UKCPR
University of Kentucky
Center for
Poverty Research

Discussion Paper Series
DP 2016-08

ISSN: 1936-9379

Contextualizing Family Food Decisions: The Role of Household Characteristics, Neighborhood Deprivation, and Local Food Environments

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Preferred citation
Bowen, S., & Winkler, R., & Bloom, J., & MacNell, L. (2016). Contextualizing family food decisions: The role of household characteristics, neighborhood deprivation, and local food environments. University of Kentucky Center for Poverty Research Discussion Paper Series, DP2016-08. 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

We employ multilevel models with neighborhood and state effects (fixed effects and random effects) to analyze the associations between household characteristics, neighborhood characteristics, regional attributes and dietary quality. We use data from the USDA National Household Food Acquisition and Purchase Survey. Our dependent variable is a Healthy Eating Index that incorporates dollars spent and amount of food in several categories. Key explanatory variables at the household level include variables household financial condition, housing burden, home ownership, car access, household size. We include a variable for the number of large food stores in the neighborhood, a neighborhood deprivation index, and a regional food price index, along with neighborhood and state random effects. Our model shows that at the household level, financial condition and home ownership are significantly and positively related to dietary quality, while U.S. citizenship status and living in a rural area were negatively associated with dietary quality. The number of large food stores in the neighborhood is significantly and positively associated with dietary quality. Neighborhood deprivation is not significantly associated with dietary quality, nor is the regional food price index. However, the neighborhood and state random effects variables were both significant, and the neighborhood variable explains close to half of the variation in household dietary quality. Our results highlight the complexity of understanding factors at different spatial scales that influence dietary quality. Food environments are important in shaping household food decisions, as are household finances. Future research should work on untangling additional neighborhood-level factors that matter for dietary quality.

Executive summary

A growing body of literature focuses on disparities in access to healthy foods and on the relationships between local food environments and outcomes related to diet and health. This work has had direct policy implications, as evidenced by healthier food retail legislation at the state and federal levels. At the same time, recent research also suggests that the food environment-diet relationship is far from straightforward, and that household finances, not proximity to stores, may be more important. These studies suggest that the local food environment interacts in critical ways with issues related to poverty and household resources. In this analysis, we employ multilevel models with neighborhood and state effects (fixed effects and random effects) to analyze the associations between household characteristics, neighborhood characteristics, regional attributes and dietary quality. We use data from the USDA National Household Food Acquisition and Purchase Survey (FoodAPS). Our dependent variable is a Healthy Eating Index that incorporates dollars spent and amount of food (measured by weight) in several categories: fruit, vegetables, snacks, and sweetened beverages. Key explanatory variables at the household level include variables household financial condition, housing burden, home ownership, car access, household size. We include a variable for the number of large food stores in the neighborhood, a neighborhood deprivation index, and a regional food price index, along with neighborhood and state random effects. Our model shows that at the household level, financial condition and home ownership are significantly and positively related to dietary quality, while U.S. citizenship status and living in a rural area were negatively associated with dietary quality. The number of large food stores in the neighborhood is significantly and positively associated with dietary quality. Neighborhood deprivation is not significantly associated with dietary quality, nor is the regional food price index. However, the neighborhood

and state random effects variables were both significant, and the neighborhood variable explains close to half of the variation in household dietary quality. Our results highlight the complexity of understanding factors at different spatial scales that influence dietary quality. Food environments are important in shaping household food decisions, as are household finances. Future research should work on untangling additional neighborhood-level factors that matter for dietary quality.

Introduction

An increasing number of researchers explore disparities in access to healthy foods and the relationships between local food environments and dietary outcomes[1-3]. Residents of poorer neighborhoods, neighborhoods with higher proportions of people of color, and rural areas tend to live farther away from large supermarkets or supercenters[4-6]. Though these neighborhoods may have a higher number of small grocery, corner, and convenience stores[5,7,8], scholars point that that these stores tend to carry fewer healthy foods[9,10] and have higher prices than supermarkets[11-13]. The majority of food environment research has focused on proximity-based measures of food access; for example, scholars for example, scholars have compared different types of food stores in terms of differences in price, food availability, and food quality [14-16]. However, recent studies suggest that the food environment-diet relationship is far from straightforward.

While some scholars have found a correlation between consumption of healthy foods (e.g. fresh produce) and access to large supermarkets[17,18], two recent large-scale studies found that improved access to supermarkets was generally unrelated to dietary quality[4,5]. To account for this, researchers suggest that household finances are a more critical factor in determining what people eat than proximity to food stores[6-8]. In fact, many people intentionally bypass their nearest stores altogether, preferring to incur high travel costs to reach farther food stores that offer more affordable food and more healthy options[19-23]. Most recently, a report from the large-

scale, nationally representative FoodAPS project found that the average consumer's primary store is not the closest one to their home, and that they travel as much as an additional 1.5 miles to reach their preferred store[24]. This study also highlights the role that transportation can play in food purchasing decisions; fewer consumers without cars reported bypassing their nearest store to shop for food. Several other studies have similarly found that transportation can be a major barrier to food access for low-income individuals[25-27], with others finding that they often travel farther for food than wealthier individuals, suggesting higher transportation costs[28-30].

These studies suggest that the local food environment interacts in critical ways with issues related to poverty and household resources. Until now, however, we have not had representative data that would allow us to contextualize family food decisions within the complex array of factors at the household and neighborhood level. Yet, the consequences of living in an area with poor food access are likely to vary from place to place and for different types of households. For example, food access may look very different in urban and rural areas, for several reasons; these might include the availability of public transportation in urban vs. rural areas, lower cost of living in rural areas, and potentially greater access to gardens or farm produce in rural areas[31]. Race and ethnicity may also differentially affect people's experiences living in places with low food access[32]. In order to expand our understanding of issues of food access beyond proximity to different store types, a growing number of scholars call for multilevel studies that explore interactions between household variables and neighborhood variables and their varying effects on dietary outcomes[1,7,33].

Methods

This study employs multilevel models with neighborhood and state effects (fixed effects and random effects) to analyze the associations between household characteristics, neighborhood

characteristics, regional attributes and dietary quality. We used the R Project for Statistical Computing version 3.0.1 for analysis, including library packages *MASS* version 7.3 and *nlme* version 3.1. Data were imported into R from SAS and merged by each individual's household identification number (HHNUM).

At the household level (level 1), we expect that characteristics such as financial well-being, educational attainment, race/ethnicity, household structure, citizenship status, homeownership, access to a car, and the number of large stores in the neighborhood will impact dietary choices. We recognize that households located within the same census block group will not be independent from one another with regards to the number of large stores in the neighborhood. We also expect that neighborhood-level conditions could impact the local social and food environment within which household dietary decisions are made. For these reasons, we investigate effects at the neighborhood level (level 2). Here, we expect that neighborhood characteristics such as neighborhood deprivation (a fixed effect specified in the model through an index score at the block group level) will impact household dietary choices. Because other aspects of the neighborhood environment (i.e., culture, social trust) could also be important, we include a random effect at the neighborhood level as well.

Next, we are interested in the possibility that the cost of food varies across space and that these price differences impact food choices. Data on average food prices are available in the FoodAPS data at the county level and are included in our model as a fixed effect. Because the FoodAPS data are structured so that only one or a small number of usually spatially clustered counties were sampled within each state, it is difficult to separate the cost of food at the county level from other county-level social and economic conditions that might impact food choices or from state-level effects that could be related to state policy differences in providing access to

food and social services. So, given county-state complications in the structure of the data, we include a random state effect that we believe captures some mix of social and economic regional effects that occur at the county or state level (level 3).

Our proposed research approach included spatial analysis to investigate the possibility that relationships between household characteristics and diet vary across space, using geographically weighted regression (GWR) at the block group level. As we explored the data, we decided that approach was not viable or appropriate to the data structure and decided to implement the multilevel approach described above to model spatial effects through neighborhood and regional effects. The FoodAPS data are structured so that the sample of 3,286 households for which relevant data are available are located within 27 states with a range of between 22 to 439 observations per state. Relatively few (n= 649 of over 200,000) block groups are represented in the sample, with a range of 1 to 38 household observations within each block group and an average of 5.1 households per block group. The sample size was not large enough within the average block group to reasonably represent the block group, nor were there enough block groups included in the dataset to distinguish spatial effects from the impacts of observable conditions, such as rurality and economic conditions. In short, GWR is an exploratory tool that works well for uncovering possible spatial variance in relationships between variables; but we feel like the multilevel modeling approach we ultimately decided to take is both better suited to the data structure and also offers more concrete and policy applicable findings.

Data

We use data from the USDA National Household Food Acquisition and Purchase Survey (FoodAPS). Our dependent variable is a Healthy Eating Index that incorporates dollars spent and amount of food (measured by weight) in several categories: fruit, vegetables, snacks, and

sweetened beverages. The Healthy Eating Index was created using principal components analysis based on the following variables: dollars per person spent on fruits, dollars per person spent on vegetables, grams of fruits acquired per person, grams of vegetables acquired per person, dollars per person spent on snacks, and dollars per person spent on sweetened beverages. The components load on three factors with an eigenvalue >1. The first is essentially the "buying a lot of food" factor, which is closely related to household size. The factor of interest is the second one, the Healthy Eating Index. We scored this second factor so that fruits and vegetables contributed positively to the index, and snacks and sweetened beverages contributed negatively to the index. The third factor is of potential interest for future analysis, and is essentially those households that buy a lot of sweetened beverages but not snacks.

Table 1 outlines the variables included in the analysis. Key explanatory variables at the household level include a household financial index, based on principal component analysis that included monthly household income (positively associated with index), self-reported problems paying utility bills (negatively associated with the index), self-reported problems paying other bills (negatively associated with the index), and self-reported financial condition (negatively associated with index); this latter variable is a categorical measure of how comfortable and secure financially the head of household feels, ranging from 1, "very comfortable and secure," to 5, "in over your head". We also include a measure to capture the influence of housing circumstances[12,13]: housing burden, operationalized as shelter costs for the previous month (including rent or mortgage, insurance, property taxes, and utilities) as a proportion of the previous month's household income. In addition, we include a binary variable measuring home ownership and a binary variable measuring access to a car, which previous research indicates may affect the food environment-diet relationship[14]. We also include control variables at the

household level, including household size, the number of children under age 12, whether the home is in a rural area, and the primary respondent's race/ethnicity, citizenship status, and education level.

The concept of "food access" includes a number of dimensions, including availability and affordability[3]. Our model operationalizes availability as the number of supermarkets within 1 mile of the centroid of urban block groups and within 10 miles of rural block groups[1]. We operationalize affordability using an index of food prices in the county in which participants live, which is the measure most consistently linked to dietary outcomes[3].

Finally, based on previous qualitative research conducted with low-income women in North Carolina, we hypothesized that neighborhood deprivation, previously linked to health outcomes[15-17], would also influence dietary quality. Using several variables derived from the Census 2010 and the American Community Survey (2008-2012), to represent multiple, theoretically-distinct constructs of neighborhood social disadvantage[16], we use a neighborhood deprivation index. The neighborhood deprivation index was developed using principal components analysis based on the following variables: median household income (negatively associated with index), percent homeowners (negatively associated with index), percent single parent households among households with children (positively associated with index), and percent Black race (positively associated with index). The index is calculated at the census tract level.

Results

Results are shown in Table 2, page 254.

Model 1 is a simple OLS model based on household-level variables that we expected

[1] Rural is operationalized as a sparsely populated area with fewer than 2,500 people, while urban areas have more than 2,500 people.

would impact healthy eating. For this model, the Healthy Eating Index was the dependent variable. Based on Model 1, we found that housing burden, car access, household size, the presence of children in the household, and whether the head of household was Black or Latino had no effect on healthy eating. The following variables were positively associated with dietary quality: financial condition, home ownership, education of the head of household, and whether the head of household identified her or her race as “other” (not White, Black, or Hispanic). The number of supermarkets in the neighborhood was also positively associated with dietary quality. Citizenship status and living in a rural area were negatively associated with dietary quality.

Next, we wanted to see how neighborhood conditions impacted healthy eating. Model 2 is a multilevel mixed effects model. It includes the same level 1 household characteristics as the household level OLS model, but it also includes fixed effects for neighborhood deprivation (level 2 - block group) and for the regional food price index (level 3- state/county), as well as random effects at the neighborhood and state levels. We not that we are referring to level 3 as regional effects because there are only a few counties in each state, with counties clustered together, making it difficult to separate county and state effects. The "regional effects" are thus a combination of state and county effects.

Understanding how neighborhood conditions impact dietary quality is of particular importance to our research question. Based on our hypothesis that neighborhood deprivation would have a significant effect on household food purchases and thus dietary quality, Model 2 includes an index for neighborhood deprivation. Altogether, Model 2 is specified to address four concurrent issues that can't be addressed with the OLS model: (1) to adjust for the fact that households within the same neighborhoods are not independent from one another, particularly on variables such as number of stores in the neighborhood and the neighborhood deprivation index;

(2) to test for the effects of neighborhood-level impacts on household diets; (3) to test the relationship between regional food prices and dietary quality; and (4) to adjust for the fact that unspecified factors operating at the regional level (e.g., social and economic conditions, state and local policies) may impact household dietary quality.

The results for Model 2 are shown in Table 2. Most of the relationships identified as significant in Model 1 are still significant in Model 2. The only change is that the years of education of the head of household is no longer significant. The number of supermarkets in the neighborhood is still significant and positively associated with dietary quality. However, contrary to our expectations, neither the county-level food price index nor the index for neighborhood deprivation is significant. In other words, living in a deprived neighborhood or a region with higher food prices does not significantly affect healthy eating. However, neighborhood conditions do matter. Approximately 3.1% of the variation between households can be explained by unspecified random neighborhood effects, or neighborhood-level differences. This is a small relationship, but it is almost half of the overall variance explained in the model that includes multiple household level characteristics. Therefore, there are unspecified neighborhood conditions (for example, local culture, social trust, or other aspects of the food retail environment) that account for as much of the variation in household level dietary quality as a full suite of household-level variables. State effects are also statistically significant, but substantively negligible.

Discussion

Our results highlight the complexity of understanding factors at different spatial scales that influence dietary quality. Overall, our model predicted only 6.8% of the variation in household dietary quality. Dietary quality is likely affected by a wide range of factors at multiple

scales, which helps explain our low adjusted R^2 value. This is further complicated by the fact that our model measures dietary quality in terms of household food purchases, as opposed to individual people's consumption patterns (as in the case of dietary recalls, for example). We note that previous versions of the model—for example, those with dependent variables comprised of just one or two dietary components, such as per person dollars spent on fruit or vegetables—had even lower R^2 values. However, as we continue to refine our model, we will work to identify additional key variables to improve our model.

Given this caveat, however, our research suggests that places matters. First, food environments do matter: the number of supermarkets in a neighborhood was significantly related to household dietary quality. Contrary to our expectations, however, the county price index was not significantly related to dietary quality when controlling for other factors.

In addition, and echoing several recent studies[6-8], our results highlight the importance of household finances in shaping food decisions and by extension, dietary quality. We found a significant relationship between household dietary quality and financial condition. Although housing burden was not significantly related to dietary quality, home ownership had a significant and positive effect on dietary quality.

In general, we found a lack of associations between the race/ethnicity of the head of household and dietary quality, with one exception. Having a household head who identified as "other" (non-White, Black, or Hispanic) was significantly and positively associated with dietary quality. This category consisted of people identifying as Asian, Native Hawaiian or Other Pacific Islander, American Indian or Alaska Native, or another race. In addition, although there was not a significant association between Hispanic heads of household and dietary quality, there was a significant negative association between U.S. citizenship and dietary quality. In other words,

non-citizens had higher dietary quality. This is in keeping with research on immigrants and dietary acculturation. This literature finds that immigrants generally have healthier diets than the U.S. born population among arrival to the United States, and that that dietary quality deteriorates as immigrants adapt to U.S. culture. Among Latinos, acculturation is generally associated with less healthy diets, including lower intake of fruits and vegetables and higher consumption of fast food, junk food, and sugar-sweetened beverages.[34-37]

Although our index of neighborhood material hardship was not significantly related to dietary quality, we conclude based on our analysis that place matters. First, living in a rural area was significantly and negatively related to dietary quality. While it is often assumed that people living in rural areas will have better access to healthy food because of farming and gardening traditions, studies of food insecurity indicate that rural areas have higher food insecurity rates than urban, suburban or exurban areas, as well as higher poverty and lower educational attainment rates[38-39]. Researchers have attributed differences in food access between rural and urban areas in part to a lack of transportation infrastructure in rural areas, as well as to larger distances between supermarkets due to insufficient population bases and issues with food distribution[39-40]. Second, the random neighborhood effects variable was significant. We note that the index of neighborhood deprivation is highly negatively correlated with home ownership (-0.38); homeowners are less likely to live in deprived neighborhoods. (In addition, the index of neighborhood deprivation includes percent home ownership as one component). Because of this, neighborhood deprivation becomes significant if we take homeownership out of the model. Similarly, neighborhood deprivation is highly negatively correlated with the number of large supermarkets; more deprived neighborhoods have fewer stores. Taken together, this means that neighborhood deprivation may matter, but that is so closely linked to home ownership and the

presence of supermarkets that it becomes insignificant when we include these variables. However, our multilevel model also tests for neighborhood effects beyond what we've measured with the deprivation scale. This suggests that neighborhood does matter, even net of the effects of the number of stores in a neighborhood and presence of homeowner-occupied houses.

In subsequent analyses, we will work to try to identify additional neighborhood-level variables that could explain this variation. These could include, for example, the prevalence in the neighborhood of other types of food retail outlets besides large supermarkets: for example, farmers' markets or smaller corner or "ethnic" grocery stores, on the one hand, or fast food restaurants, on the other hand. Particularly given our finding about citizenship status, it could also include a measure of the degree to which neighborhoods are isolated immigrant enclaves, which could provide a protective effect on dietary quality by enabling immigrants to maintain food traditions that are healthier than typical U.S. diets. A study of Hispanic immigrants in New York City found that adherence to a healthier diet pattern was positively associated with both neighborhood poverty and neighborhood linguistic isolation; the authors conclude that this research supports the hypothesis that living in immigrant enclaves is associated with healthy diet patterns among Hispanics.[41]

Conclusions

Our findings demonstrate promising evidence that place matters for dietary quality. Food environments explain part, but not all, of the relationship between dietary quality and neighborhoods. Households in neighborhoods with more supermarkets had better dietary quality. Home ownership was also significantly and positively associated with dietary quality. Both of these factors are negatively correlated with neighborhood deprivation. Thus, although neighborhood deprivation is not significant in our final model, this may be in part because

neighborhood deprivation predicts other factors that matter for dietary quality, such as home ownership and presence of supermarkets. Furthermore, we found a significant neighborhood effect that is still unspecified; future analyses will attempt to identify other neighborhood-level factors that could better explain variation in dietary quality.

Some variables that we predicted would be significant were not; for example, car access was not significantly related to dietary quality. However, our research does support our general expectation that the households that are worst off likely experience a cluster of factors, including low food access, high economic stress, and unstable housing (measured by a lack of home ownership).

This research challenges public health experts and practitioners to think more comprehensively about how consumers make food decisions. Our findings may suggest, for example, that while policies to increase access to retail food stores are helpful, policies to increase household financial resources and ensure access to adequate housing are also critical. Most challengingly, it suggests that the most effective promotion of healthy food decisions will require a "mainstreaming" of the issue, so that community development, regional transport, and anti-poverty programs all adopt healthy food promotion as an important planning principle.

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Table 1. Variables included in analysis.

Outcome	Prevalence/average	Notes
Healthy Eating Index		Principal components analysis based on the following variables: dollars per person spent on fruits, dollars per person spent on vegetables, grams of fruits acquired per person, grams of vegetables acquired per person, dollars per person spent on snacks, and dollars per person spent on sweetened beverages.
Exposures		
Financial condition index		Principal components analysis based on the following variables: Monthly household income, self-reported financial index (categorical variable from 1 = very comfortable and secure to 5 = in over your head), self-reported difficulty paying housing expenses in the last six months, and self-reported difficulty paying utilities in the last six months.
Housing burden	Mean = 39% SD = 28%	Monthly housing expenses (rent/mortgage, insurance, property tax, and utilities) as a proportion of monthly household income. People with zero income AND zero housing expenses were considered to have a 0% housing burden. People with zero income who do have housing expenses were considered to have 100% housing burden.
Home ownership	No = 2095 Yes = 2138	Whether or not the primary respondent owns the home in which they live.
Car access	No = 678 Yes = 3681	Whether the household has access to a car when needed.
Household size	Mean = 3.0 SD = 1.7	Total number of people (children and adults) in the household.
Young kids in household	Mean = 0.58 SD = 1.0	Number of children in the household under age 12.
Rural	No = 3159 Yes = 1208	Whether the household is in a rural census tract.
Race/ethnicity	White = 2618 Black = 559 Hispanic = 858 Other = 329	Race/ethnicity of the primary respondent. Respondents who indicated that they are both Hispanic and another race were only counted as Hispanic for this variable.
Citizenship status	No = 433 Yes = 3925	Whether the primary respondent is a U.S. citizen.
Educational attainment	Mean = 20.2 SD = 2.8	Years of education of the primary respondent.
Stores in neighborhood	Mean = 4.2 SD = 7.9	Number of large supermarkets within 1-mile of urban and 10-miles of rural homes.
Food price index	Mean = $262.50 SD = $54.90	Average food basket price for a family of four, at the county level.
Neighborhood deprivation		Principal components analysis based on the following variables: Median household income, percent homeowners, percent single-parent households (among households with children), and percent Black race, all at the census tract level.

Table 2. Household and multi-level models used in analysis.

	Model 1 Household-level OLS B	Model 2 Neighborhood & State effects B
Financial condition	0.0786 ***	0.0692 ***
Housing burden	0.0229	0.0503
Home ownership	0.2198 ***	0.2112 ***
Car access	0.052	0.0510
HH size	-0.04	-0.0383
Young kids in HH	-0.0247	-0.0360
Rural	-0.3363 ***	-0.2474 **
Black	-0.0036	-0.0094
Hispanic	0.135	-0.0214
Other non-White race	0.3573 ***	0.2681 **
Citizenship status	-0.3445 ***	-0.2961 ***
Educational attainment	0.03 **	0.0219
Stores in neighborhood	0.0104 **	0.0103 **
County food price index	--	0.0020
Neighborhood deprivation	--	-0.0186
N	3578	3286
Adjusted R2	0.0483	0.0668
Wald Chi2	--	206.6 ***
State effect	--	0.0078 ***
Neighborhood effect (rho)	--	0.0314 ***
** = p<0.01, *** = p<0.001		