Journal of Community Health (2019) 44:444–450
https://doi.org/10.1007/s10900-018-00601-w

ORIGINAL PAPER

Food Insecurity, Food Deserts, and Waist-to-Height Ratio: Variation by Sex and Race/Ethnicity

Alexander Testa[1] · **Dylan B. Jackson**[1]

Published online: 17 December 2018

Abstract
The purpose of this study is to investigate the association between two food-related hardships—food insecurity and living in a food desert—on waist-to-height ratio (WHtR). Data on participants from waves I and IV of the National Longitudinal Study of Adolescent to Adult Health (Add Health) were analyzed. The association between food-related hardships and waist-to-height ratio were examined using logistic regression. Models were stratified by sex and race/ethnicity to examine potential moderating effects. Study results suggest food insecurity has a positive association with WHtR among female respondents (OR = 1.360, $p = .017$). Living in a food desert has a positive association with WHtR among both females (OR = 1.247, $p = .026$) and males (OR = 1.245, $p = .024$). In models stratified by race/ethnicity living in a food desert is positively associated with WHtR among White respondents (OR = 1.279, $p = .003$). Given the link between food-related hardships and obesity, targeted interventions that alleviate food insecurity and inadequate access to healthy food retailers could be effective in reducing obesity.

Keywords Food insecurity · Food desert · Nutrition · Waist-to-height ratio · Obesity

Introduction

Obesity is a serious public health epidemic in the United States. At present, over one-third of U.S. adults are obese [1] and obesity is the second leading cause of premature death in the North America and Europe [2]. Obesity results from a interplay of individual, social, behavioral, and genetic factors. In particular, certain forms of food-related hardships including food insecurity and living in a food desert can increase the risk of obesity [3–5].

The current study extends prior research assessing the link between food-related hardships and obesity in the following ways. First, this study uses an innovative measure to assess the relationship between two food-related hardships—food insecurity and living in a food desert—on obesity in a national sample of young adults. While past work on food insecurity and obesity uses body mass index (BMI) [3, 6], this study uses a novel cutoff point of waist-to-height ratio, which has been shown to be a more accurate measure of central obesity and a host of metabolic diseases in the United States [7]. Second, the current study is the first to assess the relationship between both food insecurity and living in a food desert on obesity in a national sample that measures food deserts using the Center for Disease Control's (CDC) Modified Retail Food Environment Index (mRFEI). Third, this study examines whether the relationship between food-related hardships and obesity varies across sex and race/ethnicity.

Background

Food Insecurity and Obesity

Food insecurity is the inability to acquire adequate food due to a lack of resources. In 2016, an estimated 15.6 million households (12.3%) were food insecure throughout the year [8]. Food insecurity is a public health concern as food insecure adults are at increased risk for physical and mental health problems, such as hypertension, diabetes, depression,

✉ Alexander Testa
alexander.testa@utsa.edu

Dylan B. Jackson
dylan.jackson@utsa.edu

[1] Department of Criminal Justice, University of Texas at San Antonio, 501 W. Cesar Chavez Blvd., San Antonio, TX 78207, USA

and nutrient deficiency [9, 10]. The relationship between food insecurity and obesity can be explained through patterns of food consumption. Those who experience food insecurity often alternate between a state of hunger and a state of consumption of low-cost, high-calorie, nutrient poor foods in order to avoid hunger [11]. Additionally, food insecure individuals are at risk of overeating at times when food is available, which can result in weight gain as chronic fluctuations between times of low calorie intake and overeating can result in metabolic changes that promote fat storage [12].

Across sex, food insecurity has a stronger relationship with being overweight or obese among women compared to men [3, 6]. One explanation is that women are more likely to shield their children from food insecurity by reducing their own nutritional intake [11]. Substantially less research has assessed the food insecurity-obesity association across race/ethnicity. Overall, Black and Hispanic households are at a higher risk for food insecurity in the United States [8]. However, research examining the food insecurity-obesity link across race/ethnicity is mixed with some studies finding a stronger association among minorities [13], but other research finding no differences across race/ethnicity [3, 14]. One recent study found food insecurity to be associated with an increased likelihood of being overweight among White and Hispanic women, but not among Black women, nor among Black, White or Hispanic men [6].

Food Environments and Obesity

Food deserts are geographic areas where residents do not have access to supermarkets or grocery stores [15]. Individuals living in food deserts lack access to affordable healthy foods sold through retailers such as grocery stores and instead must rely on convenience stores, small neighborhood stores, or fast-food restaurants that have limited availability of healthy food options such as fruits or vegetables [16]. Prior research indicates that residents with access to healthy food retailers have higher quality diets and consume more fruits and vegetables [17]. Additionally, areas with better geographic access to healthy retail outlets have a lower prevalence of overweight and obese residents [4, 18], although some studies find no relationship between food access and obesity [19].

Geographic areas that are predominately composed of Black or Hispanic residents tend to have more fast-food restaurants and less access to supermarkets or grocery stores [4]. Research also finds that neighborhoods with a higher composition of Black residents are more likely to be food deserts [4, 20]. Notably, research finds also finds that Hispanic individuals live in food deserts at relatively low rates, despite being a socioeconomically disadvantaged minority group in the United States [21, 22].Still, prior research has not assessed whether the relationship between residing in a food desert and obesity varies across race/ethnicity. Moreover, extant research has not assessed whether the relationship between living in a food desert and obesity varies by sex. Given the strong association between food insecurity and obesity among women and research finding obesity is higher among both women and racial/ethnic minorities [23], this study assesses whether the association between living in a food desert and obesity varies when the sample is stratified by sex, as well as race/ethnicity.

Data

Data are from the first and fourth wave of the National Longitudinal Study of Adolescent to Adult Health (Add Health), a nationally representative survey of adolescents enrolled in grades 7–12 in the United States during the 1993–1994 academic year. Add Health initially surveyed 90,000 students at 132 schools at Wave I. Following the initial survey, approximately 20,000 individuals were chosen for in-home interviews. To date, three follow-up surveys have been conducted: Wave II administered in 1996, Wave III administered in 2001–2002, and Wave IV conducted in 2008. At Wave IV respondents were between 24 and 34 years old.

Data on food environments are obtained from the Centers for Disease Control's (CDC) Modified Retail Food Environment Index (mRFEI). The mRFEI represents the percentage of retailers that sell healthy food relative to unhealthy food retailers in a census tract and the 0.5 mile buffer around a census tract [24]. Data for the mRFEI were collected in 2008–2009 and over one million food retailers were included. Food retailers are defined in correspondence with 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). Less healthy food retailers include fast-food restaurants (NAICS 722211), small grocery stores (NAICS 44511), and convenience stores (NAICS 445120).

Because reasonable distances to food retailers in non-urban areas are larger than the 0.5 mile radius from a census tract boundary that mRFEI uses, the analysis is restricted to urban areas (81% of the sample) [25]. Urban areas are identified using Rural–Urban Community Area (RUCA) codes [26]. Respondents who reported being currently pregnant or believed they are probably pregnant were removed from the sample because their weight status may be influenced by a different set of factors than the non-pregnant population ($n = 437$).

Dependent Variable

Waist-to-height ratio (WHtR) measures the waist circumference in centimeters divided by height in centimeters. In a comparison against other screening tools (i.e. BMI), waist-to-height ratio is found to be a more accurate measurement of whole-body fat percentage and visceral adipose tissues (VAT) mass, as well a robust predictor of health problems including hypertension, diabetes, dyslipidemia, and mortality [27, 28]. Anthropometric measures of weight, height, and waist were collected by field interviewers who were trained in appropriate techniques of measuring waist circumference and height. Waist circumference was measured to the nearest 0.5 cm using a SECA 2000 metric-increment circumference tape. Height was measured to the nearest 0.5 cm using a carpenter's square, steel tape measure [29]. Per the recommendation of recent research using Add Health data, WHtR is coded as a dichotomous variable with a cutoff of 0.578 for males and the full sample of respondents, and 0.580 for females [7].

Independent Variables

Food insecurity is measured as a dichotomous indicator at wave IV. Participants responded yes or no to the following question: "In the past 12 months, was there a time when (you/your household) (were/was) worried whether food would run out before you would get money to buy more?" This question is the first item of the U.S. Household Food Security Scale [8]. A positive response suggests either marginal food security or food insecurity [3, 10, 14].

Food desert is coded as a binary measure where a positive value corresponds to a mRFEI score of zero, per the recommendation of the CDC [24]. These geographic areas have either no food retailers or contain unhealthy food retailers (i.e. convenience store, fast-food restaurant), but do not contain any healthy food retailers (i.e. supermarket, grocery store). Previous research finds the 0.5 mile buffer distance from the census tract boundary is valid for identifying urban areas with low-access to healthy food retailers [25].

Moderating Variables

Race/Ethnicity is coded as a series of dichotomous measures indicating whether the respondent identified as White, Black, or Hispanic. *Sex* is coded as a binary indicator for whether a respondent is male or female.

Control Variables

High school degree indicates whether a respondent completed high school by wave IV. *Child in home* measures whether a respondent has a biological child that lives in their home. *Concentrated disadvantage* is a standardized scale created using the proportion of respondents in a respondent's census tract: on welfare, living at or below the poverty line, currently unemployed, and the proportion of female headed households at wave I. *Public assistance* is measured at wave IV and captures whether a respondent received any form of public assistance benefits. *Adjusted household income* measures total household income before taxes adjusted for the number of individuals living in a household. Household income is transformed using the natural logarithm to adjust for the skewed distribution. *Physical activity* captures the number of times in the prior week a respondent engaged in physical activities (i.e. solo or team sports, variety of individual or group exercise). *Hours of television* indicates the number of hours a respondent watched television in the prior week. *Sugary beverages* measures the number of times in the prior week a respondent consumed regular (non-diet) sweetened drinks. *Fast-food* measures the number of times in the prior week a respondent ate from a fast-food restaurant. *Cigarettes* measures the number of days in the previous month a respondent smoked cigarettes. *Alcohol* is measured as an ordinal scale measuring how many days a respondent drank alcohol (none, once a month or less, 2–3 days per month, 1–2 days a week, 3–5 days a week, or every day/almost every day). *Anxiety* is a standardized scale from the following four items that indicate how often in the previous 30 days a 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.

Method

The relationship between food-related hardships and WHtR is assessed using a series of logistic regression analyses controlling for potential confounders. Models are stratified by sex and race/ethnicity. Equality of coefficient tests are performed to assess whether the influence of food insecurity and living in a food desert significantly differ across sex and race/ethnicity [30]. The equality of coefficients are calculated using the following formula:

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

where b represents the unstandardized regression coefficient for a covariate and s represents the standard error of a covariate. Analyses were performed using STATA 15.0. All estimates use survey weights to account for the multistage cluster design of the Add Health survey.

Results

Table 1 reports the descriptive statistics for the full sample. On average the sample is approximately 28 years old. The sample is 51.9% male. The racial/ethnic breakdown of the sample is as follows: 65.1% White, 13.4% Black, 13.4% Hispanic, 4.7% other race. In total, 11.7% of respondents reported food insecurity and 19.4% of respondents live in a food desert. Finally, 39.3% of the sample reported WHtR greater than 0.580.

Table 2 shows females are more likely to have a high WHtR. Additionally, females are more likely to be food insecure. Table 3 indicates White respondents have the lowest risk for a high WHtR. White respondents are also at the lowest risk of being food insecure, whereas Hispanic respondents are the least likely to reside in a food desert.

The results in Table 4 indicate that among the full sample both food insecurity (OR = 1.225, $p = .048$) and living in a food desert (OR = 1.247, $p = .001$) have a positive association with WHtR. Among male respondents living in a food desert (OR = 1.245, $p = .024$) is positively associated with WHtR. Among female respondents both food insecurity (1.360, $p = .017$) and residing in a food desert (1.247, $p = .026$) are positively associated with WHTR. The coefficients for food insecurity or living in a food desert do not significantly differ between males and females.

The results in Table 5 report that living in a food desert is positively related to WHtR among White respondents (OR = 1.279, $p = .003$). The coefficients do not significantly differ across race/ethnicity.

Table 1 Summary statistics for full sample (N = 10,886)

Variables	Mean (SE)/(%)	Range
Dependent variables		
WHtR	39.3%	0–1
Independent variables		
Food insecurity	11.7%	0–1
Food desert	19.4%	0–1
Control variables		
Age	28.5 (0.13)	24–34
Race/ethnicity		
White	65.1%	0–1
Black	13.4%	0–1
Hispanic	13.4%	0–1
Other race	4.7%	0–1
Male	51.9%	0–1
High school grad	92.5%	0–1
Child in home	39.3%	0–1
Disadvantage—W1	− 0.02 (0.03)	− 10.29 to 2.66
Public assistance—W4	21.5%	0–1
Adjusted income—W4	40,502 (903)	883–175,000
Physical activity—W4	6.54 (0.11)	0–47
Hours of TV—W4	12.97 (0.23)	0-150
Sugary beverage—W4	11.76 (0.29)	0–99
Fast-food—W4	2.30 (0.07)	0–55
Cigarette—W4	8.47 (0.31)	0–30
Alcohol—W4	2.49 (0.05)	0–6
Anxiety—W4	4.77 (0.06)	0–16

Table 2 Summary statistics by sex

Variables	Male (N = 5221)	Female (N = 5645)	*p* Value
	%	%	
Dependent variables			
WHtR	33.7	44.7	< .001
Independent variables			
Food insecurity	9.6	13.9	< .001
Food desert	19.6	19.2	.634

Discussion

The current study extends prior research on food-related hardship and obesity in three key ways. First, this study assesses the relationship between two key forms of food-related hardship—food insecurity and living in a food desert—on waist-to-height ratio using a nationally representative sample. Second, this study used a novel cutoff point of WHtR that has been shown in recent research to be an optimal measure for discriminating individuals with metabolic syndrome in nationally representative samples of young adults [7]. Finally, this study stratified this relationship by sex and race/ethnicity to assess variation among subgroups.

The findings demonstrated that food insecurity is associated with obesity among females. While this research uses a different measures of obesity than prior studies assessing food insecurity and obesity using the Add Health data [3], this work reaches a similar conclusion that food insecure

Table 3 Summary statistics by race/ethnicity

Variables	White (N = 5926)	Black (N = 2011)	Hispanic (N = 1987)	*p* Value
	%	%	%	
Dependent variables				
WHtR	36.1	45.3	49.5	< .001
Independent variables				
Food insecurity	10.4	18.9	10.0	< .001
Food desert	21.2	20.7	11.9	< .001

Table 4 Nutritional hardship on waist-to-height ratio (WHtR) for the full sample and stratified by sex

Variables	Full sample		Males		Females	
	OR	95% CI	OR	95% CI	OR	95% CI
Food insecurity	1.225*	(1.002, 1.499)	1.053	(0.783, 1.415)	1.360*	(1.057, 1.751)
Food desert	1.247**	(1.094, 1.420)	1.245*	(1.030, 1.505)	1.247*	(1.028, 1.512)
Observations	10,886		5221		5645	

All models include full set of control variables including: sex, race/ethnicity, high school graduate, child in home, disadvantage (W1), public assistance, adjusted household income, physical activity, hours of TV, sugary beverage consumption, fast food consumption, cigarette use, alcohol use, and anxiety

*$p < .05$; **$p < .01$

Table 5 Nutritional hardship on waist-to-height ratio (WHtR) stratified by race and ethnicity

Variables	White		Black		Hispanic	
	OR	95% CI	OR	95% CI	OR	95% CI
Food insecurity	1.221	(0.944, 1.579)	1.027	(0.703, 1.500)	1.493	(0.839, 2.688)
Food desert	1.279**	(1.091, 1.501)	1.093	(0.736, 1.622)	1.413	(0.927, 2.153)
Observations	5926		2011		1987	

All models include full set of control variables including: sex, race/ethnicity, high school graduate, child in home, disadvantage (W1), public assistance, adjusted household income, physical activity, hours of TV, sugary beverage consumption, fast food consumption, cigarette use, alcohol use, and anxiety

**$p < .01$

women have an increased odds of obesity. Further, as the cutoff point of WHtR used in the current study is associated with metabolic syndrome [7], our findings suggest food insecure women may be at a heightened risk for adverse health problems. While the exact mechanisms behind this relationship could not be examined in this study, it remains possible that women facing food insecurity face different behavioral or genetic factors that might explain this decision. For instance, women may be more likely to limit their own nutritional intake and consume less healthy foods in order to ensure that children and other household members have access to enough nutritious foods [11]. Alternatively, there may be genetic or hormonal differences that explain higher weight in food insecure women compared to men. For instance, prior research finds food insecurity leads to increased risk of low high-density lipoprotein cholesterol (HDL-C) among women but not among men, suggesting potential sex differences in metabolic responses to food insecurity [31].

Next, the results reveal that living in a food desert is positively associated with WHtR for both males and females. This finding suggests that having low access to healthy food retailers may lead to less healthy nutritional behaviors that results in higher WHtR for both men and women. Given the lack of healthy food retailers in these areas it is likely that individuals living in food deserts will have little choice in food options and rely primarily on unhealthy food outlets such as convenience stores or fast-food outlets which carry mostly processed, high calorie, nutrient poor items.

Regarding variation across race/ethnicity, food insecurity was not significantly related to WHtR for White, Black, or Hispanic respondents, whereas living in a food desert yielded a positive and significant association with WHtR only among White respondents. This result was surprising given that prior research has found Black adults tend to have lower access to healthy food retailers [4] and are at a higher risk of obesity compared to White adults [23]. As recent research finds that Black and Hispanic Americans are more resilient against hardships than Whites of similar socioeconomic status, it may be that White respondents who reside in a food desert are particularly susceptible to the adverse consequences of living in these communities [32, 33]. Still, future research is needed to further assess the mechanisms underlying this association.

There are a few limitations to this study that future research should expand upon. First, given the age range of the Add Health sample (24–34 years old) it is possible that effects of food-related hardships on obesity have not yet manifested for many respondents. For instance, in the United States, approximately 43% of middle-age adults (40–59 years old) are obese compared to 35% of young adults (20–39 years old) [1]. Therefore, food insecurity and living in a food desert could translate into obesity and other health issues for certain individuals in the coming years as respondents grow older. Second, the measure of food insecurity uses one question of a more detailed multi-item survey that is used by the USDA. However, the use of this measure is consistent with prior research assessing the relationship

between food insecurity and obesity using Add Health data and therefore this study can be evaluated in the context of extant literature [3]. Additionally, rates of food insecurity between Add Health and USDA measures are fairly consistent. In December 2008, the USDA reported a national food insecurity rate of 14.6%, whereas respondents in the Add Health sample who were interviewed in December 2008 reported only a slightly higher food insecurity rate of 15.9% [34]. Still, it is possible that severity of food insecurity could influence WHtR. Future research should reassess the questions posed in this study using the full USDA food insecurity module in order to assess heterogeneity across ranges of severity of food insecurity. Third, the mRFEI measures geographic access to food retailers. Future research could also examine other important dimensions of the local food retail environment such as affordability, accommodation (hours local retailers are open) or the quality of food sold by local retailers. Fourth, this study focused on the role of living in a food desert on obesity. However, future research should investigate the role of areas with high amounts of unhealthy relative to healthy food retailers known as food swamps on obesity [35]. Fifth, this study measures food deserts using the Center for Disease Control Modified Retail Food Environment Index. At present, this is the only measure of food environments available in the Add Health data. However, future research should continue to investigate the association between living in a food desert and obesity using alternative measures of food deserts, such as the USDA Food Desert Locator. Finally, this study assessed both food insecurity status and food deserts on obesity at one point in time. Future research can expand on the current study by drawing on data that can assess how changes in food insecurity status and access to food retailers corresponds with changes in weight overtime.

We end with a discussion about the implications of this study for intervention. The findings suggest that policies which alleviate food insecurity, especially for women, may be beneficial. Mobile feeding programs can help alleviate food insecurity, especially in food deserts by delivering meals directly to individual's homes or accessible local sites, such as schools or community centers. In particular, in mobile feeding programs, food is distributed to clients and clients are able to take what food they need, thereby removing barriers to accessing to food in underserved areas [36]. Second, given the link between food deserts and obesity, policy initiatives that award loans and grants targeted at developing and equipping food retailers to sell healthy foods such as the Healthy Food Financing Initiative (HFFI) can be expanded with a focus on targeting both food deserts and areas with high rates of obesity [37]. Alternatively, in the context of urban areas it could beneficial to improve the availability of healthy food options at small local stores in lieu of opening large grocery retailers [38].

Conclusions

Across sex, food insecurity was associated with higher WHtR among female respondents. Living in a food desert had a positive association with WHtR among both males and females. When the sample was stratified by race/ethnicity, living in a food desert was associated with WHtR among White respondents. Future research, including prospective studies are needed to further understand the connection between food-related hardships and obesity.

Acknowledgements 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 website (http://www.cpc.unc.edu/addhealth). No direct support was received from Grant P01-HD31921 for this analysis.

Compliance with Ethical Standards

Conflict of interest Authors do not have any conflicts of interest including financial interests or relationships or affiliations relevant to the subject of the manuscript.

References

1. Hales, C. M., Fryar, C. D., Carroll, M. D., et al. (2018). Trends in obesity and severe obesity prevalence in US youth and adults by sex and age, 2007–2008 to 2015–2016. *JAMA, 319*, 1723–1725.
2. Di Angelantonio, E., Bhupathiraju, S. N., Wormser, D., et al. (2016). Body-mass index and all-cause mortality: Individual-participant-data meta-analysis of 239 prospective studies in four continents. *The Lancet, 388*, 776–786.
3. Gooding, H. C., Walls, C. E., & Richmond, T. K. (2012). Food insecurity and increased BMI in young adult women. *Obesity, 20*, 1896–1901.
4. Larson, N. I., Story, M. T., & Nelson, M. C. (2009). Neighborhood environments: Disparities in access to healthy foods in the US. *American Journal of Preventive Medicine, 36*, 74–81.
5. Spence, J. C., Cutumisu, N., Edwards, J., et al. (2009). Relation between local food environments and obesity among adults. *BMC Public Health, 9*, 192.
6. Hernandez, D. C., Reesor, L. M., & Murillo, R. (2017). Food insecurity and adult overweight/obesity: Gender and race/ethnic disparities. *Appetite, 117*, 373–378.
7. Bohr, A. D., Laurson, K., & McQueen, M. B. (2016). A novel cutoff for the waist-to-height ratio predicting metabolic syndrome in young American adults. *BMC Public Health, 16*, 295.
8. Coleman-Jensen, A., Rabbit, M. P., Gregory, C. A., et al. (2017). *Household food security in the United States in 2016*. Washington, DC: U.S. Department of Agriculture.

9. Gundersen, C., Kreider, B., & Pepper, J. (2011). The economics of food insecurity in the United States. *Applied Economic Perspectives and Policy, 33*, 281–303.
10. Gundersen, C., & Ziliak, J. P. (2015). Food insecurity and health outcomes. *Health Affairs, 34*, 1830–1839.
11. Dinour, L. M., Bergen, D., & Yeh, M. C. (2007). The food insecurity–obesity paradox: A review of the literature and the role food stamps may play. *Journal of the American Dietetic Association, 107*, 1952–1961.
12. Stinson, E. J., Votruba, S. B., Venti, C., et al. (2018). Food insecurity is associated with maladaptive eating behaviors and objectively measured overeating. *Obesity*. https://doi.org/10.1002/oby.22305.
13. Adams, E. J., Grummer-Strawn, L., & Chavez, G. (2003). Food insecurity is associated with increased risk of obesity in California women. *The Journal of Nutrition, 133*, 1070–1074.
14. Pan, L., Sherry, B., Njai, R., et al. (2012). Food insecurity is associated with obesity among US adults in 12 states. *Journal of the Academy of Nutrition and Dietetics, 112*, 1403–1409.
15. Cummins, S., & Macintyre, S. (2002). A systematic study of an urban foodscape: The price and availability of food in greater Glasgow. *Urban Studies, 39*, 2115–2130.
16. National Research Council. (2009). *The public health effects of food deserts*. Washington, DC: National Academies Press.
17. Caspi, C. E., Sorensen, G., Subramanian, S. V., et al. (2012). The local food environment and diet: A systematic review. *Health Place, 18*, 1172–1187.
18. Morland, K. B., & Evenson, K. R. (2009). Obesity prevalence and the local food environment. *Health Place, 15*, 491–495.
19. Cummins, S., Flint, E., Matthews, S. A. (2014). New neighborhood grocery store increased awareness of food access but did not alter dietary habits or obesity. *Health Affairs, 33*(2), 283–291.
20. Lewis, L. B., Sloane, D. C., Nascimento, L. M., et al. (2011). African Americans' access to healthy food options in South Los Angeles restaurants. *American Journal of Public Health, 95*, 668–673.
21. Gordon, C., Purciel-Hill, M., Ghai, N. R., et al. (2011). Measuring food deserts in New York City's low-income neighborhoods. *Health Place, 17*, 696–700.
22. Osypuk, T. L., Roux, A. V., Hadley, C., et al. (2009). Are immigrant enclaves healthy places to live? The multi-ethnic study of atherosclerosis. *Social Science & Medicine, 69*, 110–120.
23. Ogden, C. L., Carroll, M. D., Fryar, C. D., et al. (2015). *Prevalence of obesity among adults and youth: United States, 2011–2014*. Atlanta: US Department of Health and Human Services.
24. Centers for Disease Control and Prevention. (2011). *Census tract level state maps of the Modified Retail Food Environment Index (mRFEI)*. Atlanta: US Department of Health and Human Services.
25. Santorelli, M. L., & Okeke, J. O. (2017). Evaluating community measures of healthy food access. *Journal of Community Health, 42*, 991–997.
26. United States Department of Agriculture Economic Research Service. (2015). *Rural-urban commuting area codes*. Washington, DC: U.S. Department of Agriculture.
27. Ashwell, M., Gunn, P., & Gibson, S. (2012). Waist-to-height ratio is a better screening tool than waist circumference and BMI for adult cardiometabolic risk factors: Systematic review and meta-analysis. *Obesity Reviews, 13*, 275–286.
28. Ashwell, M., Mayhew, L., Richardson, J., et al. (2014). Waist-to-height ratio is more predictive of years of life lost than body mass index. *PLoS ONE, 9*, e103483.
29. Entzel, P., Whitsel, E. A., Richardson, A., et al. (2009). *Add health wave IV documentation: Cardiovascular and anthropometric measures*. Chapel Hill: UNC Population Research Center.
30. Paternoster, R., Brame, R., Mazerolle, P., et al. (1998). Using the correct statistical test for the equality of regression coefficients. *Criminology, 36*, 859–866.
31. Shin, J. I., Bautista, L. E., Walsh, M. C., et al. (2015). Food insecurity and dyslipidemia in a representative population-based sample in the US. *Preventive Medicine, 77*, 186–190.
32. Assari, S., & Lankarani, M. M. (2016). Depressive symptoms are associated with more hopelessness among white than black older adults. *Frontiers in Public Health, 4*, 82.
33. Graham, C., & Pinto, S. (2018). Unequal hopes and lives in the USA: Optimism, race, place, and premature mortality. *Journal of Population Economics*, 1–69.
34. Nord, M., Andrews, M., & Carlson, A. (2009). *Household food security in the United States, 2008*. Washington, DC: U.S. Department of Agriculture.
35. Hager, E. R., Cockerham, A., O'Reilly, N., et al. (2017). Food swamps and food deserts in Baltimore City, MD, USA: Associations with dietary behaviours among urban adolescent girls. *Public Health Nutrition, 20*, 2598–2607.
36. Feeding America. (2018). *Mobile food pantry program*. Chicago: Feeding America.
37. Flournoy, R. (2011). *Healthy food, Healthy communities: Promising strategies to improve access to fresh, healthy food and transform communities*. Oakland: PolicyLink.
38. Moore, L. V., & Diez Roux, A. V. (2006). Associations of neighborhood characteristics with the location and type of food stores. *American Journal of Public Health, 96*, 325–331.