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Car Ownership and the Association between Fruit and Vegetable Availability and Diet

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Abstract

Objective: Nearly all research on the food environment and diet has not accounted for car ownership – a potential key modifying factor. This study examined the modifying effect of car ownership on the relationship between neighborhood fruit and vegetable availability and intake.

Methods: Data on respondents' (n=760) fruit and vegetable intake, car ownership, and demographics came from the 2008 New Orleans Behavioral Risk Factor Surveillance System. Shelf space data on fresh, frozen, and canned fruits and vegetables were collected in 2008 from a random sample of New Orleans stores (n=114). Availability measures were constructed by summing the amount of fruit and vegetable shelf space in all stores within defined distances from respondent households. Regression analyses controlled for demographics and were run separately for respondents with and without a car.

Results: Fruit and vegetable availability was positively associated with intake among non-car owners. An additional 100 meters of shelf space within 2 kilometers of a residence was predictive of a half-serving/day increase in fruit and vegetable intake**.** Availability was not associated with intake among car owners.

Conclusions: Future research and interventions to increase neighborhood healthy food options, should consider car ownership rates in their target areas as an important modifying factor.

Keywords

Diet; Fruit; Vegetables; Environment; Neighborhood

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Conflict of interest statement
The authors declare that there are no conflicts of interest.

Introduction

Research has grown on the built environment and health, especially research on food access and its influence on diet and bodyweight (Giskes et al., 2011; Larson et al., 2009). Most work has relied on access indicators based on food stores in residential neighborhoods. But access is a complex phenomenon, and a key aspect of geographic access – car ownership – has been largely overlooked. Car ownership is important to this body of research, because it affords greater mobility and allows residents to more easily shop beyond neighborhood boundaries.

Studies show that living closer to healthy foods or suppliers of such foods (e.g. supermarkets) is associated with greater diet quality and lower obesity risk. Access to unhealthy energy-dense foods or establishments that sell them (e.g. convenience stores, fast-food restaurants) shows the opposite effect. However, findings have not always been consistent, with several studies showing null or contradictory results (Giskes et al., 2011; Larson et al., 2009). While a few studies include car ownership as an independent variable (Rose et al., 2009b; Zenk et al., 2009; Izumi et al., 2011), most research has not incorporated such data nor examined its modifying effect. The omission of car ownership may help explain some of the inconsistent findings, and even among studies that found consistent associations between access, diet, and bodyweight, effect sizes may be diluted due to the grouping of households with and without a car (Bodor et al., 2010; Franco et al., 2009; Giskes et al., 2011; Larson et al., 2009; Morland et al., 2009; Wang et al., 2007).

To address this gap in the literature, this study examined whether the influence of food environments on intake varied by car ownership. This study hypothesized that fruit and vegetable intake was associated with the availability of these foods in a neighborhood for residents who did not own a car, and that there is no such association for car owners.

Methods

This study was conducted in New Orleans in 2008. Respondent data came from the New Orleans Behavioral Risk Factor Surveillance System (BRFSS), the local version of the national telephone survey coordinated by the US Centers for Disease Control and Prevention (CDC). Households were selected with a random-digit-dial method, followed by a random selection of one adult household member. Information on demographics, income, household car ownership, and fruit and vegetable intake was collected. Fruit and vegetable intake was assessed using the standard six-question CDC module (Serdula et al., 2004). Individuals missing any of the intake questions, or data on car ownership or demographics, other than income, were excluded (n=192). A poverty index ratio (PIR) was calculated for each respondent by dividing household income by the US Census Bureau poverty threshold corresponding to that household's size. The respondents' missing income data (n=86) were assigned a PIR based on their race and education via a probability-based imputation method, so as to avoid having a potentially biased or non-representative sample. The final analytic sample included 760 respondents. Data were weighted using CDC-provided sampling weights. Further details on the BRFSS study protocol and the local New Orleans version of it have been previously described (Beaudoin et al., 2007; Centers for Disease Control and Prevention, 2006). This study was approved by the Tulane University IRB.

A 2008 census of retail food outlets (N=380) was obtained by updating our 2007 list with on-the-ground enumeration (Rose et al., 2009a). Stores were classified as supermarkets, mid-size stores, small food stores, convenience stores, drug stores, and general merchandise stores, using previously-recorded North American Industry Classification System codes. Details on how stores were classified have been previously published (Miller et al., 2012). A 30% sample was randomly selected within each store category, which yielded a total sample of 114 stores. This approach assured that our sample had representation of all store types, proportional to their overall existence in the city. Teams were sent into these stores and linear shelf space measurements on all fruits and vegetables (including fresh, canned, and frozen) were collected using a rolling-tape device (Rolatape, Model 112, Spokane, WA). Shelf space has long been shown to be predictive of purchasing behavior in the marketing literature (Curhan, 1974; Wilkinson et al., 1982). This study adopted this measure to characterize the food environment, with our particular in-store survey showing a high inter-rater reliability for fruit and vegetable measurements (Cohen et al., 2007). Details on the enumeration method and in-store survey have been previously described (Rose et al., 2009a).

All stores were geocoded using ArcGIS 9.3 (ESRI, Redlands, CA) and network distances were calculated from households to stores. Data for unobserved stores were imputed using a probability based hot-deck method. This method involves assigning data to an unobserved case using a randomly selected donor case with similar characteristics. For example, each unobserved supermarket was matched with data from a randomly chosen supermarket that had been observed; each small grocery received data from a randomly-chosen small grocery, etc. Because of the random assignment from existing cases, this approach not only preserves the mean values of variables like shelf space, but it also preserves the distribution of these variables in the observed data. This imputation method has been used previously and is justified given the substantial variation in shelf space by store type (Farley et al., 2009; Rose et al., 2009b). Cumulative fruit and vegetable availability was assessed for each respondent by summing the shelf space devoted to all fruits and vegetables found in all stores within 2 kilometers of a household. Measures were also developed for within 500 meters and 1 kilometer. Previous research has found these particular distances to be relevant when defining a household’s food environment (Bodor et al., 2010; Franco et al., 2009; Rose et al., 2009b).

Statistical Analyses

Analyses were performed using STATA/SE 11.0 (StataCorp, College Station, TX). Linear regression models accounted for the multi-stage sample design and clustering at the census tract level by estimating Huber-White standard errors with the *cluster* option. Separate models were estimated for households with a car (n=655) and for households without one (n=105). Fruit and vegetable intake as the outcome was in servings/day. In all models, gender, race, PIR, age, and education were control variables.

Results

In the full sample, bivariate results showed males, African Americans, and non-car owners having lower intake (Table 1). Higher education and being above 185% of poverty was associated with greater intake.

Regression analyses showed different results depending on car ownership (Table 2). Among car owners, cumulative fruit and vegetable availability at any distance was not associated with intake. For non-car owners, intake was positively associated ($\beta = 0.005$, p-value = 0.016) with availability within 2 kilometers of their household, though not within 500 meters or 1 kilometer.

Discussion

Among individuals without a car, the amount of fruit and vegetable shelf space within 2 kilometers of their residence was significantly associated with intake. An additional 100 meters of shelf space was predictive of a half-serving/day increase in fruit and vegetable intake. No associations were found for this group of non-car owners when measuring availability at 500 meters or 1 kilometer. This suggests that a larger radius may be more appropriate when defining a household's food environment, or that the planned nature of fruit and vegetable purchases makes a wider radius more pertinent. Among car owners, availability did not significantly influence intake, possibly due to the greater mobility afforded by a household car.

Few studies have directly examined the effects of food access by car ownership (Inagami et al., 2009; Macdonald et al., 2011). In the one U.S. study (Inagami et al., 2009), fast-food access was more strongly associated with BMI among those without cars as compared to car owners. While their access indicator and outcome differs from our work, their findings are consistent with our results showing the modifying effect of car ownership.

This study is not without limitations. First, it used a cross-sectional design so causality cannot be inferred. Second, not all stores in the city were surveyed. The large number of stores and the time intensive nature of the in-store survey precluded this. However, research has shown that store type accounts for much of the variance in shelf space (Farley et al., 2009), which supports our imputation approach of randomly assigning data based on store type. As an additional check, we conducted an analysis to see how sensitive our reported results were to this imputation approach. Specifically, we ran the same analysis, but using only the observed stores (i.e. no imputation). This sensitivity analysis showed similar results without the imputation. Availability and intake was positively associated among non-car owners at 2 kilometers, with no such association found for those with cars.

Conclusions

This study is the first to demonstrate the effect of car ownership on the relationship between fruit and vegetable availability and diet. Interventions that seek to increase healthy foods in neighborhoods, may want to consider car ownership rates in their targeting of intervention areas. Additionally, while there has been a call for use of longitudinal and experimental designs, and some recent studies have addressed this (Boone-Heinonen et al., 2011; Leung et al., 2011), future research should also incorporate car ownership data, since it can significantly modify the relationship between availability and intake.

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Highlights

- Fruit and vegetable availability associated with intake among non-car owners.
- No relationship between availability and intake among those with cars.
- Future research/interventions should account for car ownership as a modifying factor.

Table 1

Descriptive characteristics of study sample and fruit and vegetable intake, New Orleans BRFSS, 2008

Variable	N	%	Mean intake in servings per day (SD)
Total	760	100.0	3.9 (2.0)
Gender			
Female	522	68.7	4.2 (2.3)
Male	238	31.3	3.6 (1.8)*
Race/Ethnicity			
White (reference)	380	50.0	4.1 (2.0)
African American	339	44.6	3.6 (2.1)*
Other	41	5.4	4.4 (2.4)
Poverty Index Ratio			
Below 1.00 (reference)	97	12.8	3.5 (2.2)
1.00 – 1.85	129	16.9	3.4 (2.0)
> 1.85	534	70.3	4.1 (2.1)*
Age			
18 – 30 (reference)	43	5.7	4.1 (2.1)
31 – 50	229	30.1	3.9 (2.0)
> 50	488	64.2	3.9 (2.1)
Educational Attainment			
Less than high school (reference)	66	8.7	2.9 (1.8)
High school graduate	150	19.7	3.1 (2.0)
Attend some college	183	24.1	4.1 (2.2)*
College graduate or higher	361	47.5	4.3 (2.0)*
Car Ownership			
Yes	655	86.2	4.0 (2.1)
No	105	13.8	3.4 (2.2)*

SD – standard deviation

*p<0.05

Table 2

Associations between fruit and vegetable intake (dependent variable) and cumulative shelf space by car ownership, New Orleans BRFSS, 2008

	Own Car (n=655)			No Car (n=105)		
Distance around each household [a]	β [b]	**SE**	**p-value**	β [b]	**SE**	**p-value**
500 meters	0.004	0.005	0.398	0.014	0.014	0.329
1 kilometer	0.002	0.002	0.271	0.007	0.004	0.070
2 kilometers	0.001	0.001	0.277	0.005	0.002	0.016

SE – Standard Error

[a]Neighborhood fruit and vegetable availability was determined for each household at three different network distances – 500 m, 1km, and 2km. Shelf space of all fruits and vegetables in all stores within a defined distance was summed. Models were run separately for each distance.

[b]Each coefficient is estimated from a separate linear regression model and describes the relationship between fruit and vegetable intake (servings per day) and the total amount of fruit and vegetable shelf space (meters) in the respondent's neighborhood. Each model adjusted for gender, race, poverty status, age, and education.