Short Communication

Comparing food desert residents with non-food desert residents on grocery shopping behaviours, diet and BMI: results from a propensity score analysis

Rebecca C Woodruff*, Regine Haardörfer, Ilana G Raskind, April Hermstad and Michelle C Kegler
Emory Prevention Research Center, Behavioral Sciences and Health Education Department, Rollins School of Public Health, Emory University, 1518 Clifton Road NE, Atlanta, GA 30032, USA

Abstract

Objective: To determine whether residence in a US Department of Agriculture-designated food desert is associated with perceived access to healthy foods, grocery shopping behaviours, diet and BMI among a national sample of primary food shoppers.
Design: Data for the present study came from a self-administered cross-sectional survey administered in 2015. Residential addresses of respondents were geocoded to determine whether their census tract of residence was a designated food desert or not. Inverse probability of treatment-weighted regression was used to assess whether residence in a food desert was associated with dependent variables of interest.
Setting: USA.
Participants: Of 4942 adult survey respondents, residential addresses of 75·0 % (*n* 3705) primary food shoppers were included in the analysis.
Results: Residence in a food desert (11·1 %, *n* 411) was not significantly associated with perceived access to healthy foods, most grocery shopping behaviours or dietary behaviour, but was significantly associated with primarily shopping at a superstore or supercentre *v.* a large grocery store (OR = 1·32; 95 % CI 1·02, 1·71; $P = 0·03$) and higher BMI ($b = 1·14$; 95 % CI 0·36, 1·93; $P = 0·004$).
Conclusions: Results suggest that food desert residents shop at different food stores and have higher BMI than non-food desert residents.

Limited access to healthy food retailers may contribute to the high prevalence of obesity and chronic disease in the USA[1]. Supermarkets and grocery stores are typically considered retailers of healthy foods, as these stores have been shown to sell a larger selection of affordably priced, healthier food items compared with smaller food stores[2]. However, multiple systematic reviews have documented disparities in access to healthy food retailers[3,4]. According to the US Department of Agriculture, 6·2 % of the US population resides in a census tract that is classified as a food desert, meaning it is both low-income and has limited access to healthy food retailers[5]. Prior systematic

reviews have found mixed results regarding the association between various measures of access to healthy food retailers and dietary behaviour[6] and weight[7], although no known studies have examined variation in these outcomes by food desert status at a national scale. One prior study from South Carolina suggests that such differences may exist[8] and could be explored on a national scale. Such research may assist in interpreting descriptive analyses of the food shopping and dietary behaviours of food desert residents[9,10] and assist public health practitioners with targeting interventions to improve local food environments as a chronic disease prevention strategy.

Corresponding author: Email rwoodr2@emory.edu

Methods

The current secondary analysis used data from the National Home Environment Survey, an online survey commissioned by the Emory Prevention Research Center to characterize the home food environments of US adults. The survey was administered in autumn 2015 by Lightspeed (http://www.lightspeedresearch.com/), an online market research firm which maintains a panel of over 5·5 million respondents in forty-five countries.

Eligible participants were adults aged 18–75 years living in the USA and who were able to read English. The study used recruitment quotas to ensure the demographic, socio-economic and geographic distribution of the sample reflected that of the overall US population. Matching variables used for the recruitment quotas included age, gender, race/ethnicity, geographic region and annual household income. Lightspeed identified panellists meeting eligibility criteria and sent survey invitations by email. Participants who provided informed consent and completed the 30 min survey received compensation provided by Lightspeed. A total of 12 396 individuals consented to participate in the study; reasons for not completing the survey included not meeting a recruitment quota (n 3811, 30·7 %), discontinuation of the survey (n 2994, 24·2 %) and termination by Lightspeed due to in-survey quality violations (n 649, 5·2 %).

Of the 4942 respondents, 75·0 % were included in the current analysis; participants were excluded if they reported no involvement with grocery shopping for the household (16·1 %), reported fruit and vegetable intake that exceeded three times the standard deviation added to the interquartile range (3·9 %), and inability to geocode the residential address to a census tract to determine its food desert status (2·1 %). Less than 3 % of the sample was excluded due to missing data; missingness was associated with younger age, male sex, Asian race, single or widowed/separated/divorced marital status, earning in the $US 15 000–49 000 range, living with others, not being on food stamps, and living in a small town or suburban area. The Emory University Institutional Review Board approved all study procedures.

Residence in a food desert was determined by geocoding participants' residential addresses using Google Earth Pro, joining them to census tracts in ArcMap 10.5.1 (ArcGIS Desktop: Release 10) and matching them to the US Department of Agriculture's Food Access Research Atlas. This Atlas designates census tracts as food deserts if they are low-income (poverty rate ≥20 % or median family income <80 % of either the state or metropolitan-area median income) and low-access (≥500 people or 33 % of population living either 1·61 km (1 mile; urban) or 16·1 km (10 miles; rural) from the nearest supermarket, supercentre or large grocery store)[5].

The survey was self-administered online and included seventy-five questions and periodic quality check questions. Involvement with grocery shopping was determined by asking who the primary food shopper for the household is. Respondents were included in the analysis if they indicated that they were the primary food shopper, that they take turns with someone else or go with someone else; those who indicated that their spouse/partner, parent/parent-in-law or someone else was the primary shopper were excluded.

Perceived access to healthy foods was measured by summing participants' responses to six items assessing quality, selection, and ease of purchasing fruits and vegetables and low-fat products in their neighbourhood on a five-point Likert scale (from 1 = 'strongly disagree' to 5 = 'strongly agree', range = 6–30)[11].

Store type was assessed with a single item asking participants to think about the place where the primary food shopper(s) for the household shops most frequently for groceries and to indicate the store type. Response options were 'large chain grocery store', 'smaller grocery store', 'superstore or supercentre' (e.g. Wal-Mart or Target), 'warehouse club store' (e.g. Sam's Club or Costco), 'dollar store', 'convenience store with or without a gas station attached' (e.g. 7-Eleven or mini-market), 'farmers' market or co-op' or 'specialty store' (e.g. an ethnic specialty store, meat market, seafood market, greengrocer or bakery). Frequency of grocery shopping was assessed by asking the respondent how many times per month the primary food shopper usually shops at that store. Responses were categorized into >4 times/month, 4 times/month or <4 times/month for analyses. Distance from store to home was measured by asking, 'About how many miles is this store from your home?' Respondents recorded an open integer representing the number of miles. Amount spent per trip was assessed by asking how much the primary food shopper(s) usually spend on food each time they shop at the store, including all methods of payment (e.g. cash, electronic benefit transfer/food stamps, debit/credit card). Response options were <$US 25, $US 25–49·99, $US 50–74·99, $US 75–99·99, $US 100–149·99, $US 150–199·99 or ≥$US 200.

Fruit and vegetable consumption was measured using an eighteen-item screener asking about frequency and quantity of consumption of nine type of fruits and vegetables[12]. Dietary fat intake as a percentage of total daily energy intake was estimated using a brief screener assessing frequency of consumption per week of fifteen food items[13]. BMI (kg/m^2) was calculated from self-reported height and weight.

Propensity score analysis using inverse probability of treatment-weighted regression was the analytic approach. This method is commonly used in observational research to at least partially account for systematic differences between

the exposed and unexposed groups due to non-random assignment mechanisms by creating a pseudo-population that is better balanced on observed characteristics linked to group membership[14]. Propensity scores were generated by performing the regression of an indicator variable for residence in a food desert or not *v.* the following theoretical confounders: age, gender, race, marital status, employment status, education, income, indicator variables for living alone and presence of children in the home, car ownership, receipt of Supplemental Nutrition Assistance Program (SNAP) benefits and rurality. The inverse of the propensity scores (i.e. inverse probability of treatment weights) were used as weighting variables to account for systematic differences in food desert residents and non-food desert residents. Data were analysed with the statistical software package SAS version 9.4 using the GENMOD, SURVEYREG and SURVEYLOGISITIC procedures to account for these weights and produce robust standard errors.

Results

Relatively few respondents lived in a food desert (11·1 %; Table 1). The sample tended to be middle-aged (mean age = 45·5 (sd 15·18) years), female (57·0 %) and White (66·7 %). Most were employed for wages or self-employed (54·8 %) and had a college degree or higher (49·4 %). The majority (73·6 %) lived with at least one other person in the home and 34·8 % had at least one child living at home. Just over 14 % of respondents reported receiving SNAP benefits. Most lived in suburban (42·6 %) or urban (28·2 %) areas, and the majority owned a car (90·9 %).

In bivariate analyses prior to applying the inverse probability of treatment weights, food desert residents were more likely to be African American ($P < 0.0001$), to be unemployed ($P = 0.002$), more likely to have some college ($P = 0.006$) or high school or less ($P = 0.004$), to report lower household income levels and to report receiving SNAP benefits ($P < 0.0001$). Food desert residents were less likely to report living in suburban areas ($P < 0.0001$). After applying inverse probability of treatment weights, there were no significant differences between food desert and non-food desert residents in demographic, socio-economic or geographic characteristics (Table 1).

The majority of respondents reported primarily shopping at a large grocery store (53·5 %) or superstore/supercentre (27·3 %; Table 2). Few respondents reported primarily shopping at a dollar store or convenience store (1·2 %). The primary store was located a mean of 8·6 (sd 12·10) km (5·4 (sd 7·52) miles) from the respondent's home. Most respondents shopped for groceries fewer than 4 times/month (35·2 %) and spent $US 50–99·99 each trip (37·1 %). Mean perceived access to healthy foods

score was 22·1 (sd 6·25). Respondents reported eating a mean of 2·5 (sd 2·02) daily servings of fruits and vegetables, consumed a mean of 34·6 (sd 4·64) % of their total daily energy intake from dietary fat and had a mean BMI of 27·8 (sd 6·84) kg/m^2.

In inverse probability of treatment-weighted models, food desert residents were more likely to shop at a superstore or supercentre *v.* a large grocery store (OR = 1·32; 95 % CI 1·02, 1·71; $P = 0.03$) and had higher BMI ($b = 1·14$; 95 % CI 0·36, 1·93; $P = 0.004$) relative to non-food desert residents (Table 2). Food desert residents did not report significantly different perceived access to healthy foods, frequency of grocery shopping, distance from home to primary store, dollar amount spent per shopping trip, fruit and vegetable intake or dietary fat intake, relative to non-residents.

Discussion

The present study found that although residence in a food desert was significantly associated with the most frequently used grocery store type and BMI, it was not significantly associated with perceived access to healthy foods, other grocery shopping practices or dietary behaviour among primary food shoppers in the USA, after accounting for systematic differences in the characteristics of the populations who live in food deserts *v.* non-food deserts. This finding is surprising, given that it contradicts social ecological frameworks of health promotion which suggest that community-level factors are important determinants of health behaviours[1]. Additionally, these findings contradict those from similar studies which found that food shopping behaviours vary by community-level access to healthy foods[8] and food security[15], although these studies were conducted among specific geographic areas and are not directly comparable to this national study.

Recently, critiques of the food desert concept have emerged in the peer-reviewed literature[16–18]. These articles suggest that determining access to healthy foods in geographic areas defined by arbitrary administrative boundaries may overlook other important dimensions of access, including the quantity, quality and affordability of products sold within these stores and local community-led solutions to increase access to healthy foods[19]. Replications of the present study using other innovative approaches to measuring the community food environment, including the use of activity spaces, multidimensional measures of access that account for in-store food environments and the Centers for Disease Control and Prevention's healthier food retail tracts, would advance this area of research.

Strengths of the present study include that it is the first known analysis to use residence in a food desert as an

Table 1 Demographic, socio-economic and geographic characteristics of primary food shoppers in the USA by food desert status, 2015

		Unweighted			Inverse probability of treatment-weighted		
Characteristic	Total, unweighted (n 3705)	Does not live in a food desert (n 3294)	Lives in a food desert (n 411)	P	Does not live in a food desert (n 3294)	Lives in a food desert (n 411)	P
	Mean, SD or %	Mean, SD or %	Mean, SD or %		Mean, SD or %	Mean, SD or %	
Age (years)				0·91			0·91
Mean	45·5	45·5	45·5		45·5	44·9	
SD	15·18	15·16	15·30		16·15	45·1	
Female (%)	57·0	56·5	61·1	0·08	57·0	56·5	0·64
Race (%)							
White	66·7	67·6	59·8	Ref.	66·7	66·2	Ref.
African American	12·8	11·9	20·2	<0·0001	12·8	13·1	0·67
Hispanic	14·6	14·5	15·3	0·23	14·5	14·3	0·88
Asian	5·3	5·5	3·7	0·30	5·3	5·6	0·60
Other	0·7	0·6	1·0	0·32	0·7	0·8	0·44
Marital status (%)							
Married or partnered	55·1	55·5	52·1	Ref.	55·1	55·9	Ref.
Divorced, separated or widowed	16·0	15·8	17·5	0·25	16·0	15·7	0·61
Single	28·9	28·7	30·4	0·31	28·9	28·4	0·58
Employment status (%)							
Employed for wages or self-employed	54·8	56·1	44·5	Ref.	54·9	56·4	Ref.
Unemployed	9·0	8·6	11·7	0·002	9·0	8·9	0·66
Homemaker, student or retired	36·2	35·3	43·8	<0·0001	36·2	34·7	0·16
Highest education (%)							
College graduate or higher	49·4	50·4	41·6	Ref.	49·4	47·9	Ref.
Some college	31·9	31·3	36·0	0·006	31·9	33·0	0·22
High school or less	18·7	18·3	22·4	0·004	18·7	19·1	0·44
Annual household income (%)							
≥$US 100 000	19·0	20·2	9·0	Ref.	19·0	18·6	Ref.
$US 75 000–99 999	11·9	12·1	10·0	0·01	11·8	10·8	0·42
$US 50 000–74 999	17·2	17·3	16·1	0·0006	17·2	17·4	0·67
$US 35 000–49 999	13·6	13·0	17·5	<0·001	13·5	13·0	0·74
$US 25 000–34 999	12·2	12·0	13·6	<0·001	12·2	12·7	0·49
$US 15 000–24 999	12·7	12·4	15·3	<0·001	12·7	13·7	0·27
<$US 15 000	13·6	13·0	18·5	<0·001	13·6	13·7	0·77
At least one other person in home (%)	73·6	74·0	70·6	0·14	73·6	73·7	0·92
At least one child in the home (%)	34·8	34·9	33·6	0·59	34·8	36·9	0·06
Owns a car (%)	90·9	91·0	90·3	0·63	90·9	91·1	0·82
Receives SNAP benefits (%)	14·7	13·9	21·2	<0·0001	14·7	16·1	0·11
Neighbourhood type (%)							
Urban	28·2	27·6	33·4	Ref.	28·2	29·9	Ref.
Suburban	42·6	44·0	31·0	<0·0001	42·5	41·5	0·13
Small town	15·7	14·9	21·7	0·21	15·7	14·8	0·13
Rural	13·6	13·5	13·9	0·32	13·6	13·8	0·60

SNAP, Supplemental Nutrition Assistance Program; ref., reference category.
Bivariate associations between residence in a food desert and outcomes were generated using unadjusted linear, binary logistic and multinomial logistic regression models, depending on the dependent variable type.

independent variable among a national sample, as well as the first known application of propensity score analysis within this content area. Limitations include that the data are cross-sectional, limiting causal inference, and that US adults without Internet access would have been systematically excluded from this study. Additionally, as Lightspeed's methods of recruiting its underlying panel are unavailable, we have limited ability to conclude that these results represent or generalize to the broader US population. Despite these limitations, these findings add to the growing literature assessing the relationship between access to healthy food retailers and chronic disease-related outcomes.

Table 2 Perceived access to healthy foods, grocery shopping practices, diet and BMI stratified by residence in a food desert among primary food shoppers in the USA, 2015

	Descriptive statistics				Regression results					
	Does not live in a food desert (n 3294)		Lives in a food desert (n 411)		Unweighted bivariate model			Inverse probability of treatment-weighted model		
	Mean or %	SD or n	Mean or %	SD or n	OR or b	95 % CI	P	OR or b	95 % CI	P
Perceived access to healthy foods (mean and SD)	22·2	6·16	21·2	6·83	−1·02	−1·66, −0·38	0·002	−0·62	−1·39, 0·15	0·12
Primary store type (% and n)										
Large grocery store	54·1	1781	48·7	200	Ref.	–	–	Ref.	–	–
Superstore or supercentre	26·4	870	34·1	140	1·26	0·91, 1·74	0·17	1·32	1·02, 1·71	0·03
Smaller grocery store	11·2	369	12·7	52	1·43	1·14, 1·81	0·002	1·18	0·82, 1·70	0·37
Warehouse club	4·5	149	2·9	12	0·72	0·39, 1·32	0·28	0·76	0·37, 1·54	0·44
Farmers' market, co-op or specialty store	2·6	84	1·2	5	†	–	–	†	–	–
Dollar store or convenience store	1·3	41	0·5	2	†	–	–	†	–	–
Frequency of grocery shopping (% and n)										
>4 times/month	33·8	1112	28·5	117	Ref.			Ref.		
4 times/month	32·2	1062	26·8	110	0·98	0·75, 1·29	0·91	0·96	0·71, 1·30	0·79
<4 times/month	34·0	1120	44·8	184	1·56	1·22, 2·00	0·0004	1·28	0·97, 1·69	0·08
Distance from home to primary store (miles*; mean and SD)	5·4	7·46	5·8	7·95	0·08	−0·06, 0·22	0·27	0·04	−0·10, 0·17	0·58
Dollar amount spent per shopping trip (% and n)										
≥$US 200	5·2	172	6·1	25	Ref.			Ref.		
$US 150–$199·99	7·4	245	7·5	31	0·87	0·50, 1·53	0·63	1·01	0·54, 1·90	0·98
$US 100–$149·99	18·9	622	22·1	91	1·01	0·63, 1·62	0·98	1·12	0·66, 1·90	0·68
$US 50–$99·99	37·4	1233	34·6	142	0·79	0·50, 1·25	0·32	0·82	0·49, 1·37	0·45
$US 25–$49·99	24·4	803	22·9	94	0·81	0·50, 1·29	0·37	0·74	0·44, 1·26	0·27
<$US 25	6·7	219	6·8	28	0·88	0·50, 1·56	0·66	0·73	0·39, 1·37	0·33
Fruit and vegetable intake (servings/d; mean and SD)	2·5	2·03	2·3	1·96	−0·14	−0·35, 0·06	0·18	−0·06	−0·28, 0·16	0·58
Dietary fat intake (% of total daily energy intake; mean and SD)	34·7	4·72	34·4	3·94	−0·29	−0·77, 0·18	0·23	−0·45	−0·93, 0·03	0·06
BMI (kg/m^2; mean and SD)	27·6	6·69	29·4	7·75	1·77	1·07, 2·47	<0·0001	1·14	0·36, 1·93	0·004

Ref., reference category.

P values were generated by performing the regression of each dependent variable *v.* an indicator variable for residence in a food desert or not. Linear regression was used for the following outcomes: perceived access to healthy foods, fruit and vegetable intake, dietary fat intake and BMI. Poisson regression was used for distance from home to primary store. Multinomial logistic regression was used for primary store type, frequency of grocery shopping and dollar amount spent per shopping trip. Robust standard errors were used for the weighted regression analyses to account for the inverse probability of treatment weights.

*1 mile ≈ 1·61 km.

†The categories for farmers' market, co-op or specialty store and dollar store or convenience store were omitted from the models due to sparse data.

Conclusions

Results suggest that food desert residents shop at different food stores and have higher BMI than non-food desert residents, although there was no evidence to support that the two groups differed on other grocery shopping characteristics or dietary behaviours. Future research using innovative, multidimensional conceptualizations of access to healthy foods are needed to better understand how community food environments influence health.

Acknowledgements

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