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David Hartley PhD, MHA
University of Southern Maine, Muskie School of Public Service, Maine Rural Health Research Center

Nathaniel J. Anderson MS, MPH
University of Southern Maine, Muskie School of Public Service

Kimberley Fox MPH
University of Southern Maine, Cutler Institute

Jennifer D. Lenardson MHS
University of Southern Maine, Maine Rural Health Research Center

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ORIGINAL ARTICLE

How Does the Rural Food Environment Affect Rural Childhood Obesity?

David Hartley, PhD, MHA, Nathaniel Anderson, MPH,
Kimberley Fox, MPA, and Jennifer Lenardson, MHS

Abstract

Background: The food environment, including access to retail food outlets and the presence of healthy food in the home, has been shown to be associated with eating behavior and obesity, but this relationship is not well understood in rural locations.

Methods: A statewide Maine household survey in 2009 of parents of children enrolled in Medicaid (n = 1421) oversampled in 6 rural communities, resulting in n = 272 for 6 target communities. The food environment was measured using modified Nutrition Environment Measures Survey in Stores (NEMS-S) for 46 retail food outlets. Multivariate analysis assessed factors affecting home food environment, child's eating behavior, and BMI.

Results: Home food behaviors (how often the family eats together, child eats breakfast, vegetables served) and parent food consumption were significantly associated with children's healthy eating behaviors. The only significant predictor of childhood obesity was parent eating behavior. We observed several alternative strategies such as hunting, gardening, and buying from local farmers. Parents who drove over 20 miles to shop were found to shop at stores with higher NEMS scores as compared to parents who drove shorter distances.

Conclusions: Current approaches to defining the food environment spatially may not be appropriate for measuring the rural food environment due to long-distance trips, careful price shopping, and local alternative strategies. Strategies to place healthier food in the home should be combined with interventions directed at parents' and families' eating behaviors.

Introduction

Low-income people living in rural areas of the United States have higher rates of obesity than those living in urban areas.[1–6] Prevalence estimates based on self-reported height and weight suggest that rural residents are 12–15% more likely to be obese than urban residents.[7–9] The reasons for differences in urban and rural obesity rates among families of comparable income are still unknown, but some studies of rural home and neighborhood environments suggest that availability of healthy foods in the community and home may be a contributing factor.[10,11] Availability is one common construct in describing and measuring the food environment. In the home, fruits, vegetables, whole grains, and low-fat dairy are common indicators, whereas in the community, proximity/distance, variety, quality, and price have been suggested to operationalize this construct.[12] Studies in urban areas have found that poor food environments in low-income neighborhoods (*e.g.*, fewer supermarkets) are associated with limited fruit and vegetable consumption in low-income households and with higher rates of obesity.[13–18]

Few studies have evaluated rural food environments and their association with healthy food consumption and obesity rates. While those with better access to supermarkets have been found to have better availability of healthy food in the home[19] and healthier diets,[20] rural studies have found that almost 75% of rural food outlets were convenience stores, where produce options are limited.[21] Another rural study found a correlation between availability of fresh fruit, vegetables, and low-fat milk and obesity rates.[11] "Availability," however, is an imprecise term. One urban study captured the complexity of the shopping habits of urban residents, noting BMI was a function of grocery store choice, which was only partially determined by proximity, because many residents shop outside their neighborhoods.[22] Many rural residents must travel to larger towns for healthcare, school, and employment, and these trips may also include grocery shopping. Measurement and inferences involving the rural food environment must acknowledge this complexity.

Our failure to understand how the food environment in rural communities may differ from that in cities, and how

University of Southern Maine, Muskie School of Public Service, Cutler Institute for Health and Social Policy, Portland, ME.
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that difference may affect nutrition and obesity among low-income rural children, has left policymakers and practitioners with little direction when targeting interventions to rural children. Understanding the ways in which the rural food environment affects childhood obesity rates is important for the development of effective interventions that will increase access to and consumption of healthy foods and improve the health of rural communities.

This study examines the association between the rural food environment and rural low-income children's food consumption and obesity rates in six rural towns in Maine. The framework for this study (Fig. 1) drew on existing ecologic models. Glanz and colleagues have suggested several constructs influencing eating patterns, including the policy environment, the community nutrition environment (food outlets and accessibility), the organizational environment (home, school, work, other), and a consumer nutrition environment consisting of available healthy options, price, promotion, placement, etc.[23] In their study of environmental influences on chronic illness, Teo et al. used a similar model, focusing on the household as a key construct through which the community environment influences individuals. Their model suggests that family structure and socioeconomic status are key variables defining the household.[24] We have merged these models, with particular emphasis on the household as a construct that includes availability of healthy food and family meal patterns,[25] as well as family income and parent education.

Our model acknowledges the crucial influence of parents on children's eating behavior. Parents have primary control over the foods that enter the home and food preparation methods, directly affecting the availability of healthy food. Family meals promote positive dietary intake among children,[26] and parent modeling and intake of fruit and vegetables have also consistently been shown to have a positive association with children's intake of fruit and vegetables.[27]

We have also added alternative food sources, such as gardening, hunting, and farmer's markets. In their study of diverse low-income populations, Gittelsohn and Sharma suggested that families in some rural settings may be more likely to procure food through alternative strategies such as interhousehold food sharing.[28] Similarly, community-level interventions to promote healthy eating have included alternative sources, such as food sharing and family eating, gardening, and a food-buying club.[29] We added hunting, animal husbandry, gardening, and farmers markets as alternative strategies likely to be found in low-income rural Maine households. Although farmers' markets may be seen as part of the community food environment, we suggest that the decision to patronize them belongs in the household construct along with gardening. Some of these alternative strategies raise children's interest in healthy food, affecting not only what food is in the home, but also what foods children are likely to eat.[30]

We suggest a theoretical causal pathway from the community food environment to the household food environment (available healthy food and family behavior) to the child's food consumption to the child's BMI (Fig. 1). Because this is a cross-sectional study, causal relationships could not be confirmed. Thus, we sought evidence through measures of association that such pathways are worthy of further study. We acknowledge that this model

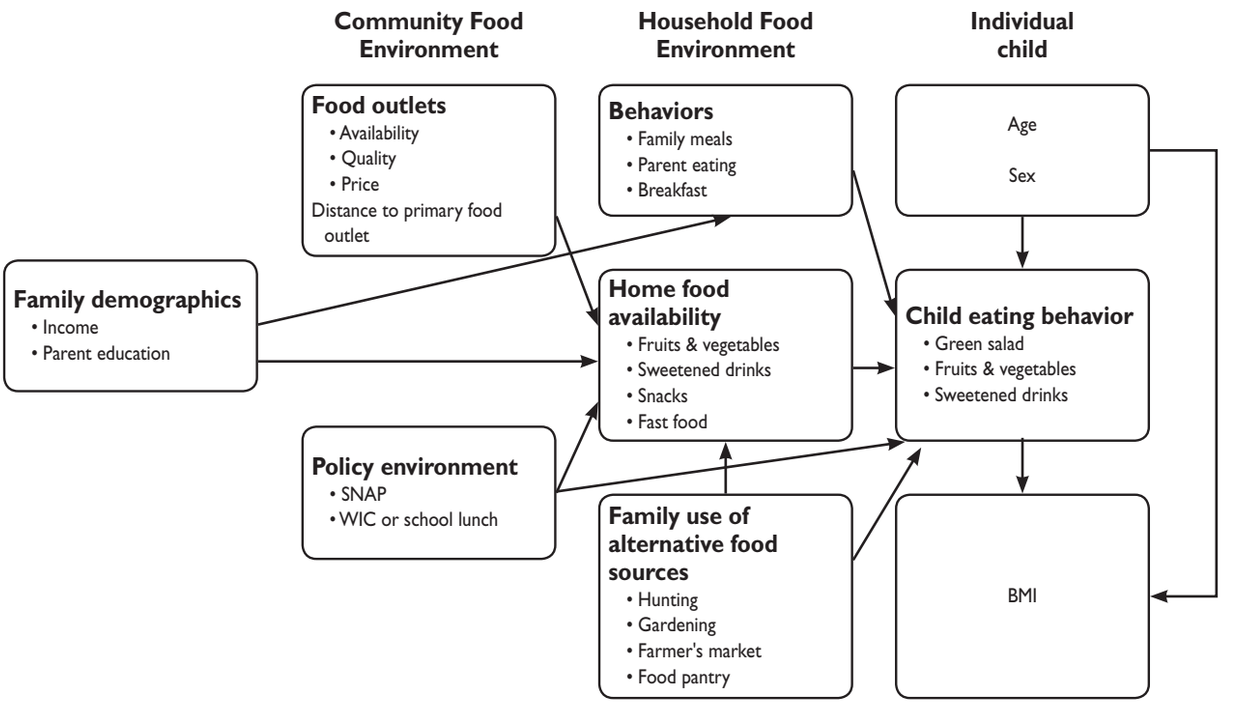

Figure 1. Conceptual framework.

is incomplete, in that it does not include the built environment and physical activity variables found in more complex models of the influences on childhood obesity,[31] nor does it include individual-level variables such as taste preferences and attitudes.[25] It also does not include restaurants and the school food environment because those elements of the food environment have been studied extensively, and because we believe rural–urban differences are less likely in those domains. We chose to limit our model to the rural food environment, with emphasis on the household and its influence on the child. We have included specific indicators within each construct in Figure 1, indicating how the conceptual framework maps to the analytic framework and findings.

Methods

Data were gathered at each stage of our causal pathway. We investigated the community food environment (defined as food access, cost and quality for healthy foods such as fruits and vegetables, low-fat food items, and whole grain products) in 6 rural low-income Maine communities with varying rates of obesity using a mixed methods study design. Qualitative data were collected from focus groups (see Data Sources, below) to help identify the breadth of area and stores to include in food audits and to develop survey questions related to barriers to purchasing healthy food and alternative strategies to get healthy food. The relationships between community and home food environment, child food consumption, and obesity were quantitatively assessed through survey data from an expanded statewide survey of parents with children enrolled in MaineCare (Maine's Medicaid program) and rural-modified food environment audits. All work conducted for this study received Institutional Review Board approval.

Study Population and Target Community Selection

The study population was rural, low-income families who are enrolled in the MaineCare program. Six rural communities in Maine were selected for study, using both community-level and family-level data. Criteria for rural community selection included: (1) The number of children enrolled in MaineCare as measured by Maine Care 2007 enrollment data, (2) a range of the obesity and overweight rates of MaineCare children calculated from parent reported height and weight on the statewide MaineCare child survey, (3) the degree of rurality, and (4) presence of innovative community-based programs to support healthy eating as identified by the study advisory committee. Rurality was measured using rural–urban continuum codes at a county level, and sites were selected to include both rural areas adjacent to urban areas, some that are not adjacent to urban areas, and one frontier community (defined, per Beale and Cromartie,[32] as whole counties with a population density of less than 7 persons per square mile.)

Data Sources

In the spring of 2009, in each of the 6 selected rural Maine communities, we conducted focus groups of parents with children enrolled in the MaineCare program. Participants were randomly selected from a list of parents of Medicaid-eligible children, drawn from Medicaid eligibility data, recruited by telephone, and compensated with a $60 gas card, approved by the University of Southern Maine's Institutional Review Board. The moderator's guide was developed based on our prior studies with low-income parents and children.[33] The focus groups helped us define the 'neighborhood' in terms of food outlets commonly used to buy food for the home in the target communities thereby establishing the radius of the food audits. The focus groups also served to inform the development of survey questions by identifying factors that inhibit or support healthy eating in rural low-income communities, including awareness and use of farmers markets and other alternative strategies for accessing healthy foods. A detailed description of the methods and findings of the focus groups has been published separately.[34]

To measure the community food environment, we adapted the Nutrition Environment Measurement Survey (NEMS-Store), which includes measures of store nutrition environments that assess the availability, quality, and pricing differences between healthier and less-healthy options for the following foods: Milk, fresh fruits and vegetables, ground beef, hot dogs, frozen dinners, baked goods, beverages (soda/juice), whole-grain bread, baked chips, and cereal.[35] To focus solely on access to healthy foods, we adapted the NEMS to include only healthier foods that adhere to the Dietary Guidelines for Americans[36] (Table 1). Because rural areas have a small number of large outlets with ample storage, we eliminated a shelf space measure for milk as a variable and added frozen fruits and vegetables because of their longer shelf life and nutritional equivalency to fresh produce. In total, the audit included 62 food items and 370 data points.

Table 1. 14 Food Types Assessed in the ME-NEMS by Availability, Quality, and Price (Maine 2009)

Fresh fruits/vegetables
Canned fruits/vegetables
Frozen fruits/vegetables
Whole grain bread, rice, pasta, and cereal
Lean ground beef/chicken
Canned tuna (in water)
Milk
Low-fat cheese
Low-fat yogurt
100% Fruit juice

Data were collected for 46 superstores, grocery stores, and convenience/other stores located in or near our 6 communities. Stores were identified by a list of food vendors accepting food stamps in the targeted communities, provided by the state Supplemental Nutrition Assistance Program (SNAP), which included all types of stores, including convenience stores and dollar stores. By supplementing the list with environmental scans of the communities and findings from focus groups, we captured all food vendors.

The ME-NEMS tool was pilot tested for interrater and test–retest reliability by 3 surveyors and was found to be generally acceptable throughout the food groups. Individual items with less than 80% agreement were either removed or modified. Our research team was trained in use of the NEMS-Store instrument by Emory University staff. We followed the scoring rubric recommended by Emory with modifications accounting for the elimination of unhealthy items. Scores for availability and quality were based on the percent of items present, and the percent of those items present that met quality standards, although we found minimal variation in quality.

For each individual store examined using the ME-NEMS, a score representing the sum of all availability, quality, and price scores was calculated by adding scores for 14 categories of food (Table 1). Stores were categorized by superstore, small grocery, and convenience stores. No dollar stores were found in our 6 towns. For each of the 6 towns and food store types, we calculated a mean availability, quality, and price score and then a mean total score. Availability and quality scoring followed the methods recommended by NEMS with some adaptation based on changes to food content in the ME-NEMS. Price scores were modified from the original NEMS methodology to compare actual price to the median range of prices for all items in a category across all stores, resulting in a variable scaled so that low-cost stores received a higher score on the price index. This approach was not tested for validity beyond its obvious face validity. We created an aggregate score for each community, summed across the stores in that community, and across scores for availability, price, and quality. Variability was small, with a range in total scores for the six communities from 41 to 57 (possible score = 78).* We used a second NEMS-derived variable as an alternative indicator of the community food environment. In the household survey, we asked each respondent to identify their primary food outlet—the store where the majority of their food shopping takes place. The summary NEMS score for that store was used as an alternative indicator of the food environment, with a range of 54 to 78 and a mean of 73. We also asked survey respondents how far they had to drive to reach that primary store.

A household survey of parents of children currently enrolled in MaineCare that had been in the program for at least 9 mo provided data on rural residents' home food environments, child food consumption, and other factors potentially contributing to obesity in the home. The survey randomly selected 1 child per household from MaineCare eligibility data provided by the Maine Department of Health and Human Services. The survey was conducted from July through November, 2009, and included information on demographics, health status, health care utilization, as well as health behaviors; more specific questions addressed child food consumption, distance traveled to primary grocery store, and some family meal habits to allow us to compare results of selected rural communities with MaineCare enrollees statewide. We measured the home food environment in two domains: Food available in the home (fruits, vegetables, sweetened beverages, snacks, fast food), and family eating behaviors (how often family eats together, how often child eats breakfast, how often fruits and vegetables and low fat milk are served). These questions were taken from Project EAT (Eating Among Teens),[37] from the Healthy Home Survey,[38] and from the *National Health and Nutrition Examination Survey* (NHANES) Diet Behavior and Nutrition Questionnaire.[39] Details are provided in the footnotes to Table 2. We calculated a single score for each domain. We also calculated a parent consumption score to test the association between parent role modeling of eating behaviors and children's eating and obesity outcomes.

In the selected 6 rural towns, we oversampled parents of children enrolled in MaineCare and conducted a modified survey that included more detailed questions specific to healthy eating behaviors, consumption patterns, and food availability in the home. Additional questions included height and weight (parent's self report), physical activity (at school and home), screen time, food consumption (fruit, vegetables, sweetened drinks, etc.), distance and name of primary food store, use of alternative food sources, eating habits of the child, availability of food in the home, family and parental eating behaviors and participation in subsidized food programs [SNAP, Special Supplemental Nutrition Program for Women, Infants, and Children (WIC), and school lunch]. Specific survey questions were derived from existing validated survey questions related to community or home food environments and from focus group findings of rural-specific barriers and strategies for accessing healthy foods. A more detailed description of our methodology and a copy of the final survey are available from the authors on request.

Analysis

To address our research questions, we examined overweight and obesity, child consumption, and household food environment using household- and community-level food environment characteristics and demographics as predictors. All frequency differences were evaluated with chi-squared

*Details of the specific wording of survey questions, and development of the scoring system are available from the authors on request.

tests of independence; means were compared using *t*-tests. Unless stated otherwise, any reported differences are statistically significant at the 0.05 level or less. Our bivariate analysis examines both overweight and obese associations, so as to identify which specification is most appropriate as a dependent variable in our multivariate model.

We used multivariate regression analysis to examine the hypothesized causal pathways between food environment, child consumption, and obesity. The first model used ordinal logit regression to investigate the link between community and home food environment with the home food availability score as the dependent variable, and key predictors including the community-level NEMS score for all stores in the community (described above) and travel time to the primary food source. Control variables included demographics (age, sex, parent's education level), food policy measures (SNAP, WIC, subsidized lunch receipt), and use of alternative food strategies and

Table 2. Sample Description and Characteristics by Overweight and Obesity (Maine 2009)

Characteristic	Percent of sample (*n* = 272)	Percent overweight or obese (*n* = 242)[a]	Significance	Percent obese (*n* = 242)[a]	Significance
Full sample (age 2+)	100.0	47.9		27.7	
Demographics					
Age			*		
Ages 2–5	26.1	39.3		28.6	
Ages 6–12	41.5	58.4		29.7	
Ages 13+	32.4	41.2		24.7	
Sex					
Male	57.4	50.4		31.9	
Female	42.6	44.6		21.8	
Health status					*
Excellent/very good	81.3	46.2		24.4	
Good/fair/poor	18.8	55.6		42.2	
Parent education level					
High school degree/GED or less	47.4	50.0		24.1	
Respondent has more than high school education	52.6	46.0		31.0	
Food assistance/sources					
Food stamps/SNAP receipt					
Household gets food stamps/SNAP	62.5	48.6		27.4	
No SNAP	37.5	46.9		28.1	
Child food assistance receipt					
Child gets free lunch or WIC	68.8	48.8		26.2	
No food assistance	31.3	46.0		31.1	
Household use of food pantry					
Used food pantry in past 12 mo	20.6	51.0		35.3	
No food pantry use	79.4	47.1		25.7	
Alternative food strategies					
Grows, hunts, or raises animals	68.4	46.7		27.0	
Does not grow/hunt/raise animals	31.6	50.7		29.3	
Farmers market use					
Buys food from farmer/at market	71.0	44.2		26.2	
Does not buy food from farmer	29.0	57.1		31.4	
Distance to primary food store					
Distance to main food store >21 min	23.0	44.4		22.2	
Distance to main food store ≤20 min	77.0	49.2		29.4	

Continued on page 455

farmer's markets. Ordinal logit was chosen because the dependent variable takes only whole numbers as values, resulting in nonrandom errors. The second model examined factors affecting the child consumption score using all of the independent variables from the first model plus measures of availability of healthy foods, home food behaviors, and parent behaviors. The dependent variable for model 2 had a continuous range of values, so ordinary least squares was appropriate for this model. A final model used logistic regression to examine the association between all of these factors and the ultimate outcome of interest—childhood obesity defined as having a BMI above the 95th percentile for their age and sex.

Results

The total sample for households in the six communities was 272; however, households with children under age 4 were not asked all questions, so the sample is smaller for some indicators. Descriptive statistics for the full sample are shown in Table 2. The second and third columns of that table show the percent of each subpopulation overweight and/or obese, as indicated by the column headings, thus indicating variables that are likely to be associated with (or predictive of) childhood obesity.

The rates of children being overweight (47.9%) and obese (27.7%) in the full sample are above nationally

Table 2. Sample Description and Characteristics by Overweight and Obesity (Maine 2009) *continued*

Characteristic	Percent of sample (n = 272)	Percent overweight or obese (n = 242)[a]	Significance	Percent obese (n = 242)[a]	Significance
Child food consumption (age 4+ only)[b]					
Summary Consumption Score[c]					
Consumption Score above 75th percentile (22+)	18.4	50.0		18.4	
Consumption Score in 75th percentile (21)	81.6	48.5		29.0	
Home food environment, availability					
Food Environment Availability Score[d]					
Food Availability Score above 75th percentile (5+)	22.4	37.7		24.5	
Food Availability Score in 75th percentile (4)	77.6	50.8		28.6	
Home food environment, behaviors					
Food Environment Behaviors Score[e]					
Behaviors Score above 75th percentile (6+)	5.9	42.9		14.3	
Behaviors Score in 75th percentile (5)	94.1	48.3		28.5	
Parent consumption					
Parent Consumption Score[f]					
Parent Consumption above 75th percentile (>12.5)	23.6	50.0		28.6	
Parent Consumption in 75th percentile (12.5)	76.4	47.3		26.9	
Other obesity-related behaviors					
Exercise					*
Exercises 3+ days/wk	85.8	47.7		24.6	
Exercises <3 days/wk	14.2	54.8		45.2	
Screen time					
Less than 2 hr of screen time on average weekday	81.0	46.5		26.5	
2+ hr of screen time	19.0	56.1		31.7	

* Difference in rate of overweight/obesity for given characteristic is significant at $p < 0.05$.

[a] There were 242 respondents with children age 2–17 with valid responses to height and weight items required to compute BMI.

[b] Child food consumption questions were only asked if child was age 4 or older (n = 228).

[c] Food consumption score items include: How often did the child eat green salad, vegetables, fruit, and soda/sweetened drinks.

[d] Home food environment availability score items include: How many times fast food was purchased in the past week, and how often fruits, vegetables, soda/sweetened beverages, and sweet or salty snacks are available in the home.

[e] Home food environment behaviors score items include: How often the family sits and eats dinner together, how often the child eats breakfast, how often skim or 1% milk is served with meals, and how often vegetables are served with dinner.

[f] Parent consumption score items include: how often the parent eats fruit, vegetables, soda/sweetened drinks and sweet/salty snacks.

GED, General Educational Development; SNAP, Supplemental Nutrition Assistance Program.

reported norms. In our sample, males are slightly, but not significantly more likely to be obese compared to females (31.9% vs. 21.8% $p < 0.10$). Those in excellent or very good health are less likely to be obese than those less healthy (24.4 vs. 42.2% $p < 0.05$), and those buying food from a farmer or at a farmer's market are marginally less likely to be overweight or obese (44.2% vs. 57.1%). Although not shown in Table 2, we also asked about gardening and animal husbandry, and found that those who raise their own food are slightly less likely to have overweight or obese children, but these differences were also not significant.

We found few significant relationships between the community food environment as measured by either indicator and by variables used to measure the home food environment (data not shown). However, we observed a relationship between distance traveled to the primary store and store food scores. Respondents who drove more than 20 miles shopped at stores with higher NEMS scores (74.3 vs. 72.7, $p < 0.10$; not shown in tables). Although this finding is only marginally significant, it suggests that some rural parents may drive greater distances to obtain better selection, quality, or price. Further research is needed to explore this relationship.

As seen in Table 2, our two indicators of the home food environment were not significantly associated with a child being overweight or obese. Similarly, neither aggregate NEMS scores at the town level, nor individual NEMS scores for the primary food store, showed a significant relationship to the home food environment indicators (data not shown).

To measure children's eating behavior, our household survey asked whether and how often the child eats salad, vegetables, fruit, and soda, and from this information we compiled a child food consumption score for each child. Although this score was not significantly associated with obesity (Table 2), we found a significant relationship between this indicator and each of the home food environment scores (Table 3). That is, computed scores for food availability in the home, family eating behaviors, and parent eating behaviors were each significantly associated with the child's eating behavior score.

In our survey, we asked several questions about alternative sources of food, such as raising one's own food through gardening or animal husbandry and purchasing from a farmer or a farmers' market. We found that 68% of our sample raised some of their own food, and 71% purchased some food from farmers. Households that purchased some food from farmers had significantly higher scores for home food availability (data not shown), and children in these households had significantly higher food consumption scores as compared with families who did not buy from farmers (15.3 vs. 11.5, $p < 0.01$; Table 3).

We ran several multivariate models to test the links between community and home food environments, between food environment and eating behavior, and between all of these factors and BMI. In our first model, predicting home food environment as measured by the availability score, we found that families in our sample who received SNAP benefits had greater availability of healthy foods relative to those with no SNAP benefits (Table 4, model 1). Confirming one of our bivariate results, use of a farmer's market was also positively associated with the availability of healthy food in the home. Families that reported needing to drive more than 20 min to their primary food store had lower average availability scores, although this finding was only marginally significant.

We found that the strongest home food environment predictors of children's eating behavior were home food behaviors and parent's consumption (Table 4, model 2). Availability of food in the home had no significant effect on child consumption after the other measures of food environment and demographic differences were taken into account. SNAP receipt and use of farmer's markets also had marginally significant positive associations with children's consumption of healthy food. Consistent with prior literature, we also found that boys had lower average scores than girls, and the youngest children had higher consumption scores relative to teens. We tested our ordinary least squares (OLS) models against the assumptions of OLS, and found that all assumptions were met, with the exception of nonrandom residuals detected in model 1. An ordinal logit model was fit for model 1, which does not assume normally distributed errors. The final logistic regression model examines factors associated with childhood obesity (Table 5). Parent consumption of healthy foods was the only food environment variable showing a statistically significant association with childhood obesity; it shows a negative association with having an obese child.

Discussion

Our conceptual framework is based on a number of studies establishing evidence linking our three key constructs: Community food environment to home food environment, home food environment to child's eating behavior, and eating behavior to obesity. Although our bivariate findings offer some support for the first two of these links, our multivariate models find minimal evidence for the first link, and evidence for the second link is limited to behavioral aspects of the home food environment. The community food environment, as indicated by the presence of retail food outlets, and the availability of high-quality food at reasonable prices, has been identified as a key environmental determinant of childhood nutrition.[40] Areas not served by large stores or supermarkets have been described as "food deserts," and have been linked to poor-quality diets.[16] Studies of food deserts and the food environment are often focused on the distance to a supermarket, on the assumption that a supermarket is the most reliable means to variety and quality at a reasonable price. Our findings suggest that travel time is indeed

Table 3. Mean Child Food Consumption Score by Characteristic (Maine 2009)

Characteristic	Sample size	Mean score (Min,Max)	SD
Full sample (age 4+)	228	14.2 (–14 , 43.5)	9.3
Demographics			
Age*			
Ages 4–12	143	15.6	9.1
Ages 13+	85	11.9	9.3
Sex*			
Male	128	12.8	9.6
Female	100	16.0	8.7
Health status			
Excellent/very good	186	14.7	9.6
Good/fair/poor	42	12.1	7.9
Parent education level			
High school degree/GED or less	112	14.3	9.2
Respondent has more than high school education	116	14.1	9.5
Food assistance sources			
Food stamps/SNAP receipt			
Household gets food stamps/SNAP	136	14.8	9.3
No SNAP	92	13.3	9.3
Child food assistance receipt			
Child gets free lunch or WIC	163	14.5	8.9
No food assistance	65	13.2	10.4
Household use of food pantry			
Used food pantry in past 12 mo	47	13.6	9.6
No food pantry use	181	14.3	9.3
Alternative food strategies			
Grows, raises or hunts for some food	157	14.5	9
Does not grow/raise/hunt	71	13.6	10.2
Farmers market use*			
Buys food from farmer/at market	161	15.3	9.4
Does not buy food from farmer	67	11.5	8.6
Distance to primary food store			
Distance to main food store >21 min	49	14.2	9.7
Distance to main food store ≤20 min	177	14.3	9.3
Home food environment			
Food Environment Availability Score*			
Food Availability Score above 75th percentile	50	18.8	8.5
Food Availability Score in 75th percentile	178	12.9	9.2
Food Environment Behaviors Score*			
Behaviors Score above 75th percentile	16	20.0	7.8
Behaviors Score in 75th percentile	212	13.8	9.3
Parent Consumption Score*			
Parent Consumption Score above 75th percentile	52	20.0	9.3
Parent Consumption Score in 75th percentile	174	12.5	8.7

*t-test or analysis of variance (ANOVA) test for difference in means is significant at $p < 0.01$.

SD, Standard deviation; SNAP, Supplemental Nutrition Assistance Program; WIC, Special Supplemental Nutrition Program for Women, Infants, and Children.

related to home food availability, but that the quality, selection, and price (as measured by the NEMS) available either in the local retail food environment or at the more distant supermarket are not the primary determinants of home food availability. A majority of the families in our sample procure some of their food from local farmers, and this strategy proved to be significantly associated with healthy food in the home. Although not statistically significant, most of these families also engaged in gardening and/or hunting. These strategies distinguish rural low-income families from their urban counterparts, as suggested by Gittelsohn and Sharma[28] and Jilcott,[41] and may partially explain the lack of a significant link between our NEMS-derived variables and the home food environment.

The second link of our model explores the association

Table 4. Ordinal Logit and OLS Regression Results Predicting Home Food Availability and Child Consumption (Maine 2009)

	Model 1 Ordinal logit model Home food availability			Model 2 OLS model Child food consumption		
Variable	**OR**		**95% CI**	**Estimate**		**SE**
Age						
0–5	1.78	*	(1.03, 3.07)	3.49	*	1.75
6–12	1.56		(0.93, 2.62)	2.13		1.24
13–17 (Ref)						
Sex						
Male	1.16		(0.76, 1.77)	–2.94	**	1.07
Health status						
Excellent/very good	0.89		(0.5, 1.59)	0.74		1.46
Parent's education level						
High School degree or less	0.85		(0.55, 1.33)	0.94		1.15
SNAP/food stamp receipt						
Family receives SNAP	1.97	**	(1.23, 3.14)	2.08		1.22
Food assistance receipt						
Child received WIC or school lunch assistance	0.79		(0.48, 1.28)	1.37		1.31
Food pantry use						
Used food pantry in past 12 mo	0.99		(0.57, 1.75)	0.35		1.44
Grows/raises/hunts for food						
Grows, raises or hunts for some food	1.50		(0.95, 2.37)	–1.69		1.22
Farmer's market use						
Gets food from farmer/farmer's market	2.39	**	(1.47, 3.89)	2.41		1.26
Travel time to primary food source						
Travels more than 20 min	0.53	*	(0.32, 0.88)	1.24		1.34
Availability/quality/price NEMS score for stores in town[a]	1.03		(0.84, 1.28)	0.16		0.54
Home Food Availability Score[a]				0.78		0.60
Home Food Behaviors Score[a]				2.71	**	0.60
Parent Consumption Score[a]				2.58	**	0.64
	$N = 297$[b]			$N = 224$		
	–2 Log likelihood = 843.6			$R^2 = 0.34$		

*$p < 0.05$.

** $p < 0.01$.

[a] Continuous independent variables were standardized to $\mu = 0, \sigma = 1$.

[b] This model has a larger sample size because it includes households with children under the age of 2 years, which were not included in other analyses, due to missing values.

OLS, Ordinary least squares; OR, odds ratio; CI, confidence interval; SE, standard error; SNAP, Supplemental Nutrition Assistance Program; WIC, Special Supplemental Nutrition Program for Women, Infants, and Children; NEMS, Nutrition Environment Measures Survey.

between the household food environment and the child's food consumption. Here too, our bivariate findings confirm the associations suggested by prior research, that home food availability, family eating behaviors, and parent behaviors are associated with healthy eating. However, only home food behaviors, parental consumption of healthy food, and receipt of food stamps were associated with children's food consumption when controlling for other factors, and only parental food consumption was significantly related to the probability that a child becomes obese. Considering the determinants of obesity not included in our model, it is not surprising that most of our variables are not significantly related to obesity. Our finding that home and parental behaviors are a major influence on a child's eating behavior, whereas home food availability is not, does not suggest a rural-specific interpretation, but does confirm the importance of these factors found in prior studies.

Table 5. Logistic Regression Results Predicting Obesity (Maine 2009)

Variable	OR	Significance	95% CI
Age			
0–5	1.56		(0.47 , 5.52)
6–12	1.54		(0.66 , 3.61)
13–17 (Ref)	1.00		
Sex			
Male	2.39	*	(1.14 , 5.03)
Health status			
Excellent/very good	0.44		(0.17 , 1.17)
Parent's education level			
High school degree or less	0.45		(0.20 , 1.00)
SNAP/food stamp receipt			
Family receives SNAP	0.91		(0.41 , 2.02)
Food assistance receipt			
Child received WIC or school lunch assistance	1.08		(0.46 , 2.54)
Food pantry use			
Used food pantry in past 12 mo	1.41		(0.57 , 3.47)
Grows/raises/hunts for food			
Grows, raises or hunts for some food	1.03		(0.47 , 2.27)
Farmer's market use			
Gets food from farmer/farmer's market	1.21		(0.53 , 2.74)
Travel time to primary food source			
Travels more than 20 min	0.54		(0.21 , 1.35)
Weekly physical activity			
Exercises 3 or more days per wk	0.52		(0.17 , 1.58)
Average daily screen time			
Less than 2 hr of screen time	1.34		(0.50 , 3.62)
2 or more hr of screen time (Ref)	1.00		
Home Food Availability Score[a]	1.23		(0.83 , 1.82)
Home Food Behaviors Score[a]	1.12		(0.73 , 1.72)
Parent Consumption Score[a]	0.64	*	(0.42 , 0.99)
Child Consumption Score[a]	0.86		(0.56 , 1.32)
Availability/quality/price NEMS Score for stores in town[a]	1.13		(0.79 , 1.62)
N	202		
–2 Log likelihood	206.48		

*$p < 0.05$

[a]Continuous independent variables were standardized to $\mu = 0, \omega = 1$.

OR, Odds ratio; CI, confidence interval; SNAP, Supplemental Nutrition Assistance Program; WIC, Special Supplemental Nutrition Program for Women, Infants, and Children; NEMS, Nutrition Environment Measures Survey.

Conclusions

Our findings regarding driving distance are inconclusive, but suggest that low-income rural families are likely to have a car, or the use of a car, and to use that vehicle for major shopping trips to distant supermarkets. But it is local food procured through alternative strategies that differentiate households where healthy food is available. The limited studies of rural food deserts have not explored these sources of healthy food extensively. Further research should explore the extent to which routine shopping at distant supermarkets and alternative local strategies render the food desert concept less meaningful in rural areas.

On the other hand, our findings suggest that strategies to place more healthy food in the home are not likely to be effective unless they are combined with factors that we found significant, such as parents who eat healthy food and families that eat together. Such strategies have been found effective in other studies,[42] and some have concluded that "…families are apt to achieve health together, or not at all."[43] At the policy level, we found that SNAP is a positive influence on the home food environment independent of other strategies, suggesting that SNAP helps to promote healthy food environments in poor rural households.

This study has several limitations. We focused on 6 small rural communities in Maine. The number of low-income families in such small towns is limited, thus the sample size in each community for the household survey was small. The household survey relied on respondent self-report and a proxy measure of children's eating behavior. Parents may have given responses perceived as socially acceptable. Our measurement of the food environment did not quantify alternative food sources such as farmers markets or community food banks and did not account for the nutritional content of school lunch programs. Finally, because this was a cross-sectional study, our analysis cannot confirm the causal pathway suggested by our model.

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Author Disclosure Statement

The authors have no conflicts of interest to report.

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Address correspondence to:
David Hartley, PhD, MHA
University of Southern Maine
Muskie School of Public Service
PO Box 9300
Portland, ME 04104

E-mail: davidh@usm.maine.edu