Fresh produce consumption and the association between frequency of food shopping, car access, and distance to supermarkets

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ABSTRACT

Background. Fresh fruit and vegetables are important components of a healthy diet. Distance to a supermarket has been associated with the ability to access fresh produce.

Methods. A randomly sampled telephone survey was conducted with the main shopper for 3000 households in New Orleans, Louisiana in 2011. Individuals were asked where and how often they shopped for groceries, frequency of consumption of a variety of foods, and whether they had access to a car. Bivariate models assessed the relationship between four outcomes: car access, distance to the store patronized by the respondent, number of monthly shopping trips, and daily servings of produce. Structural equation modeling (SEM) was used to distinguish direct and indirect effects.

Results. In bivariate models, car access was positively associated with number of shopping trips and produce consumption while distance was inversely associated with shopping trips. In SEM models, produce consumption was not associated with car access or distance, but to the number of monthly shopping trips.

Conclusion. The frequency of shopping is associated with car access but a further distance deters it. Access to stores closer to the shopper may promote more frequent shopping and consumption of produce.

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Introduction

Fresh fruit and vegetables, having low energy density and high fiber content, are important components of a healthy diet and are associated with reduced chronic diseases and optimal weight management (Hung et al., 2004; Serdula et al., 1996; Joint WHO/FAO Expert Consultation on Diet, 2002; Guidelines Advisory Committee, 2010; Winkleby & Cubbin, 2004; Yao & Roberts, 2001; Rolls et al., 2004).

Individual consumption of fresh fruit and vegetables is dependent upon both the availability of produce in the consumer environment and personal and household characteristics. Factors known to be associated with fruit and vegetable consumption include age, gender, race, education level, income, and household size/children in the household

(Casagrande et al., 2007; Tamers et al., 2009; Kimmons et al., 2009; Laforge et al., 1994).

Car ownership or access may be another important factor to consider when exploring the relationship between access to healthy food and consumption of fruit and vegetables. This is a particularly important concern for low-income households which may have less car availability and, therefore, greater challenges for making healthy food purchases (Caraher et al., 1998). Findings from a study in Glasgow, Scotland, suggested that, for those households without car access compared to households with car access, proximity to a supermarket had a stronger association with increased fruit consumption (Thornton et al., 2012). Low-income residents in Austin, Texas, identified constraints related to food purchasing (specifically time and money) as particularly strong for those lacking vehicle access (Clifton, 2004). Additionally, lack of transportation has been identified as a common barrier for purchasing fruit and vegetables, particularly for older adults and those without cars (Haynes-Maslow et al., 2013).

Some evidence has accumulated around the association between distance to food stores, availability and consumption of fresh produce. Previous research in New Orleans, Louisiana, found a significant positive association between shelf space dedicated to fresh vegetables in

neighborhood stores and resident consumption of fresh vegetables (Bodor et al., 2008). A positive association between access to supermarkets and fruit consumption was found among participants of the National Food Stamp Program (Rose & Richards, 2004). Fruit and vegetable consumption was higher among residents with a large grocery store in their neighborhood compared to those without such a store and higher among residents with increased supermarket density in the residential census tract compared to those with lower supermarket density (Zenk et al., 2013; Morland et al., 2002). Much of this previous research, however, considers the distance to the closest food retail outlet instead of the distance to the food retail outlets actually patronized by neighborhood residents. Drewnoswski et al. found that only 14% of participants in a population-based study in Seattle, Washington shopped at their closest supermarket (Drewnoswki et al., 2012).

New Orleans has documented food access issues with many neighborhoods across the city that are considered food deserts and food swamps as well as a history of racial disparities in access to supermarkets (Rose et al., 2009, 2011). Areas are considered food deserts if they are low-income and far from a supermarket (USDA, 2014). Food swamps often exist in food deserts and are areas with an abundance of unhealthy foods (Rose et al., 2009). Considering that New Orleans has a median income well below national levels (New Orleans: $44,379; US: $ 51,371) (US Census Bureau, 2012) many low-income individuals without car access may face multiple barriers to shopping in areas where supermarkets are located and be constrained to shopping at those stores located closest to them geographically.

As supermarkets offer the most shelf space devoted to fresh fruit and vegetables compared to other types of stores, it is assumed that shopping at a supermarket would provide the best opportunity for purchase and then consumption of fresh produce (Farley et al., 2009). Because canned and frozen produce can last much longer than fresh produce, frequency of shopping is more likely to influence the household availability of fresh produce. Given the potential importance of car access to supermarket access and thereby fresh produce, we hypothesized that personal and household characteristics would be related to consumption of fresh produce through car access, distance to patronized store, and frequency of shopping (See Fig. 1). Individuals with access to a car may consume more fresh produce because they can more easily access supermarkets. We aim to examine the potential for mediating effects of car access, frequency of shopping and distance on consumption of fresh produce.

Materials and methods

Sampling and survey tool

A randomly sampled, address-based telephone survey of households in Orleans Parish, Louisiana was conducted with the household's main grocery shopper in 2011. The sample of households was obtained from Survey Sampling International and included information on randomly drawn residential addresses registered with the US Postal Service and matched to telephone numbers. The Wolfgang Frese Survey Research Laboratory at Mississippi State University conducted the survey (The Wolfgang Frese Survey Research Laboratory). Telephone numbers were dialed a maximum of eight times before being retired and followed a call schedule similar to the Behavioral Risk Factors Surveillance System (BRFSS) (Centers for Disease Control and Prevention, 2005). All study protocols and procedures were approved by the Tulane Institutional Review Board. All respondents provided oral consent prior to answering the survey questions.

The interview was approximately 15 min and addressed where and how often the respondent shopped for groceries. Specific information included the store name and location where the respondent shopped for food, number of shopping trips made per month and mode of transportation to the store. Eating habits were assessed in terms of daily, weekly, monthly, or yearly frequency of consumption of fresh, canned and frozen fruits and vegetables, chips and salty snacks, candy, pastries, sweet baked goods, diet and regular carbonated drinks and fast food. The consumption questions were modeled after the BRFSS question structure (Centers for Disease Control and Prevention (CDC), 2011). Reported amounts were calculated in terms of daily servings for analysis where one time of consumption is considered one serving. Additional variables included car ownership and car access (yes/no), education (years), gender (females coded 1; males coded 0), food assistance (yes/no), marital status (married/cohabitating or other), race (African American or other), number of children in household (none or one or more), and household size (total number of children and adults). Questions were from a previous study in New Orleans by the lead author (Gustat et al., 2012). Respondents indicated the income category that best described their annual household income and for analysis, the midpoint of the chosen category was used as a continuous variable. Self-reported weight and height were used to calculate body mass index (BMI) (kg/m^2). Respondent addresses and store locations were geocoded using ArcGIS 10 (ESRI, Redlands, CA). Driving distance from residence to patronized store was derived using the ArcGIS Network Analyst Extension (ESRI & ArcGIS; Charreire et al., 2010).
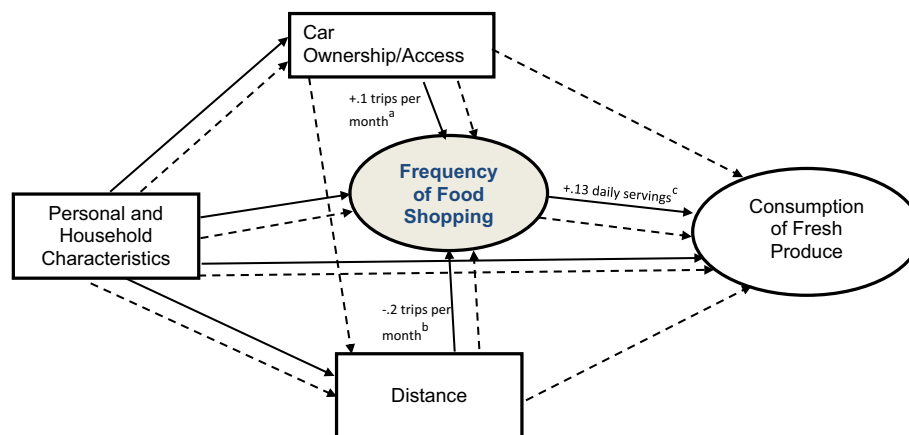

Fig. 1. Relationship between personal and household characteristics, car access, distance, frequency of food shopping and consumption of fresh produce; New Orleans, Louisiana, 2011. Dashed arrows represent hypothesized relationships; solid arrows represent observed relationships. [a]Car ownership/access was associated with an increase in 0.1 shopping trips per month. [b]Increased distance was associated with a decrease of 0.2 shopping trips per month. [c]Each additional shopping trip was associated with an increase of 0.13 servings of fresh produce per day.

Statistical analysis

Because the data are not normally distributed, medians and interquartile ranges are presented for the continuous variables and frequency distributions for the categorical variables were computed. Four outcome measures were used: car ownership, distance to patronized store in kilometers, monthly frequency of grocery shopping and servings of fresh produce consumed per day. Bivariate relationships between each of these variables were assessed using logistic regression models when car access was the outcome; ordinary least squares regression was used to examine relationships with the outcomes of distance and consumption of produce in servings; Poisson regression was used to examine number of shopping trips per month. Linear structural equation models were developed to assess the multivariable relationships between the socio-demographic variables and the four outcomes. The outcome variables for each model are included as mediators in the subsequent models with the final model of daily servings of produce including the potential mediators of car ownership, distance to the grocery store and monthly shopping trips. This approach distinguishes mediated pathways from direct pathways with multiple outcomes (Preacher & Hayes, 2008). The approach described by Sobel was used to test the significance of the indirect effects (Sobel, 1982). Models were run with and without income in the model due to the large numbers of respondents who refused to report income. The analyses were conducted in SAS version 9.2 (SAS Institute, Cary, NC). Data were analyzed in 2013–2014.

Results

Almost 27,000 calls were made to obtain 3000 completed surveys. Of the calls made, 50% resulted in no answer, a busy signal or went to voicemail all eight tries. Another 26% were to non-working numbers. About 12% of numbers answered cited health or communication problems preventing participation, the main grocery shopper was unavailable, asked for a call back another time, or refused prior to introduction. Only 1% of answered calls resulted in refusal after the study explanation.

Respondents were excluded if they had missing data on weight and height, those who reported shopping less than once per month, more than twice per day, if they did not identify the specific store where they shopped or if the store was not available to the general public (such as the military commissary). The final analytical sample was 2097. Additionally, many (34.2%) respondents refused to report income. A sample of 1408 was used when income was included as a variable in analysis.

Median age of respondents was 60 years (interquartile range (IQR) 19 years; range 18–95) (Table 1). Median grocery shopping trips per month was 6 (IQR 6; range 1–30). Respondents reported a median of 2 (IQR 2.9; range 0–14) servings of fresh produce per day. Median distance to the supermarket patronized by respondents was 4 km (IQR 5.1; range 0.04–38.3), while the closest store was approximately 2.3 km away (data not shown). The majority of respondents (85.4%) owned their own car or had access to a car when they needed one. Median annual income of those reporting income was $42,500 (IQR: $70,000; range $5000–$87,500).

Compared to the general population of New Orleans who are 51.6% female, 60.2% African-American with a mean age of 34.6 years and an average income of $36,631, the study sample is comprised of older individuals with a higher income who are more likely to be female and less likely African-American (U.S. Census Bureau, 2010; The Data Center analysis of US Census Bureau data from Census, 2000). Additionally, fewer of the study sample respondents are on food assistance than the general population (sample: 10.4% v. New Orleans: 26.0%) (Supplemental Nutrition Assistance Program (SNAP) Data System, 2013).

Table 1

Characteristics of the study sample; New Orleans, Louisiana, 2011 (n = 2097)[a].

Variable	Median (IQR) [min, max]
Age (years)	60.0 (19.0) [18, 95]
Education (years)	14.0 (5.0) [4.5, 17]
BMI (kg/m^2)	26.6 (7.1) [13.3, 48.9]
Household size	2.0 (2.0) [1, 26]
Shopping trips per month	6.0 (5.0) [0.3, 30]
Serving fresh produce per day	2.0 (2.9) [0, 14]
Average distance to store patronized (km)	4.0 (5.1) [0.04, 38.3]
Annual income (n = 1408)	$42,500 ($70,000) [$5000, $87,500]
	Frequency (%)
Gender	
Male	541 (25.8)
Female	1556 (74.2)
Race	
African-American	1142 (54.5)
Other	955 (45.5)
Marital status	
Not married	1106 (52.7)
Married or cohabitating	991 (47.3)
Receive food assistance	
No	1878 (89.6)
Yes	219 (10.4)
Children in household	
Households with no children	1593 (76.0)
Households with children	504 (24.0)
Car ownership/access	
No	304 (14.5)
Yes	1793 (85.5)

IQR = Interquartile range.
[a] Sample size = 2097 except for income (n = 1408).

Bivariate associations between the four outcome variables are summarized in Table 2. Positive associations were observed between car access and shopping trips per month and car access and consumption of fresh produce, and shopping trips per month and consumption of produce. Distance to the store was inversely associated with shopping trips per month. No significant associations were observed between distance to the respondent's store and car access or distance and daily consumption of produce. As we were interested in the direction, and statistical significance of the relationships and not the magnitude, coefficients are not shown.

Structural equation models were developed to examine the influence of the personal characteristics on each of the outcome variables and the mediating effects of each of the outcome variables (car access, distance to store, shopping trips per month) on produce consumption. Because many respondents did not report income, models were run with and without income. As the results did not differ significantly, only models with income are shown (Table 3). In the model examining car access, being married, higher education, and higher income were positively associated with car ownership (p < 0.001 for all). Inverse associations with car access were seen with age and being on food assistance (p < 0.001 for both). When predicting distance to the patronized

Table 2

Bivariate relationships[a] between car access, distance to store, monthly shopping trips, and consumption of produce[b]; New Orleans, Louisiana, 2011.

Variable	Car access	Distance	Shopping trips/month
Distance (km)	NS		
Shopping trips per month	+	−	
Consumption fresh produce[b]	+	NS	+

NS = No statistically significant relationship observed.
+ = Statistically significant positive bivariate associations, p < 0.05.
− = Statistically significant inverse bivariate associations, p < 0.05.
[a] Each variable was examined with each of the four variables: car access, distance to store, shopping trips per month, and daily consumption of fresh produce. Logistic regression was used to examine car access as dependent variable. Ordinary least squares regression was used to examine distance to store and consumption of produce. Poisson regression was used to examine shopping trips per month.
[b] Daily servings.

Table 3
Structural equation models of four outcomes: car ownership, distance, monthly shopping trips and daily consumption of produce; New Orleans, Louisiana; 2011.

Predictor variables	Model outcomes			
	Car access +	Distance to store (km)[a]	Shopping trips per month[a]	Servings of fresh produce per day[a]
Age	−0.1132***	−0.1126***	0.0145	−0.0918**
Female gender	0.0183	0.0048	−0.0499	0.1412***
Black race	−0.0113	0.2813***	−0.1120***	−0.1464***
Married	0.1610***	−0.0306	0.1046***	0.0508
Education	0.2113***	−0.0534	−0.0536	0.0488
Income	0.1068***	0.0714***	0.0169***	0.1034***
BMI	0.0219	−0.0202	−0.0635*	−0.0100
Food assistance	−0.1537***	−0.0215	−0.0096	−0.0064
HH size	0.0162	0.0458	0.0651	−0.0699*
# of children	−0.0238	−0.0236	0.0105	0.0559
Car access		0.0542	0.0964***	0.0074
Distance to store (km)			−0.1883***	0.0416
Shopping trips per month				0.1261***
R-square	0.22	0.10	0.09	0.10

[a] Model coefficients are presented.
*** $p < 0.001$.
** $p < 0.01$.
* $p \leq 0.05$.

store, African-American race, and income were significantly, positively associated (p < 0.001 for both). Age was significantly, inversely associated (p < 0.001).

For the outcome of shopping trips per month, being married (p < 0.001), higher income (p < 0.001), and car access (p < 0.001), were significantly, positively associated with shopping trips per month (Table 3). Being African American (p < 0.001), BMI (p < 0.05) and distance to the patronized store (p < 0.001) were significantly, inversely associated with shopping trips per month. The final model of daily servings of fresh produce was positively associated with being female (p < 0.001), income (p < 0.001), and shopping trips per month (p < 0.001) (Table 3). Significant inverse associations were seen with age (p < 0.001), being African American (p < 0.001) and household size (p < 0.05) with daily servings of fresh produce.

Regarding the mediating effects, access to a car increased the number of shopping trips per month by 0.0964 (~0.1) trips per month but had no effect on consumption of fresh produce. Each additional kilometer to the store a respondent had to travel was associated with a decrease in 0.1883 (~0.2) shopping trips per month but had no effect on consumption of fresh produce. Each additional shopping trip per month increased the consumption of fresh produce by 0.1261 servings of fresh produce per day (Table 3). In sum, consumption of fresh produce was not directly associated with car ownership or distance to store patronized. Shopping frequency mediated the effect of car access and distance from a shopper's home to their food store of choice on consumption of fresh fruits and vegetables.

Discussion

Car access was directly associated with consumption of fresh produce in the bivariate model. Distance was inversely associated. However, in the structural equation models, car access and distance were not directly associated to fresh produce consumption. Fresh produce consumption was mediated by the frequency of shopping trips per month. Similarly, shopping frequency was mediated by distance to the patronized store and car access. Access to an automobile allowed consumers to shop more frequently, but the farther the consumer had to travel to reach his/her store of choice deterred more frequent shopping.

Fresh produce has a shorter shelf life than processed foods, necessitating more frequent purchases. Low income consumers are less able to afford to allow fresh produce to spoil and may therefore only purchase produce that they know will be used quickly. The choice to shop at a more distant store deters more frequent trips to that store and reduces

opportunities to stock fresh produce after purchases from the previous trip have been consumed.

Structural equation modeling allows for the distinction between direct and indirect pathways of relationships between variables. This technique allows us to test models overall while using multiple dependent variables to examine mediating effects versus examining the individual coefficients in individual regression models. Strengths of the modeling procedure include the broad data-analytic framework allowing our multi-outcome model to be tested (Tomarken & Waller, 2005). Limitations to the procedure include increased model complexity and potential biased between-group parameter estimates when the sample size is small (<50) which is not an issue in the present study. Not unique to structural equation modeling, a general limitation includes omitted variables. We recognize that much of the variance of the models is unexplained, indicated by the low R-square values. There are likely more factors associated with the models we tested than were assessed in the interview. However, structural equation modeling allows for an examination of the mediation effects. If we just examined the linear and/or logistic models, we would conclude that car access relates to consumption. The mediation models indicate that shopping frequency is a mediating factor to produce consumption and that distance and car access are mediating factors to shopping frequency.

Our initial hypothesized association with the relationship of car access to consumption was not supported by our analysis. We anticipated a direct relationship between car access and produce consumption as well as distance traveled to store patronized and produce consumption (Fig. 1). Similar non-significant findings between automobile use and fruit and vegetable consumption were reported by Fuller et al. (Fuller et al., 2013). However, both car access and distance to patronized store were directly related to frequency of shopping. Likewise, a study by Aggarwal et al. found distance to be less important than other factors such as supermarket choice (Aggarwal et al., 2014). These results contribute to an additional understanding of the complex relationship that exists between the neighborhood food environment and food shopping and consumption behaviors of neighborhood residents.

The majority of respondents reported shopping at a supermarket and having access to a car when needed. This finding is consistent with previous research (Rose & Richards, 2004). Yet, there is still much work to be done to improve the diet quality of New Orleans' residents to increase consumption of fruits and vegetables as recommended by national guidelines (U.S. Department of Agriculture & U.S. Department of Health and Human Services, 2010).

Produce consumption was low overall at 2.7 ($\pm$2.1) servings of fresh produce per day. An analysis of national BRFSS fruit and vegetable consumption data found only 32.5% of U.S. adults consumed fruit two or more times per day and only 26.3% consumed vegetables two or more times per day (State-specific trends in fruit and vegetable consumption among adults — United States, 2000–2009, 2010). The proportions are even lower in Louisiana where 24.6% of adults consumed fruit two or more times per day and 21.3% consumed vegetables two or more times per day (State-specific trends in fruit and vegetable consumption among adults — United States, 2000–2009, 2010). Policies and programs that promote and facilitate environmental and systems changes to decrease the distance residents travel for grocery shopping may lead to increased frequency of shopping and perhaps increased consumption of fresh produce. Increasing transportation options allow residents easier access to stores they wish to patronize and may also increase frequency of shopping and potentially consumption of fruits and vegetables.

There are several strengths worth mentioning. The large sample is geographically representative of New Orleans, a city with documented disparities in access to supermarkets and healthy food options and is a random sample of landline holders in the city (Rose et al., 2011; Bodor et al., 2010). Our data included actual stores where people reported shopping. Most other research in the food environment literature only accounts for geographic proximity and does not account for the actual locations of the stores where neighborhood residents shop.

There are a number of limitations to consider. The missing data for those not reporting income was sizable. However, models were run with and without the inclusion of the income variable and little differences were seen. Several variables were self-reported and could have been biased. Weight and height are often under and over reported, respectively (Merrill & Richardson, 2009). Dietary assessment data is often misreported as well and the dietary data in this sample has not been validated (Black & Cole, 2001; Rennie et al., 2007). However, the data assessed is asked in a similar way to the BRFSS (Centers for Disease Control and Prevention (CDC), 2011). The landline-based phone survey produced a biased sample older than is representative of the city as a whole. We anticipated a higher percentage of older female respondents as we were targeting the primary household shopper. Older respondents may have different personal and household needs and therefore represent different shopping and consumption patterns than a broader range of individuals. Additionally, the low percentage of respondents reporting federal food assistance (10.4%) indicated an under-representation of low income households as approximately one quarter of residents of New Orleans receive SNAP benefits (Supplemental Nutrition Assistance Program (SNAP) Data System, 2013). However, this may indicate that food access situation is worse overall than is being reported by the identified respondents.

These findings provide evidence to support the availability of stores closer to residents to promote more frequent shopping and consumption of fresh produce. This is in alignment with the intention of fresh food financing programs as they continue to be implemented across the country in that respondents who travel further to grocery shop, shop less often and those who shop more frequently consume more fresh fruits and vegetables (Giang et al., 2008; Karpyn et al., 2010; New Orleans Fresh Food Retailer Initiative: Program Overview, 2011). These data indicate that it will be important for these fresh food financing initiatives to incentivize increased geographic access to food stores with healthy food options and that cater to the preferences of the residents within the surrounding neighborhood to ensure that these newly opened stores are utilized.

Conflict of interest statement

The authors declare that there are no conflicts of interest.

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