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Association of individual and neighborhood factors with home food availability: Evidence from the National Health and Nutrition Examination Survey (NHANES)

Weiwen Chai, PhD,

Assistant Professor, Department of Nutrition and Health Sciences, University of Nebraska-Lincoln, 1700 N 35th street Rm 104B, Lincoln, NE 68583, Phone: (402) 472-7822

Jessie X. Fan, PhD, and

Professor, Department of Family and Consumer Studies, University of Utah, 220 S 1400 E AEB 228, Salt Lake City, UT 84112, (801) 581-4170

Ming Wen, PhD

Professor, Department of Sociology, University of Utah, 380 S 1530 E Rm 301, Salt Lake City, UT 84112, 801-581-8041

Abstract

Background—Accumulating evidence suggests the important role of the home food environment in an individual's dietary intake.

Objective—This study examined the associations of individual and neighborhood-level factors with the availability of healthy and unhealthy foods in the home using a nationally representative sample from the 2007–2008 and 2009–2010 National Health and Nutrition Examination Surveys (NHANES).

Design—A cross-sectional study design was used with NHANES merged with the 2000 census data. Food availability was measured through self-report questionnaire regarding the frequency of foods/drinks available in the home.

Participants—The analysis included 8975 participants aged 19–65 years.

Statistical analyses performed—Associations of individual and neighborhood factors with home food availability (always/most of the time available) were assessed using logistic regression modeling accounting for NHANES' complex survey design and weights. Individual-level and neighborhood-level factors were simultaneously included in the analysis.

Results—Family income-to-needs ratio was positively associated with the availability of dark green vegetables (odds ratio [OR]=1.07; 95% confidence interval [95%CI]=1.00–1.13), fat-free/

Correspondence to: Weiwen Chai.

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Conflict Interest

No authors report a conflict of interest.

low-fat milk (OR=1.16; 95%CI=1.07–1.25), and salty snacks (OR=1.12; 95%CI=1.04–1.20) in the home. College graduates were more likely to have fruits (OR=1.96, 95%CI=1.48–2.60), vegetables (OR=1.48; 95%CI=1.16–1.88), and fat-free/low-fat milk (OR=1.81; 95%CI=1.55–2.12) and less likely to have salty snacks (OR=0.77; 95%CI=0.63–0.95) and sugary drinks (OR=0.46, 95%CI=0.37–0.57) available compared to non-college graduates. Tract socioeconomic status (SES) scores were positively associated with fruit (OR=1.15; 95%CI=1.02–1.29), vegetable (OR=1.14; 95%CI=1.03–1.26), and fat-free/low-fat milk (OR=1.25; 95%CI=1.10–1.42) availability. Urban residents were associated with greater availability of fruits (OR=1.47; 95%CI=1.05–2.08) and fat-free/low-fat milk (OR=1.33; 95%CI=1.02–1.73) in the home compared to rural residents. Food desert status was not associated with home food availability.

Conclusions—The results show that SES at both individual (education, income) and neighborhood level was linked to home food availability, suggesting a need to improve the home food environment for socioeconomically disadvantaged individuals and neighborhoods.

Keywords

Individual factors; neighborhood factors; healthy food availability; unhealthy food availability; socioeconomic status

INTRODUCTION

The prevalence of obesity remains high in the United States with approximately 35% of men and 40% of women being obese in 2013–2014.¹ Although evidence links poor diet quality to obesity and risk of chronic diseases,^{2–4} to date many individuals across the country do not meet dietary recommendations, with fewer than one in three adults consuming the recommended amount of vegetables each day.⁵ The home food environment such as the availability of healthy or unhealthy foods in the home can be one of the important moderators of a person's dietary intake.^{6–8} Previous work showed the overall home availability of obesogenic unhealthy foods was significantly associated with energy intake of both adults and their adolescent children.⁶ Grant et al. reported that home food inventory scores were associated, positively or inversely with saturated fat, sugar, and other nutrient intake among participants aged 50 years old.⁸ In addition, a study by Emery et al. demonstrated that homes of obese individuals had less healthy foods available than homes of non-obese individuals.⁹

There are various factors that may influence the home food environment and dietary habits. An individual's socioeconomic status (SES) can be considered as one of the main contributors.^{10–12} Masters et al. reported high-income homes had the highest prevalence of fruits and fat-free/low-fat milk always available in a nationally representative sample.¹¹ Individuals with low income were reported to consume fewer fruits and vegetables and a high proportion of their dietary energy intake was from fat and empty calorie foods relative to their high-income counterparts.¹³ However, there are various SES indicators including both monetary and non-monetary related factors. Literature suggests that using different SES measures are important for capturing the effects of social inequalities in home food availability.¹² For example, a study by Wilson et al. reported that while both higher household income and education level were individually associated with higher fruit and

vegetable availability scores, higher education but not income level was also independently associated with decreased availability of sweetened beverages in the home.¹²

Beyond individual-level factors, a growing body of evidence suggests that neighborhood deprivation, neighborhood minority composition, and rural neighborhood are linked to poor dietary patterns and obesity.^{14–16} These neighborhoods are most often affected by poor access to supermarkets and healthy foods.^{15,17,18} It has been suggested that neighborhood residents who have better access to supermarkets and limited access to convenience stores tend to have healthier diets and lower obesity rates,^{17,19} since affordable, high quality foods are more likely to be found in supermarkets than in convenience stores.²⁰ However, a recent study found that nutrition profiles of foods and beverages household purchased did not differ according to whether people shopped at large supermarkets, mass merchandisers or a combination of supermarkets and small convenience stores.²¹ While more research is needed to investigate neighborhood effects on energy balance and obesity, no study to date has explored how various neighborhood factors such as neighborhood SES, area population density (rural-urban status) and food desert status may contribute to the home food environment, which likely serves as a mediator or moderator for the link between neighborhood and health outcomes.

The ecological framework emphasizes the multiple influences on a person's health behaviors and outcomes.²² The underlying etiology for an obesogenic home food environment is complex involving contributing factors at different levels. Given the importance of the home food environment in an individual's dietary intake and in turn the development or prevention of obesity, the current study examined the associations of individual and neighborhood-level factors with the availability of healthy (fruits, dark green vegetables, and fat-free/low-fat milk) and unhealthy foods (salty snacks and sugary drinks) in the home among adults aged 19–65 years using a nationally representative sample from 2007–2008 and 2009–2010 National Health and Nutrition Examination Surveys (NHANES).

METHODS

Sample

Individual-level data used in this study were from the 2007–2008 and 2009–2010 waves of the continuous NHANES merged with the 2000 census data using the geographic information system (GIS) techniques. NHANES is a program of studies designed to assess the health and nutritional status of adults and children in the United States. Since 1999, the survey has examined a nationally representative sample of about 5,000 people each year. NHANES uses a complex, multistage, probability sampling design to select participants who are representative of the civilian, noninstitutionalized US population.²³ The 2007–2008 and 2009–2010 data were used since questions regarding home food availability were only available in 2007–2008 and 2009–2010 NHANES surveys. The 2000 census data (instead of the most recent 2010 census data) was used because the 2000 census information was collected prior to the collection of the outcome data, which would allow a temporal sequence from the hypothesized predictors to the outcome variables (home food availability) since the reverse hypothesis, for example, the effect of home food environment on

neighborhood characteristics (e.g., tract-level SES, urban-rural status, food desert status) seems less likely.

The present study focused on 8975 adults aged 19 to 65 years. The 2007–2008 and 2009–2010 NHANES had 9571 age-eligible respondents. Sequential exclusions included: missing food availability data (N=142), pregnancy (N=125), missing body mass index (BMI) values (N=326), and missing tract SES score (N=3). The weighted percentage of missing income data was 6.9% of the sample. Missing family income-to-needs ratios were imputed by adding a random component to the weighted sample mean of non-missing values. There were no missing data for the remaining variables included in the analyses. Participants with and without these missing values had similar distributions of individual characteristics (age, sex, race/ethnicity, BMI, immigrant status, income-to-needs ratio, education, marital status, and family size). The final sample size was 8975 adults including 4479 men and 4496 Women. The study was approved by the Institutional Review Board at the University of Utah.

Home Food Availability Questions and Outcome Variables

The home food availability questions from NHANES measure the frequency of availability of fruits (fresh, dried, canned and frozen fruits), dark green vegetables (fresh, dried, canned and frozen vegetables), fat-free/low-fat milk (1%, skim or fat-free; excluding 2%), salty snacks (such as chips and crackers; excluding nuts) and sugary drinks (soft drinks, fruit-flavored drinks, or fruit punch; excluding diet drinks, 100 percent juice or sport drinks) in the home. A five-point scale (always, most of the time, sometimes, rarely or never available) was used for survey responses and was coded on a scale of 1–5 with “1” referring “always” and “5” referring “never available”. The response also included “Refused” (coded as “7”) and “I don’t know” (coded as “9”).²³ Participants who responded with “Refused” or “I don’t know” were excluded from the analyses. The outcome/dependent variables (the frequency of home food availabilities) were further categorized into two categories stressing the importance of contrasting the two values in the outcome: 1) “always/most of the time available” (recoded as “1”) for participants who responded with “always” or “most of the time available”; and 2) “sometimes/rarely/never available” (recoded as “2”) for participants who responded with “sometimes”, “rarely”, or “never available”.

Individual and Neighborhood-Level Variables

Individual-level independent variables included in the analyses were age (continuous), sex (male vs. female), race-ethnicity (self-reported non-Hispanic white [reference group], non-Hispanic black, and Hispanic), immigrant status (foreign-born vs. US-born), BMI (continuous), education (college graduates vs. non-college graduates), family income-to-needs ratio (continuous), marital status (married/cohabiting vs. not married/cohabiting), and family size (number of people living in the household, continuous). Income-to-needs ratio was computed by NHANES staff using annual family income divided by the federal poverty threshold for the appropriate family size, location, and year.²⁴

The literature provides evidence that tract-level indicators are more consistently related to residents’ health than indicators at other geographic levels.^{25–27} As such, we used census

tract as our main neighborhood geographic unit. The 2000 census data were used to create tract-level (neighborhood) variables. The independent neighborhood variables included in the analyses were tract urban-rural status (urban vs. rural), tract SES score (continuous), and the United States Department of Agriculture (USDA) defined food desert status (food desert vs. non-food desert areas). Tract rural-urban status was defined using the USDA 2000 primary Rural-Urban Commuting Areas (RUCA) codes. The primary RUCA codes use measures of population density, urbanization, and daily commuting to classify census tracts into 10 detailed urban-rural categories.²⁸ For this analysis, urban was defined as all metro tracts (RUCA=1–3, areas with a population of at least 50,000 people) and rural as all non-metro tracts (RUCA=4–10, areas with a population of less than 50,000 people) following the literature.³⁰ Tract SES score, a composite scale of neighborhood SES was derived from the 2000 census including percent households with annual income at \$75,000 or more (i.e., concentrated affluence), percent residents living in poverty (i.e., concentrated poverty), and percent college-educated residents (i.e., aggregate education). Tract SES score was constructed based on the above three SES indicators and has acceptable reliability ($\alpha=0.85$).²⁹ Food desert areas were determined using USDA Food Desert Locator, which defined food deserts as low income tracts with at least 500 people or 33 percent of residents in the tract living more than a mile from a supermarket, super center or large grocery store (for rural census tracts, the distance is more than 10 miles).³⁰ The Centers for Disease Control and Prevention (CDC) Research Data Center has NHANES participants' addresses which are not available to the public. Therefore, census tract-level variables were created for the entire United States based on 2000 census data. The tract-level data were sent to CDC Research Data Center to be geo-linked to NHANES database via participants' addresses. The researchers in the study had no access to information that could potentially identify the survey subjects.

Data Analysis

SAS 9.4 (SAS Institute Inc, Cary, NC)³¹ was used for all statistical analyses. Associations between individual and neighborhood-level factors and home food availability were assessed using logistic regression modeling accounting for the complex survey design and sample weighting methodology of NHANES.³² The outcome/dependent variables (home food availability variables) were characterized as dichotomous (always/most of the time available vs. sometimes/rarely/never available [reference group]). The independent variables (covariates) included in the full models were age, sex, race/ethnicity, immigrant status, marital status, family size, income-to-needs ratio, education, BMI, urban-rural status, tract SES score and food desert status. The models were also adjusted for two dichotomous variables of imputed income status and top-coded income status (since NHANES topcoded income status at 5) for controlling for potential biases. To further elucidate how neighborhood factors could influence home food availability, reduced models were estimated which included all the individual-level variables from the full models and only one neighborhood-level variable (tract SES score, urban-rural status or food desert status). Analyses were conducted through remotely accessing to the CDC Research Data Center secured sever, where only SAS can be used. However, SAS does not have a procedure that can simultaneously account for both complex sample design of NHANES and multilevel modeling. Therefore, both survey modeling (Proc Surveylogistic) and unweighted multilevel

modeling (Proc Glimmix) were performed separately. The two approaches yielded similar results on neighborhood effects. This study opted to report the results of the more conservative approach (survey modeling accounting for complex survey design and weights).

RESULTS

A total of 8975 adults aged from 19–65 years (mean age: 41.5 years) were included in this analysis. Overall, the prevalence of foods always or most of the time available in the home were 85.4% for fruits, 77.2% for dark green vegetables, 38.8% for fat-free/low-fat milk, 62.5% for salty snacks and 56.3% for sugary drinks.

Table 1 demonstrates individual and neighborhood demographics by neighborhood SES (Low neighborhood SES: <median tract SES score; high neighborhood SES: median tract SES score). Participants living in neighborhoods with lower tract SES scores were younger (40.0 vs. 42.6 years), more likely to be blacks (18.1% vs. 7.3%) or Hispanics (21.9% vs. 8.9%) and had a lower average family income-to-needs ratio (2.3 vs. 3.6) and higher BMI (29.3 vs. 28.1) compared to those living in neighborhoods with higher tract SES scores. The rates of having a college degree (15.1% vs. 36.5%) and being married/cohabitating with a partner (56.8% vs. 68.1%) were lower among participants from low-SES neighborhoods than those from high-SES neighborhoods. Additionally, neighborhoods with lower tract SES scores were more likely to be associated with food desert status relative to neighborhoods with higher tract SES scores (14.5% vs. 0.6%).

Table 2 shows the associations of individual-level variables with home food availability. For SES related individual variables, family income-to-needs ratio was positively associated with the availability (always/most of the time available) of dark green vegetables (odds ratio [OR]=1.07; 95% confidence interval [95%CI]=1.00–1.13; interpreted as: one unit increase in income-to-needs ratio was associated with 7% increase in odds of having dark green vegetables always or most of the time available in the home), fat-free/low-fat milk (OR=1.16; 95%CI=1.07–1.25), and salty snacks (OR=1.12; 95%CI=1.04–1.20) in the home. College graduates were more likely to have fruits (OR=1.96; 95%CI=1.48–2.60), vegetables (OR=1.48; 95%CI=1.16–1.88), and fat-free/low-fat milk (OR=1.81; 95%CI=1.55–2.12) and less likely to have salty snacks (OR=0.77; 95%CI=0.63–0.95) and sugary drinks (OR=0.46; 95%CI=0.37–0.57) available in the home compared to those without a college degree.

With respect to other relevant individual-level factors, lower availability of fruits (OR=0.71; 95%CI=0.54–0.93), fat-free/low-fat milk (OR=0.39; 95%CI=0.31–0.48), and salty snacks (OR=0.62; 95%CI=0.50–0.76) and higher availability of vegetables (OR=1.50; 95%CI=1.18–1.91) were observed for blacks relative to Whites. Hispanics had lower availability of all examined foods (fruits: OR=0.79, 95%CI=0.62–0.99; vegetables: OR=0.80, 95%CI=0.65–0.98; fat-free/low-fat milk: OR=0.59, 95%CI=0.47–0.75; salty snack: OR=0.72, 95%CI=0.57–0.93; sugary drinks: OR=0.73, 95%CI=0.60–0.90) compared to Whites. Relative to US-born citizens, immigrants were more likely to have vegetables (OR=1.33; 95%CI=1.05–1.67) and less likely to have salty snacks (OR=0.38; 95%CI=0.31–0.46) and sugary drinks (OR=0.66; 95%CI=0.56–0.78) available in the home. In addition,

being married or cohabitating with a partner was associated with higher availability of all foods examined in the study compared to those living alone ($P < 0.05$). Similarly, family size was positively associated with the availability of all tested foods ($P < 0.05$) except for fat-free/low-fat milk. Men were associated with lower availability of healthy foods (fruits, vegetables and milk) versus women ($P < 0.05$).

Associations of neighborhood-level factors with home food availability are presented in Table 3. Tract SES scores were positively associated with fruit (OR=1.15; 95%CI=1.02–1.29; interpreted as: one unit increase in SES score was associated with 15% increase in odds of having fruits always or most of the time available in the home), vegetable (OR=1.14; 95%CI=1.03–1.26), and fat-free/low-fat milk (OR=1.25; 95%CI=1.10–1.42) availability after controlling for individual and other neighborhood-level variables. Urban status was associated with higher availability of fruits (OR=1.47, 95%CI=1.05–2.08) and fat-free/low-fat milk (OR=1.33, 95%CI=1.02–1.73) compared to rural status in the full models. The results were similar for the reduced models except for the association between tract SES scores and sugary drink availability which was significant in the reduced model (OR=0.88, 95%CI=0.79–0.98). Food desert status was not associated with home food availability in both full and reduced models.

DISCUSSION

The current results showed that SES at both individual (income-to-needs ratio and education such as having a college degree) and neighborhood level (tract SES score) was positively associated with home availability of healthy foods including fruits, vegetables and fat-free/low-fat milk. In addition, having a college degree was inversely associated with the availability of unhealthy foods such as salty snacks and sugary drinks compared to those without a college degree. The only exception to this pattern was the observed positive association between income-to-needs ratio and salty snack availability. The current results were primarily in agreement with findings by Masters et al., demonstrating high-income homes had a significantly greater prevalence of fruits, fat-free/low-fat milk and salty snacks always available compared to low-income homes among US youth aged 6–19 years utilizing NHANES.¹¹ The current study did not observe the association of income with fruit availability but instead observed a positive association between income-to-needs ratio and vegetable availability in the adult population. The study by Masters et al. only examined the individual-level factors such as income-to-poverty ratio and race/ethnicity.¹¹ The multivariable models used in the current study included not only relevant individual-level but also neighborhood-level variables to further elucidate how these multilevel factors influence the home food environment.

It is well established in the literature that healthier foods and diets cost more than unhealthier ones,^{33–35} which may help to explain the positive associations between income-to-needs ratio and the availability of healthy foods such as vegetables and fat-free/low-fat milk in the home. Previous work found that the cost of diet significantly mediated the association between income and diet quality, suggesting that social gradient in diet quality may be in part explained by food price and diet cost.³⁶ However, the current study also found that family income-to-needs ratio was positively associated with the availability of

unhealthy foods such as salty snacks. This finding appears to be consistent with previously reported income-related household food purchases suggesting high-income households spent more dollars per person on both healthy and unhealthy foods compared to low-income households.³⁷

Interestingly, the current results indicated that college graduates were more likely to have all the healthy foods (fruits, vegetables and fat-free/low-fat milk) and less likely to have all the unhealthy foods (salty snacks and sugary drinks) available in the home compared to non-college graduates after controlling for income and other relevant covariates. Specifically, there was an approximately two-fold increase in odds of having fruits or fat-free/low-fat milk and a two-fold decrease in odds of having sugary drinks available among participants with college degrees relative to those without. Thus, regardless of income level, college graduates may be more conscious of the importance of creating a healthier home food environment and following dietary recommendations of healthy eating compared to non-college graduates. This was supported by previously documented positive impact of education on individual's health knowledge including knowledge related to healthy eating.³⁸ Aggarwal et al. found that the effect of food price and diet cost on income–diet quality pathway was stronger among participants with lower education compared with their higher education counterparts, suggesting that education extends beyond individual's purchasing power and affordability and that with proper nutrition knowledge one can achieve better quality diets within the given budget constraints.³⁶ The current finding regarding the stronger effect of education versus income suggests that non-monetary, SES related factors such as education level, often positively linked to one's nutrition and health knowledge,^{39,40} may serve as a more relevant predictor than economic resources for an individual's home food environment in terms of healthy and unhealthy food availability. These results also speak to the importance of including multiple SES indicators when examining the relationships between SES and home food availability and food purchasing habits.^{12,41}

As to the neighborhood effects, the current study found that neighborhood SES was also linked to greater availability of healthy foods including fruits, dark green vegetables, and fat-free/low-fat milk even after controlling for individual-level sociodemographic factors. Although previous work showed that low-income neighborhoods had less physical access to supermarkets that have a variety of choices of healthy foods and more access to convenience stores that sell unhealthy foods,^{17,42,43} no associations between food desert status and home food availability were observed in this study, suggesting the pathway between neighborhood SES and home food environment may not be mediated by the food environment in the neighborhood. In fact, a recent study reported that shopping primarily at big supermarkets was not associated with a better nutrition profile of foods and beverages that households purchased than was shopping primarily at mass merchandisers or at a combination of large and small stores and these results were consistent across race/ethnicity groups.²¹ Neighborhood SES reflects individual-level SES to some extent as suggested by the current demographic data showing low SES neighborhoods had larger proportions of low-income, less educated and minority (black, Hispanic) residents compared to high SES neighborhoods. That said, the current findings nevertheless suggest that neighborhood SES was an independent predictor for the availability of healthy foods such as fruits, vegetables and fat-free/low-fat milk in the home since the current analyses took into account various

potential confounders at individual level and the associations were significant with and without the additional adjustment for other neighborhood covariates.

The current results showed that rural residents were less likely to have healthy foods such as fruits and fat-free/low-fat milk available in the home compared to urban residents. These findings seem to lend indirect support for the notion that rural-urban cultural differences in terms of food preferences might exist beyond the environmental influences such as the accessibility to supermarkets where wide selections of high quality, healthy foods with low prices are available.^{44,45} Future research is necessary to investigate the mechanisms at various levels through which rural-urban residence affects home food environment. In any event, the rural-urban differences in home healthy food availability may help explain the persistent higher obesity rate of rural residents compared to urban residents in the U.S.⁴⁶

In addition to SES indicators, home food availability was associated with other relevant individual-level characteristics such as age, sex, race/ethnicity, immigrant status, marital status, and family size in this study. Interestingly, the current results showed that overall immigrants had a healthier home food environment than US-born individuals. For instance, foreign-born adults had higher availability of vegetables and lower availability of salty snacks and sugary drinks compared to US-born citizens. This could be partially due to the healthy immigrant effect, that is, immigrants have healthier lifestyles in their home countries, are among the healthiest from their home country, and are those most willing and able to endure the stressors associated with immigration, thereby placing them at a health advantage.⁴⁷ The healthy immigrant effect is apparently evidenced in their home food environment with more available healthy foods and less available unhealthy foods than native-born citizens. Another intriguing observation was that being married or living with a partner were more likely to have all types of foods, whether healthy or not, stored in the home compared to participants living alone, suggesting marriage could be both a positive and negative influence on the home food environment.

This is the first study to assess the associations of both individual and neighborhood-level factors with home food environment in terms of the availability of healthy and unhealthy foods in a large-scale, nationally representative sample in the U.S. (NHANES). There were several limitations of the study. First and foremost, due to the cross-sectional design, no causality should be assumed from the results. Second, the neighborhood was defined by census tract, an administrative unit used in the US census. While this approach takes advantage of easily accessible census data and is often adopted in the literature, the drawback of using artificially defined spatial boundaries to circumscribe socio-culturally meaningful neighborhoods is an inevitable exposure misspecification, a conservative bias commonly shared in studies of neighborhood effects on health. Third, there was a time gap between individual-level (2007–2008 and 2009–2010 NHANES) and tract-level (2000 census) data collection. In addition, the home food availability measures were only included in the 2007–2008 and 2009–2010 waves of NHANES. Thus, the current results may not completely reflect the most updated situation regarding how individual and neighborhood factors influence the home food environment. Further, misreporting of home food availability might occur due to the self-report measures used in the study. Lastly, residual confounding may still exist despite controlling for potential confounders in the analyses.

CONCLUSIONS

The results from this multilevel nationwide study demonstrate that SES at both individual (e.g., income and education) and neighborhood level were positively associated with the availability of healthy foods (fruits, vegetables, fat-free/low-fat milk) in the home. In addition, education level was also inversely associated with the availability of unhealthy foods (salty snacks, sugary drinks). Further, rural residents compared to their urban counterparts were less likely to have healthy foods such as fruits and fat-free/low-fat milk available in the home. The availability of healthy or unhealthy foods at home was also associated, either positively or inversely with other relevant characteristics such as age, sex, race/ethnicity, immigrant status, marital status, and family size. Future research elucidating how individual and neighborhood-level factors influence home food environment may be valuable for researchers, dietitians, nutrition educators and policy makers to form strategies and develop direct interventions for healthy eating. The current results suggest the needs to improve home food environment for socioeconomically disadvantaged individuals and neighborhoods.

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Table 1

Individual and neighborhood characteristics of adults aged 19 to 65 years in the United States participating in NHANES^a 2007–2010 by neighborhood socioeconomic status (SES)

	Neighborhood SES			
	All	High SES ^b	Low SES ^b	P value ^c
Individual Characteristics				
N	8975	4118	4857	
Age (year), mean (95% CI) ^d	41.5 (41.0, 42.0)	42.6 (42.0, 43.2)	40.0 (38.9, 41.1)	0.0001
Sex, n (%)				
Male	4479 (49.9)	2034 (49.4)	2458 (50.6)	0.24
Female	4496 (50.1)	2084 (50.6)	2399 (49.4)	0.24
Race/ethnicity, n (%)				
Black	1086 (12.1)	301 (7.3)	879 (18.1)	<0.0001
Hispanic	1301(14.5)	367 (8.9)	1064 (21.9)	0.0002
White	5968 (66.5)	3142 (76.3)	2613 (53.8)	0.0002
Other	619 (6.9)	308 (7.5)	301 (6.2)	0.35
Foreign born, n (%)	1651 (18.4)	651 (15.8)	1054 (21.7)	0.07
Body mass index (kg/m ²), mean (95% CI) ^d	28.6 (28.3, 28.8)	28.1 (27.8, 28.3)	29.3 (28.9, 29.6)	<0.0001
Family income-to-needs ratio ^e , mean (95% CI) ^d	3.0 (2.9, 3.1)	3.6 (3.5, 3.7)	2.3 (2.2, 2.5)	<0.0001
College graduates, n (%)	2432 (27.1)	1053 (36.5)	733 (15.1)	<0.0001
Married/cohabitating, n (%)	5672 (63.2)	2804 (68.1)	2759 (56.8)	<0.0001
Family size (number of people), mean (95% CI) ^d	3.0 (2.9, 3.1)	3.0 (2.9, 3.2)	3.0 (2.9, 3.2)	0.81
Neighborhood characteristics				
Tract SES score ^f , mean (95% CI) ^d	0.10 (−0.02, 0.21)	0.70 (0.59–0.81)	−0.68 (−0.77, −0.59)	<0.0001
Rural-urban status ^g , n (%)				
Urban	7180 (80.0)	3562 (86.5)	3473 (71.5)	0.05
Rural	1795 (20.0)	556 (13.5)	1384 (28.5)	0.05
Food desert status ^h , n (%)	601 (6.7)	25 (0.6)	704 (14.5)	<0.0001

^aNHANES=National Health and Nutrition Examination Survey

^bLow neighborhood SES and high neighborhood SES were defined based on tract SES scores. Low neighborhood SES: <median score; high neighborhood SES: median score.

^cP values for differences between low neighborhood SES and high neighborhood SES were estimated using chi-square test for categorical variables or t test for continuous variables.

^d95% CI = 95% confidence interval for the mean

^eFamily income-to-needs ratio: a ratio in which the numerator is a family's household annual income and the denominator is the federal poverty threshold given the appropriate family size, location and year.

^fTract SES score was constructed based on percent affluent households, percent residents in poverty and percent college educated residents.

^gTract rural-urban status was defined using the U.S. Department of Agriculture (USDA) 2000 primary Rural-Urban Commuting Areas codes.

^hFood desert status was determined using USDA Food Desert Locator.

Table 2

Associations of individual factors with home food availability among adults aged 19 to 65 years in the United States participating in NHANES^a 2007–2010 (N=8975)

	Fruits			Dark green vegetables			Fat-free/low-fat milk			Salty snacks			Sugary drinks		
	OR (95% CI) ^{b,c}	P ^c		OR (95% CI) ^{b,c}	P ^c		OR (95% CI) ^{b,c}	P ^c		OR (95% CI) ^{b,c}	P ^c		OR (95% CI) ^{b,c}	P ^c	
Individual Characteristics															
Age (year)	1.02 (1.00–1.02)	0.0001		1.02 (1.01–1.02)	<0.0001		1.00 (0.99–1.00)	0.23		1.00 (0.99–1.00)	0.04		0.99 (0.99–1.01)	0.61	
Male (vs. female)	0.74 (0.65–0.84)	<0.0001		0.72 (0.74–0.91)	0.0005		0.91 (0.82–0.99)	0.04		0.97 (0.89–1.05)	0.37		1.06 (0.97–1.17)	0.19	
Black (vs. White)	0.71 (0.54–0.93)	0.01		1.50 (1.18–1.91)	0.002		0.39 (0.31–0.48)	<0.0001		0.62 (0.50–0.76)	<0.0001		1.12 (0.89–1.40)	0.32	
Hispanic (vs. White)	0.79 (0.62–0.99)	0.04		0.80 (0.65–0.98)	0.03		0.59 (0.47–0.75)	<0.0001		0.72 (0.57–0.93)	0.01		0.73 (0.60–0.90)	0.004	
Foreign-born (vs. US-born)	1.20 (0.97–1.47)	0.09		1.33 (1.05–1.67)	0.02		0.82 (0.67–1.01)	0.06		0.38 (0.31–0.46)	<0.0001		0.66 (0.56–0.78)	<0.0001	
Body mass index (kg/m ²)	1.01 (0.99–1.02)	0.30		0.99 (0.99–1.01)	0.41		1.01 (0.08–1.02)	0.08		1.00 (0.99–1.01)	0.56		1.01 (0.99–1.01)	0.30	
Married/cohabitating (vs. not)	1.56 (1.31–1.86)	<0.0001		1.31 (1.14–1.51)	0.0004		1.31 (1.12–1.53)	0.002		1.42 (1.20–1.69)	0.0003		1.17 (1.01–1.35)	0.04	
Family size (number of people)	1.42 (1.30–1.55)	<0.0001		1.20 (1.14–1.27)	<0.0001		1.03 (0.97–1.09)	0.28		1.16 (1.09–1.22)	<0.0001		1.11 (1.06–1.16)	0.0001	
Individual SES^d Characteristics															
Income-to-needs ratio ^e	1.01 (0.95–1.07)	0.83		1.07 (1.00–1.13) ^f	0.047		1.16 (1.07–1.25)	0.001		1.12 (1.04–1.20)	0.004		1.04 (0.97–1.11)	0.25	
College graduates (vs. non-college graduates)	1.96 (1.48–2.60)	<0.0001		1.48 (1.16–1.88)	0.003		1.81 (1.55–2.12)	<0.0001		0.77 (0.63–0.95)	0.02		0.46 (0.37–0.57)	<0.0001	

^aNHANES=National Health and Nutrition Examination Survey

^bOR=odds ratio; 95% CI=95% confidence interval

^cOR, 95% CI and P values were estimated using logistic regression modeling. The multivariable models included the following covariates: age, sex, race/ethnicity, immigrant status, family income-to-needs ratio, education, body mass index, marital status, family size, tract SES score, urban-rural status and food desert status; Models were also adjusted for two dichotomous variables of imputed income status and top-coded income status.

The outcome/dependent variables (home food availability) were characterized as dichotomous (always/most of the time available vs. sometimes/rarely/never available [reference group]).

^dSES=socioeconomic status

^eA ratio in which the numerator is a family's household annual income and the denominator is the federal poverty threshold given the appropriate family size, location and year.

Table 3

Associations of neighborhood factors with home food availability among adults aged 19 to 65 years in the United States participating in NHANES^a 2007–2010 (N=8975)

Neighborhood Characteristics	Model 1 ^b		Model 2 ^c	
	OR (95% CI) ^{d,e}	P ^e	OR (95% CI) ^{d,e}	P ^e
Fruits				
Tract SES ^f score ^g	1.21 (1.08–1.34)	0.0006	1.15 (1.02–1.29)	0.02
Urban status (vs. rural status) ^h	1.40 (1.02–1.92)	0.03	1.47 (1.05–2.08)	0.03
Food desert status (vs. non-food desert) ⁱ	0.83 (0.63–1.10)	0.20	0.89 (0.66–1.20)	0.44
Dark green vegetables				
Tract SES ^f score ^g	1.16 (1.05–1.27)	0.004	1.14 (1.03–1.26)	0.01
Urban status (vs. rural status) ^h	1.20 (0.99–1.46)	0.06	1.21 (0.99–1.47)	0.06
Food desert status (vs. non-food desert) ⁱ	1.01 (0.74–1.37)	0.96	1.09 (0.78–1.51)	0.62
Fat-free/low-fat milk				
Tract SES ^f score ^g	1.28 (1.11–1.48)	0.001	1.25 (1.10–1.42)	0.002
Urban status (vs. rural status) ^h	1.44 (1.11–1.87)	0.008	1.33 (1.02–1.73)	0.03
Food desert status (vs. non-food desert) ⁱ	1.04 (0.72–1.49)	0.85	1.18 (0.84–1.66)	0.33
Salty snacks				
Tract SES ^f score ^g	1.05 (0.95–1.16)	0.38	1.05 (0.94–1.16)	0.38
Urban status (vs. rural status) ^h	0.98 (0.75–1.30)	0.91	0.94 (0.70–1.28)	0.71
Food desert status (vs. non-food desert) ⁱ	0.91 (0.70–1.18)	0.46	0.93 (0.70–1.22)	0.58
Sugary drinks				
Tract SES ^f score ^g	0.88 (0.79–0.98)	0.026	0.93 (0.83–1.04)	0.19
Urban status (vs. rural status) ^h	0.70 (0.45–1.09)	0.11	0.72 (0.43–1.19)	0.19
Food desert status (vs. non-food desert) ⁱ	1.18 (0.81–1.73)	0.38	1.16 (0.78–1.72)	0.44

^aNHANES=National Health and Nutrition Examination Survey

^bModel 1 included all the individual-level covariates (age, sex, race/ethnicity, immigrant status, income-to-needs ratio, education, body mass index, marital status, family size) and one single neighborhood-level variable examined; Model were also adjusted for two dichotomous variables of imputed income status and top-coded income status.

^cModel 2 included all the individual-level covariates in Model 1 and all the neighborhood-level variables examined (urban-rural status, tract SES score, and food desert status); Models were also adjusted for two dichotomous variables of imputed income status and top-coded income status.

^dOR=odds ratio; 95% CI=95% confidence interval

^eOR, 95% CI and P values were estimated using logistic regression modeling.

The outcome/dependent variables (home food availability) were characterized as dichotomous (always/most of the time available vs. sometimes/rarely/never available [reference group]).

^fSES=socioeconomic status

^gTract SES score was constructed based on percent affluent households, percent residents in poverty and percent college educated residents.

^hTract rural-urban status was defined using the U.S. Department of Agriculture (USDA) 2000 primary Rural-Urban Commuting Areas codes.

ⁱFood desert areas were determined using USDA Food Desert Locator.

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