Sleep Health 5 (2019) 128–134

Contents lists available at ScienceDirect

Sleep Health

Journal of the National Sleep Foundation

journal homepage: sleephealthjournal.org

The association between food deserts and short sleep duration among young adults in the United States: variation by race and ethnicity

Alexander Testa, PhD

Department of Criminal Justice, University of Texas at San Antonio, 501 W Cesar Chavez Blvd, San Antonio, TX 78207

ARTICLE INFO

Article history:
Received 25 June 2018
Received in revised form 7 November 2018
Accepted 12 November 2018

Keywords:
Sleep
Food desert
Nutrition
Diet

ABSTRACT

Background: Both food deserts and short sleep duration are serious public health problems that affect the lives of millions of Americans. Although recent research has begun to link community characteristics to sleep problems, the relationship between living in a food desert and sleep behavior has gone largely unexplored.

Methods: Using data from the National Longitudinal Study from Adolescent to Adult Health and data on food retailers from the Modified Retail Food Environment Index, this study applies multivariable logistic regression to assess the association between living in a food desert and short sleep duration. Models were stratified by race and ethnicity to examine potential moderating effects. Supplemental analyses are conducted where the comparison category is restricted to respondents who live in census tracts with low access to healthy food retailers but do not live in food deserts.

Results: In adjusted logistic regression models, living in a food desert is not associated with short sleep duration. When the sample is stratified, living in a food desert has a positive and significant association with short sleep duration among Hispanic respondents in both the main analysis (odds ratio = 1.7; 95% confidence interval = 1.0-2.7) and supplemental models (odds ratio = 1.9; 95% confidence interval = 1.2-3.2).

Conclusions: Living in a food desert is not associated with short sleep duration among young adults. Study results indicate that living in a food desert is associated with increased odds for short sleep duration among Hispanics. Potential explanations for this finding are discussed in the context of extant research.

Introduction

Environmental conditions are recognized as an important contributing factor to disparities in health behavior.[1] In recent years, scholars have increasingly focused on the relationship between local food environments and health.[2] Of notable interest is the role of food deserts in shaping health.[3] Food deserts are geographic areas where access to nutritious food is limited. Approximately 23.5 million individuals live in food deserts across the United States.[4] Because dietary decisions are often made based on locally available food outlets, residents of food deserts tend to consume more energy-dense, nutrient-poor foods.[3] Moreover, living in a food desert is associated with adverse health conditions including obesity and cardiovascular disease.[5,6]

An important component of the relationship between food deserts and health that remains overlooked is sleep behavior. Current estimates suggest that approximately 1 in 3 US adults does not get the recommended 7 hours of sleep or more per night.[7] Like food deserts, inadequate sleep is a serious public health concern that is related to a host of physical and psychosocial health problems including hypertension, dyslipidemia, cardiovascular disease, metabolic syndrome, mortality, depression, anxiety disorders, and inhibited cognitive functioning.[8,9] Notably, research finds that neighborhood conditions are associated with lower sleep quality and shortened sleep duration in adults.[10–14]

Although past research has not investigated the association between living in a food desert and sleep, there are several reasons to expect that living in a food desert may be associated with sleep behavior. First, persons living in food deserts spend longer time accessing food items on average.[4,15] Accordingly, living in a food desert can make obtaining food on a daily basis a more difficult and time-consuming task, which in turn may lead to reductions in sleep as a means to compensate for lost time. Second, living in a food desert is associated with several socioeconomic, health, and lifestyle factors that may increase the likelihood for short

E-mail address: alexander.testa@utsa.edu.

https://doi.org/10.1016/j.sleh.2018.11.006

sleep duration. For instance, living in a food desert is associated with poor dietary behavior.[3] Healthier diets, marked by a higher consumption of nutrient-rich foods, are associated with reduced odds of short sleep duration, potentially by supporting the release of hormones such as insulin, ghrelin, and cholecystokinin that promote sleep patterns.[16] Likewise, sleep curtailment can influence metabolism and satiety regulation, leading to frequent snacking and increased consumption of high-energy, nutrient-poor foods.[17] Residence in food deserts is linked to obesity,[5] which has been shown to increase the likelihood of short sleep duration.[18] Experiencing food hardships is also stressful life circumstance[19] that can lead to reductions in sleep quality by making it difficult to fall or stay asleep.[10,20] Living in a food desert also co-occurs with other poor health behaviors aside from diet, including smoking, alcohol consumption, and reductions in exercise and physical activity, each of which is a lifestyle factor linked to sleep behavior.[10,20–25] Finally, food deserts are often located in economically disadvantaged neighborhoods,[3] which are found in prior research to inhibit sleep quality.[13]

In sum, there are multiple reasons to believe that living in a food desert will be positively associated with likelihood of short sleep duration. The current study extends research on the built environment and sleep behavior by providing the first assessment of the association between living in a food desert and short sleep duration. Moreover, because both the composition of food retail environments[26] and sleep patterns vary by race and ethnicity,[10] this study stratifies the sample and conducts exploratory analysis of whether the association between living in a food desert and short sleep duration differs across Black, White, and Hispanic individuals.

Methods

Data

Data for this study are drawn from 2 sources. The primary data are from waves I and IV of the National Longitudinal Study of Adolescent to Adult Health (Add Health). Add Health is a nationally representative survey that sampled 90,000 students in grades 7-12 from 132 schools in the 1993-1994 academic year.[27] Since the initial survey, 20,000 individuals were selected to participate in 3 follow-up interviews. Wave II was administered in 1996, wave III was administered in 2001-2002, and wave IV was conducted in 2008. A total of 15,701 respondents participated in the wave IV interview. Data for Add Health are collected through in-home interviews that last approximately 1 to 2 hours and cover an array of topics including the respondents' physical and mental health, family dynamics, socioeconomic status, and decision-making processes. Additionally, Add Health collects contextual data on communities to understand ways social environments influence health and behavior. To date, Add Health has been used by an extensive network of researchers, resulting in over 2000 peer-reviewed research articles.[27]

Data on food retailers are drawn from the Modified Retail Food Environment Index (mRFEI), which was created by the Centers for Disease Control and Prevention. The mRFEI measures over 1 million food retailers from 65,345 US census tracts in 2008-2009. The mRFEI provides the ratio of healthy to unhealthy food retailers within a census tract and the 0.5-mile buffer surrounding the tract. Food retailers are measured using the North American Industry Classification System (NAICS). Healthy food retailers are defined as supermarkets (NAICS 445100), larger grocery stores (NAICS 445100), fruit and vegetable markets (NAICS 445230), and warehouse clubs (NAICS 452910). Unhealthy food retailers include fast-food restaurants (NAICS 722211), small grocery stores (NAICS 44511), and convenience stores (NAICS 445120). The mRFEI score is calculated using the following formula:

$$\text{mRFEI} = 100 \times \frac{\#\text{Healthy food retailers}}{\#\text{Healthy food retailers} + \#\text{less healthy food retailers}}$$

The mRFEI data were linked to 15,696 census tracts at Wave IV of the Add Health survey through the ancillary studies in Add Health program. Given that prior research finds that the Centers for Disease Control and Prevention definition of access to food retailers (census tract and 0.5-mile buffer) is valid for urban areas,[28] this analysis restricts the sample to respondents living in urban census tracts (N = 11,509). Finally, as a result of missing data from nonresponse, the analytic sample is 9617. Missing data were addressed using listwise deletion, which may be less problematic than imputation, particularly because the loss of cases does not generate issues regarding statistical power in the current study.[29] Figure 1 provides a description of how the final sample was obtained.

Measures

Dependent variable

At wave IV, participants were asked what time they usually go to bed and wake up on (1) days when you have to go to work, school, or similar activities and (2) on days when you do not have to get up at a certain time. Sleep time was calculated using a weighted average where weekday (ie, wake up for work or school) items count for 5 of the 7 days and the weekend items (ie, do not have to get up) count for 2 of the 7 days. Short sleep is coded as a binary variable where 1 equals sleeping less than 7 hours per night on average, which is the recommended minimum amount of sleep made by the National Sleep Foundation.[30] The most common reason for missing data regarding sleep duration is the result of respondents providing sleep times that seemed either implausible or impossible through reporting errors such as mistakenly switching their sleep and wake-up times, resulting in negative values.

Independent variable

The focal independent variable is living in a food desert. Consistent with the definition of the Centers for Disease Control and Prevention,[31] food deserts are coded as a binary variable indicating whether a respondent lives in a census tract with an mRFEI score of zero (ie, census tracts with no healthy food retailers).

Moderating variables

Race/ethnicity is coded as a categorical variable based on whether a respondent identifies as White, Black, Hispanic, or other race.

Control variables

The current study controls for several demographic and background characteristics (age, sex, high school degree, child abuse victim, fatalism, prior short sleep, hard drug use, parent education). This analysis also controls for several variables measuring lifestyle, socioeconomic status, and contextual characteristics (concentrated disadvantage, material hardship, anxiety symptoms, obesity, fast-food consumption, exercise, smoking, and alcohol use). A detailed description of each of these variables appears in Table 1.

Statistical procedures

The analyses are performed in Stata version 15.0. Estimates apply survey weights using the SVY command in Stata to adjust for the multistage cluster design of the Add Health Survey. The analysis uses multivariable logistic regression and adjusts for individual and

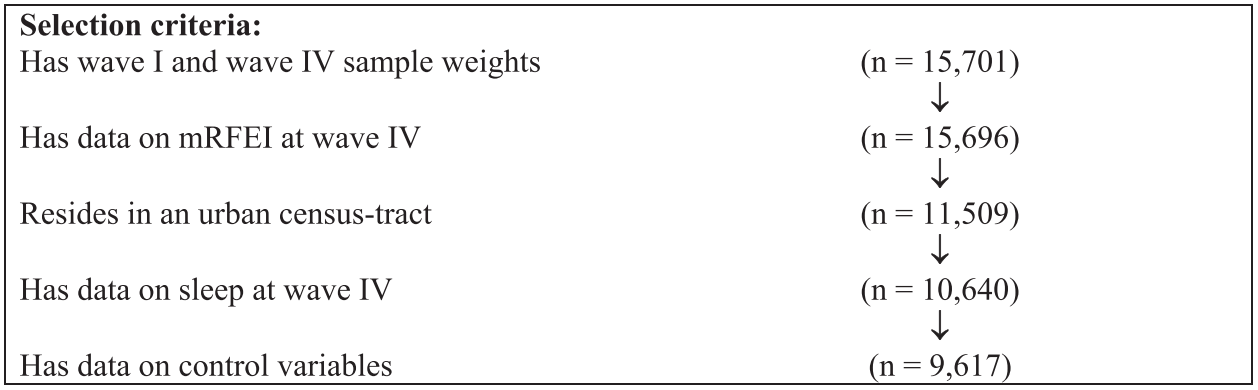

Fig. 1. Sample selection flowchart for the national longitudinal study of Add Health waves I and IV.

Table 1
Description of variables from the Add Health waves I and IV

Variables	Description	Coding	Wave
Dependent variable			
Short sleep duration	Respondent sleeps less than 7 h per night.	1 = Yes	W4
Independent variable			
Food desert	Respondent lives in a census tract with an mRFEI score of 0.	1 = Yes	W4
Control variables			
White	Respondent is White.	1 = Yes	W1
Black	Respondent is Black.	1 = Yes	W1
Hispanic	Respondent is Hispanic.	1 = Yes	W1
Other race	Respondent is other race.	1 = Yes	W1
Age	Respondent's age in years	Number of years	W4
Male	Respondent is male.	1 = Yes	W1
High school graduate	Respondent graduated high school.	1 = Yes	W4
Child abuse victim	Respondent reported being hit with a fist; kicked; or thrown down to the floor, into a wall, or down the stairs by a parent or adult caregiver before their 18th birthday.	1 = Yes	W4
Fatal	Respondent's perceived likelihood of living to age 35 (no chance, some chance, 50-50 chance, a good chance, almost certain)	5-point scale	W1
Short sleep	Respondent reported usually sleeping less than 8 h per night.	1 = Yes	W1
Hard drug use	Respondent reported using illegal drugs aside from marijuana.	1 = Yes	W1
Concentrated disadvantage	The proportion of residents within a respondent's census tract that are on welfare, living at or below the poverty line, or unemployed, and the proportion of female-headed households	Standardized scale	W1 and W4
Parent education			
Parent: high school graduate	Highest level of education attained by either parent was high school.	Standardized scale	W1
Parent: post–high school	Highest level of education attained by either parent was post–high school education.	1 = Yes	W1
Parent: missing	Highest level of education attained by either parent was missing.	1 = Yes	W1
Material hardship	Scale combining responses to a series of questions asking respondents in the prior year whether or not they were: (1) unable to pay for phone service; (2) unable to pay the full amount of rent or mortgage; (3) evicted from house or apartment because of missed payments; (4) unable to pay gas, electric, or oil bills because of a lack of money; (5) had household services shut off because of missing payments; or (6) were worried food would run out because of a lack of money	Six-point scale	W4
Anxiety symptoms	Scale constructed from the following 4 items measuring how often in the past 30 d the respondent felt the following: (1) unable to control the important things in life, (2) confident in ability to handle personal problems (reverse coded), (3) things were going your away (reverse coded), and (4) difficulties were piling up so high that they could not be overcome	Sixteen-point scale	W4
Obesity	Respondent's body mass index is ≥30.	1 = Yes	W4
Fast food	Number of times in the previous week a respondent consumed fast food (ie, McDonald's, Burger King, Wendy's, Arby's, Pizza Hut, Taco Bell, or Kentucky Fried Chicken or a local fast-food restaurant)	Count	W4
Exercise	Number of times in the previous week a respondent engaged in physical exercise at wave IV (ie, solo or team sports, individual or group exercise)	Count	W4
Smoking			
Cigarettes: none	The total number of cigarettes consumed in the past month by a respondent was zero.	1 = Yes	W4
Cigarettes: 1-19 cigarettes	The total number of cigarettes consumed in the past month by a respondent was between 1 and 19.	1 = Yes	W4
Cigarettes: 20 or more cigarettes	The total number of cigarettes consumed in the past month by a respondent was 20 or more.	1 = Yes	W4
Alcohol use			
Alcohol: none	Respondent reported consuming zero alcoholic drinks in the prior month	1 = Yes	W4
Alcohol: less than once a week	Respondent reported consuming alcoholic drinks less than once per week in the prior month	1 = Yes	W4
Alcohol: 1-2 d/wk	Respondent reported consuming alcoholic drinks 1-2 d/wk in the prior month	1 = Yes	W4
Alcohol: ≥3 d/wk	Respondent reported consuming alcoholic drinks ≥3 d/wk in the prior month	1 = Yes	W4

W1, wave 1; W4, wave 4.

contextual characteristics that may be related to living in a food desert and short sleep duration. Variance inflation factors were in acceptable ranges, indicating no issues related to multicollinearity. To test moderation effects, models were stratified by race and ethnicity, and equality of coefficient tests were applied to determine whether the influence of living in a food desert on short sleep duration differs across White, Black, and Hispanic respondents.[32] Equality of coefficients is calculated using the formula below:

$$z = \frac{b_1 - b_2}{\sqrt{(s_1{}^2) + (s_2{}^2)}}$$

where b represents the unstandardized regression coefficient for a given covariate and s represents the standard error of a given covariate.

Results

Table 2 reports the descriptive statistics for the analytic sample. Overall, 22.6% of the sample reported sleeping less than 7 hours per night. About 16.3% of respondents reside in a food desert. On average, the sample is 28 years old. Regarding race/ethnicity, 64.7% of respondents are White, 14.6% Black, 14.8% Hispanic and 5.9% other race/ethnicity. Half of the sample is male.

Table 3 reports the results of the logistic regression of the association between living in a desert and short sleep duration. Model 1 regresses sleep duration on the food desert measure, adjusting for individual and contextual characteristics. Living in a food desert does not exhibit a significant association with short sleep duration. Among the covariates, Black respondents are approximately 40% more likely than White respondents to experience short sleep duration (odds ratio [OR] = 1.4; 95% confidence interval [CI] = 1.1-1.7), and men are twice as likely than women to sleep less than 7 hours per night (OR = 2.0; 95% CI = 1.7-2.3). Respondents who reported being a child abuse victim are approximately 30% more likely to experience short sleep duration (OR = 1.3; 95% CI = 1.1-1.6). Respondents who reported short sleep during wave I are about 70% more likely to experience short sleep duration at wave IV (OR = 1.7; 95% CI = 1.4-1.9). Respondents whose parents graduated high school (OR = 1.6; 95% CI 1.3-2.1) or had post–high school education (OR = 1.5; 95% CI = 1.2-1.9) had an increased likelihood of short sleep duration relative to respondent's whose parents had less than a high school education.

Several wave IV control variables are associated with short sleep duration. Anxiety symptoms have a positive association with short sleep duration (OR = 1.0; 95% CI = 1.0-1.1). Respondents who are obese are 40% more likely to experience short sleep duration (OR = 1.4; 95% CI = 1.2-1.6). Fast-food consumption is positively associated with short sleep duration (OR = 1.0; 95% CI = 1.0-1.1). Individuals who smoke 20 or more cigarettes per month were about 30% more likely than nonsmokers to experience short sleep duration (OR = 1.3; 95% CI = 1.0-1.5).

Models 2 through 4 stratify the sample by race and ethnicity. These results indicate that there is no significant association between living in a food desert and short sleep duration among White or Black respondents. For Hispanic respondents, living in a food desert is associated with a higher likelihood of short sleep duration (OR = 1.7; 95% CI = 1.0-2.7). The coefficient for Hispanic respondents significantly differs in comparison to Black respondents (z score = 2.20, $P < .05$).

Next, to reduce the influence of unobserved heterogeneity, an additional set of analyses is conducted where the sample is restricted to respondents who live in a census tract with an mRFEI score of less than 10. This provides a separate analysis that compares those who live in a food desert to respondents with low access to healthy food retailers. The threshold of 10 is selected because it is below the national average and has been shown by past research to be associated with lower-quality nutrition.[31,33] The results reported in Table 4 are similar to those in the main sample. Specifically, in model 1, there is no significant association between living in a food desert and short sleep duration. When the model is stratified by race/ethnicity, there is no significant association between living in a food desert and short sleep among White or Black respondents. Model 4 indicates that, among Hispanic respondents, living in a food desert nearly doubles the odds of short sleep duration (OR = 1.9; 95% CI = 1.2-3.2).

Discussion

Inadequate sleep is a serious public health problem that negatively affects the lives of millions of Americans, as well as results in billions of dollars in both direct and indirect costs annually. For instance, lack of sleep is estimated to cost over $400 billion (2.28% of GDP) in lost work force productivity in the United States each year.[34] Moreover, sleep deficiencies results in billions of dollars in annual medical expenses resulting from traffic accidents, industrial accidents, medical errors, and sleep-related health care costs.[34,35] Those who experience short sleep duration are also at risk for a host of medical conditions, including increased risk for all-cause mortality.[8,9]

Using data from a national sample of young adults living in urban areas, this study presented the first empirical test of whether living in a food desert is associated with short sleep duration. The findings indicate that living in a food desert is not associated with short sleep

Table 2
Summary statistics of the analytic sample from the Add Health waves I and IV (N = 9617)

Variables	Mean (SE)/%
Dependent variable	
Short sleep duration	22.6%
Independent variable	
Food desert	16.3%
Demographic and wave I variables	
White	64.7%
Black	14.6%
Hispanic	14.8%
Other race	5.9%
Age: W4	28.4 (12.8)
Male	50.4%
High school graduate	91.7%
Child abuse victim	18.9%
Fatal: W1	4.4 (.02)
Short sleep: W1	38.6%
Hard drug use: W1	12.4%
Concentrated disadvantage: W1	−0.0 (.03)
Parent education	
Less than high school: W1	11.6%
High school graduate: W1	27.2%
Post–high school: W1	55.6%
Missing: W1	5.5%
Wave 4 controls	
Concentrated disadvantage: W4	−0.02 (.02)
Material hardship: W4	52.5 (.03)
Anxiety symptoms: W4	4.9 (.06)
Obesity: W4	34.9%
Fast food: W4	2.3 (.08)
Exercise: W4	6.4 (.10)
Smoking	
None: W4	62.6%
1-19 cigarettes a month: W4	11.3%
20 or more cigarettes a month: W4	26.1%
Alcohol	
None: W4	23.5%
Less than once a week: W4	42.2%
1-2 d/wk: W4	21.2%
≥3 d/wk: W4	13.1%

duration. This suggests that although living in a food desert is associated with a variety of adverse health conditions, food deserts are not an aspect of urban environments that are directly harmful for sleep behavior. One possible explanation for this finding is that residence in a food desert may overlap with other characteristics that more directly influence sleep behavior, such as obesity, dietary and lifestyle behavior, socioeconomic conditions, and neighborhood disorder.[11–14] Thus, the null findings may be the result of controlling for many relevant individual and contextual characteristics that are associated with living in a food desert and short sleep duration. Alternatively, it may be that accessibility to food retailers does not alter the daily lives of many individuals significantly enough to alter sleep patterns. For instance, it is possible that many people residing in a food desert may adjust their shopping and dietary patterns to cope with the circumstances of the local neighborhood conditions in ways that do not negatively influence their sleep. Finally, there may be no association between food deserts and sleep in a large multiracial/ethnic sample. Rather, any association may be conditional on race/ethnicity given that patterns of neighborhood clustering, access to healthy foods, and sleep vary across race/ethnicity.

Given this possibility, this study explored whether the association between living in a food desert and short sleep duration varied by race and ethnicity. These results demonstrated a positive association between living in a food desert and short sleep among Hispanic respondents. There are a few reasons why living in a food desert and may be particularly harmful for sleep among Hispanic individuals. First, prior research finds that despite being a relatively disadvantaged minority group, Hispanics in the United States live in food deserts at relatively low rates.[26,36,37] The Add Health data also support this conclusion, as 9.4% of Hispanic respondents lived in a food desert compared to 16% of White respondents and nearly 18% of Black respondents. Given these patterns, it is possible that Hispanics who do reside in a food desert may experience particularly high levels of adversity and difficulty adjusting to life in a food desert. In turn, these daily adversities may contribute to inadequate sleep. Future research should assess whether Hispanics who reside in food deserts experience greater adversity than those who do not and whether this may partially explain the positive association between living in a food desert and short sleep duration among Hispanics.

Second, persons who live in a food desert tend to spend more time obtaining food from full service retailers than those who do not live in a food desert, net of economic status.[4,15] Prior research on racial and ethnic variation in dietary behavior finds that Hispanics tend to have diets composed of less fast-food and snack items but more whole-food items such as rice, beans, and fruit.[38] Because these food items are most commonly sold in healthy food retailers, Hispanics who live in a food desert live further from food retailers that sell foods that are part of typical diets. Therefore, Hispanics who live in food deserts may spend greater amounts of time traveling to food retailers outside of their local communities, thereby exacerbating daily time constraints and generating a reduction in overall sleep as a means to make up for lost time. Future research that measures shopping patterns such as time spent commuting to grocery stores or the mode of transportation used, and how these patterns vary across race/ethnicity would be valuable.

Third, reductions in accessibility to food retailers may reduce sleep by altering the dietary patterns of Hispanics. Indeed, food deserts are associated with lower-quality dietary behavior,[3] and prior research finds an association between lower-quality nutrition and

Table 3
Results of logistic regression of food deserts on short sleep duration and other covariates from the Add Health waves I and IV

	Model 1: Full sample		Model 2: White only		Model 3: Black only		Model 4: Hispanic only	
Variables	OR	(95% CI)	OR	(95% CI)	OR	(95% CI)	OR	(95% CI)
Independent variable								
Food desert	1.1	(0.9-1.3)	1.2	(0.9-1.5)	0.9	(0.6-1.2)	1.7*	(1.0-2.7)
Race/ethnicity								
Black	1.4*	(1.1-1.7)						
Hispanic	1.0	(0.9-1.2)						
Other race	1.3	(0.9-1.7)						
Control variables								
Age: W4	1.0	(1.0-1.1)	1.0	(0.9-1.0)	1.1	(0.9-1.2)	1.0	(0.9-1.1)
Male	2.0***	(1.7-2.3)	2.1***	(1.7-2.5)	1.7**	(1.2-2.5)	2.0**	(1.3-3.0)
High school graduate	1.3	(1.0-1.7)	1.4	(0.9-2.1)	1.3	(0.8-2.1)	1.2	(0.6-2.4)
Child abuse victim	1.3***	(1.1-1.6)	1.3*	(1.1-1.6)	1.6*	(1.1-2.3)	1.0	(0.7-1.5)
Fatal: W1	0.9*	(0.8-1.0)	0.9	(0.8-1.0)	1.0	(0.9-1.2)	0.8*	(0.6-0.9)
Short sleep: W1	1.7***	(1.4-1.9)	1.8***	(1.5-2.2)	1.5*	(1.0-2.1)	1.8**	(1.2-2.8)
Hard drug use: W1	1.1	(0.9-1.3)	1.1	(0.8-1.3)	0.5	(0.2-1.1)	1.3	(0.9-2.1)
Concentrated disadvantage: W1	1.0	(0.9-1.1)	1.1	(1.0-1.2)	1.0	(0.9-1.2)	0.8*	(0.6-1.0)
Parent: high school graduate: W1	1.6***	(1.3-2.1)	2.1**	(1.3-3.4)	1.6*	(1.1-2.6)	1.3	(0.8-1.9)
Parent: post–high school: W1	1.5**	(1.2-1.9)	1.8**	(1.2-2.8)	1.6*	(1.0-2.6)	1.4	(0.9-2.0)
Parent: missing: W1	1.4	(1.0-2.1)	2.4**	(1.4-4.3)	1.0	(0.5-2.0)	0.9	(0.4-1.8)
Concentrated disadvantage: W4	1.2	(1.0-1.4)	1.2	(0.9-1.7)	1.1	(0.8-1.5)	1.1	(0.6-2.0)
Material hardship: W4	1.0	(0.9-1.1)	1.1	(1.0-1.1)	0.9	(0.8-1.0)	0.9	(0.8-1.1)
Anxiety symptoms: W4	1.0**	(1.0-1.1)	1.0*	(1.0-1.1)	1.1*	(1.0-1.1)	1.0	(1.0-1.1)
Obesity: W4	1.4***	(1.2-1.6)	1.4***	(1.2-1.8)	1.2	(1.0-1.6)	1.3	(0.9-1.9)
Fast food: W4	1.0**	(1.0-1.1)	1.0*	(1.0-1.1)	1.0	(1.0-1.1)	1.1	(1.0-1.1)
Exercise: W4	1.0	(1.0-1.0)	1.0	(1.0-1.0)	1.0	(1.0-1.0)	1.0	(1.0-1.0)
Cigarettes: 1-19 a month: W4	1.0	(0.8-1.2)	0.8	(0.6-1.2)	1.5*	(1.0-2.4)	1.0	(0.7-1.6)
Cigarettes: 20 or more a month: W4	1.3*	(1.0-1.5)	1.3*	(1.0-1.6)	1.1	(0.7-1.7)	1.6	(1.0-2.5)
Alcohol: less than once a week: W4	1.1	(0.9-1.3)	0.9	(0.7-1.2)	1.3	(0.8-2.0)	1.5	(0.9-2.3)
Alcohol: 1-2 d/wk: W4	1.0	(0.8-1.3)	0.8	(0.6-1.1)	1.9*	(1.2-3.1)	1.3	(0.7-2.2)
Alcohol: ≥3 d/wk: W4	1.1	(0.8-1.5)	1.0	(0.7-1.4)	1.3	(0.7-2.2)	1.4	(0.7-2.7)
Constant	0.0***	(0.0-0.1)	0.1***	(0.0-0.3)	0.0*	(0.0-0.3)	0.1	(0.0-1.1)
n	9617		4928		1915		1852	

***$P < .001$, **$P < .01$, *$P < .05$.
Reference: White is reference category for race/ethnicity, less than high school is reference category for parent education, none is reference category for cigarette smoking, and none is reference category for alcohol use.

short sleep duration.[16,17]Accordingly, living in a food desert can substantially alter dietary patterns among Hispanics, leading to greater consumption of processed and high-energy, nutrient-dense foods, which in turn worsens sleep. Although measures of dietary behavior such as fast-food consumption did not explain the association between living in a food desert and short sleep duration among Hispanics, future research with more detailed measures of daily dietary intake should assess this possibility.

Limitations

The current study has limitations that can be expanded upon by future work. First, because the mRFEI is only validated for urban areas, the results should not be generalized to suburban or rural contexts. Second, variables such as socioeconomic status or dietary behavior could not be directly measured. However, the current study included proxies to capture these concepts, such as material hardship and fast-food consumption. Third, some participants had incomplete survey data; however, missing data were not overwhelmingly large, and the current study still maintained adequate statistical power. Fourth, although the current study controlled for a host of individual and contextual characteristics, there may be other characteristics of the built environment that this study was unable to control for, which may be related to both food deserts and sleep, such as excessive noise and light exposure.

Future directions

There are also several areas for future research that can expand upon the current study. First, this study measured access to food retailers at one point. Future research that assesses changes in food retail environments and sleep behavior over time would be valuable. Second, this study focused on young adults. Future research should address the questions posed in this study with alternative data that offer a broader age range beyond early adulthood. Third, the focus of this study was on geographic access to food retailers. However, future research should assess other aspects of local food environments, such as the relationship between food affordability and sleep problems. It is possible that some individuals live within a reasonable proximity to healthy food outlets, yet because food prices are high, they must travel further distances to access affordable food options. Fourth, this study measured short sleep duration as the focal outcome. Future research should continue to assess the relationship between food deserts and sleep using alternative measures of sleep behavior, such as the Pittsburgh Sleep Quality Index.[39] Finally, future research should continue to investigate the association between living in a food desert and sleep with alternative sources of data. Notably, the Add Health survey reports lower levels of short sleep duration than national estimations by the Centers for Disease Control and Prevention.[7] These differences may be partially attributable to the way in which respondents are asked about sleep patterns. For instance, the Centers for Disease Control and Prevention study on short sleep duration asks respondents, “On average, how many hours to sleep do you get in a 24-hour period?”[7] In contrast, the Add Health survey at wave IV asks respondents, “What time do you usually go to sleep/wake up?” Accordingly, future research should seek to replicate the findings in this study using alternative sources of data that measure sleep duration in different ways.

Table 4
Results of logistic regression of food deserts on short sleep duration and other covariates from the Add Health Waves I and IV (sample restricted to respondents living in a census tract with an mRFEI score of less than 10)

	Model 1: Full sample		Model 2: White only		Model 3: Black only		Model 4: Hispanic only	
Variables	OR	(95% CI)	OR	(95% CI)	OR	(95% CI)	OR	(95% CI)
Independent variable								
Food desert	1.1	(0.9-1.4)	1.1	(0.9-1.5)	1.1	(0.7-1.7)	1.9*	(1.2-3.2)
Race/ethnicity								
Black	1.1	(0.9-1.5)						
Hispanic	1.0	(0.7-1.2)						
Other race	1.1	(0.7-1.7)						
Control variables								
Age: W4	1.0	(1.0-1.1)	1.0	(0.9-1.1)	1.1	(0.9-1.2)	1.0	(0.9-1.1)
Male	2.2***	(1.8-2.7)	2.4***	(1.9-3.1)	1.4	(0.8-2.4)	3.0***	(1.7-5.4)
High school graduate	1.6*	(1.1-2.4)	1.8	(1.0-3.2)	1.9	(0.8-4.1)	1.3	(0.4-3.8)
Child abuse victim	1.4**	(1.2-1.8)	1.3	(0.9-1.8)	1.9*	(1.2-3.1)	1.3	(0.7-2.6)
Fatal: W1	0.9	(0.8-1.0)	0.9	(0.8-1.1)	1.0	(0.9-1.3)	0.8	(0.6-1.2)
Short sleep: W1	1.9***	(1.5-2.3)	1.9***	(1.4-2.6)	2.0**	(1.3-3.2)	2.7***	(1.7-4.3)
Hard drug use: W1	1.2	(0.8-1.7)	1.2	(0.8-1.9)	0.5	(0.2-1.5)	1.0	(0.5-2.0)
Concentrated disadvantage: W1	1.0	(0.9-1.2)	1.1	(0.9-1.3)	1.0	(0.9-1.3)	0.8	(0.6-1.1)
Parent: high school graduate: W1	1.6*	(1.1-2.2)	1.7	(0.9-3.1)	1.2	(0.7-2.1)	1.8	(1.0-3.1)
Parent: post–high school: W1	1.6**	(1.2-2.3)	1.8	(1.0-3.3)	1.4	(0.8-2.5)	1.6	(0.9-2.9)
Parent: missing: W1	1.4	(0.8-2.5)	2.3*	(1.0-4.9)	0.6	(0.3-1.5)	1.3	(0.5-3.4)
Concentrated disadvantage: W4	1.1	(0.9-1.5)	1.1	(0.7-1.6)	1.1	(0.7-1.6)	1.3	(0.6-2.9)
Material hardship: W4	1.0	(0.9-1.1)	1.1*	(1.0-1.3)	0.9	(0.7-1.0)	0.8	(0.6-1.1)
Anxiety symptoms: W4	1.0	(1.0-1.1)	1.0	(1.0-1.1)	1.1	(1.0-1.2)	1.0	(0.9-1.1)
Obesity: W4	1.4***	(1.2-1.8)	1.3	(1.0-1.7)	1.5*	(1.0-2.1)	1.5	(0.8-2.7)
Fast food: W4	1.0	(1.0-1.1)	1.0	(1.0-1.1)	1.1	(1.0-1.1)	1.0	(1.0-1.1)
Exercise: W4	1.0	(1.0-1.0)	1.0	(1.0-1.0)	1.0	(1.0-1.0)	1.0	(1.0-1.1)
Cigarettes: 1-19 a month: W4	1.0	(0.8-1.4)	0.9	(0.6-1.5)	1.9	(0.9-4.0)	1.0	(0.5-2.1)
Cigarettes: 20 or more a month: W4	1.2	(0.9-1.5)	1.4	(1.0-2.0)	1.1	(0.7-1.7)	0.9	(0.5-1.7)
Alcohol: less than once a week: W4	1.0	(0.8-1.3)	0.9	(0.6-1.2)	1.4	(0.8-2.4)	1.2	(0.6-2.3)
Alcohol: 1-2 d/wk: W4	1.0	(0.7-1.3)	0.7	(0.5-1.1)	2.1*	(1.1-4.1)	1.1	(0.5-2.7)
Alcohol: ≥3 d/wk: W4	1.0	(0.7-1.4)	0.8	(0.5-1.3)	1.2	(0.6-2.8)	1.6	(0.6-3.8)
Constant	0.0***	(0.0-0.2)	0.0*	(0.0-0.5)	0.0**	(0.0-0.3)	0.0	(0.0-1.1)
n	4842		2491		1093		876	

*** $P < .001$, ** $P < .01$, * $P < .05$.
Reference: White is reference category for race/ethnicity, less than high school is reference category for parent education, none is reference category for cigarette smoking, and none is reference category for alcohol use.

Conclusions

The current study extends prior literature on understanding sleep problems by providing the first assessment of the relationship between living in a food desert and short sleep duration. The results indicate that, on average, individuals who live in a food desert are not more likely to experience short sleep duration than those that do not. When the sample is stratified by race and ethnicity, the results indicate that, among Hispanics, residing in a food desert significantly increases the likelihood of short sleep duration. Still, the current study is a preliminary assessment into the association between food deserts and sleep. Future research should continue to investigate how neighborhood conditions and deficiencies in resources within geographic areas are associated with sleep behavior.

Disclosure

Alexander Testa has no conflicts of interest.

Acknowledgment

This research uses data from Add Health, a program project directed by Kathleen Mullan Harris and designed by J. Richard Udry, Peter S. Bearman, and Kathleen Mullan Harris at the University of North Carolina at Chapel Hill and funded by grant P01-HD31921 from the Eunice Kennedy Shriver National Institute of Child Health and Human Development, with cooperative funding from 23 other federal agencies and foundations. Special acknowledgment is due Ronald R. Rindfuss and Barbara Entwisle for assistance in the original design. Information on how to obtain the Add Health data files is available on the Add Health Web site (http://www.cpc.unc.edu/addhealth). No direct support was received from grant P01-HD31921 for this analysis.

References

1. Berrigan D, McKinno RA. Built environment and health. *Prev Med*. 2008;47:239–240.
2. Lytle LA, Sokol RL. Measures of the food environment: a systematic review of the field, 2007–2015. *Health Place*. 2017;44:18–34.
3. Walker RE, Keane CR, Burke JG. Disparities and access to healthy food in the United States: a review of food deserts literature. *Health Place*. 2010;16:876–884.
4. Ver Ploeg M, Breneman V, Farrigan T, et al. Access to Affordable and Nutritious Food—Measuring and Understanding Food Deserts and Their Consequences: Report to Congress. Washington, DC: US Department of Agriculture; 2009.
5. Larson NI, Story MT, Nelson MC. Neighborhood environments: disparities in access to healthy foods in the US. *Am J Prev Med*. 2009;36:74–81.
6. Kelli HM, Hammadah M, Ahmed H, et al. Association between living in food deserts and cardiovascular risk. *Circ Cardiovasc Qual Outcomes*. 2017;10:e003532.
7. Centers for Disease Control and Prevention. Insufficient Sleep Is a Public Health Problem. Atlanta, GA: US Department of Health and Human Services; 2015.
8. Itani O, Jike M, Watanabe N, Kaneita Y. Short sleep duration and health outcomes: a systematic review, meta-analysis, and meta-regression. *Sleep Med*. 2017;32:246–256.
9. Medic G, Wille M, Hemels ME. Short-and long-term health consequences of sleep disruption. *Nat Sci Sleep*. 2017;9:151–161.
10. Hale L, Do DP. Racial differences in self-reports of sleep duration in a population-based study. *Sleep*. 2007;30:1096–1103.
11. Hale L, Hill TD, Burdette AM. Does sleep quality mediate the association between neighborhood disorder and self-rated physical health? *Prev Med*. 2010;51:275–278.
12. Hale L, Hill TD, Friedman E, et al. Perceived neighborhood quality, sleep quality, and health status: evidence from the Survey of the Health of Wisconsin. *Soc Sci Med*. 2013;79:16–22.
13. Hill TD, Burdette AM, Hale L. Neighborhood disorder, sleep quality, and psychological distress: testing a model of structural amplification. *Health Place*. 2009;15:1006–1013.
14. Hill TD, Trinh HN, Wen M, Hale L. Perceived neighborhood safety and sleep quality: a global analysis of six countries. *Sleep Med*. 2016;18:56–60.
15. Widener MJ, Farber S, Neutens T, Horner MW. Using urban commuting data to calculate a spatiotemporal accessibility measure for food environment studies. *Health Place*. 2013;21:1–9.
16. Mondin TC, Stuart AL, Williams LJ, et al. Diet quality, dietary patterns and short sleep duration: a cross-sectional population-based study. *Eur J Nutr*. 2018:1–11.
17. Nedeltcheva AV, Kilkus JM, Imperial J, et al. Sleep curtailment is accompanied by increased intake of calories from snacks. *Am J Clin Nutr*. 2008;89:126–133.
18. Cappuccio FP, Taggart FM, Kandala NB, et al. Meta-analysis of short sleep duration and obesity in children and adults. *Sleep*. 2008;31:619–626.
19. Whitaker RC, Phillips SM, Orzol SM. Food insecurity and the risks of depression and anxiety in mothers and behavior problems in their preschool-aged children. *Pediatrics*. 2006;118:e859–e868.
20. Van Reeth O, Weibel L, Spiegel K, et al. Physiology of sleep (review)—interactions between stress and sleep: from basic research to clinical situations. *Sleep Med Rev*. 2000;4:201–219.
21. Hosler AS, Michaels IH. Peer reviewed: association between food distress and smoking among racially and ethnically diverse adults, Schenectady, New York, 2013-2014. *Prev Chronic Dis*. 2017;14:1–12.
22. Cohen DA, Hunter G, Williamson S, Dubowitz T. Are food deserts also play deserts?. *J Urban Health*. 2016;93:235–243.
23. Ebrahim IO, Shapiro CM, Williams AJ, Fenwick PB. Alcohol and sleep: effects on normal sleep. *Alcoholism*. 2013;37:539–549.
24. Phillips BA, Danner FJ. Cigarette smoking and sleep disturbance. *Arch Intern Med*. 1995;155:734–737.
25. Singh NA, Clements KM, Fiatarone MA. A randomized controlled trial of the effect of exercise on sleep. *Sleep*. 1997;20:95–101.
26. Gordon C, Purciel-Hill M, Ghai NR, et al. Measuring food deserts in New York City's low-income neighborhoods. *Health Place*. 2011;17:696–700.
27. Harris KM. The Add Health Study: Design and Accomplishments. Chapel Hill, NC: University of North Carolina at Chapel Hill; 2013.
28. Santorelli ML, Okeke JO. Evaluating community measures of healthy food access. *J Community Health*. 2017;42:991–997.
29. Allison PD. Missing data. Sage; 2001.
30. Hirshkowitz M, Whiton K, Albert SM, et al. National Sleep Foundation's sleep time duration recommendations: methodology and results summary. *Sleep Health*. 2015;1:40–43.
31. Centers for Disease Control and Prevention. Census Tract Level State Maps of the Modified Retail Food Environment Index (mRFEI). Atlanta, GA: US Department of Health and Human Services; 2011.
32. Paternoster R, Brame R, Mazerolle P, Piquero A. Using the correct statistical test for the equality of regression coefficients. *Crim*. 1998;36:859–866.
33. Koh K, Grady SC, Vojnovic I. Using simulated data to investigate the spatial patterns of obesity prevalence at the census tract level in metropolitan Detroit. *Appl Geogr*. 2015;62:19–28.
34. Hafner M, Stepanek M, Taylor J, et al. Why sleep matters—the economic costs of insufficient sleep: a cross-country comparative analysis. *Rand Health Q*. 2017;6:11–81.
35. Walsh JK, Engelhardt CL. The direct economic costs of insomnia in the United States for 1995. *Sleep*. 1999;22:S386–S393.
36. Galvez MP, Morland K, Raines C, et al. Race and food store availability in an inner-city neighbourhood. *Public Health Nutr*. 2008;11:624–631.
37. Osypuk TL, Roux AV, Hadley C, Kandula NR. Are immigrant enclaves healthy places to live? The Multi-Ethnic Study of Atherosclerosis. *Soc Sci Med*. 2009;69(1):110–120.
38. Ayala GX, Baquero B, Klinger S. A systematic review of the relationship between acculturation and diet among Latinos in the United States: implications for future research. *J Am Diet Assoc*. 2008;108:1330–1344.
39. Buysse DJ, Reynolds CF, Monk TH, et al. The Pittsburgh Sleep Quality Index: a new instrument for psychiatric practice and research. *Psychiatry Res*. 1989;28:193–213.