



Perceived neighbourhood food environment and overweight and obesity among Supplemental Nutrition Assistance Program-Education (SNAP-Ed) participants in the Midwest US

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Abstract

Objective: To evaluate the relationship between neighbourhood food environment perceptions and obesity among Supplemental Nutrition Assistance Program-Education (SNAP-Ed) or Expanded Food and Nutrition Education Program (EFNEP) participants.

Design: A cross-sectional study conducted during SNAP-Ed or EFNEP programme participation in six states in the Midwest US between May 2016 and November 2017.

Setting: Community centres, food pantries and other SNAP-Ed or EFNEP recruitment locations.

Participants: Convenience sample of 1743 low-income, adult nutrition education programme participants.

Results: Controlling for participant location and other demographic variables, those who perceived that a large selection of fruits and vegetables were available to them were 22 % less likely to be obese (adjusted odds ratio 0.78, 95 % CI 0.63, 0.97). In addition, participants who perceived the distance to the grocery store where they purchased most of their groceries to be greater than 5 miles were 1.36 times more likely to be overweight or obese than those who travelled shorter distances for their groceries.

Conclusions: SNAP-Ed or EFNEP participants' weight status may be associated with their perceptions of their neighbourhood food environments. Programmes incorporating nutrition education and food access initiatives should attempt to better understand participant perceptions in order to address barriers in their efforts and to ensure that healthy food is accessible to low-income residents.

Keywords

Supplemental Nutrition Assistance
Program-Education
Individual perception
Obesity

Individuals' perceptions of their neighbourhood food environments, including their perceived food availability and affordability, may play an important role in their dietary choices. Research suggests that an individual's perception of food availability, accessibility and affordability may explain some of the variation in diet quality observed among people of different socioeconomic groups⁽¹⁾. Similarly, perceived access to fruits and vegetables can significantly increase consumption of fruits and vegetables⁽²⁾. Hence, having a better understanding of how individuals' perceptions of their environments relate to the variation in dietary intake is vital when assessing the effect of dietary behaviours on individual health outcomes, especially in low-income populations.

Previous studies suggest several factors may affect access to healthy dietary options, including availability, access and types of food stores; the distance travelled for grocery shopping; and the availability of transportation to food stores. For instance, the availability of a variety of stores in the neighbourhood largely impacts the availability of diverse food choices^(3,4). Large supermarkets generally provide a greater number of nutrient-dense products at a lower cost compared with smaller grocery stores and convenience stores^(4–6). Compared with large supermarkets, convenience stores tend to sell high-energy foods, and the availability and variety of fresh foods may vary⁽⁴⁾. Research studies have noted differences in the quality of produce and fresh food offerings in grocery stores in areas

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with greater low-income, rural and minority populations⁽⁶⁾. As a result, residents of these areas may experience added challenges in obtaining healthy foods⁽⁶⁾. One strategy to address the issue of food access and availability focuses on introducing new supermarkets and grocery stores in low-income neighbourhoods. Stores are introduced with the intent to improve healthy food access, ultimately improving dietary outcomes and lowering diet-related diseases⁽⁷⁾. However, recent research has suggested that introducing these structural interventions may not alter consumption patterns or result in desired healthy dietary outcomes. For instance, a recent study in Philadelphia found that introducing a new supermarket in a low-income neighbourhood area without many supermarket options did not improve healthy food consumption and purchasing patterns or reduce BMI among respondents living in a 3-square mile area of the new grocery store compared with respondents in a comparison community⁽⁸⁾. The authors used a quasi-experimental longitudinal study design to compare the outcomes between a neighbourhood with a new supermarket and a similar neighbourhood with no supermarket. They used a difference-in-differences framework to estimate the difference between the control and treatment neighbourhood outcomes. The study did not find significant differences in BMI and fresh fruit and vegetable consumption between control and treatment neighbourhood residents. Similarly, in a study modelling the mechanisms associated with nutritional inequality, Alcott and colleagues⁽⁹⁾ illustrated that providing low-income households with access to similar food products and prices as those found in higher-income areas may not significantly reduce nutritional inequality. They used household grocery purchase data to study the within-household variation by comparing their purchasing behaviour before and after the introduction of a new supermarket. The authors found that the effects of supermarket introduction on healthy eating for households in food deserts might be economically insignificant even if they are sometimes statistically significant. These findings challenge the assumption that policies increasing the number of grocery stores in low-income neighbourhoods will automatically increase healthy food consumption.

Food environment perceptions may be related to BMI or other health outcomes. Liese and colleagues⁽¹⁰⁾ observed a relationship between the perceived lack of neighbourhood access to adequate food shopping and higher participant BMI. Research shows that individual perceptions of the local food environment are also associated with the objective local food environment⁽¹¹⁾. Individual perceptions of access to healthy foods in many studies mirrored the reality of low-income and vulnerable populations' food environments^(1,12,13). Cummins and colleagues⁽⁸⁾ concluded that bridging the gap between structural changes in the neighbourhood and people's perceptions was important in order to produce desired effects of policies on diet-related

behaviour and health outcomes. Given that local food environment perceptions play a critical role in influencing the effectiveness of health interventions and policies, it is important to study these factors and their relationship to health outcomes in vulnerable populations.

In this study, we assessed neighbourhood food environment perceptions among Supplemental Nutrition Assistance Program-Education (SNAP-Ed) and Expanded Food and Nutrition Education Program (EFNEP) participants. These two programmes provide community nutrition education programming to more than 3 million low-income adults and youth each year. These programmes also collaborate with local and state organisations to implement initiatives to increase access to healthy foods in organisations and communities^(14,15). We evaluated the relationship between participants' perceptions of their neighbourhood food environments and participants' health, notably obesity prevalence. We conducted a quantitative survey using a convenience sample of SNAP-Ed and EFNEP participants (*n* 1743) across six north central states. This is the first study to collect survey data from EFNEP and SNAP-Ed programme participants across several states to assess participants' perceptions of their neighbourhood food environments. Our research contributes to the existing literature by reporting on SNAP-Ed and EFNEP participants' perceptions of their environments and the relationship between participants' perceptions and their health outcomes.

Methods

Setting and context

This cross-sectional study stems from a multistate collaboration of EFNEP and/or SNAP-Ed programmes in six states (Illinois, Indiana, Michigan, Minnesota, Missouri and Wisconsin). Nationally, EFNEP and SNAP-Ed nutrition education programmes provide community education lessons on nutrition, food resource management, food safety and physical activity to more than 1 million low-income adults each year⁽¹⁶⁾. These programmes work to develop community partnerships and initiatives to increase healthy food and physical activity access for low-income populations through policy, systems and environmental changes^(14,15). The programmes classify 'low-income' based on the family eligibility for state or federal food assistance programmes such as the Special Supplemental Nutrition Assistance for Women, Infants and Children (WIC) and the Supplemental Nutrition Assistance Program (SNAP), at or below 185 % of the Federal Poverty guidelines^(14,15). For SNAP-Ed and EFNEP and for this study, we recruited participants by partnering with local agencies that serve eligible low-income populations. Examples of local agencies include Special Supplemental Nutrition Assistance for Women, Infants, and Children offices, housing shelters, food



pantries and community centres in low-income housing complexes⁽¹⁶⁾.

Convenience sampling was used to recruit adults to participate in a cross-sectional study and complete one self-administered questionnaire. To be able to participate in the study, individuals had to be eligible to participate in the EFNEP or SNAP-Ed programmes, at least 18 years of age, and able to speak and understand either English or Spanish. The survey was available in both languages. Participants were asked to answer questions about their perceptions of food and physical activity options available to them, nutrition-related health behaviours and personal characteristics. Participants were able to complete the survey at any point during their recruitment or participation in the SNAP-Ed or EFNEP programmes. Study participation was voluntary and did not affect their participation in the EFNEP or SNAP-Ed programmes. Participants were provided an incentive to complete the survey, and the value and form of the incentive varied by state from \$0.00 to \$10.00. Institutional Review Board (IRB) approval was obtained through each individual state institution prior to data collection. Data were collected from May to November 2017. There were 1849 surveys with complete outcome variable responses. We excluded eighty-nine respondents due to missing demographic or food environment information, thus leading to a sample size of 1760. We further excluded seventeen outliers based on the distribution of calculated BMI distribution values, leading to an analysis sample size of 1743.

Measures

Neighbourhood food environment

In April–May 2016, the Effect of Neighborhood Characteristics on Food Consumption and Health Behavior survey was adapted from existing, validated surveys created to assess the neighbourhood food environment perceptions^(17–20). The adapted survey was piloted through the Nutrition Education Program (IRB approval # 1603017383) at the authors' university in three urban areas (n 66 participants). Following the review of these data, three focus groups among SNAP-Ed participants were held to gain a better understanding of participant responses and comprehension of the survey questions. This feedback was incorporated into a revision of the survey, with the final survey version utilised in all six states.

BMI

Participant BMI was calculated using self-reported height (inches) and weight (pounds). BMI was calculated as $BMI (kg/m^2) = [Weight \text{ in pounds} / (Height \text{ in inches} \times Height \text{ in inches})] \times 703$.

Other covariates

Additional covariates included participant age, gender, neighbourhood type (urban/suburban/rural), educational attainment, race (American Indian or Alaska Native;

Hawaiian or Pacific Islander; Asian or Asian American; Black or African American; Non-Hispanic White; Multiracial) and marital status.

Analysis

Our primary categorical dependent variables were being obese ($BMI \geq 30 \text{ kg/m}^2$) and being overweight or obese ($BMI \geq 25 \text{ kg/m}^2$). The obese categorical variable is coded as '1' if the participant has $BMI \geq 30 \text{ kg/m}^2$ and '0' otherwise. Similarly, the overweight or obese categorical variable is coded as '1' if the participant has $BMI \geq 25 \text{ kg/m}^2$ and '0' otherwise. The dependent variables were regressed on the explanatory variables using an ordinary least square (for BMI) and logistic regression (for being obese and being overweight or obese). All analyses were completed in STATA, version 15 (StataCorp LLC). Both unadjusted and adjusted models were estimated. Unadjusted regression analyses were performed with independent variables defining the participants' perceptions of their food environment.

The final adjusted models included gender, age, race, marital status, employment status, state of residence and if region of residence was rural, urban or suburban variables. Except for the state of residence, all the other covariates were self-reported by the participant. Other statistically significant independent variables from the unadjusted analysis were also included in the adjusted analysis.

Results

Sample characteristics

The descriptive statistics are presented in Table 1. The final sample (n 1743) was 78% female with an average age of 44.43 years. Almost 42% of the sample was married and 41% was employed. Fifty-five percent resided in urban areas, while 31% and 14% lived in rural and suburban areas, respectively. Most (59%) of the respondents were non-Hispanic White, with 17% non-Hispanic Black and 11% Hispanic. Overall, 43% of participants were classified as obese and 74% of participants were classified as overweight or obese. There were 237 surveys from Illinois, 190 from Indiana, 444 from Michigan, 269 from Minnesota, 417 from Missouri and 186 from Wisconsin. The distribution of the demographic characteristics by state for SNAP participants is available in the online supplementary material, Appendix Table A.3. According to the United States Department of Agriculture (USDA) report on characteristics of SNAP households⁽²¹⁾, 6.7% of the SNAP participants in the country reside in rural areas and nearly 63% of them are female. As stated above, we recruited a convenience sample from each state. Hence, our sample is not a representative of the SNAP, SNAP-Ed and EFNEP programme participant population in any state or the entire country.

Table 1 Sample descriptive statistics (*n* 1743)

Variable name	Frequency of participants	% or average	SD
Age (years)		44.43	17.11
Female (%)	1361	78.08	
Non-Hispanic White (%)	1033	59.27	
Non-Hispanic Black (%)	306	17.56	
Hispanic (%)	194	11.13	
Other race (%)	210	12.05	
Married (%)	748	42.91	
Residing area = urban (%)	964	55.31	
Residing area = rural (%)	534	30.64	
Residing area = suburban (%)	245	14.06	
Employed (%)	726	41.65	
Obese (%)	761	43.66	
Obese or overweight (%)	1298	74.47	
Neither obese nor overweight (%)	445	25.53	
BMI (kg/m ²)		30.37	8.11
State of residence = Indiana (%)	190	10.90	
State of residence = Illinois (%)	237	13.60	
State of residence = Michigan (%)	444	25.47	
State of residence = Minnesota (%)	269	15.43	
State of residence = Missouri (%)	417	23.92	
State of residence = Wisconsin (%)	186	10.67	
Number of participants	1743	1743	

Percentages are reported for dichotomous variables. Means and sd are reported for continuous variables (age and BMI).

The questions included in this analysis pertaining to the respondent's neighbourhood food environment are presented in Table 2. These questions were answered on a 5-point Likert scale from strongly agree to strongly disagree. The perception of food availability in the neighbourhood, distance of grocery stores from the participant's home, amount of grocery shopping conducted within 20 min of walking distance and the type of store where the participants completed most of their food purchasing are considered as independent variables. Food environment questions were converted to binary variables with 1 representing strongly agree or agree responses, and 0 representing all other responses, to compare those who perceived the statement to be true to all others. Research shows that households living further than 5 miles from their principal grocery store consumed significantly less fruits and vegetables than those households living closer to the grocery store^(8,22). Following the literature, the categorical responses for distance of the grocery store where the households did most of their shopping were collapsed into two categories: distance less than or equal to 5 miles and distance more than 5 miles. The distribution of responses to the original questions is presented in the online supplementary material, Appendix Table A.1. Table 3 illustrates participant food environment perceptions by urban, rural and suburban neighbourhood. Perceptions of the availability of a large selection of affordable fresh fruits and vegetables, opportunities to purchase fast food and healthy meals were significantly different between those who reside in urban and rural areas (see online supplementary material,

Table 2 Participants' perception of their local food environment (*n* 1743)

Participant perceptions	Frequency of participants	Percent of participants
<i>Food environment variables (participants who agree/strongly agree)</i>		
Availability of large selection of affordable fresh fruits and vegetables	1195	68.56
Plenty of opportunities to purchase fast food	1431	82.10
Plenty of opportunities to purchase a healthy meal	900	51.64
Lack of public transportation limits food store choices	545	31.27
Plenty of opportunities to purchase healthy snack choices	943	54.10
Plenty of opportunity to purchase affordable, healthy food	815	46.76
More than half of food shopping done within 20 min walk (1 mile)	669	38.38
<i>Food stores where most of the food shopping is performed</i>		
Supermarkets or large superstores	1316	75.50
Small grocery stores, bodegas or delis	287	16.47
Convenience stores	65	3.73
Not sure/others	75	4.30
<i>Distance from home of the place where most of the household grocery shopping is conducted</i>		
Less than or equal to 5 miles	1100	63.11
More than 5 miles	643	36.89
Number of participants	1743	1743

Appendix Table A.4). There were also differences by neighbourhood regard to the type of store most frequently used for grocery shopping and the distances travelled to shopping store locations (see online supplementary material, Appendix Table A.4).

Perception of food environment

Sixty-eight percentage of the participants agreed that there was a large selection of fresh fruits and vegetables available for purchase in their neighbourhood. However, only 50 % of participants perceived that they had many opportunities to purchase a healthy and affordable meal and healthy snacks in their environment. Sixty-two percentage of the participants agreed that there were many opportunities for purchasing fast food in their neighbourhood. Seventy-five percentage of the participants purchased most of their groceries at supermarkets or large superstores. From the full sample, 27 % stated that the primary store where they did most of their food shopping was 1 mile or less away, while 36 % reported more than 1 mile and less than 5 miles away, 19 % between 1 and 5 miles, and 18 % more than 10 miles (see online supplementary material, Appendix Table A.2). The distance to where most shopping occurs differed by residing area (urban, rural and suburban). Sixty-one percentage of those living in rural areas travelled 5 or more miles away to the store where most household shopping occurred compared with 25 %

**Table 3** Distribution of food environment variables for urban, suburban and rural participants (*n* 1743)

Participant perceptions	Urban		Rural		Suburban	
	Frequency	%	Frequency	%	Frequency	%
<i>Food environment variables (percentage/frequency of participants who agree/strongly agree)</i>						
Availability of large selection of affordable fresh fruits and vegetables	683	70.85	342	64.04	170	69.39
Plenty of opportunities to purchase fast food	814	84.44	414	77.53	203	82.86
Plenty of opportunities to purchase a healthy meal	519	53.84	253	47.38	128	52.24
Lack of public transportation limits food store choices	313	32.47	161	30.15	71	28.98
Plenty of healthy snack choices available for purchase	518	53.73	283	53.00	142	57.96
Plenty of opportunity to purchase affordable healthy food	453	46.99	232	43.45	130	53.06
More than or equal to half of food shopping done within 20 min walk (1 mile)	439	45.54	122	22.85	108	44.08
<i>Food stores where most of the food shopping is performed</i>						
Supermarkets or large superstores	729	75.62	399	74.72	188	76.73
Small grocery stores, bodegas or delis	148	15.35	112	20.97	27	11.02
Convenience stores	48	4.98	11	2.06	6	2.45
Not sure/others	39	4.05	12	2.25	24	9.80
<i>Distance from home of the place where most of the household grocery shopping is conducted</i>						
Less than 5 miles	719	74.59	209	39.14	172	70.20
5 miles or more	245	25.41	352	60.86	73	29.80

and 30% of those living in urban and suburban areas, respectively (Table 3).

Association with overweight or obesity

Table 4 illustrates the results of logistic regression analyses predicting the odds of being obese and overweight or obese. Participant's perception of the availability of large selection of affordable fresh fruits and vegetables; perception of many opportunities to purchase affordable healthy food; perception of an acceptable distance from home to the grocery store where they shopped for the majority of their groceries; and perception that a lack of transportation limited food store choices were significantly associated with being overweight in the unadjusted analyses ($P < 0.05$). Distances of 5 or more miles from a participant's home to their primary grocery store and shopping for groceries most often at supermarkets and superstores were also significantly associated with being overweight or obese in unadjusted analyses. After adjusting for demographic characteristics, public transportation limitations and perceptions of distances greater than 5 miles to the primary grocery store were positive and significantly associated with overweight or obese weight status.

Association with obesity

Participant's perception of the availability of a large selection of affordable fresh fruits and vegetables, and shopping most often at convenience stores and supermarkets, was significantly associated with being obese in the unadjusted analysis ($P < 0.05$). Participant's perception of the availability of a large selection of fresh fruits and vegetables, report of shopping most often at convenience stores, and traveling a distance greater than 5 miles from the participant's home to the primary grocery store were associated with being obese after adjusting for demographic characteristics. Participants who perceived that a large selection of

fresh fruits and vegetables was available were 22% less likely to be obese than those who did not in the adjusted analyses (95% CI 0.63, 0.97). In unadjusted analyses, participants who purchased most of their food at convenience stores were 52% less likely to be obese than those who shopped most frequently at other locations (95% CI 0.27, 0.83). This significance was not sustained in adjusted analyses (adjusted odds ratio (AOR) 0.56; 95% CI 0.31, 1.02). It should be noted that only 4% of the sample reported purchasing most of their food at convenience stores, of which 75% were residing in urban areas.

Discussion

Our results suggest that a participants' perception of their neighbourhood food environment is associated with their weight. Participants who perceived that a large selection of fruits and vegetables was available to them were 20% less likely to be obese compared with those who did not perceive a large selection of fruits and vegetables to be available. This finding justifies the recently updated programme goals of SNAP-Ed and EFNEP to not only focus on direct education and individual-level knowledge and behaviour changes but also include the improvement of access to fresh fruits and vegetables in organisational and community settings available to low-income populations^(14,15). These programmes aim to promote healthy food intake and ultimately to have a positive impact on health outcomes^(14,15) of these individuals and households.

Participants who reported that they purchased most of their food at large supermarkets were more likely to be overweight and/or obese in unadjusted models. However, this relationship was not sustained in the adjusted models. Therefore, the inconsistency between

Table 4 Unadjusted and adjusted OR from logistic regression models predicting overweight or obesity and obesity among participants (*n* 1743)

Variable name	Overweight or obese				Obese			
	Unadjusted OR		Adjusted OR		Unadjusted OR		Adjusted OR	
<i>Food environment variables</i>								
Availability of large selection of affordable fresh fruits and vegetables	0.76**	0.59–0.96	0.77*	0.58–1.02	0.83*	0.68–1.02	0.79**	0.64–0.98
Plenty of opportunities to purchase fast food	0.94	0.71–1.25			0.95	0.74–1.22		
Plenty of opportunities to purchase a healthy meal	0.90	0.72–1.12			0.95	0.79–1.15		
Lack of public transportation limits food store choices	0.74**	0.59–0.93	0.70***	0.55–0.89	0.97	0.79–1.20		
Plenty of opportunities to purchase healthy snack choices	0.84	0.67–1.04			0.92	0.76–1.11		
Plenty of opportunity to purchase affordable, healthy food	0.80**	0.64–0.99	0.87	0.68–1.12	0.90	0.74–1.09		
More than half of food shopping done within 20 min walk (1 mile)	0.86	0.69–1.08			0.86	0.70–1.04		
<i>Kind of food stores where most of the food shopping is performed</i>								
Supermarkets or large superstores	1.36**	1.07–1.74	1.17	0.91–1.52	1.36***	1.09–1.70	1.13	0.89–1.45
Small grocery stores, bodegas or delis	0.81	0.61–1.07			0.85	0.65–1.10		
Convenience stores	0.76	0.44–1.30			0.48***	0.27–0.83	0.56*	0.30–1.00
<i>Distance from home of the place where most of the household grocery shopping is conducted (miles)</i>								
Less than or equal to 5 miles	Base		Base		Base		Base	
More than 5 miles	1.41***	1.12–1.78	1.39**	1.08–1.80	1.18*	0.97–1.44	1.18	0.95–1.47
<i>Demographic variables</i>								
Age	1.01***	1.01–1.02	1.02***	1.01–1.03	1.00**	1.00–1.01	1.00	1.00–1.01
Female	1.19	0.92–1.54	1.07	0.82–1.38	1.49***	1.18–1.88	1.38***	1.08–1.77
Non-Hispanic White	Base		Base		Base		Base	
Non-Hispanic Black	1.07	0.80–1.45	1.34*	0.98–1.84	1.13	0.88–1.7	1.31**	1.00–1.77
Hispanic	0.66**	0.48–0.91	0.81	0.58–1.13	0.67**	0.49–0.91	0.75*	0.54–1.03
Other race	1.30	0.89–1.89	1.47*	0.97–2.21	1.02	0.75–1.40	1.03	0.73–1.43
Married	1.26**	1.01–1.57	1.21*	0.96–1.54	1.03	0.85–1.25	1.05	0.85–1.29
Employed	0.94	0.75–1.17	1.04	0.83–1.31	0.87	0.72–1.05	0.91	0.74–1.11
Residing area = urban	1.41**	1.04–1.92	1.50**	1.10–2.04	1.34**	1.00–1.79	1.31*	0.98–1.76
Residing area = rural	1.57***	1.12–2.19	1.36	0.96–1.92	1.26	0.92–1.72	1.18	0.85–1.63
Residing area = suburban	Base		Base		Base		Base	
<i>n</i>	1743		1743		1743		1743	

*, **, *** $P < 0.1$, $P < 0.05$, $P < 0.001$ significance. SE are adjusted for heteroskedasticity. Estimates are controlled for state fixed effects. The reference case for overweight or obese models is defined as BMI ≤ 25 kg/m². The reference case for obese models is defined as BMI ≤ 30 kg/m².

the perception of available fruits and vegetables and shopping frequency at supermarkets or large superstores still warrants further study. Previous studies indicate that the quality of fresh fruits and vegetables could be inadequate in low-income neighbourhood stores⁽⁶⁾, leading to a possible explanation for our observation. More research is needed to clarify the relationship between shopping at large supermarkets and obesity, as most of the previous research and programmes have focused on improving access to healthy food through development of new food stores.

The distance people travel to get to food stores may affect food choices and health outcomes. In the adjusted models, participants who perceived the distance of the primary grocery store to be more than 5 miles were 60 % more likely to be overweight or obese, and this is consistent with previous literature⁽²³⁾. In this study, 31 % of the participants resided in rural areas, and nearly 61 % of those residing in

rural areas travelled more than 5 miles to their primary grocery store. In adjusted models, however, those residing in rural areas were not more likely to be obese or obese/overweight compared with those in the other areas. It must be noted that while 31 % of participants in this study was from rural areas, only 19.3 % of US population resides in rural areas⁽²⁴⁾. The observed differences could be due to convenience sampling methods used in this study.

In the unadjusted model, participants who shopped most often at convenience stores were 50 % less likely to be obese compared with those who stated otherwise. This significance was not sustained in the adjusted model. Previous literature is not consistent for the relationship between convenience store proximity and obesity. Some studies found no link between proximity to convenience store and BMI^(25,26), while other studies report a positive correlation between proximity to convenience store and BMI^(27,28). Further, studies found that individuals with a



convenience store and supermarket in their neighbourhood perceived that their neighbourhood had higher availability of fruits and vegetables⁽²⁹⁾.

In this study, participants who perceived a lack of available public transportation were less likely to be obese or overweight (AOR 0.72, 95 % CI 0.57, 0.92). To our knowledge, this observation has not been made in previous studies and contradicts a growing literature connecting public transportation use to lower obesity rates^(30,31). While transportation limitations could result in more walking⁽³²⁾, this finding warrants further study to understand how transportation access affects food purchasing decisions in this population. It is unclear if the participants of this study perceived that they walked more due to the lack of transportation, or if participants were providing their opinions on public transportation options that they do not need to use, or if there were other factors that would explain the lower probability of these participants' being overweight or obese. We investigated the potential difference in public transportation perceptions by region of residence (urban or rural) and there was no statistical difference in public transportation perceptions by this region of residence (data not shown). Participants with limited transportation options may still experience real limitations related to the cost or quality of food available to them. A previous study⁽³³⁾ on community food resources showed that residents of a low-income neighbourhood lacking public transportation options had limited availability of fresh food and were incurring higher costs for fruits, vegetables and bread compared with those living in neighbourhoods with a greater availability of public transportation. While research shows that 66 % of SNAP households use their own vehicle to go shopping, 21 % use someone else's car or rideshare to go food shopping, and 13 % walk, bike or take public transportation, supporting the potential utility of transportation solutions to address potential food access challenges for low-income populations⁽³⁴⁾. Transportation solutions might include physical infrastructure improvement to support active living, systems to improve communication about available options and programmes including ride-sharing services, discounted taxis and grocery delivery services. The relationship between transportation options, food consumption and long-term health still warrants additional study.

Limitations

To the best of our knowledge, this is the first study to investigate the perception of neighbourhood food environments in a large, multistate sample of SNAP-Ed and EFNEP participants. This study has several limitations. We used cross-sectional data from a convenience sample, which restricts causal inference. The participants in this survey were not necessarily the primary shoppers for their households, although the EFNEP and SNAP-Ed programmes did include

lessons on making healthy choices for both the participant and their families, such as shopping strategies, reading nutrition labels, preparing shopping lists and food preparation tips. In this context, a questionnaire about the participants' perceptions of their neighbourhood food environments is complementary to the content of the programme's focus on encouraging healthy food purchases.

One drawback of the study is that the participants were allowed to complete the survey at any point during their participation in the programme and there is the possibility that some participants completed the survey at the beginning of the programme and some at the end. However, the eligibility criteria for the programme were consistent throughout the period of the survey, thus not affecting the target group of survey respondents. This study was also independent of the participants' progress or status in the nutrition education programmes. While many participants of the study (20 %) had not completed any nutrition education classes, one of the topics discussed during the programmes was 'Making Food Dollars Stretch', which could potentially influence perceptions about affordable food in terms of purchasing more given income limitations. However, we do not have evidence as to whether the concept of 'making food dollars stretch' would impact one's perception of neighbourhood food options or the distance one travels to purchase food. Further, the SNAP-Ed and EFNEP programmes are implemented differently between states, and the state programmes collaborate with different agencies for the delivery of the programmes' content, affecting the sample recruited from state to state. However, it is important to note that each state shared the goal of reaching its entire SNAP-eligible population.

We did not ask about the participants' incomes in the survey. The SNAP-Ed and EFNEP programmes have income criteria for participation (below 185 % of the federal poverty guideline). The inclusion criteria stated that the participants had to be eligible to participate in the two programmes, and we did not further assess income because, by definition, the study population was restricted by the programmes' participation criteria. We had no reason to consider that the state programmes would allow participants who were not eligible for their programmes to participate in this study.

While the issue was not raised during either survey development or the pilot testing/focus groups, it is possible that the participants might have been confused by the survey question wording. For instance, while the survey wording referred to 'The type of food store where most of the food shopping is performed', it is not clear whether some participants considered this to mean where they shopped most often or where most of their food was purchased. It is possible that a person might shop at a convenience store more often than at a supermarket or large grocery store, but they still might purchase the bulk of the food they consume at the less frequently visited location. There is also the possibility of other misclassification biases due to



differences in interpretations of the shopping store categories. For instance, it is not clear whether participants included dollar stores with more offerings than traditional convenience stores in the same category. However, no such misunderstandings were apparent during the pilot development of the survey.

We asked participants about the distance from their home to the places where most of their food shopping is completed, but we missed the opportunity to ask the participants which mode of transportation they used most often when going food shopping. This information could have provided valuable contextual information about their habits and the options that were available to them. The survey was conducted from May to November 2017, which might have led to a seasonality bias due to variations in the month or week in which the participants responded to the survey. To account for this variation, we controlled for the participant interview month in our estimation, thus controlling for variation in participant response due to the seasonality.

This study provides information to illustrate the importance of addressing resident perceptions in the development of food environment options. There is a need for clarity regarding how perceptions affect food purchasing behaviours and motivations for healthy food intake. Future studies on the perceptions of the food environment should also consider the motivations for decisions made.

Public health implications

Perceptions of the food environment may have an impact on health outcomes, particularly in low-income populations where obesity rates are high. Hence, the design of future interventions and policies to modify the environment should also take into consideration the resident's perception in order to maximise potential impact. Programmes like SNAP-Ed and EFNEP have an opportunity to affect participant perceptions through education on existing food options, techniques for stretching food dollars and through the implementation of community food access initiatives and collaborations with various local organisations and community governments. SNAP-ED and EFNEP can develop policies, systems and physical, social and economic solutions to improve food access for low-income populations. It is important for programme providers to be aware of participant perceptions and facilitate discussions to address perceived barriers to healthy eating and active living.

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Supplementary material

For supplementary material accompanying this paper visit <https://doi.org/10.1017/S136898002000155X>.

References

1. Inglis V, Ball K & Crawford D (2008) Socioeconomic variations in women's diets: what is the role of perceptions of the local food environment? *J Epidemiol Community Health* **62**, 191–197.
2. Caldwell EM, Kobayashi MM, DuBow WM *et al.* (2009) Perceived access to fruits and vegetables associated with increased consumption. *Public Health Nutr* **12**, 1743–1750.
3. Gosliner W, Brown DM, Sun BC *et al.* (2018) Availability, quality and price of produce in low-income neighbourhood food stores in California raise equity issues. *Public Health Nutr* **21**, 1639–1648.
4. Krukowski RA, West DS, Harvey-Berino J *et al.* (2010) Neighborhood impact on healthy food availability and pricing in food stores. *J Community Health* **35**, 315–320.
5. Story M, Kaphingst KM, Robinson-O'Brien R *et al.* (2008) Creating healthy food and eating environments: policy and environmental approaches. *Annu Rev Public Health* **29**, 253–272.
6. Larson NI, Story MT & Nelson MC (2009) Neighborhood environments: disparities in access to healthy foods in the US. *Am J Prev Med* **36**, 74–81.
7. Gortmaker SL, Swinburn BA, Levy D *et al.* (2011) Changing the future of obesity: science, policy, and action. *Lancet* **378**, 838–847.
8. Cummins S, Flint E & Matthews SA (2014) New neighborhood grocery store increased awareness of food access but did not alter dietary habits or obesity. *Health Aff* **33**, 283–291.



9. Allcott H, Diamond R, Dubé JP *et al.* (2019) Food deserts and the causes of nutritional inequality. *QJEcon* **134**, 1793–1844.
10. Liese A, Ma X, Hutto B *et al.* (2017) Food shopping and acquisition behaviors in relation to BMI among residents of low-income communities in south Carolina. *Int J Environ Res Public Health* **14**, 1075.
11. Moore LV, Roux AVD & Brines S (2008) Comparing perception-based and geographic information system (GIS)-based characterizations of the local food environment. *J Urban Health* **85**, 206–216.
12. Jilcott SB, Laraia BA, Evenson KR *et al.* (2009) Perceptions of the community food environment and related influences on food choice among midlife women residing in rural and urban areas: a qualitative analysis. *Women Health* **49**, 164–180.
13. Freedman DA & Bell BA (2009) Access to healthful foods among an urban food insecure population: perceptions versus reality. *J Urban Health* **86**, 825–838.
14. USDA National Institute of Food and Agriculture (2017) The Expanded Food and Nutrition Education Program Policies. <https://nifa.usda.gov/program/expanded-food-and-nutrition-education-program-efnep> (accessed March 2020).
15. USDA National Institute of Food and Agriculture (2019) FY 2020 SNAP-Ed Plan Guidance. <https://nifa.usda.gov/program/expanded-food-and-nutrition-education-program-efnep> (accessed March 2020).
16. Gleason S, Wolford B, Wilkin M *et al.* (2018) Analysis of Supplemental Nutrition Assistance Program Education (SNAP-Ed) data for all states study: final report. Prepared by Altarum Institute for the U.S. Department of Agriculture, Food and Nutrition Service.
17. Echeverria SE, Diez-Roux AV & Link BG (2004) Reliability of self-reported neighborhood characteristics. *J Urban Health* **81**, 682–701.
18. Green SH & Glanz K (2015) Development of the perceived nutrition environment measures survey. *Am J Prev Med* **49**, 50–61.
19. Moore LV, Diez Roux AV, Nettleton JA *et al.* (2008) Associations of the local food environment with diet quality—a comparison of assessments based on surveys and geographic information systems: the multi-ethnic study of atherosclerosis. *Am J Epidemiol* **167**, 917–924.
20. US Census Bureau (2019) Survey of Income and Program Participation. <https://www.census.gov/sipp/> (accessed September 2019).
21. USDA National Institute of Food and Agriculture (2019) Characteristics of Supplemental Nutrition Assistance Program Households: Fiscal Year 2017. <https://fns-prod.azureedge.net/sites/default/files/resource-files/Characteristics2017.pdf> (accessed March 2020).
22. Rose D & Richards R (2004) Food store access and household fruit and vegetable use among participants in the US Food Stamp Program. *Public Health Nutr* **7**, 1081–1088.
23. Ghosh-Dastidar B, Cohen D, Hunter G *et al.* (2014) Distance to store, food prices, and obesity in urban food deserts. *Am J Prev Med* **47**, 587–595.
24. US Census 2011–2015 American Community Survey, 5-year estimates and 2015 American Community Survey, 1-year estimates. [cited 2016].
25. Black JL, Macinko J, Dixon LB *et al.* (2010) Neighborhoods and obesity in New York City. *Health Place* **16**, 489–499.
26. Wang MC, Kim S, Gonzalez AA *et al.* (2007) Socioeconomic and food-related physical characteristics of the neighbourhood environment are associated with body mass index. *J Epidemiol Community Health* **61**, 491–498.
27. Powell LM, Auld MC, Chaloupka FJ *et al.* (2007) Associations between access to food stores and adolescent body mass index. *Am J Prev Med* **33**, S301–S307.
28. Bodor JN, Rice JC, Farley TA *et al.* (2010) The association between obesity and urban food environments. *J Urban Health* **87**, 771–781.
29. Gustafson AA, Sharkey J, Samuel-Hodge CD *et al.* (2011) Perceived and objective measures of the food store environment and the association with weight and diet among low-income women in North Carolina. *Public Health Nutr* **14**, 1032–1038. <https://www.census.gov/library/visualizations/2016/comm/acs-rural-urban.html> (accessed March 2020).
30. King DM & Jacobson SH (2017) What is driving obesity? A review of the connections between obesity and motorized transportation. *Curr Obes Rep* **6**, 3–9.
31. She Z, King DM & Jacobson SH (2019) Is promoting public transit an effective intervention for obesity? A longitudinal study of the relation between public transit usage and obesity. *Trans Res A Policy Pract* **119**, 162–169.
32. Belfort CA, Nazir N, Perri MG (2012) Prevalence of obesity among adults from rural and urban areas of the United States; findings from NHANES (2005–2008). *J Rural Health* **28**, 392–397.
33. Lopez-Class M & Hosler AS (2010) Assessment of community food resources: a Latino neighborhood study in upstate New York. *J Poverty* **14**, 369–381.
34. Ver Ploeg M, Mancino L, Todd JE *et al.* (2015) Where do Americans usually shop for food and how do they travel to get there? Initial findings from the National Household Food Acquisition and Purchase Survey (No. 1476-2017-3882).