar store formats or convenience stores, which are more accessible (i.e., higher store density) than supermarkets and full-service grocery stores in the Mississippi Delta region.

After being asked what would help them to eat better, I find that less than half the survey respondents believed that family preferences and the taste of the food would help them improve their vegetable intake (Table 4.1). Only 35.61% of respondents believed their vegetable intake would increase if vegetables tasted better, and 41.95% believe they would consume more if their family also consumed more vegetables. Previous studies by Cleary et al. (2010) and Sharkey at al. (2010) found price to be a recurring barrier to healthy food consumption in rural areas. I find that 52.2% of respondents saw price as a barrier to consuming vegetables in this survey, creating an area of concern surrounding the choice to eat less healthy options.

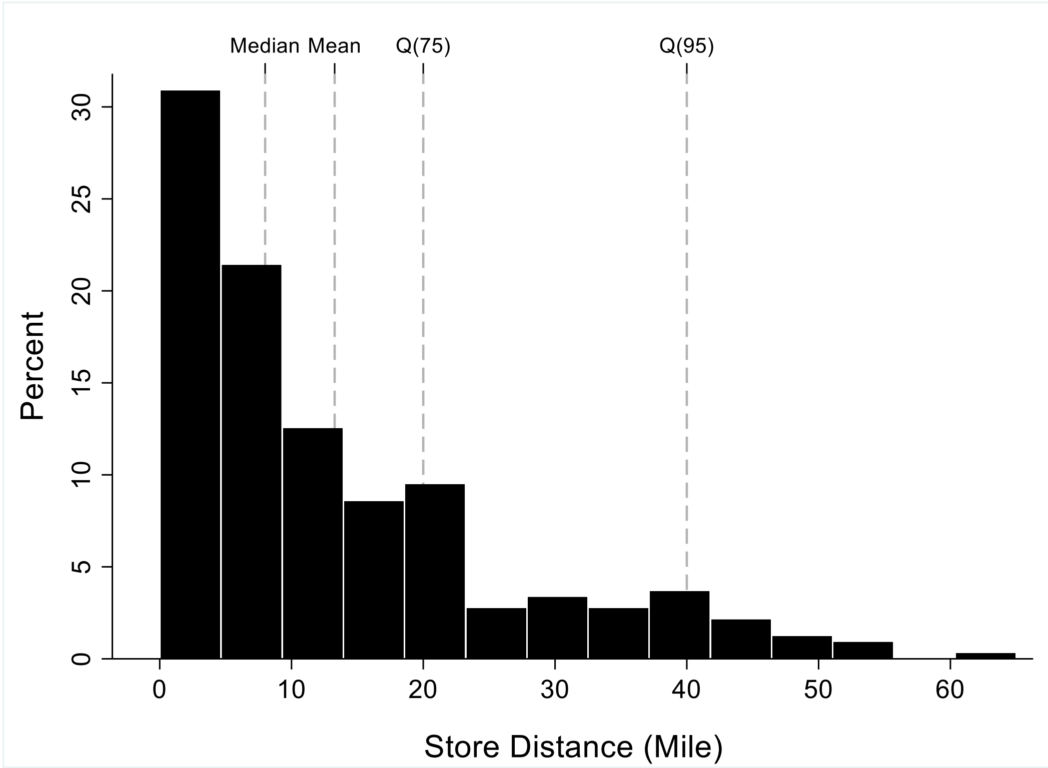

Figure 4.1 Store Distance Distribution to the Nearest Full-Service Grocery Store Based on Survey Respondents

Figure 4.2 shows the percentage of daily, weekly, and monthly consumption of vegetables, salad, fruits, and fruit juices. I generally find that many individuals are not consuming fruits and vegetables daily, as recommended by the Dietary Guideline of America. Only 18.5% of individuals consume vegetables daily, and 12.75% consume salad daily (Figure 4.2). Most individuals reported that they consume fruits (56.10%) and vegetables (54.63%) on a weekly basis. Even if individuals report daily consumption, however, is not equivalent to consuming the recommended nutritional intake of 1.5 cups per day for fruits and 2 to 3 cups per day for vegetables (USDA and HHS, 2020). These findings are consistent with findings from a study conducted in the Mississippi Delta by McCabe-Sellers et al. (2007).

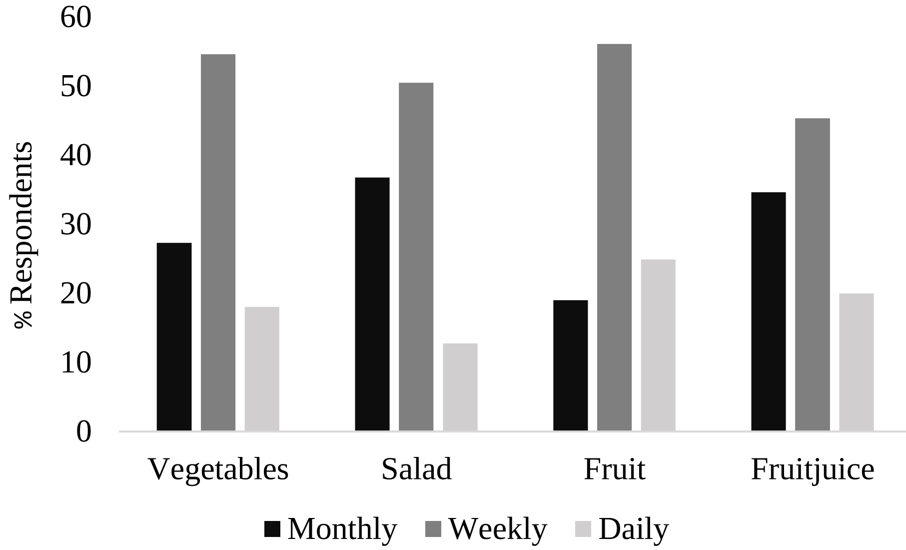

Figure 4.2 Percentage Frequency of Consumption of Fruits and Vegetables from Survey Respondents

Extended Ordered Probit (EOP) Regression Results

I present the results of the main regression model in Table 4.2. The ordered probit regression estimated accounts for the fact that SNAP participation might be endogenous as unobserved factors that may influence SNAP participation may also affect fruit and vegetables consumption. In the main model (Table 4.2), I find that the correlation between the errors from the consumption frequency and SNAP participation are statistically significant for the salad and fruit juice regressions, indicating that unobservable factors that affect SNAP participation also tend to affect frequency of salad and fruit juice consumption. For example, the correlation in the salad model is positive (0.587), suggesting that factors not accounted for in the model that increase the probability of SNAP participation also tend to increase the likelihood of more frequent salad consumption. Similar results were found in the alternative models estimated and reported in Tables 4.3 and 4.4.

In what follows, I will discuss general insights regarding the effect of the explanatory variables on the frequency of consumption. While the coefficients from the regression model cannot be interpreted directly, the sign of the coefficient shows whether the dependent variable (frequency of consumption) increases or decreases given a change in the explanatory variables. I find that an increase in the distance travelled to a full-service grocery store is associated with a lower frequency of vegetables and salad consumption. Similar outcomes are found in studies that have assessed the correlation between the distance residents must travel to the nearest food outlets in areas facing economic hardship (Connell et al., 2006; Michimi and Wimberly, 2010; and Jilcott et al., 2010). In these studies, longer distances are correlated with eating less healthy food options. My results also show that individuals living in counties with access to public transportation are more likely to consume fruits and fruit juice more frequently.

The results shown in Table 4.2 indicate that older individuals are more likely to consume vegetables, fruits, and fruit juice more frequently. To some extent this difference in consumption could be due to the autonomy that older individuals have over their life to eat or prepare the food that they want or prefer, or even their ability to afford healthier food options. McCabe-Sellers et al. (2007) and Thompson et al. (2011a) also found an association between younger individuals and a lower diet quality compared to older individuals. I also find that African Americans in comparison to other races are less likely to consume vegetables frequently. African Americans are, however, more likely to consume salad and fruit juices. I did not find statistical differences in consumption across gender and education categories.

Individual-perceived barriers to consuming fruits and vegetables include the taste of fruits and vegetables (*Taste*), whether their family ate more (*Family*), and the price of the fruits and vegetables (*Price*). Statistically significant differences are only found for vegetable consumption within the model. Both *Family* and *Price* increase the likelihood that individuals consume vegetables more frequently. The increased consumption in vegetables despite these variables being considered a barrier, helps me to measure preference as a factor of how often individuals consume vegetables. Individuals who do not consider *Price* and *Family* to be a barrier are also not likely to consume vegetables more frequently, which may be partially explained by individuals having a preference in what they consume regardless of outside factors. From the group of barrier variables, *Family* and *Price* have the highest average percentage of respondents believing that they were potential barrier to consuming vegetables more frequently.

SNAP is controlled for as an endogenous variable using age, gender, race, education, and employment. As expected, individuals who are older, college educated, and full time employed are less likely to participate in SNAP. African Americans, however, are more likely to participate in SNAP compared to Whites and other races. SNAP participation helps to measure socioeconomic status of participants, as income level is a known determinant of SNAP eligibility. Socioeconomic status partially helps to shape individual food consumption choices as well as the frequency of consumption of certain foods, depending on cost, accessibility, and other factors. Overall, I find that SNAP participation is more likely among groups who are may be socioeconomically disadvantaged. When compared to individuals who do not participate in SNAP, SNAP participation increases the likelihood that individuals will consume more fruit juice, and decreases the likelihood that salads are consumed more frequently.

While I find that exposure to healthy eating advertisement is correlated with increased consumption frequencies of vegetables, fruits, and fruit juice, those result were not statistically significant. Caspi et al. (2017) studied food store environments and their relationship with customer purchase behavior and found that in-store marketing efforts that promoted healthy purchases had inconsistent associations with the decision to buy healthy foods. The availability of healthy food promotions proved irrelevant to customer behaviors partly because there was an equal amount of less healthy food promotion accessed via the same medium.

For the first alternative specification of the EOP regression estimation reported in Table 4.3, I use the count of convenience stores within a 30-mile range and the minimum distance to a supermarket from a zip code centroid as the measures of the food environment. The count and distance measures reflect measures that are not individually reported by survey respondents but constructed using store location data. The estimated coefficients for the food environment variables in this model specification are all statistically insignificant at the 1%, 5%, or 10% levels. The second alternative is reported in Table 4.4, where I use two distance weighted indices of the five closest stores as a measure of the food environment, instead of the food environment measure reported by survey respondents. *SupeIndex* and *ConvIndex* are concentration indices that measure availability in terms of store density and store distances. The indices summarize the concentration of the closest five stores into a single value, with higher indices indicating a longer average distance to the store format. Therefore, I expect that higher indices for both supermarkets and grocery stores to be associated with less frequent consumption of fruits and vegetables. I find that the estimated *SupeIndex* coefficients from the published store availability data were statistically insignificant (1%, 5%, or 10% level) for vegetables, salads, and fruits but increased the likelihood that respondents consumed fruit juice.

Zip-code-level data are used for the geographical measures of the food environment (*Supemin1, ConvCount30, SupeIndex, and ConvIndex*), as opposed to the individual data used in the main model. Given the small geographic area in this study, this makes it difficult to capture the differences in the food environment in the alternative models because of the low variability within the data. While the main model reported in Table 4.2 does not have the best fit compared to the alternative models (Tables 4.3 and 4.4) in terms of AIC values, the zip-code-level food environment variables are not statistically significant in the alternative models and do not provide useful insights regarding the food environment in our target region. Hence, I focus on the main model for the remaining discussion on marginal effects because it offers more explanatory power of the food environment. The statistically insignificant geographical food environment measures in the EOP regression will also be statistically insignificant if they are to be estimated at the average margins, so I do not report the average marginal effects for the alternative specifications in Tables 4.2 and 4.3.

Table 4.2 EOP Regression Results Showing Frequency of Consumption for Vegetables. Salads, Fruits, and Fruit Juice

	Vegetables		Salad		Fruits		Fruit Juice	
	Coeff.	**St. Error**	**Coeff.**	**St. Error**	**Coeff.**	**St. Error**	**Coeff.**	**St. Error**
Dep. Var. = Freq. Of Cons.								
Store Distance	-0.012*	(0.006)	-0.011**	(0.005)	-0.009	(0.006)	-0.008	(0.006)
Shop Conv Store	-0.195	(0.178)	0.030	(0.147)	-0.027	(0.175)	-0.176	(0.167)
Shop Doll Store	-0.468**	(0.200)	-0.001	(0.166)	-0.204	(0.197)	-0.290	(0.188)
TransportComm	0.409*	(0.238)	0.211	(0.196)	0.021	(0.235)	0.380*	(0.223)
Family	0.351*	(0.195)	0.167	(0.169)	0.014	(0.193)	0.181	(0.183)
Taste	-0.223	(0.186)	0.042	(0.154)	-0.200	(0.183)	0.041	(0.176)
Price	0.397**	(0.181)	-0.071	(0.150)	0.124	(0.178)	-0.013	(0.172)
Advertisement	0.263	(0.177)	-0.029	(0.146)	0.001	(0.174)	0.004	(0.165)
SNAP	0.870	(0.669)	-1.251**	(0.495)	0.825	(0.660)	1.331**	(0.561)
Age	0.011*	(0.006)	-0.001	(0.006)	0.011*	(0.006)	0.011**	(0.006)
Gender (Male =1)	-0.128	(0.216)	-0.200	(0.216)	-0.182	(0.212)	0.143	(0.213)
Race (African American =1)	-0.535**	(0.267)	0.421*	(0.238)	0.127	(0.279)	0.651**	(0.324)
Education (College =1)	0.026	(0.213)	-0.175	(0.190)	0.079	(0.209)	0.192	(0.199)
τ_1	-0.437	(0.488)	-0.453	(0.408)	-0.333	(0.476)	0.855**	(0.425)
τ_2	1.236***	(0.456)	0.815	(0.508)	1.270***	(0.448)	2.134***	(0.413)
SNAP								
Age	-0.008***	(0.002)	-0.008***	(0.002)	-0.008***	(0.002)	-0.008***	(0.002)
Gender (Male =1)	0.068	(0.065)	0.065	(0.065)	0.068	(0.065)	0.068	(0.065)
Race (African American =1)	0.199***	(0.066)	0.201***	(0.066)	0.199***	(0.066)	0.199***	(0.066)
Education (College =1)	-0.152***	(0.053)	-0.155***	(0.053)	-0.152***	(0.053)	-0.152***	(0.053)
Employment (FullEmployed =1)	-0.268***	(0.060)	-0.272***	(0.060)	-0.268***	(0.060)	-0.268***	(0.060)
Constant	0.690***	(0.135)	0.693***	(0.135)	0.690***	(0.135)	0.690***	(0.135)
Var(e.SNAP)	0.134***	(0.013)	0.134***	(0.013)	0.134***	(0.013)	0.134***	(0.013)
Corr(e.SNAP e.Freq.)	-0.165	(0.265)	0.587***	(0.171)	-0.168	(0.261)	-0.393*	(0.225)
No. Observation	205		204		205		205	
AIC	586.395		591.566		605.820		605.724	
Log. Lik.	-270.198		-272.783		-279.91		-279.862	

Standard errors are in parenthesis. ***, **, and * specify the P-value statistical significance at the 1%, 5%, and 10% level respectively. The frequency of consumption dependent variable is daily =3, weekly=2, and monthly=1

Table 4.3 EOP Regression Results Showing Frequency of Consumption for Food Categories with Distance and Store Count Food Environment Measures

	Vegetables		Salad		Fruits		Fruit Juice	
	Coeff.	**St. Error**	**Coeff.**	**St. Error**	**Coeff.**	**St. Error**	**Coeff.**	**St. Error**
Dep. Var. = Freq. Of Cons.								
Shop Conv Store	-0.169	(0.178)	0.020	(0.158)	-0.034	(0.174)	-0.179	(0.177)
Shop Doll Store	-0.557***	(0.207)	-0.027	(0.184)	-0.229	(0.200)	-0.194	(0.202)
Supemin1	0.007	(0.013)	-0.007	(0.011)	0.008	(0.012)	-0.006	(0.013)
ConvCount30	0.006	(0.006)	-0.001	(0.005)	0.005	(0.006)	0.003	(0.006)
TransportComm	0.515**	(0.251)	0.171	(0.219)	-0.020	(0.244)	0.270	(0.244)
Family	0.370*	(0.201)	0.211	(0.187)	-0.011	(0.197)	0.189	(0.200)
Taste	-0.236	(0.193)	0.054	(0.171)	-0.203	(0.187)	0.075	(0.193)
Price	0.498***	(0.182)	-0.070	(0.162)	0.203	(0.176)	-0.075	(0.183)
Advertisement	0.141	(0.178)	0.004	(0.158)	-0.053	(0.174)	0.030	(0.175)
SNAP	0.932	(0.610)	-1.023**	(0.515)	0.990*	(0.588)	1.071*	(0.586)
Age	0.012**	(0.006)	-0.002	(0.006)	0.011*	(0.006)	0.012*	(0.006)
Gender (Male =1)	-0.097	(0.214)	-0.260	(0.216)	-0.131	(0.209)	0.208	(0.214)
Race (African American =1)	-0.531*	(0.277)	0.295	(0.263)	0.159	(0.289)	0.656**	(0.322)
Education (College =1)	-0.014	(0.216)	-0.188	(0.197)	0.127	(0.208)	0.136	(0.210)
τ_1	0.146	(0.848)	-0.648	(0.744)	0.328	(0.827)	1.005	(0.821)
τ_2	1.794**	(0.828)	0.672	(0.796)	1.861**	(0.809)	2.320***	(0.809)
SNAP								
Age	-0.009***	(0.002)	-0.009***	(0.002)	-0.009***	(0.002)	-0.009***	(0.002)
Gender (Male =1)	0.050	(0.065)	0.047	(0.065)	0.050	(0.065)	0.050	(0.065)
Race (African American =1)	0.192***	(0.068)	0.194***	(0.068)	0.192***	(0.068)	0.192***	(0.068)
Education (College =1)	-0.167***	(0.054)	-0.170***	(0.054)	-0.167***	(0.054)	-0.167***	(0.054)
Employment (FullEmployed =1)	-0.300***	(0.062)	-0.304***	(0.062)	-0.300***	(0.062)	-0.300***	(0.062)
Constant	0.782***	(0.143)	0.786***	(0.143)	0.782***	(0.143)	0.782***	(0.143)
var(e.SNAP)	0.135***	(0.013)	0.134***	(0.013)	0.135***	(0.013)	0.135***	(0.013)
corr(e.SNAP e.Freq)	-0.205	(0.244)	0.494***	(0.186)	-0.241	(0.236)	-0.273	(0.236)
No. Observation	201		200		201		201	
AIC	580.174		590.809		602.218		596.895	
Log. Lik.	-267.898		-272.684		-279.866		-276.149	

Standard errors are in parenthesis. ***, **, and * specify the P-value statistical significance at the 1%, 5%, and 10% level respectively. The frequency of consumption dependent variable is daily =3, weekly=2, and monthly=1

Table 4.4 EOP Regression Results Showing Frequency of Consumption for Food Categories with Distance-Weighted Concentrated Index Food Environment Measures

	Vegetables		Salad		Fruits		Fruit Juice	
	Coeff.	**St. Error**	**Coeff.**	**St. Error**	**Coeff.**	**St. Error**	**Coeff.**	**St. Error**
Dep. Var. = Freq. Of Cons.								
Shop Conv Store	-0.162	(0.177)	0.013	(0.158)	-0.023	(0.173)	-0.185	(0.173)
Shop Doll Store	-0.565***	(0.209)	-0.032	(0.186)	-0.231	(0.202)	-0.182	(0.201)
ConvIndex	-0.017	(0.029)	0.015	(0.026)	-0.003	(0.028)	-0.026	(0.027)
SupeIndex	0.158	(0.290)	0.094	(0.257)	0.052	(0.286)	0.564**	(0.285)
TransportComm	0.540**	(0.258)	0.166	(0.225)	-0.016	(0.251)	0.278	(0.247)
Family	0.361*	(0.197)	0.235	(0.185)	-0.030	(0.194)	0.212	(0.194)
Taste	-0.231	(0.193)	0.046	(0.172)	-0.188	(0.188)	0.069	(0.190)
Price	0.502***	(0.182)	-0.070	(0.163)	0.208	(0.177)	-0.090	(0.182)
Advertisement	0.160	(0.176)	0.012	(0.158)	-0.034	(0.172)	0.026	(0.171)
SNAP	0.924	(0.609)	-1.009*	(0.518)	0.954	(0.592)	1.165**	(0.566)
Age	0.012**	(0.006)	-0.001	(0.006)	0.010*	(0.006)	0.013**	(0.006)
Gender (Male =1)	-0.085	(0.214)	-0.271	(0.216)	-0.120	(0.209)	0.218	(0.214)
Race (African American =1)	-0.517*	(0.271)	0.323	(0.257)	0.133	(0.283)	0.724**	(0.325)
Education (College =1)	0.004	(0.217)	-0.189	(0.198)	0.130	(0.209)	0.164	(0.209)
τ_1	-0.210	(0.554)	-0.238	(0.499)	-0.133	(0.539)	1.597***	(0.507)
τ_2	1.433***	(0.528)	1.088*	(0.578)	1.403***	(0.513)	2.900***	(0.515)
SNAP								
Age	-0.009***	(0.002)	-0.009***	(0.002)	-0.009***	(0.002)	-0.009***	(0.002)
Gender (Male =1)	0.050	(0.065)	0.047	(0.065)	0.050	(0.065)	0.050	(0.065)
Race (African American =1)	0.192***	(0.068)	0.194***	(0.068)	0.192***	(0.068)	0.192***	(0.068)
Education (College =1)	-0.167***	(0.054)	-0.170***	(0.054)	-0.167***	(0.054)	-0.167***	(0.054)
Employment (FullEmployed =1)	-0.300***	(0.062)	-0.304***	(0.062)	-0.300***	(0.062)	-0.300***	(0.062)
Constant	0.782***	(0.143)	0.786***	(0.143)	0.782***	(0.143)	0.782***	(0.143)
var(e.SNAP)	0.135***	(0.013)	0.134***	(0.013)	0.135***	(0.013)	0.135***	(0.013)
corr(e.SNAP e.Freq)	-0.205	(0.244)	0.488***	(0.187)	-0.228	(0.237)	-0.313	(0.229)
No. Observation	201		200		201		201	
AIC	580.808		591.139		602.831		595.986	
Log. Lik.	-265.402		-270.611		-278.055		-272.944	

Standard errors are in parenthesis. ***, **, and * specify the P-value statistical significance at the 1%, 5%, and 10% level respectively. The frequency of consumption dependent variable is daily =3, weekly=2, and monthly=1

Average Marginal Effects Results

The results from the ordered probit regression with an endogenous covariate is not easily and directly interpretable given the model's non-linear functional form. Because of this, I estimate average marginal effects which are presented in Table 4.5. Marginal effect estimates are only presented for the main model reported in Table 4.1 where the food environment measures are based on the HOP Community Survey responses.

Generally, I find that store distance significantly influences the frequency of consumption of vegetables and salads. For example, the 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 and salads daily (p-value <0.10). This is especially important because some researchers find that insufficient transportation access in rural areas tend to affect some groups more than others. Low density of full-service stores and supermarkets increases the difficulty of healthy food access for rural, low-income, and elderly residents (McGhee et al., 2011; Morland et al., 2011; Hendrickson et al., 2006). The opposite is seen for less frequent consumption patterns where individuals are 0.4 and 0.5 percentage point more likely to consume vegetables and salads on a monthly basis, respectively, for each additional mile that they must travel (p-value <0.05). Similar correlations have been found between the distance travelled to a full-service grocery store and consumption patterns in previous literature, where farther commute distances decreased fruit and vegetable intake (Sharkey et al., 2010; Michimi and Wimberly, 2010). While the effect of store distance on the frequency of consumption of fruits in this study is statistically insignificant, it generally shows a negative correlation with the distance a resident must travel to the nearest full-service grocery store. Other studies have conducted similar assessments and find similar correlations to be statistically significant. Rose and Richard (2004) find that ease of access to supermarket is associated with increased fruits consumption, and Sharkey et al. (2010) find a 1.2 percentage point decrease in fruit consumption for each additional mile to a store with a good selection of food.

Residents in areas with limited access to full-service grocery stores usually travel longer distances for a full grocery shopping experience. Consequently, individuals with limited access resort to purchasing foods at alternative store formats such as convenience and dollar stores. I find that individuals who shop for food at dollar store formats compared to individuals who do not, are 11.10 percentage points less likely to consume vegetables daily (p-value <0.05). This finding helps to capture the negative effect of shopping at dollar store formats, and by extension, stores that do not provide a full-service grocery shopping experience with a wider assortment of fresh fruit and vegetables. Strategies to increase the assortment of healthier food options as store formats such as convenience and dollar stores could help improve the food environment and by extension healthy food consumption in areas with limited access to full-service grocery stores.

In addition, because residents must travel long distances to increase access to a full-service grocery store experience, it is important for public transportations to be available in rural areas. Particularly in the Mississippi Delta, there is a lack of access to personal vehicles by residents. In counties where there is public transportation, residents are 10.35 percentage points more likely to consume fruit juice on a daily basis (p-value <0.10) and 9.69 percentage points more likely to consume vegetables daily (p-value <0.10). The marginal effects for the availability for public transportation shows expected results which are not unique to this study. Similar findings highlighting that unreliable access to transportation is known to limit food access—especially among low-income households (Connell et al., 2006; Kaiser et al., 2017). The marginal effects from the public transportation environmental factor highlights the need for ease of access related interventions in socioeconomically deprived areas. In the Mississippi Delta region, there is an immediate need for the implementation of more accessible public transportation to help bridge the gap between the lack of personal transportation and spatial access to supermarkets and full-service stores where individuals can have a full grocery shopping experience. Interventions that focus on getting individuals to healthy food are necessary, as it may be more difficult to bring healthy food to the people by increasing market entries of larger retail stores in rural areas.

Individuals who perceive price as a barrier to consuming more vegetables are 9.41 percentage points (p-value <0.05) more likely to consume vegetables daily compared to individuals who do not perceive price as a barrier (Figure 4.4). Price is a barrier to the consumption of healthier and more expensive food options. Prior studies find that price barriers decrease the probability of eating healthier (Cleary et al., 2018; Kaiser et al., 2017; French, 2003), and is sometime explained by the higher cost per serving for fruits and vegetables in stores found in rural areas. One study conducted in the Mississippi Delta finds that the price per serving of fruits and vegetables is more expensive in this region when compared to the national price per serving (Connell et al., 2012). My results regarding food price as a barrier is different from the literature. The increase in daily consumption despite price being perceived as a barrier is indicative that individuals who acknowledge price as a barrier may also be consuming vegetables more frequently. For individuals with lower fruit and vegetable consumption in my study, the consumption of healthier food options might be due to preferences and other behavioral components rather than factors that are generally perceived to prevent more frequent fruits and vegetables consumption (e.g., prices). I was unable to capture the effects of preference in my research, however.

McGhee at al. (2011) find that despite residents' perceived price barriers —healthy foods are too expensive—personal preferences and family members tend to be more influential on food purchases. For my study, I find that family influence is likely to cause an 8.3 percentage point increase in the consumption of vegetables on a daily basis. The home environment is a dietary influence that may be overlooked but plays an important role in consumption in terms of what individuals are familiar with, what they prefer, and even how they prepare food. To increase intake in households where family is a large influence on dietary intake, there may need to be initiatives focused on the family environment that target increased fruit and vegetable consumption. Parental choices are often reflected in children, adolescents, and elderly who have less autonomy over what is consumed in the household. McGhee at al. (2011) also find that the taste of food was not much of a barrier because individuals tend to buy vegetables because they like them. However, individuals who perceive taste to be a barrier compared to individuals who do not are all-around statistically insignificant for fruits, fruit juice, salads, and vegetables for all frequencies in my study.

An implication of my findings associated with the residents' perceived barriers can be the implementation of behavioral interventions in the Mississippi Delta region to address the high obesity rates, since a direct solution to prices barriers may not be as effective among individuals who consume infrequently. Several policies have been geared towards lowering healthier food prices in efforts to increase healthier food consumption. While this is an accepted approach, it is possible that it may not be reaching the target audience of those consuming fruit and vegetables less frequently and who may not perceive price to be a barrier. Policies could redirect their strategies to include initiatives that target individuals who do not see food price as a barrier to consuming more fruits and vegetables and whose low consumption may be due to dietary preferences. This alternative approach could improve the probability that the programs become more effective in helping to improve consumption frequency and lowering the occurrence of obesity and the associated non-communicative health risk.

I find that SNAP participation influences salad and fruit consumption, but the effect differs across food products. SNAP participation is associated with a 36.25 percentage point increase (p-value <0.10) in the likelihood of consuming fruit juice daily and 30.37 percentage point decrease (p-value <0.10) in the likelihood of consuming salads daily. While studies in the literature find that SNAP participation expand food supply in low-income households (Hendrickson et al., 2006; McCabe-Sellers et al., 2007), the decrease is salad consumption is expected for SNAP participants who usually have lower income and may need to buy low-cost high energy foods—unlike salads—because of budget constraints.

There were no statistically significant differences noted in the consumption frequency of vegetables, salads, fruits, and fruit juice among males in comparison to females. In an assessment of the diet quality of lower Mississippi Delta adults, McCabe-Sellers et al. (2007) found no differences in overall diet quality between males and females. Their study, however, used a 24-hour recall and the HEI score to measure intake, as opposed to my 30-day dietary recall using the National Cancer Institute EATS food frequency questionnaire. There were no statistically significant differences in the frequency of consumption of fruits, fruit juice, vegetables, and salads among survey respondents with a college education when compared to individuals who were not college-educated. Other studies, however, have found educational attainment to be a significant factor associated with consumption and diet quality. College educated individuals tend to eat a more nutritious diet, be better able to afford a nutritious diet, and have higher levels of nutrition concern (McCabe-Sellers et al., 2007; Dittus, Hillers, and Beerman, 1995).

Table 4.5 Estimated Marginal Effects of the Frequency of Consumption on the Independent Variables

	Vegetable		Salad		Fruits		Fruit Juice	
	dy/dx	**Std. Error**	**dy/dx**	**Std. Error**	**dy/dx**	**Std. Error**	**dy/dx**	**Std. Error**
Store Distance								
Monthly	0.004**	(0.002)	0.005**	(0.002)	0.002	(0.002)	0.003	(0.002)
Weekly	-0.001	(0.001)	-0.002**	(0.001)	0.000	(0.001)	-0.001	(0.001)
Daily	-0.003*	(0.001)	-0.003**	(0.001)	-0.003	(0.002)	-0.002	(0.002)
Shop Conv Store								
Monthly	0.059	(0.054)	-0.013	(0.064)	0.007	(0.046)	0.062	(0.058)
Weekly	-0.013	(0.013)	0.006	(0.028)	0.001	(0.008)	-0.014	(0.014)
Daily	-0.046	(0.042)	0.007	(0.036)	-0.008	(0.054)	-0.048	(0.045)
Shop Doll Store								
Monthly	0.141**	(0.059)	0.000	(0.072)	0.054	(0.052)	0.102	(0.065)
Weekly	-0.030	(0.019)	0.000	(0.032)	0.009	(0.011)	-0.023	(0.017)
Daily	-0.111**	(0.047)	0.000	(0.040)	-0.063	(0.060)	-0.079	(0.050)
TransportComm								
Monthly	-0.123*	(0.072)	-0.092	(0.083)	-0.006	(0.062)	-0.134*	(0.077)
Weekly	0.026	(0.020)	0.041	(0.037)	-0.001	(0.011)	0.030	(0.021)
Daily	0.097*	(0.056)	0.051	(0.047)	0.006	(0.072)	0.103*	(0.060)
Family								
Monthly	-0.106*	(0.059)	-0.073	(0.071)	-0.004	(0.051)	-0.064	(0.065)
Weekly	0.023	(0.016)	0.032	(0.032)	-0.001	(0.009)	0.014	(0.015)
Daily	0.083*	(0.046)	0.040	(0.040)	0.004	(0.059)	0.049	(0.050)

(Continued)

Table 4.5 Continued

	Vegetable		Salad		Fruits		Fruit Juice	
	dy/dx	**Std. Error**	**dy/dx**	**Std. Error**	**dy/dx**	**Std. Error**	**dy/dx**	**Std. Error**
Taste								
Monthly	0.067	(0.056)	-0.018	(0.067)	0.053	(0.048)	-0.014	(0.062)
Weekly	-0.014	(0.013)	0.008	(0.030)	0.009	(0.011)	0.003	(0.014)
Daily	-0.053	(0.044)	0.010	(0.037)	-0.062	(0.056)	0.011	(0.048)
Price								
Monthly	-0.120**	(0.054)	0.031	(0.066)	-0.033	(0.047)	0.005	(0.060)
Weekly	0.026	(0.016)	-0.014	(0.029)	-0.006	(0.009)	-0.001	(0.014)
Daily	0.094**	(0.044)	-0.017	(0.037)	0.038	(0.055)	-0.004	(0.047)
Advertisement								
Monthly	-0.081	(0.055)	0.013	(0.063)	0.000	(0.046)	-0.001	(0.058)
Weekly	0.019	(0.016)	-0.006	(0.028)	0.000	(0.008)	0.000	(0.013)
Daily	0.061	(0.040)	-0.007	(0.036)	0.000	(0.054)	0.001	(0.045)
SNAP								
Monthly	-0.262	(0.212)	0.544*	(0.289)	-0.217	(0.183)	-0.468*	(0.241)
Weekly	0.056	(0.052)	-0.240*	(0.133)	-0.037	(0.041)	0.106	(0.067)
Daily	0.206	(0.167)	-0.304*	(0.167)	0.254	(0.213)	0.362*	(0.187)
Age								
Monthly	-0.003*	(0.002)	0.000	(0.003)	-0.003*	(0.002)	-0.004*	(0.002)
Weekly	0.001	(0.001)	0.000	(0.001)	0.000	(0.001)	0.001	(0.001)
Daily	0.003*	(0.001)	0.000	(0.001)	0.003*	(0.002)	0.003*	(0.002)

(Continued)

Table 4.5 Continued

	Vegetables		Salad		Fruits		Fruit Juice	
	dy/dx	**Std. Error**	**dy/dx**	**Std. Error**	**dy/dx**	**Std. Error**	**dy/dx**	**Std. Error**
Gender								
Monthly	0.039	(0.068)	0.089	(0.095)	0.050	(0.061)	-0.049	(0.071)
Weekly	-0.010	(0.020)	-0.045	(0.053)	0.004	(0.006)	0.009	(0.011)
Daily	-0.029	(0.048)	-0.045	(0.043)	-0.054	(0.061)	0.040	(0.061)
Race								
Monthly	0.145**	(0.066)	-0.187	(0.118)	-0.035	(0.078)	-0.254**	(0.113)
Weekly	-0.002	(0.022)	0.101	(0.074)	-0.003	(0.005)	0.110	(0.067)
Daily	-0.144*	(0.082)	0.086*	(0.047)	0.038	(0.081)	0.144**	(0.050)
Education								
Monthly	-0.008	(0.064)	0.076	(0.089)	-0.021	(0.055)	-0.068	(0.074)
Weekly	0.002	(0.014)	-0.034	(0.040)	-0.004	(0.010)	0.015	(0.018)
Daily	0.006	(0.051)	-0.043	(0.050)	0.024	(0.065)	0.052	(0.057)

Standard errors are in parenthesis. ***, **, and * specify the P-value statistical significance at the 1%, 5%, and 10% level respectively.

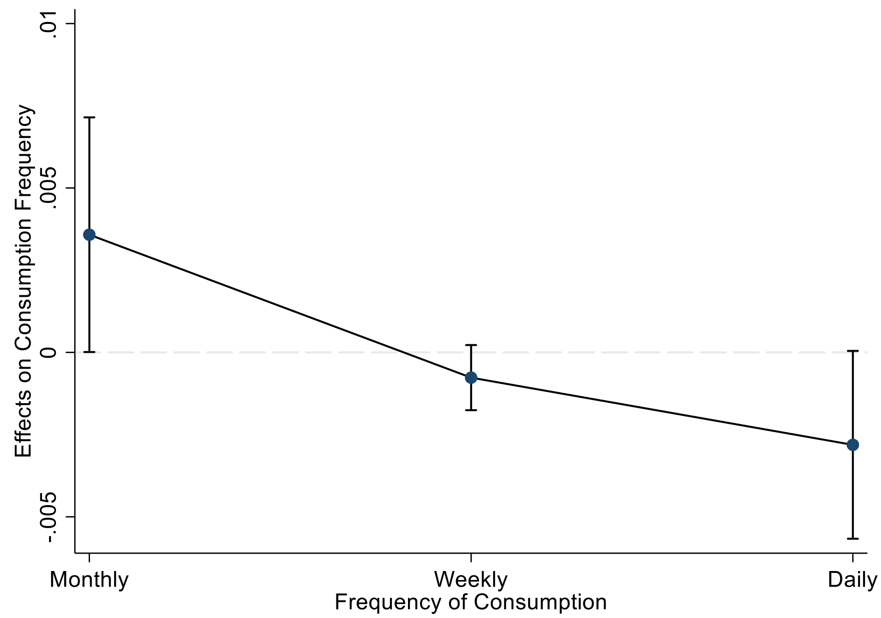

Figure 4.3 Marginal Effects of the Distance Residents Travel to the Nearest Full-Serviced Grocery Store for Vegetables at the 95% Confidence Interval

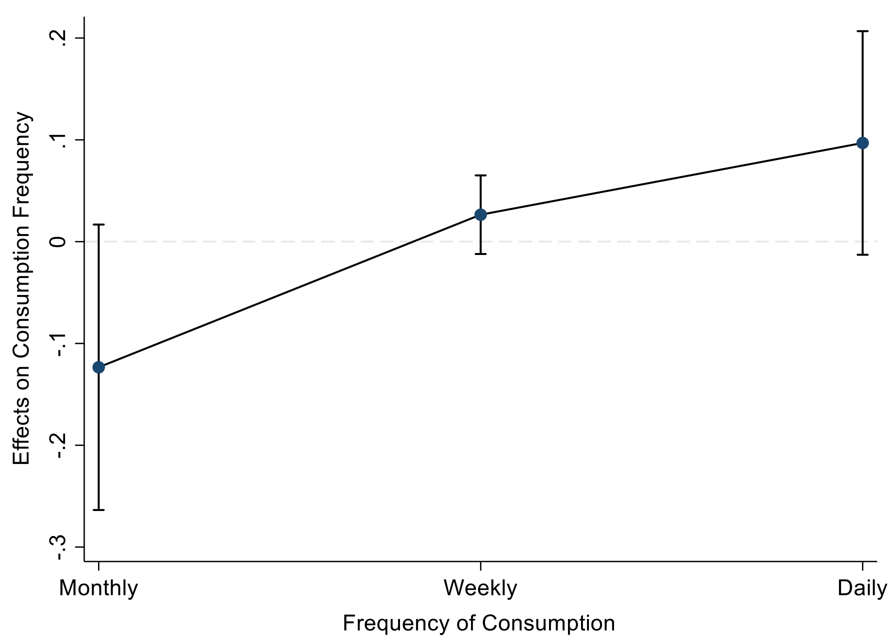

Figure 4.4 Marginal Effects of Public Transportation Available to Residents for Vegetables at the 95% Confidence Interval

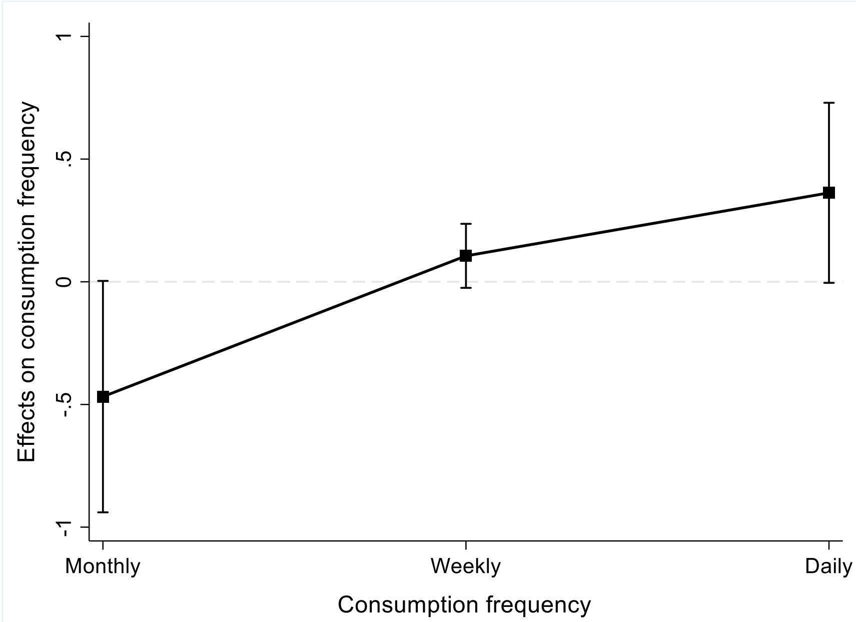

Figure 4.5 Marginal Effects of SNAP Participation on Consumption Frequency for Fruit Juice at the 95% Confidence Interval

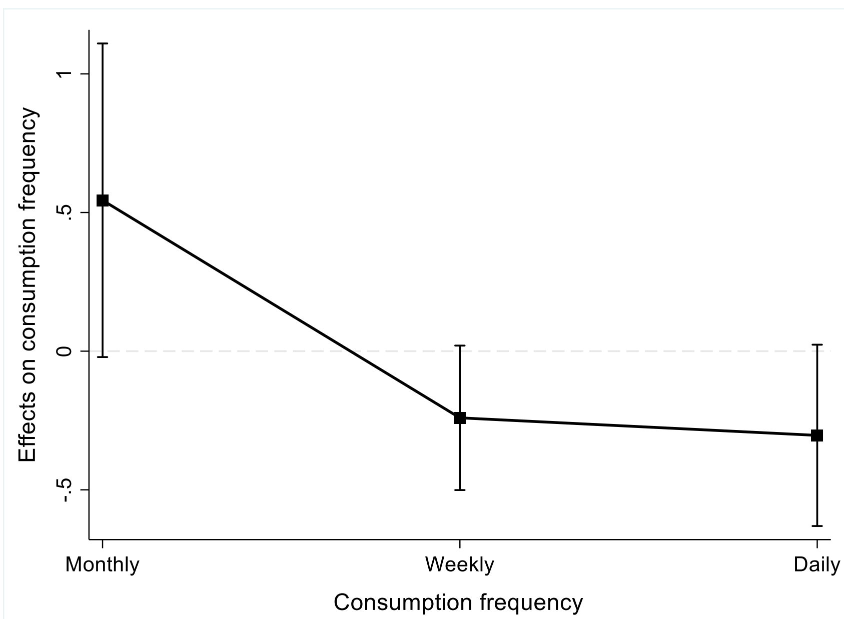

Figure 4.6 Marginal Effects of SNAP Participation on Consumption Frequency for Salad at the 95% Confidence Interval

CHAPTER V

CONCLUSION

The goal of my study was to examine the relationship between local food environment factors and the consumption of fruits and vegetables among individuals living in the region with the nation's highest obesity rates, the Mississippi Delta. To achieve this, I looked at seven counties with the highest obesity rates in the Mississippi Delta and examined food environment factors and how they affect individual consumption frequencies of fruit and vegetables. Specifically, I examined how food environment variables including individual-reported distances (miles) to the nearest full-service grocery store, whether individuals shop at convenience stores or dollar store formats, measures of store density, and whether individuals have access to public transportation within their communities correlate to frequency of fruit and vegetable consumption. Insights from this study help us understand how consumption patterns of healthy foods are affected by store density, household proximity to stores, and accessibility to healthy foods. I also examined differences in fruit and vegetable consumptions across groups based on SNAP participation and demographic characteristics such as reported age, gender, race, and educational attainment. The assessment of these variables helps to highlight how economic conditions of the household affect consumption frequency of fruits and vegetables, as well as the differences across demographic groups. This information helps to provide insight for communities in the Mississippi Delta and inform local strategies to address obesity from a food environment, food systems, and policies perspective. This is particularly important for policy makers seeking to address issues within the food system of the Mississippi Delta region.

I used data from the first round of the HOP Community Survey collected in 2020. Survey respondents were located across seven target counties — Holmes, Humphreys, Issaquena, Leflore, Sharkey, Sunflower, and Washington. The survey included a simplified version of the National Cancer Institute Eating at America’s Table Study (EATS) food frequency questionnaire to gauge consumption frequency of different fruit and vegetable items based on a 30-day consumption recall. I also used store location data from the USDA Food and Nutrition Service SNAP retailer to assess the location and density of SNAP-participating stores in the zip code of survey respondents. I estimated an ordered probit regression model with an endogenous covariate to evaluate the effect of food environment factors and other demographic variables on the frequency of fruit and vegetable consumption. My main model assessed food environment measures from the HOP Community survey, and my alternative model specifications assessed the geographic food environment measures obtained from the store availability data.

The food environment measures proved to be statistically significant across the different food groups. I find that individuals who travel longer distances to the nearest full-service grocery store and who shop at dollar store formats are less likely to consume vegetables frequently (i.e., on a daily basis). This finding is informative, particularly when considering the effects of proximity and store density within rural Mississippi Delta communities. On average, individuals in my study travel 13.28 miles from their residence to a full-service grocery, with 25% of survey respondents traveling between 20 and 65 miles. The longer distances traveled to access full-service stores could explain why many respondents (75.6%) shop for groceries at dollar stores which are more accessible (i.e., higher store density) when compared to supermarkets and full-service grocery stores. Understanding this aspect of the food environment is particularly insightful for initiatives geared towards improving healthy consumption via increasing access to the different food shopping options that are available to individuals. In many cases, supermarkets or grocery stores do not find it economically viable to locate in some areas, thus, in such cases, it is important to identify strategies to promote healthier food assortment in existing stores and to get people to where the food is. Such strategies could include increasing access to transportation. The availability of public transportation as a measure of accessibility is another food environment measure statistically significant in my study. My results show that having public transportation access increases the likelihood that individuals will consume vegetables more frequently, which points to the importance of making transportation services available, particularly in areas with low store access.

The differences across the demographic groups and the characteristics of the built environment can provide a granular understanding of the food environment and its impact on the frequency of consumption of fruits, fruit juice, salads, and vegetables. Differences in the consumption pattern of individuals in rural Mississippi are found to be correlated with age, race, and socioeconomic status. These finding can be helpful to policy makers who help to determine local, state, and federal initiatives geared toward poor food environments, consumption behaviors, and negative health outcomes. Because of the individual level data used, it is more probable to implement initiatives geared towards this specific region/group of individuals. Access to this information can be used to improve the food environment in the Mississippi Delta and foster better diets that incorporate fruits and vegetables.

The data I use in my study have some important limitations that need to be acknowledged. The HOP Community Survey did not include key variables of interest such as income—a major determinant of socioeconomic status and SNAP eligibility, which are factors that could play a role in individuals being able to afford a healthy diet. The absence of the information resulted in the utilization of employment status as a proxy for income. Another limitation is the relatively small sample size and the survey sample not being representative of the general demographics of the region. For example, the survey had majority women, African American, and respondents between the ages of 18 and 60. The limited sample size and geographic focus of the survey also resulted in data with low variability across areas within the focus region. For example, given the similarities in store access within the Delta region, it was difficult to identify changes in fruit and vegetable consumption due to changes in store access, specifically when using distance measures based on store locations and zip codes. Another limitation of the data used is the lack of preference data which represents a promising avenue for future research that could influence purchasing and consumption behavior-based interventions for the food environment in the Mississippi Delta. Notwithstanding these limitations in the data used, the results in this study provide useful insights regarding the food environment in the Delta region and how food environment factors could play a role in fruit and vegetable consumption.

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