UKCPR
University of Kentucky
Center for
Poverty Research

Discussion Paper Series
DP 2016-10

ISSN: 1936-9379

The Influence of SNAP Participation and Food Environment on Nutritional Quality of Food at Home Purchases

Amy Hillier, MSW, PhD
Associate Professor,
University of Pennsylvania School of Design

Benjamin Chrisinger, MUEP, PhD
Postdoctoral Research Fellow
Stanford University Medical School

Tony E. Smith, PhD
Professor
University of Pennsylvania School of Engineering and Applied Sciences

Eliza Whiteman, MS, MA
Doctoral student
University of Pennsylvania School of Design

Michael Kallan, MS,
Senior Biostatistician
University of Pennsylvania Perelman School of Medicine

Preferred citation:
Hillier, A., & Benjamin, C., & Smith, T., & Whiteman, E., & Kallan, M. (2016). The influence of SNAP participation and food environment on nutritional quality of food at home purchases. University of Kentucky Center for Poverty Research Discussion Paper Series, DP2016-10. Retrieved [Date] from http://www.ukcpr.org/research/discussion-papers.

This project was supported through funding by the U.S. Department of Agriculture, Economic Research Service and the Food Nutrition Service, Agreement Numbers 58-5000-1-0050 and 58-5000-3-0066. The opinions and conclusions expressed herein are solely those of the authors and should not be construed as representing the opinions or policies of the sponsoring agency.

Abstract

A growing body of research describes how individuals make food shopping decisions in both time and space. The FoodAPS dataset provides a unique opportunity for understanding these patterns among a large sample across income, SNAP status, and settings. We addressed three questions in our research: (1) Where do participants shop for food at home (FAH) and how do individual characteristics interact with store characteristics and distance? (2) How does the nutritional content of foods purchased change as time from SNAP distribution increases? and (3) How does store choice influence the nutritional quality of FAH purchases? We used a conditional logit model to answer the first question, determining that overall, participants choose full-service supermarkets, larger stores, and stores closer to home but that store choice is influences by SNAP status, ethnicity, race, sex, car ownership and the level of urbanization of the county of residence. For the second question, we used general linear modeling to determine changes over time in dietary quality of FAH purchases, as measured by composite Health Eating Index (HEI) score. We found an increase in HEI-2010 score in the days immediately following SNAP distribution followed by a decrease until 20 days after distribution and then a moderate increase to the end of the SNAP-cycle. For the final question, we used a generalized estimating equation (GEE) model for repeated-measures to analyze the impact of store type on composite HEI score of FAH events. We found that purchases made at limited assortment stores had significantly higher HEI scores while dollar stores had significantly lower HEI scores than purchases at conventional supermarkets. Participating in SNAP had significant positive impact on composite HEI scores, relative to households income-eligible for SNAP but not participating. These results require closer consideration but have important implications for policies relating to what types of foods stores should be subsidized, through healthy food financing initiatives and SNAP and WIC authorization,

and the way SNAP benefits are distributed over the course of the month.

Executive summary

A growing body of research describes how individuals make food shopping decisions in both time and space. We have collaborated on numerous local-scale studies which provide a strong theoretical and methodological foundation for broader food access questions. In these studies, we relied on relatively small convenience samples and a combination of in-person surveys, in-depth qualitative interviews, food store receipts, and food store audits. The FoodAPS dataset provided us with a unique opportunity for understanding these patterns among a large sample across income, SNAP status, and urban, suburban and rural settings.

We addressed three questions in our research:

1. Where do participants shop for food at home (FAH) and how do individual and household characteristics interact with store characteristics and distance?
2. How does the nutritional content of foods purchased change as time from SNAP distribution increases?
3. How does store choice influence the nutritional quality of FAH purchases?

Question 1: Store choice

We used a conditional logit model to answer this first question. To define the choice set—the relevant set of stores from which participants likely choose their primary food store—we created shopping clusters by grouping nearby block groups where participants lived.

Overall, we found that participants choose full-service supermarkets, larger stores, and stores closer to home but that store choice is influences by SNAP status, ethnicity, race, sex, car

ownership and the level of urbanization of the county of residence. Specifically, participants receiving SNAP were even more likely to choose larger stores while participants in highly urban areas were less likely to choose larger stores than their suburban and rural counterparts. Hispanic participants were more likely than non-Hispanic participants to choose full-service supermarkets. White participants were more likely to travel further than non-white participants, as were participants who owned a car and participants living in less urbanized areas.

Question 2: Nutritional quality of FAH and time from SNAP distribution

For the second question, we used general linear modeling to determine changes in dietary quality of FAH purchases, as measured by composite Health Eating Index (HEI) score of FAH purchases. Control variables included age of the primary respondent as a continuous variable and sex, race and ethnicity as categorical variables.

Total HEI-2010 scores by household had a wide distribution from 24.73 at the 5th percentile to 70.20 at the 95th. Mean HEI-2010 among SNAP households was 46.16 (SD=13.96). Date of SNAP distribution was well distributed across the month. We found an increase in HEI-2010 score in the days immediately following SNAP distribution followed by a decrease until 20 days after distribution and then a moderate increase to the end of the SNAP-cycle.

To account for skewed spending directly following SNAP distribution, the number of days since SNAP (DSS) was grouped into four time buckets based on raw distribution for regression analysis: 1) ≤1 day, 2) 2-5 days, 3) 6-19 days and 4) >19 days. Unadjusted regression of DSS against HEI-2010 score yields a 5.27-point decrease in household HEI-2010 between the second and fifth DSS as compared to ≤1 DSS ($p<0.01$). After controlling for demographic and household characteristics and amount of last SNAP benefit, the decrease in HEI-2010 in 2-5 DSS is 5.8 points

($p<0.01$). This mean drop in HEI-2010 continues in the 6-19 and the >19-DSS brackets although they have smaller decreases of 4.23 points ($p<0.05$) and 4.53 points ($p<0.01$) respectively.

Question 3: Nutritional quality of FAH and store type

For the final question, we used a generalized estimating equation (GEE) model for repeated-measures to analyze the impact of store type on composite HEI score of FAH purchases. The primary independent variable was store type based on sub-channel categories in the TDLinx/STARS dataset.

Controlling for the host of shopper characteristics (age, race/ethnicity, education, car ownership), purchases at natural/gourmet and limited assortment stores had significantly higher composite HEI scores than conventional supermarkets while purchases at dollar stores and all other stores had significantly lower composite HEI scores than conventional supermarkets. Purchases by households enrolled in SNAP did not have significantly different composite HEI scores from households that were not SNAP eligible, but purchases by households that were eligible for SNAP based on household income but not receiving SNAP had significantly lower composite HEI scores than households enrolled in SNAP. Smaller shopping trips (involving expenditures of less than $30) had significantly lower composite HEI scores than larger shopping trips (involving expenditures of more than $30). Shopping trips further from home had lower HEI scores than food shopping trips closer to home.

Research implications

These results together provide additional evidence of significant spatial and temporal elements to food shopping that must be considered in any analysis of "food deserts" or access to healthful foods. They confirm what we have learned from our previous research in Philadelphia

and Chester PA about the relevance of distance from home to food shopping and the many ways that relationship varies based on race, ethnicity, sex, car ownership, and the level of urbanization in an area. They also confirm what we have learned about the relationship between healthfulness of food purchases and the type of food store where they are purchased. Identifying a distinct temporal pattern in the healthfulness of foods purchased based on days since SNAP distribution provides an important additional consideration in understanding food shopping patterns among low-income households. We are still considering the implications of the research about store type and HEI but would suggest based on these findings that public financing and SNAP authorization of dollar stores or other smaller stores (such as convenience stores) should be reconsidered because they tend to involve lower nutritional quality than supermarkets and other larger-format foods stores.

Research limitations and next steps

We recognize that these results are somewhat preliminary and require some additional adjustments to finalize our models. We would have liked to use the many HEI component scores for the second and third research questions, but we had too many questions about how to represent those scores to proceed. As we learn more about how these scores work, we will incorporate these additional outcome variables.

Introduction

A growing body of research describes how individuals make food shopping decisions in both time and space, adding needed complexity to our understanding of "food deserts." We have collaborated on numerous local-scale studies which provide a strong theoretical and methodological foundation for broader food access questions. We have worked with several colleagues (S Kumanyika, K Glanz, A Karpyn, C Cannuscio, K DiSantis, J Hirsch, M Barnett) to

develop a better understanding of food shopping behavior of low-income urban residents and how the community and consumer food environments (Glanz et al., 2005) impact diet quality and obesity risk. Relying on in-person surveys, in-depth qualitative interviews, food store receipts, and food store audits, our studies have led to the following conclusions:

- **Most people travel beyond the closest supermarket to do most of their food shopping** (Cannuscio et al., 2012; Hillier et al., 2011). Most people shop at multiple food stores (DiSantis et al., 2012; Chrisinger et al., in preparation). People travel further to shop at stores with greater availability of healthful foods (Cannuscio et al., 2012). These conclusions are consistent with other recent studies, including Black et al., 2013 and Zenk et al., 2011.
- **Distance from home is only one of many significant factors in food store choice.** Food store choice also varies by use of federal food assistance benefits (Hillier et al., 2011), vehicle ownership, race/ethnicity, and gender, and activity space of food shoppers and proximity to transit, prices, size, and availability of healthful foods at stores (Hillier et al., in press; Liese et al., 2013; Kerr et al., 2012; Jilcott et al., 2011). Food shoppers have different expectations for different types of food shopping trips, and this has consequences for mode of transportation (Hirsch & Hillier 2013).
- **The type of food store chosen (i.e., full-service supermarket, limited assortment, convenience store) influences the healthfulness of foods purchased** (Chrisinger et al., in review; Jilcott et al., 2011; Gustafson et al., 2013; Gustafson, et al., 2012).

The FoodAPS data set has allowed us to test the generalizability of our findings from Philadelphia and offer insights on the interactions between food environment, food choice, and food assistance.

In our initial proposal from May 2014, we identified three research questions:

1. Where do participants shop for food at home (FAH) and how do individual/household characteristics interact with store characteristics and distance?
2. How does store choice influence the nutritional quality of FAH purchases, controlling for individual and household characteristics?
3. How does the local food environment influence the nutritional quality of FAH purchases?

For all three questions, we proposed to investigate how SNAP participation interacts with the outcomes of interest. In September 2015, we requested an amendment to these original research questions, reflecting the interest of a new doctoral student, Eliza Whiteman, in the time of month of food purchases. Because of the considerable time required to work with the nutrition data, we decided not to pursue our original research question about the local food environment, thus substituting our original third research question with the following:

3. How does the nutritional content of foods purchased to be consumed at home change as time from SNAP distribution increases?

This final report is organized around these three research questions. We report on the research methods, data, results and discussion for each of these research questions separately, then address our findings from all three research questions together in the final conclusion section. We acknowledge that we have work to do in finalizing all of these models; we anticipate that feedback from the University of Kentucky and Economic Research Services team will be very helpful in that process.

Question 1: **Methods**

Consistent with our approach in Hillier et al, 2015, we used a conditional logit model to

determine how individual shopper, trip distance, and food store characteristics interact and help explain food store choice. We approached the question of choice set—the pool of stores from which individual shoppers are choosing—differently, however. These two elements of our discrete choice model are described below.

Conditional logit model

Given a set of *individuals* (*households*) $i \in I$ and *stores*, $s \in S$, if the set of store alternatives relevant for individual, i, is denoted by $S_i \subseteq S$, then our *conditional logit model* takes the general form

$$(1) \qquad P_i(s) = \frac{\exp(V_{is})}{\sum_{s' \in S_i} \exp(V_{is'})} \ , \ s \in S_i, i \in I$$

where $P_i(s)$ denotes the probability that store s is chosen by individual i from set S_i. These choice probabilities are assumed to depend on the *value*, V_{is}, of each store s to individual i. As in linear regression, these values are assumed to be representable as linear functions of a relevant set of store attributes, $(x_{sj} : j = 1,..,J)$, such as size and availability of healthful foods at store s. These values may differ among individuals, depending on attributes, $(z_{ik} : k = 1,..,K)$, such as the sex and race of the individual. Such value differences can be captured by interacting individual attributes with each store attribute. The primary measure of accessibility was the travel distance from individual i's residence to each store s, designated as *home distance*, $d_1(is)$. However, we were also interested in the distance to store s from the place where i spends the most time (such as job location), here designated as *place distance*, $d_2(is)$. As with store attributes, the value of these distance accessibilities may differ among individuals. For example, such distances may be less

important for car owners. Such effects can again be captured by interacting these distances with individual attributes. Hence in the most general model considered here, values of stores for individuals are taken to be linear functions of the form:

$$(2) \qquad V_{is} = \sum_{j=1}^{J}\left[\beta_j x_{sj} + \sum_{k=1}^{K}\beta_{kj} z_{ik} x_{sj}\right] + \sum_{h=1}^{2}\left[\theta_h d_h(is) + \sum_{k=1}^{K}\theta_{kh} z_{ik} d_h(is)\right]$$

where the first term on the right hand side involves store attributes together with individual interaction effects and the second term involves distances (residential and place) together with their individual interaction effects.

Following standard terminology, coefficients β_j and θ_h are referred to as the "main effects" for store attribute j and distance attribute h, respectively. Similarly, for any given individual attribute, k, coefficients β_{kj} and θ_{kh} are referred to as "interaction effects" between k and, respectively, store attribute, j, and distance attribute, h. To interpret these coefficients, note for example that the effects of store attribute j can be isolated by considering two hypothetical stores, s and s', that differ only with respect to attribute j. To capture the effects of a unit change in attribute, j, suppose in addition that $x_{sj} - x_{s'j} = 1$. Then the relative likelihood of any individual i choosing store s versus s' is seen from (1) and (2) to be of the form:(3)

$$P_i(s)/P_i(s') = \exp\left[\beta_j(x_{sj} - x_{s'j}) + \sum_{k=1}^{K}\beta_{kj} z_{ik}(x_{sj} - x_{s'j})\right] = \exp\left(\beta_j + \sum_{k=1}^{K}\beta_{kj} z_{ik}\right)$$

So in this context it is clear that "main effect", β_j, reflects that component of change in the relative

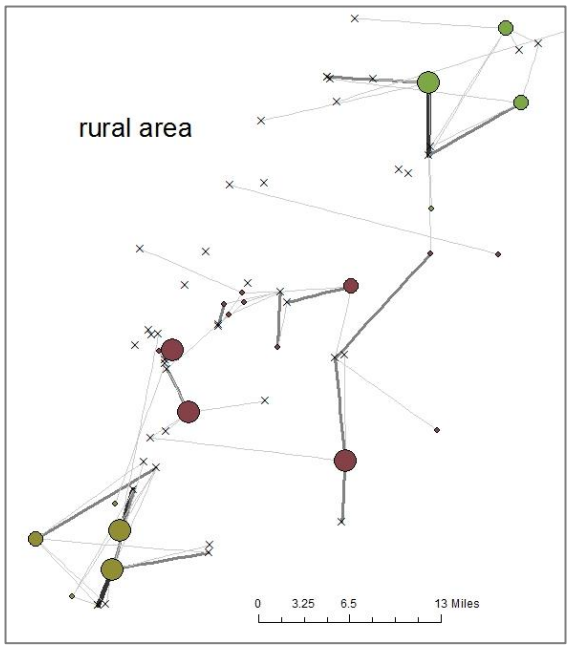
likelihood of choosing s versus s' which is common to *all* individuals, i.[1] Similarly, β_{kj}, reflects the additional component of change in this relative likelihood that is specific to individuals with k^{th} attribute level, z_{ik}.[2] Parallel interpretations can be given to the distance parameters, θ_h and θ_{kh}.

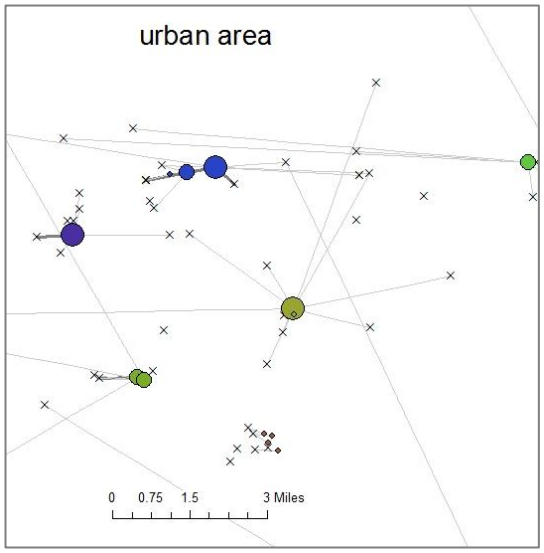
Store choices and choice sets

We defined the relevant *store choice* for each individual i to be the primary food store used by the primary adult respondent in the FoodAPS household. We identified the relevant choice set, S_i, for each individual i to be the set of all store choices made by individuals in i's shopping cluster. We created these shopping clusters by grouping nearby block groups where participants lived using visual inspection of maps in ArcGIS showing lines between block group centroids and the primary food stores chosen by participants in each block group. Each block group could only be in one shopping cluster. In Figure 1.1 below, the small dots represent block group centroids of participants, the x's represent all food stores, and the large colored dots represent primary stores chosen, graduated based on the number of people in the dataset who chose that as their primary store. The colors show distinct food shopping clusters

[1] Technically one should add "for all individuals for whom both s and s' are relevant options". But since β_j is clearly independent of these particular option choices, we ignore this complication.

[2] By taking logs in (3), these can also be interpreted as linear changes in "log odds", similar to logistic regression. Alternatively, one can obtain interpretations in terms of "elasticities" and "cross-elasticities" of substitution, as for example in Section 3.6 of Train (2009).





This generated 221 shopping clusters that included a maximum of 105 different participants and 20 different stores.

Ideally, this choice set would include all of the store-choice options actually perceived by each individual to be relevant. But since this data is typically not available (and indeed may not even be fully known to individuals themselves), it is necessary to define such sets exogenously.[3]

Question 1: **Data**

The primary food store (from the household dataset) served as the dependent variable. Shopper characteristics served as independent variables. These included sex (**SEX**; female or not), race (**RACE**; white or not), ethnicity (HISP; Hispanic or not); SNAP participation (**SNAP**), car

[3] For additional discussion of such choice-set identification issues, see for example Fotheringham (1988) and Pelligrini (1997).

ownership (**CAR**), and distance to primary store from home (**DIST**) from the individual and household FoodAPS datasets. We also included the percent urban population of the county in which the participant lived (**URBAN**; from 2010 US Census) to better understand urban/rural/suburban differences, particularly in regard to distance traveled to primary food store.

Store characteristics also served as independent variables. These included store type (**SUPMKT**, full-service supermarket or not) and square footage (**SQFT;** continuous) from the TDLinx/STARS datasets.

Question 1: Results

Only primary shoppers for whom characteristics were known about their primary food store were included in the analyses. Data on store characteristics were incomplete for 693 of the primary stores chosen, leading to a sample of 4015 (reduced from 4826). We further eliminated participants choosing stores too far to be relevant choices for others in their shopping cluster. We did this manually, visually inspecting all participant-primary food store combinations in ArcMap that involved a distance of 10 miles or more. This led us to develop the rule that if a store trip was more than twice as long as the next longest trip in the shopping cluster, we would eliminate it. This led to the removal of an additional 18 participants and a final sample of 3997.

SQFT, **SUPMKT** and **DIST** were the three significant main effects in the model. Overall, participants were more likely to choose larger stores, full-service supermarkets rather than other types of food stores, and stores closer to home. Interaction effects show that participants receiving SNAP were even more likely to choose larger stores (**SQFT-SNAP**) while participants in highly urban areas were less likely to choose larger stores than their suburban and rural counterparts (**SQFT-URBAN**). Hispanic participants were more likely than non-Hispanic participants to choose

full-service supermarkets (**SUPMKT-HISP**). White participants were more likely to travel further than non-white participants (**DIST-RACE**), as were participants who owned a car (**DIST-CAR**) and participants living in less urbanized areas (**DIST-URBAN**).

Question 1: Discussion

None of these results are surprising and all are consistent with our findings from Philadelphia. All things being equal, people choose larger supermarkets closer to home. But of course, all things are not equal and these results indicated differences across sex, race, ethnicity, car ownership, and rura/urban locations.

We conducted additional analyses to see if there was anything more to be said about SNAP participation. To do so, we first constructed a logistic regression of **SNAP** on the other shopper attributes. These results were qualitatively the same as the pairwise correlations, and show that **SNAP** is most strongly (negatively) related to **RACE**. So one experiment was to drop **RACE** and see if there is an effect on **SNAP**. Here only **SQFT-SNAP** increased in significance. Finally we removed **HISP** and **SEX** as well, just to see if there was any effect. Again the conclusion was the same, so that there seem to be no further interesting conclusions that can be drawn about shoppers with **SNAP**. As one last check, we removed **SNAP** altogether, and found that **DIST-RACE** and **DIST-CAR** were slightly more significant, but with no real qualitative changes.

Finally, we considered other attributes in the same way. By dropping **SEX**, one obtains more significant **SQFT-SNAP** and **DIST-CAR**, but no qualitative changes. Similarly, dropping **HISP** or **RACE** (already done) had no qualitative effects. These results are also consistent with the general lack of correlation among these attributes. So the above regression results were adopted as final.

Question 2: Research methods

Statistical analyses were conducted using STATA 14 software on NORC Thin Client hardware. General linear modeling was used to determine changes in dietary quality as the number of days since SNAP benefit distribution increased. Regressions were controlled for household size, household income, and amount of last SNAP benefit as continuous variables. Regressions were also controlled for the age of the primary respondent as a continuous variable and for sex, race and ethnicity as categorical variables.

Question 2: Data

The Healthy Eating Index-2010 (HEI-2010) total score was used as the primary outcome variable for measuring dietary quality. The HEI-2010 was developed by the National Cancer Institute and the USDA to measure how American diets compare nutritionally to the Dietary Guidelines for Americans. The HEI-2010 total score is comprised of 12 components – eight measured for adequacy – 1) total fruit, 2) whole fruit, 3) total vegetables, 4) greens and beans, 5) whole grains, 6) dairy, 7) total protein foods, 8) seafood and plant proteins, 9) fatty acids – and three for moderation – 10) refined grains, 11) sodium, and 12) empty calories. Because the index uses a density measure and follows a universal set of standards, the index can be applied to measure and compare nutritional quality of foods at various scales including individual consumption or purchasing, restaurants, and the broader food environment (Jahns et al. 2015).

SNAP participation was determined by self-report and administrative matching. The number of days since SNAP benefits were distributed (DSS) was defined as a continuous variable by determining time from last reported SNAP disbursement to start of data collection week. For

those households nearing the end of the benefit cycle at the time of the initial survey, it was assumed they received their benefits on the same day the next month, therefore their benefits would be renewed during the study period.

Question 2: Results

FoodAPS contains a nationally representative sample of 4,826 households. Of the sample, 1,581 households were current SNAP participants while 1,233 were eligible for SNAP, but not participating. After removing observations where data were missing for DSS or where households had no FAH purchases for the data collection week, there were 1,263 remaining SNAP households. The majority of primary respondents were female (n=1,014), white (n=819) and had at least one child living in the home (n=785). Nearly sixty percent of the SNAP households in this analysis possessed a high school degree or less and 46.6% had an annual income of less than $15,000. (See Table 2.1).

Total HEI-2010 scores by household had a wide distribution from 24.73 at the 5th percentile to 70.20 at the 95th. Mean HEI-2010 among SNAP households was 46.16 (SD=13.96). Date of SNAP distribution was well distributed across the month. Visual assessment of a mean lowess curve revealed an increase in HEI-2010 score in the day immediately following SNAP distribution followed by a decrease until 20 days after distribution and then a moderate increase to the end of the SNAP-cycle. To account for skewed spending directly following SNAP distribution, DSS was grouped into four time buckets based on raw distribution for regression analysis – 1) ≤1 day, 2) 2-5 days, 3) 6-19 days and 4) >19 days. As shown in Table 2, unadjusted regression of DSS against HEI-2010 score yields a 5.27 point decrease in household HEI-2010 between the second and fifth DSS as compared to ≤1 DSS ($p<0.01$). After controlling for demographic and household

characteristics and amount of last SNAP benefit, the decrease in HEI-2010 in 2-5 DSS is 5.8 points ($p<0.01$). This mean drop in HEI-2010 continues in the 6-19 and the >19-DSS brackets although they have smaller decreases of 4.23 points ($p<0.05$) and 4.53 points ($p<0.01$) respectively.

Question 2: **Discussion**

Episodic food insecurity and inconsistent consumption of macronutrients both have significant health implications. The data analyzed in this study from USDA's FoodAPS study provide further evidence of the dynamic nature of food acquisitions and dietary quality over the SNAP-cycle. When controlling for demographic and household characteristics, on average study participants had an HEI-2010 total score of 34.31 for the week immediately following the day of their benefit distribution. If data collection took place 2-5 days from SNAP distribution, household HEI-2010 decreased by 5.8 points ($p<0.01$), which represents nearly a half a standard deviation from overall mean HEI-2010. Such a large decrease in diet quality in the days following SNAP distribution suggests SNAP participants are more able to acquire healthful foods when benefits are flush and that dietary quality is compromised as benefits are diminished. It is important to note that on the whole SNAP participants in this study had a lower HEI-2010 total score than the national average of 49.8 for men and 52.7 for women (Guenther et al. 2014). Research on the comparative healthfulness of SNAP diets has been mixed and to better understand these differences it would be useful to analyze HEI-2010 of non-SNAP FoodAPS study participants in the future.

Study Limitations

Data for this study were collected for one week per household. This means that it is not possible to compare how an individual household's dietary patterns and food purchasing acquisitions change as DSS increases. Instead, this analysis compares the dietary quality for the

week of data collection by household compared to DSS to determine if on average, households further from SNAP distribution have poorer HEI-2010 scores. While date of SNAP distribution was randomly distributed throughout the sample, this may still pose slight endogeneity problems as those households with less healthy food purchasing habits may exhibit this pattern throughout the month. Another limitation of the study is that FoodAPS provides food-purchasing data at the household level and not food consumption data. We cannot deduce from the data exactly what each individual consumed or whether the items purchased in that week were consumed during that same time period.

Implications for research and practice

This study demonstrates that increasing time from SNAP distribution is associated with a reduction in overall dietary quality. This fluctuation in dietary quality may be a result of once monthly food assistance benefit distribution, which has already been demonstrated in the literature to produce fluctuations in food spending and calorie consumption leading to episodic food insecurity. Increasing SNAP distribution to bimonthly may help to smooth these fluctuations in diet, however to properly assess this it would be useful to first compare the food shopping patterns of SNAP households to eligible non-SNAP households as well as to a higher income cohort. This analysis was not possible within the FoodAPS dataset as data collection took place at a variety of different times in the month and cannot be matched with time of income receipt for those households not participating in SNAP, however future studies could be designed to answer this question. Additionally, a pilot program where SNAP households are randomly assigned to receive benefits once or twice per month could be implemented to assess efficacy of increasing benefit distribution on diet quality.

Question 3: Research Methods

A generalized estimating equation (GEE) model for repeated-measures was performed using SAS software.

Question 3: Data

The unit of analysis was a shopping trip that involved purchase of food to be eaten at home (FAH event). The outcome variable was nutrition quality, as measured by the composite Healthy Eating Index (HEI) score of all food items purchased during FAH events.

The primary independent variable was store type based on sub-channel categories in the TDLinx/STARS dataset. See table 3.2 for a description of these categories.

Additional control variables included store characteristics including store size (in square feet) total annual sales, trip characteristics including weekday or weekend, week of month, amount spent, payment type (SNAP, WIC, cash or check, debit, credit or other), and distance traveled to store from home. Shopper/household characteristics were also included in the model: age, race/ethnicity, sex, education level of shopper, income level of household, car ownership, household size, current SNAP status (current receiving, eligible but not receiving, not eligible).

Question 3: Results

A total of 4,962 shoppers made a total of 11,472 shopping trips. Table 3.1 provides descriptive statistics on shoppers and their trips. Shopping trips were more likely to be made during the week than weekend and in later in the month. Participants spent a median of $19.79 per shopping trip, with 63.6% of trips involving expenditures of less than $30. Cash, check or debit was the most common form of payment, followed by SNAP (15.6%) and credit card (13.4%).

Question 3: Discussion

Our results provided some surprises. We were surprised that purchases made at limited assortment stores had higher HEI scores than conventional supermarkets, even in the multivariate model. This finding is worth closer analysis to see what specific foods people are buying and at which specific limited assortment stores they are making their purchases. Also surprising was that purchases made closer to home had higher composite HEI scores. Again, further analysis is warranted to make sense of that finding which is counter-intuitive to the idea that discerning shoppers would put greater effort into traveling to stores with more nutritious foods. Most of our findings were not surprising, either, particularly in regard to the relatively low nutritional quality of foods purchased at dollar stores and the positive relationship between educational status and composite HEI scores. That smaller food trips generally involve foods of lower nutritional value is not surprising but it is important, representing an important point of intervention. It would be worth adjusting the $30 threshold to see at what expenditure level nutritional quality starts to improve. A significant SNAP effect, indicating that households receiving SNAP are purchasing more healthful foods than households that are income-eligible for SNAP but not receiving SNAP, is not surprising but is very encouraging.

Conclusion

The results from these three different analyses together provide additional evidence of significant spatial and temporal elements to food shopping that must be considered in any analysis of "food deserts" or access to healthful foods. They confirm what we have learned from our previous research in Philadelphia and Chester PA about the relevance of distance from home to food shopping and the many ways that relationship varies based on race, ethnicity, sex, car

ownership, and the level of urbanization in an area. They also confirm what we have learned about the relationship between healthfulness of food purchases and the type of food store where they are purchased. Identifying a distinct temporal pattern in the healthfulness of foods purchased based on days since SNAP distribution provides an important additional consideration in understanding food shopping patterns among low-income households. Policy implications for WIC, SNAP, HFFI funding

We recognize that these results are somewhat preliminary and require some additional adjustments to finalize our models. We would have liked to use the many HEI component scores for the second and third research questions, but we had too many questions about how to represent those scores to proceed. As we learn more about how these scores work, we will incorporate these additional outcome variables. We applied for and have been granted access to the FoodAPS dataset for an additional 12 months which will allow us to take these next steps.

References

Chrisinger B, DiSantis K, Hillier, A, Kumanyika S (in review) Urban Shoppers[1] Purchases of High- and Low-Calorie Foods in Full-service Supermarkets and Other Food Retailers

Fotheringham A S, 1988, "Consumer store choice and choice set definition" *Marketing Science* **7** 299–310

Glanz K, Sallis J F, Saelens B E, Frank L D (2007), Nutrition Environment Measures Survey in stores (NEMS-S): development and evaluation, *American Journal of Preventive Medicine* 32 282–289.

Gustafson, A. A., Sharkey, J., Samuel-Hodge, C. D., Jones-Smith, J. C., Cai, J., & Ammerman, A. S. (2012). Food store environment modifies intervention effect on fruit and vegetable intake among low-income women in North Carolina. Journal of Nutrition and Metabolism, 2012 doi: 10.1155/2012/932653

Gustafson, A., Christian, J. W., Lewis, S., Moore, K., & Jilcott, S. (2013). Food venue choice, consumer food environment, but not food venue availability within daily travel patterns are associated with dietary intake among adults, Lexington Kentucky 2011. Nutrition Journal, 12(1), 1-11.

Hillier AE, Smith TE, Cannuscio CC, Karpyn A,Glanz K. (2015)A discrete choice approach to modeling food store access, *Environment and Planning B: Planning and Design* vol 42.

Jahns, L., Scheett, A., Johnson, L., Hoverson, B., Krebs-Smith, S., Payne, C., … Kranz, S. (2015). Diet Quality of Supermarket Sales Circulars measured by the Healthy Eating Index-2010. *The FASEB Journal*, *29*(1 Supplement), 132.5.

Jilcott, S. B., Wall-Bassett, E. D., Moore, J. B., & Sharkey, J. R. (2011), Use of traditional and nontraditional food venues among female participants in the supplemental nutrition assistance program (SNAP), *Journal of Hunger & Environmental Nutrition*, 6(1), 64-74.

Pellegrini, P. A., (1997), An empirical evaluation of parameter sensitivity to choice set definition in shopping destination choice models, *Papers in Regional Science,* 76 257-287

Table 1.1 Conditional Logit Results

VAR	PARAM	Z-VAL	PROB
SQFT	0.016974	6.644335	**0.000000**
SQFT-RACE	0.001983	1.038583	0.298998
SQFT-HISP	0.001182	0.633739	0.526251
SQFT-SNAP	-0.002815	-1.909759	**0.056164**
SQFT-CAR	-0.001719	-1.114230	0.265181
SQFT-SEX	-0.001604	-1.064844	0.286946
SQFT-URBAN	-0.007207	-4.955493	**0.000001**
SUPMKT	0.016943	2.536975	**0.011181**
SUPMKT-RACE	-0.003815	-0.755090	0.450195
SUPMKT-HISP	0.011398	2.442443	**0.014588**
SUPMKT-SNAP	-0.002724	-0.704852	0.480902
SUPMKT-CAR	0.001277	0.318852	0.749838
SUPMKT-SEX	-0.001735	-0.460274	0.645320
SUPMKT-URBAN	-0.004859	-1.289173	0.197338
DIST	-0.373611	-8.671101	**0.000000**
DIST-RACE	0.063106	1.877245	**0.060485**
DIST-HISP	0.010510	0.350533	0.725939
DIST-SNAP	-0.004271	-0.207091	0.835939
DIST-CAR	0.053792	1.962564	**0.049697**
DIST-SEX	0.036760	1.695529	**0.089975**
DIST-URBAN	-0.174488	-7.488753	**0.000000**

SUCCESS RATE = 38.0285%
MODEL SUCCESS RATE = 25.6263%
RANDOM SUCCESS RATE = 18.2648%

Table 2.1. Demographic Characteristics of Sample

	n	%
Total	1263	100.0
Age of Primary Respondent		
18-30	323	25.6
31-45	412	32.6
46-60	359	28.4
>60	169	13.4
Sex of Primary Respondent		
Male	249	19.7
Female	1,014	80.3
Child in Home	785	62.2
Race of Primary Respondent		
White	819	64.8
Black/African American	246	19.5
American Indian or Alaska Native	< 20	< 1.6
Asian	< 20	<1.6
Native Hawaiian or Other Pacific Islander	< 20	<1.6
Other Race	130	10.3
Multiple Races	35	2.8
Hispanic	311	24.6
Education level		
Less than high school	345	27.3
High school or GED	410	32.5
Some college	405	32.1
College graduate	102	8.1
Annual Household Income		
Less than $15k/yr	589	46.6
$15-24,999k/yr	302	23.9
$25-34,999k/yr	173	13.7
$35-49,999k/yr	101	8.0
$50-74,999k/yr	98	7.8

Being older was associated with an increase in HEI-2010 of 0.12 points for each year ($p<0.001$). Each additional year of education resulted in a 0.49 point increase in HEI-2010 ($p<0.001$) and being Hispanic was associated with a 4-point larger score ($p<0.001$). While there was a very strong positive association between primary respondents who identified as Asian, Native Hawaiian or Other Pacific Islander and HEI-2010 score, these outcomes were not statistically significant. With the exception of White and Black, the sample size within each race category was very small.

Table 2.2. Mean HEI-2010 Score by Time Since SNAP

	Freq.	Mean	SE	95% CI
Days Since SNAP				
≤ 1 day	80	49.92	1.46	47.02 - 52.83
2-5 days	197	44.65	0.98	42.72 - 46.58
6-19 days	600	46.27	0.59	45.12 - 47.42
> 19 days	386	45.98	0.69	44.63 - 47.33

Table 2.3. Days since SNAP (DSS) regressed on HEI-2010

	Unadjusted					Adjusted				
	β1	**SE**	**CI**		**p**	**β1**	**SE**	**CI**		**p**
Days Since SNAP Distribution										
<=1 day	49.922	1.557	46.867	52.977	0.000	34.309	4.254	25.963	42.655	0.000
2 - 5 days	**-5.273**	1.847	-8.895	-1.650	**0.004**	**-5.799**	1.835	-9.398	-2.199	**0.002**
6-19 days	**-3.651**	1.658	-6.904	-0.399	**0.028**	**-4.227**	1.649	-7.462	-0.991	**0.011**
>19 days	**-3.942**	1.711	-7.299	-0.585	**0.021**	**-4.528**	1.702	-7.867	-1.190	**0.008**
Age						0.115	0.031	0.055	0.176	**0.000**
Sex						-0.062	1.017	-2.057	1.932	0.951
Race										
Black/African American						-1.516	1.036	-3.548	0.516	0.144
Am. Indian or Alaska Nat.						-0.494	3.377	-7.119	6.132	0.884
Asian						7.347	4.032	-0.564	15.258	0.069
Nat. Hawaiian/Oth. Pac. Islander						15.514	7.970	-0.123	31.151	0.052
Other Race						-0.769	1.545	-3.800	2.263	0.619
Multiple Races						-0.981	2.382	-5.653	3.692	0.618
Hispanic						**3.965**	1.134	1.740	6.189	**0.000**
Children in the home						0.183	1.179	-2.130	2.497	0.876
Income						0.000	0.000	0.000	0.000	0.120
Education						**0.487**	0.149	0.194	0.781	**0.001**
SNAP benefit amount						0.002	0.003	-0.003	0.007	0.440

Table 3.1: Descriptive data on participants, shopping behaviors, and food expenditures

Individual Characteristics (n=4,962 with at least one trip)	*n (%)*
Age > 40	2,969 (59.8)
Sex (Female)	3,364 (67.8)
Race/ethnicity	
White (non-Hispanic)	3,006 (60.6)
Black/Af Am (non-Hispanic)	624 (12.6)
Hispanic (any)	1,013 (20.4)
Other (non-Hispanic)	319 (6.4)
SNAP/Income Status	
SNAP household	1,614 (32.5)
SNAP eligible, NOT receiving SNAP	1,183 (23.8)
Non-SNAP eligible	2,165 (43.6)
Education	
<HS	808 (16.3)
HS/GED	1,476 (29.7)
Some college or more	2,666 (53.7)
Missing	12 (0.2)
Own/lease car *	4,275 (86.2) [9 missing (0.2)]
Food Expenditures and Trip Characteristics (n=11,472)	
Weekend	3,308 (28.8)
Week of month	
First (days 1-7)	2,413 (21.0)
Second (days 8-14)	2,827 (24.6)
Third (days 15-21)	3,010 (26.2)
Fourth + Fifth (days 22-31)	3,222 (28.1)
Amount spent ($)	
Median [IQR]	19.79 [8.36-44.23]
% less than $30	7,294 (63.6)
Median [IQR] distance traveled from home (miles)	2.37 [1.17-5.40] [552 missing]
Payment type (can be multiple, the below is prioritization order)	1,791 (15.6)
SNAP (any)	226 (2.0)
WIC	4,730 (41.2)
Cash or check	3,000 (26.2)
Debit card	1,534 (13.4)
Credit card	41 (0.4)
Other (TANF or gift card)	145 (1.3)
Missing	

** This is actually at household level, but will treat as at the individual level.*

Table 3.2 provides descriptions of store categories and Table 3.3 shows the distribution of shopping trips by store category. Trips to conventional supermarkets made up the largest proportion of shopping trips (54.4%) followed by supercenters (19.3%). Composite HEI scores were highest at natural/gourmet stores, followed by conventional clubs, limited discount, conventional supermarkets and supercenters. Composite HEI scores were lowest at dollar stores and all other stores. Mean component HEI scores for fruits, greens and beans, and whole grains were 0 for all store categories, reflecting the reality that these healthful foods are not purchased in significant enough quantities to conduct meaningful analysis or that more work is needed for us to understand the HEI component scores. HEI component scores for vegetables could be determined; average scores were highest at natural/gourmet stores followed by limited discount stores.

Table 3.2. Store Categories and Descriptions

Store Category*	Description
conventional supermarkets	Large food stores with surface or structured parking, including both chain and independently-operated retailers; often include several in-store departments, such as a bakery, meat counter, or prepared foods section (full-service)
Discount/limited assortment supermarket	Large food stores, smaller than supermarkets and with fewer or no in-store departments, but larger than small retailers; may also emphasize price discounts (i.e. deep discount stores).
Supercenter	Household retailers, like Target, Kmart, Walmart, and CVS, who devote most store space to non-food items, but also offer a limited selection of grocery items. Even though some general retailers may offer large quantities of food (i.e. big box stores), they typically have a limited amount of perishable foods and no in-store departments.
Natural/gourmet	
Dollar store	
Conventional club	Membership-only warehouse retailers selling bulk quantity items.
Other	All other vendors including military commissaries, produce markets, co-ops, convenience stores
***Adapted from common categories used in food environment research (Morland, et al., 2002)	

Table 3.3. Distribution of 11,472 food shopping trips made by 4,962 by HEI score

Store Type	Number (%) of trips by store type	Amount spent*	Overall HEI score*	HEI Fruits*	HEI vegs*	HEI greens and beans*	HEI whole grains*
conventional supermarket	6,238 (54.4)	34.43±0.54 20.00 [9.08-42.86]	47.20±0.17 47.16 [37.49-56.70]	0.42±0.02 0 [0-0]	2.20±0.03 1.64 [0-5]	0.99±0.02 0 [0-0]	1.54±0.04 0 [0-0]
Supercenter	2,217 (19.3)	46.07±1.07 28.46 [12.60-59.88]	47.03±0.28 46.93 [37.94-56.01]	0.40±0.03 0 [0-0]	1.91±0.04 1.18 [0-4.13]	0.83±0.04 0 [0-0]	2.05±0.07 0 [0-3.20]
Discount/ limited assortment	569 (5.0)	30.63±1.47 19.54 [9.26-39.33]	47.58±0.56 47.62 [37.44-56.96]	0.37±0.05 0 [0-0]	2.59±0.09 2.73 [0-5]	0.99±0.08 0 [0-0]	1.52±0.13 0 [0-1.14]
Conventional club	361 (3.1)	100.25±5.56 66.47 [32.54-132.44]	51.85±0.81 51.50 [40.29-63.37]	0.42±0.06 0 [0-0]	1.97±0.11 1.02 [0-4.77]	1.07±0.11 0 [0-0]	1.94±0.19 0 [0-2.36]
Natural/ gourmet	270 (2.4)	38.16±2.15 30.15 [15.34-49.30]	55.26±0.89 57.46 [46.00-65.79]	0.56±0.09 0 [0-0]	2.91±0.13 3.78 [0-5]	1.80±0.14 0 [0-5]	2.27±0.23 0 [0-3.90]
Dollar store	570 (5.0)	13.43±0.63 8.00 [4.00-16.41]	42.49±0.49 41.09 [34.71-50.07]	0.16±0.03 0 [0-0]	1.20±0.08 0 [0-2.21]	0.29±0.05 0 [0-0]	1.32±0.13 0 [0-0]
Other	1,247 (10.9)	18.50±0.85 8.71 [4.00-20.50]	43.08±0.39 42.99 [33.34-53.34]	0.37±0.03 0 [0-0]	1.46±0.06 0 [0-4.04]	0.52±0.04 0 [0-0]	0.89±0.08 0 [0-0]

* Presenting as:
Mean ± standard error
Median [IQR]

Differences in HEI composite scores persisted in the multivariate GEE models (See Table 3.4), purchases at natural/gourmet and limited assortment stores had significantly higher composite HEI scores than conventional supermarkets. Purchases at dollar stores and all other stores had significantly lower composite HEI scores than conventional supermarkets. Purchases by households enrolled in SNAP did not have significantly different composite HEI scores from households that were not SNAP eligible, but purchases by households that were eligible for SNAP based on household income but not receiving SNAP had significantly lower composite HEI scores than households enrolled in SNAP. Shopping trips by participants with at least some college education had significantly higher composite HEI scores than shopping trips by participants with less than a high school education or with a high school education but no college. Smaller shopping trips (involving expenditures of less than $30) had significantly lower composite HEI scores than larger shopping trips (involving expenditures of more than $30). Shopping trips further from home had lower HEI scores than food shopping trips closer to home. Finally, purchases made using WIC or credit card had significantly higher composite HEI scores than purchases made using cash or check. Purchases made using SNAP did not have composite HEI scores that were significantly different from those made with cash or check.

Table 3.4. Results of Adjusted Multivariate GEE Models assessing predictors of HEI scores, displayed as effect (95% CI).

NOTE: The below is based on the complete case (non-missing) total of n=10,789	**Composite HEI**	**HEI Fruits***	**HEI Vegs***	**HEI Greens and Beans***	**HEI whole grains***
Store Type (ref: Conventional Supermarket)					
Supercenter	-0.53 (-1.18, 0.12)				
Discount/limited assortment	1.41 (0.29, 2.53)				
Conventional club	1.58 (-0.04, 3.19)				
Natural/gourmet	6.46 (4.72, 8.19)				
Dollar store	-2.25 (-3.32, -1.19)				
Other	-3.37 (-4.35, -2.39)				
Age > 40	1.20 (0.65, 1.76)				
Sex (Female)	1.35 (0.73, 1.96)				
Race/ethnicity (ref: White [non-Hispanic])					
Black/Af Am (non-Hispanic)	0.11 (-0.73, 0.95)				
Hispanic (any)	2.02 (1.30, 2.75)				
Other (non-Hispanic)	2.21 (0.99, 3.44)				
SNAP/Income Status (ref: non-SNAP elig.)					
SNAP household	-2.17 (-2.98, 1.37)				
SNAP eligible (non-household)	-0.96 (-1.69, -0.24)				
Education (ref: Some college +)					
<HS	-0.81 (-1.59, -0.03)				
HS/GED	-1.07 (-1.70, -0.44)				
Own/lease car	-0.32 (-1.14, 0.50)				
Weekend	-0.10 (-0.64, 0.44)				
Week of month (ref: first [days 1-7])					
Second (days 8-14)	-0.19 (-0.92, 0.54)				
Third (days 15-21)	-0.26 (-1.03, 0.50)				
Fourth + fifth (days 22-31)	-0.33 (-1.06, 0.40)				
Amount spent <$30	-6.29 (-6.84, -5.75)				
Distance traveled from home (miles)	-0.03 (-0.06, -0.01)				
Payment type (ref: cash or check)					
SNAP (any)	0.27 (-0.62, 1.15)				
WIC	10.97 (9.02, 12.92)				
Debit card	0.26 (-0.39, 0.91)				
Credit card	1.68 (0.77, 2.60)				
Other (TANF or gift card)	-0.71 (-4.79, 3.38)				