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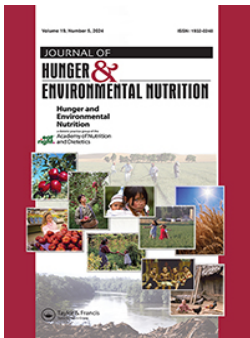
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Association of Food Environment Characteristics with Health Outcomes in Counties with a High Proportion of Native American Residents

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ABSTRACT

American Indians are disproportionately affected by nutrition-related chronic conditions. It is critical to understand Native American food environments that contribute to disparities in nutrition-related conditions. Data from the USDA Food Environment Atlas were used to examine the associations between food environment characteristics, diabetes, obesity, and food insecurity. Counties with the highest percentage of Native American residents had fewer grocery stores and more food insecurity and obesity than counties with fewer Native Americans residents. Future studies may consider evaluating policies or interventions that impact the food environment to assess the effects on obesity and food security outcomes among Native Americans.

KEYWORDS

Native American; obesity; food insecurity

Introduction

Native Americans have historically relied on local food systems and a balanced relationship with their natural food environment. However, in recent decades, the food environment of Native Americans has changed, resulting in a loss of traditional food sources and a greater exposure to unhealthy foods.¹ The forced departure from Native cultural practices to a lifestyle of poorer diet and more sedentary activity has created a situation of poor health among Native Americans. This has come in part because of land and water rights being taken from Native people, resulting in the control of the food supply by large corporations.² Currently, Native Americans experience a disproportionately higher burden of chronic disease compared to non-Hispanic whites – being 50% more likely to be obese, 30% more likely to have hypertension, and twice as likely to die from diabetes.^{3–5} Poor dietary

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patterns are a major risk factor for cardiometabolic disease and mortality,⁶ but consumption of a healthy diet may be hindered by community-level characteristics, such as the food environment.

The food environment includes the presence and type of food retail outlets, including grocery stores, convenience stores, fast-food restaurants, and governmental food assistance outlets. Some environments, commonly referred to as food deserts, are characterized by limited access to foods because of few grocery stores or supermarkets in the geographic vicinity. In the general population, poorer food access has been associated with unfavorable markers of cardiovascular disease,⁷ poorer glycemic control in patients with diabetes,⁸ and obesity.⁹ Some communities may have food accessible to them, but the food options are heavily comprised of fast-food restaurants and convenience stores with few healthy food options. While supermarket availability, which often provides greater availability of lower-cost healthy foods than other food store options,¹⁰ is not always associated with obesity, other food store types, such as convenience stores and fast-food restaurants, are associated with obesity.¹¹ Studies examining the local food environment of several Native American tribes have reported few options for getting healthy foods and long drive times for people residing on tribal reservations.^{12,13} In a geographical analysis of food merchants in California, there was a lower density of healthy food outlets on tribal lands than non-tribal lands, while the density of unhealthy food outlets was no different between the two.¹⁴

Further compounding the issue is food insecurity (i.e., the lack of reliable physical or economic access to an adequate supply of nutritious food to support a healthy lifestyle), which is associated with poor health and poor dietary intake.¹⁵ In a recent scoping review of 30 studies, food insecurity was consistently more prevalent among Native Americans in comparison to non-Hispanic whites.¹⁶ Native Americans are a heterogeneous cultural group that includes people from over 600 federal or state-recognized tribal nations in the U.S.¹⁷ Food insecurity varies by tribe and region, with as many as 56% of Native Americans being food-insecure in rural Oklahoma,¹⁸ 76% reporting food insecurity on the Navajo nation,¹⁹ and 40% of families on the Pine Ridge reservation experiencing food insecurity.²⁰ Studies reporting on food insecurity in Native Americans have found an association between food insecurity and obesity, diabetes, and hypertension.^{21,22} However, the relationship between the food environment and food insecurity among Native Americans is not well understood.

The conceptual model for these analyses was based on one proposed by Laraia,¹⁵ which suggests that age, race/ethnicity, income, and other variables can directly affect household food insecurity, which can then directly lead to metabolic changes and health impacts, such as diabetes and other chronic conditions. The link between food insecurity and health is further influenced by the food environment. It is with an adapted conceptual model (Figure 1) in

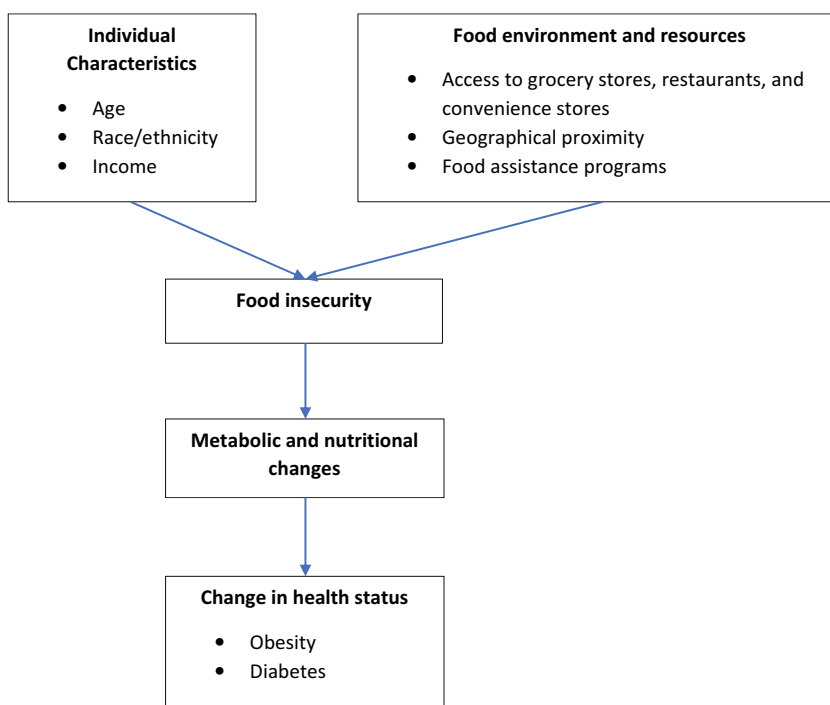


Figure 1. Conceptual diagram of factors in our analysis affecting food security and health outcomes.

mind that we sought to examine the impact of food environment on the link between food insecurity and health outcomes in a Native American population.

Few studies have characterized the food environment that Native Americans commonly encounter; the few that have been conducted, have mostly focused on specific communities or local environments, rather than larger areas, such as counties. These studies have generally shown limited food access and a high prevalence of food insecurity.^{13,14} Even fewer studies have examined how food environments are associated with the health of Native Americans,²³ and none have assessed the relationship between the food environment and food security. Despite the heterogeneity of Native American tribes and individuals, their elevated risk of cardiometabolic conditions and food insecurity is ubiquitous and warrants a broader assessment of Native Americans nationwide.

It is with this background that we examined the association between food environment and food insecurity among Native Americans by comparing the food environment, health outcomes, and food security in areas with a high percentage of Native Americans with counties with a lower percentage of Native American residents. We then examined the relationships between select food environment characteristics, food security, and health outcomes (obesity

and diabetes). These analyses are restricted to the 10 states with the highest proportion of Native American residents (Oklahoma, California, Arizona, New Mexico, Texas, Washington, Michigan, Alaska, Florida, and Oregon).²⁴ These analyses may be of value to inform policies that address the food environment and work to improve the food security of Native Americans, broadly.

Methods

Data Sources

Data for food measures and health indicators came from the U.S. Department of Agriculture's Food Environment Atlas (2020). This dataset includes 275 variables on topics such as access and proximity to grocery stores, store availability, food assistance, local food options such as farmer's markets, health and physical activity, and sociodemographic characteristics. This dataset has compiled measures from the U.S. Census Bureau, the County Business Patterns, Access to Affordable and Nutritious Food: Updated Estimates of Distances to Supermarkets Using 2010 Data, USDA's Food and Nutrition Service, Household Food Security in the United States, the USDA's Agricultural Marketing Service, and Behavioral Risk Factor Surveillance System (BRFSS). All data were at the county-level. Because the USDA food security data were the same for all counties in a given state in the Food Environment Atlas, we used 2018 food Security data from Feeding America (<https://www.feedingamerica.org/research/map-the-meal-gap/by-county>)²⁵

Food Environment Variables

Percentage of total residents and Native American residents with access to a grocery store was based on the USDA's definition: the percentage of all people in a county living more than 1 mile from a supermarket, supercenter or large grocery store if in an urban area, or more than 10 miles from a supermarket or large grocery store if in a rural area. Additional food environment characteristics of each county included the number of grocery stores; the number of convenience stores, the number of stores that are Supplemental Nutrition Assistance Program (SNAP) authorized (per 1,000 total residents); the number of stores that are authorized for the Special Supplemental Program for Women, Infants, and Children (WIC; per 1,000 residents); the number of fast food restaurants (per 1,000 residents); the number of farmer's markets (per 1,000 residents); the number of community supported agriculture (CSA) farms; and the number of Food Distribution Program on Indian Reservation (FDPIR) distribution sites. Counties were dichotomized by the percentage of Native Americans into high (the upper quartile; >1.75% of county residents being Native American) vs. low (bottom 3 quartiles).

Other Variables

County-level sociodemographic characteristics included: percentage of households with low and very low food security, percentage of adults with diabetes, poverty rate, median household income, percentage of adults with obesity, and whether the county was characterized as a metropolitan county or non-metropolitan. Metropolitan counties were defined as counties containing one or more urbanized areas (50,000 people or more residing there) or areas that are economically tied to the urbanized areas.

Analyses

County-level descriptive statistics (medians and ranges) were calculated for all food environment and sociodemographic variables. We examined differences in county-level food environment variables with chi-square and Kruskal–Wallis chi-square for categorical and continuous variables. A regression model with a beta distribution (logit link) as used to test for an association between county-level health outcomes (diabetes and obesity) and percentage food insecurity in the county with food environment variables. The beta distribution was selected because the dependent variables were in proportions that were bounded. Two separate models were fitted: (1) unadjusted that only included percentage of all residents with low access to grocery stores, counties with the highest number of Native Americans residing in them, and the percentage of Native Americans with low access to grocery stores, and (2) adjusting for county-level food environment and sociodemographic variables. The Akaike Information Criteria (AIC)²⁶ was used to determine which variables to include as covariates. Variables were added to the model one at a time and remained in the model if the AIC value was lower than the previous model without the variable. Analyses were completed using SAS statistical software, version 9.4 and R, version 3.6.1. In accordance with 45 CFR §46.102(f), this study was not submitted for institutional review board approval because it involved publicly available data and did not involve individual patient data.

Results

A total of 691 counties in the 10 states were included in our analyses. There were differences in most food environment and sociodemographic variables in counties with the highest percentage of Native Americans compared to counties with a lower percentage of Native Americans (Table 1). Notably, in counties with a high percentage of Native Americans, all residents had limited access to grocery stores compared to counties with a low percentage of Native Americans where only Native Americans had limited access to grocery stores.

Table 1. Food access and sociodemographic characteristics of counties in US states with the 10 highest number of Native Americans, by percentage of Native Americans (691 counties).

	Counties with high percentage of Native Americans ¹ N = 173	Counties with lower percentage of Native Americans ¹ N = 518	p-value ²
All residents with low access to grocery store (% total residents), 2015	26.7 (0.3–100.0)	21.8 (0–100.0)	0.0001
Native American residents with low access to grocery store (% total residents), 2015	2.1 (0–71.4)	0.13 (0–2.0)	<0.0001
Grocery stores/1,000 pop, 2014	0.2 (0–3.2)	0.17 (0–1.6)	0.04
Convenience stores/1,000 pop, 2014	0.5 (0–2.1)	0.5 (0–4.6)	0.39
Fast-food restaurants/1,000 pop, 2014	0.5 (0–1.8)	0.6 (0–2.1)	<0.0001
SNAP-authorized stores/1,000 pop, 2016	0.9 (0.3–6.0)	0.9 (0.2–3.5)	0.003
WIC-authorized stores/1,000 pop, 2012	0.2 (0–3.0)	0.1 (0–2.1)	<0.0001
FDPIR distribution sites, 2012	1.0 (0–22.0)	0 (0–17)	<0.0001
Farmers' markets/1,000 pop, 2016	0.03 (0–0.4)	0.01 (0–1.2)	<0.0001
Community supported agriculture, 2012	3.0 (0–30.0)	2.0 (0–76.0)	0.31
Food Insecurity, 2018 (%)	14.7 (9.1–28.0)	14.2 (6.8–22.5)	0.002
Diabetes in adults (%)	11.2 (4.6–18.0)	10.4 (6.4–17.1)	0.002
Obesity in adult (%)	31.7 (13.7–40.6)	28.6 (16.1–39.6)	<0.0001
Median household income (\$)	44345.0 (29040–82892)	47087.0 (27151–107126)	0.03
Poverty rate (%)	17.2 (3.7–38.0)	16.1 (4.0–35.4)	0.04
Population under 18 years of age (%)	23.7 (11.0–41.6)	23.7 (9.1–35.2)	0.12
Population 65 years and older (%)	15.5 (3.5–32.6)	15.0 (6.9–43.4)	0.68
	N (%)	N (%)	
Metro counties ³	36 (20.9)	223 (43.0)	<0.0001

High was considered in the upper quartile (>1.75% of county residents being Native American) vs. bottom 3 quartiles. Data are median (range).

Kruskal-Wallis Chi-square p-value.

Metro counties were defined as metropolitan areas that included counties containing one or more high-density urban areas containing 50,000 people or more and outlying counties that are economically tied to the central counties.

There were slightly more grocery stores, fewer fast-food restaurants, and no difference in convenience stores in counties with a high percentage of Native Americans.

Food insecurity was slightly higher in counties with a higher percentage of Native Americans than in counties with a lower percentage, as was the poverty rate. There were fewer urban counties among counties with a higher percentage of Native Americans. Counties with a higher percentage of Native Americans also had higher medians of both diabetes and obesity, compared with counties with a lower percentage of Native Americans.

Regression models predicting county-level obesity, diabetes, and food insecurity prevalence are shown in Table 2. In unadjusted analyses, a higher percentage of Native Americans with low access to grocery stores was associated with a higher percentage of obesity at the county level. This association remained significant when adjusted for the state, grocery stores, convenience stores, SNAP-authorized stores, fast-food restaurants, food insecurity, median household income, and poverty rate. Similarly, having a high percentage of

Table 2. Associations between county-level obesity, diabetes, or food insecurity prevalence and county-level food environment and sociodemographic characteristics in states with high numbers of Native Americans.

	% Food Insecure	% Obesity	% Diabetes
	Regression coefficient (p-value)	Regression coefficient (p-value)	Regression coefficient (p-value)
Percentage of all residents with low access, 2015			
Unadjusted	0.001 (0.002)	−0.0003 (0.48)	−0.003 (0.45)
Adjusted	−0.00008 (0.79)	−0.0002 (0.95)	−0.000007 (0.98)
High percentage of Native Americans¹			
Unadjusted	0.07 (0.0003)	0.11 (<0.0001)	0.05 (0.005)
Adjusted	0.06 (<0.0001)	−0.01 (0.53)	0.01 (0.52)
Percentage of residents who are Native American and have low access to grocery store, 2015			
Unadjusted	0.006 (<0.0001)	0.004 (<0.0001)	−0.004 (0.0009)
Adjusted	0.002 (0.03)	0.003 (0.006)	0.002 (0.08)

Bolded values are significant (p < 0.05).

Models adjusted for: state, grocery stores per 1,000 residents, convenience stores per 1,000 residents, SNAP authorized stores per 1,000 residents, fast food restaurants per 1,000 residents, median household income, poverty rate, and food insecurity (for obesity and diabetes models).

High was considered in the upper quartile (>1.75% of county residents being Native American) vs. bottom 3 quartiles.

Native Americans residing in a county was associated with a higher prevalence of obesity at the county level in the unadjusted model, but was no longer significant in the adjusted model.

A lower percentage of Native Americans with low access to grocery stores was associated with a higher percentage of diabetes at the county level, but this association was no longer significant when adjusted for other variables. Having a high percentage of Native Americans residing in a county was associated with diabetes in the unadjusted model, but this relationship was not significant in the adjusted model. The percentage of all residents with low food access in a county was also not associated with diabetes in either adjusted or unadjusted models.

A high percentage of Native Americans residing in a county was associated with a higher percentage of food insecurity, after adjusting for other county-level variables. Also, in counties with a lower percentage of Native Americans, it was only those with low access to a grocery store who experienced a higher prevalence of food insecurity.

Discussion

The goal of the current analysis was to evaluate associations between the food environment and food insecurity in Native Americans. Specifically, we characterized the food environment in counties with a high percentage of Native American residents and assessed the relationships of these food environment characteristics with the county-level prevalence of food insecurity, obesity, and diabetes. In this cross-sectional analysis of 10 states, counties with a high percentage of Native American residents were more likely to be rural counties

with high rates of poverty, obesity, and diabetes, and unique food environment characteristics. Findings from another study suggest that Native Americans residing in urban areas experience higher prevalence of food insecurity than rural areas, even when grocery stores were present.²⁷ In the current analysis, having a higher percentage of Native Americans with low access to grocery stores was associated with a higher prevalence of obesity at the county level. Specifically, for every 10% increase in the percentage of Native Americans with low access to grocery stores, the percentage of those with obesity also rose by 0.03%, and while this number is small, it was significant. Considering that obesity is a chronic condition with many contributing factors, recognizing the relationship of food access with obesity offers a workable solution to reduce obesity prevalence among Native Americans.

Of the few studies that have examined the food environment specifically among Native American residents, the focus was primarily on distance to nearest food outlet. For example, a survey of Native Americans in rural Montana found that while most respondents did most of their grocery shopping at grocery stores or supercenters, residents had to travel 25 miles (50 minutes) to shop, and half reported low or very low food security.²⁸ In a geographic study of Native American tribal areas, an estimated 75% of residents traveled 10 miles or less to the nearest supermarket.²⁹ The current results align with these past findings, indicating that there were modest differences in the number of grocery stores, convenience stores, fast food restaurants, and farmer's markets in counties with a high percentage of Native Americans, but a greater proportion of residents had to drive further to access a grocery store. Counties with a high proportion of Native Americans also had slightly more sites where food assistance could be received or redeemed, such as Supplemental Nutrition Assistance Program, Special Supplemental Nutrition Program for Women, Infants, and Children, or Food Distribution Program on Indian Reservations, relative to the population, but there may be transportation barriers to visiting these locations.

Several studies have evaluated the impact of interventions in local food stores on health outcomes. In one study, there was evidence that increasing shopper exposure to healthier offerings resulted in reductions in body mass index.³⁰ In another tribally owned convenience store makeover, sales of healthy foods increased even though fruit and vegetable intake was not improved.³¹ While grocery store placement on tribal lands may not always be feasible, health promotion or efforts to improve food affordability within existing stores may be an alternative solution to improve the diet and health of Native Americans. Given the relationship between access to grocery stores, obesity and food insecurity identified in the current study, initiatives to change the number, type, or qualities of food outlets to promote health should be evaluated. As another option, many Native American tribes and communities

continue to pursue food sovereignty to dictate their own food systems. These efforts, and their impacts on health and food security, were not assessed in the current study, but are worthy of future inquiry.

In contrast to the positive association between the percentage of Native Americans with low access to grocery stores and obesity, we did not find any association between the percentage of all individuals with low food access in a county and prevalence of obesity or diabetes. There has been a great deal of research done on the topic of food access and obesity in the general population, and a systematic review of 71 studies examining this topic found that most studies did not find any association, positive or negative, between the distance to the nearest store and body mass index or obesity.^{32,33} Our findings suggest that food access, or lack thereof, may have inequitable impacts on different populations within the same county. Thus, future studies may benefit by investigating differing populations residing in communities who may be particularly vulnerable to poor food access, such as elderly, low-income, and minoritized groups.

Few studies have evaluated the association between the food environment and type 2 diabetes. One ecological study of national data found that having more grocery stores per 1,000 residents was associated with a lower prevalence of type 2 diabetes, but only among those residing in low-poverty counties with a low prevalence of minorities.³⁴ No studies have identified an association between density of grocery stores and type 2 diabetes in high poverty counties or in counties with medium to high percentages of minorities. Though low access to a grocery store among Native Americans was not significantly related to type 2 diabetes in the current study, other county-level characteristics, such as food insecurity prevalence, median household income, and density of grocery stores, convenience stores, and fast-food restaurants were significantly associated with type 2 diabetes prevalence.

In the current analysis there was a positive association between obesity and counties with a higher percentage of Native Americans, but when the number of food stores and economic indicators were accounted for, this association was no longer significant. The significant association between the percentage of Native Americans with poor access to grocery stores in the adjusted model, but lack of association in the adjusted model with having a high percentage of Native Americans, regardless of access to grocery stores, suggests that obesity in Native Americans is influenced more by the percentage of individuals with poor access to grocery stores than just the percentage of Native Americans residing in a county.

Somewhat surprisingly in our analysis, there was no evidence that metropolitan/rural status affected the association between food security/food access and health outcomes. This variable was initially included in the models, but because it did not affect the regression coefficients and because of lower AIC values if not included, it was omitted in the final adjusted models. In general, food security is higher for rural areas than metropolitan areas, but the

prevalence of food security in rural areas has declined slightly in recent years.³⁵ Conversely, some have reported lower food security among urban Native Americans.²⁷ Income and access to grocery stores, specifically those that are SNAP authorized, can be different between rural and metropolitan areas, which may be stronger predictors of food security than rural/metropolitan status.

Finally, this analysis found that the proportion of Native Americans in a county and the percentage of Native Americans who had low access to a grocery store were both associated with higher county-level estimates of food insecurity. Strikingly, counties with a high percentage of Native Americans were estimated to have 0.06% greater food insecurity prevalence when compared to counties with a low percentage of Native Americans, even when accounting for access to food retailers and county poverty levels. Thus, there are likely unmeasured forces impacting food insecurity in these counties and creative qualitative approaches, such as interactive tools that engage communities as research partners,³⁶ may be needed to further understand drivers of these phenomena.

There were several limitations to this study. First, the results are based on an ecological analysis, which may not hold true when this association is examined at an individual level. These results can be used to generate hypotheses that can be evaluated with individual- or multi-level observational data. Second, these results may not be generalizable to all Native Americans in the US. Only states with the highest percentage of Native Americans were included, thus eliminating many counties with very low or zero counts of Native Americans. Further, Native Americans are an implicitly heterogeneous group that reflects various nations and customs from diverse historical regions of the U.S. Third, prevalence data for obesity and diabetes were from the BRFSS, which relies on self-report of these conditions. Self-reports can serve as a strong proxy for clinical assessments.^{37,38}

Conclusions

In conclusion, this study found that county-level food environment and socio-demographic characteristics in counties with a high percentage of Native Americans differ from counties with fewer Native Americans. Additionally, both obesity and food insecurity prevalence at the county level were associated with a higher percentage of Native Americans with low access to grocery stores. While the effect was small, increasing availability of grocery stores, which often carry a better selection of fresh fruits and vegetables at lower costs, may be a workable solution to improve the health and food security of Native Americans. Future studies may consider evaluating policies or interventions that impact the food environment to assess the effects on obesity and food security outcomes among Native Americans.

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References

1. Warne D, Wescott S. Social determinants of American Indian nutritional health. *Curr Dev Nutr*. 2019;3(Suppl 2):12–18. doi:10.1093/cdn/nzz054.
2. Alkon AH, Norgaard KM. Breaking the food chains: an investigation of food justice activism*. *Sociological Inq*. 2009;79(3):289–305. doi:10.1111/j.1475-682X.2009.00291.x.
3. Office of Minority Health. Obesity and American Indians/**Alaska** natives. Published 2017. Accessed August 31, 2021. <https://minorityhealth.hhs.gov/omh/content.aspx?lvl=3&lvlID=62&ID=6457>
4. Office of Minority Health. Diabetes and American Indians/**Alaska** natives. Published 2016. Accessed August 31, 2021. <https://minorityhealth.hhs.gov/omh/browse.aspx?lvl=4&lvlID=33>
5. Office of Minority Health. Heart disease and American Indians/**Alaska** natives. Published 2017. Accessed August 31, 2021. <https://minorityhealth.hhs.gov/omh/browse.aspx?lvl=4&lvlid=34>
6. Hu EA, Steffen LM, Coresh J, Appel LJ, Rebholz CM. Adherence to the healthy eating index-2015 and other dietary patterns may reduce risk of cardiovascular disease, cardiovascular mortality, and all-cause mortality. *J Nutr*. 2020;150(2):312–321. doi:10.1093/jn/nxz218.
7. Kelli HM, Hammadah M, Ahmed H, et al. Association between living in food deserts and cardiovascular risk. *Circulation*. 2017;10(9):e003532. doi:10.1161/CIRCOUTCOMES.116.003532.
8. Berkowitz SA, Karter AJ, Corbie-Smith G, et al. Food insecurity, food “deserts,” and glycemic control in patients with diabetes: a longitudinal analysis. *Diabetes Care*. 2018;41(6):1188–1195. doi:10.2337/dc17-1981.
9. Ghosh-Dastidar B, Cohen D, Hunter G, et al. Distance to store, food prices, and obesity in urban food deserts. *Am J Prev Med*. 2014;47(5):587–595. doi:10.1016/j.amepre.2014.07.005.
10. Gase LN, DeFosset AR, Smith LV, Kuo T. The association between self-reported grocery store access, fruit and vegetable intake, sugar-sweetened beverage consumption, and obesity in a racially diverse, low-income population. *Front Public Health*. 2014;2:229. doi:10.3389/fpubh.2014.00229.
11. Li Y, Luo M, Wu X, Xiao Q, Luo J, Jia P. Grocery store access and childhood obesity: a systematic review and meta-analysis. *Obesity Rev*. 2019;22:e12945.
12. Blue Bird Jernigan V, Salvatore AL, Styne DM, Winkleby M. Addressing food insecurity in a native American reservation using community-based participatory research. *Health Educ Res*. 2012;27(4):645–655. doi:10.1093/her/cyr089.
13. O’Connell M, Buchwald DS, Duncan GE. Food access and cost in American Indian communities in **Washington** state. *J Am Diet Assoc*. 2011;111(9):1375–1379. doi:10.1016/j.jada.2011.06.002.

14. Chodur GM, Shen Y, Kodish S, et al. Food environments around American Indian reservations: a mixed methods study. *PloS one*. 2016;11(8):e0161132. doi:10.1371/journal.pone.0161132.
15. Laraia BA. Food insecurity and chronic disease. *Adv Nutr*. 2013;4(2):203–212. doi:10.3945/an.112.003277.
16. Nikolaus CJ, Johnson S, Benally T, et al. Food insecurity among American Indian and **Alaska** native people: a scoping review to inform future research and policy needs. *Adv Nutr*. 2022. doi:10.1093/advances/nmac008.
17. National Conference of State Legislatures. Federal and state recognized tribes. <https://www.ncsl.org/research/state-tribal-institute/list-of-federal-and-state-recognized-tribes.aspx>
18. Blue Bird Jernigan V, Wetherill MS, Heard J, et al. Food insecurity and chronic diseases among American Indians in rural **Oklahoma**: the THRIVE study. *Am J Public Health*. 2017;107(3):441–446. doi:10.2105/AJPH.2016.303605.
19. Pardilla M, Prasad D, Suratkar S, Gittelsohn J. High levels of household food insecurity on the Navajo nation. *Public Health Nutr*. 2014;17(1):58–65. doi:10.1017/S1368980012005630.
20. Bauer KW, Widome R, Himes JH, et al. High food insecurity and its correlates among families living on a rural American Indian reservation. *Am J Public Health*. 2012;102(7):1346–1352. doi:10.2105/AJPH.2011.300522.
21. Jernigan VBB, Huyser KR, Valdes J, Simonds VW. Food insecurity among American Indians and **Alaska** natives: a national profile using the current population survey–food security supplement. *J Hunger Environ Nutr*. 2017;12(1):1–10. doi:10.1080/19320248.2016.1227750.
22. Blue Bird Jernigan V, Garrouette E, Krantz EM, Buchwald D. Food insecurity and obesity among American Indians and Alaska natives and whites in California. *J Hunger Environ Nutr*. 2013;8(4):458–471. doi:10.1080/19320248.2013.816987.
23. Gittelsohn J, Kim EM, He S, Pardilla M. A food store-based environmental intervention is associated with reduced BMI and improved psychosocial factors and food-related behaviors on the Navajo nation. *J Nutr*. 2013;143(9):1494–1500. doi:10.3945/jn.112.165266.
24. Centers for Disease Control and Prevention. *Tribal Population*. Public Health Professionals Gateway: Tribal Health. 2020. Atlanta, GA. Published 2020. Accessed April 17. <https://www.cdc.gov/tribal/tribes-organizations-health/tribes/state-population.html>
25. Map the Meal Gap 2020: A Report on County and Congressional District Food Insecurity and County Food Cost in the United States in 2018. Feeding America; 2020.
26. Posada D, Buckley TR, Thorne J. Model selection and model averaging in phylogenetics: advantages of Akaike information criterion and Bayesian approaches over likelihood ratio tests. *Syst Biol*. 2004;53(5):793–808. doi:10.1080/10635150490522304.
27. Tomayko EJ, Mosso KL, Cronin KA, et al. Household food insecurity and dietary patterns in rural and urban American Indian families with young children. *BMC Public Health*. 2017;17(1):611. doi:10.1186/s12889-017-4498-y.
28. Byker Shanks C, Ahmed S, Dupuis V, et al. Perceptions of food environments and nutrition among residents of the Flathead Indian reservation. *BMC Public Health*. 2020;20(1):1536. doi:10.1186/s12889-020-09584-7.
29. Kaufman P, Dicken C, and Williams R. Measuring access to healthful, affordable food in American Indian and **Alaska** native tribal areas. US Department of Agriculture Economic Research Service Economic Information Bulletin Number 131. 2014.

30. Gittelsohn J, Kim EM, He S, Pardia M. A food store-based environmental intervention is associated with reduced BMI and improved psychosocial factors and food-related behaviors on the Navajo nation. *J Nutr.* 2013;143:1494–1500.
31. Bird Jernigan VB, Salvatore AL, Williams M, et al. A healthy retail intervention in native American convenience stores: the THRIVE community-based participatory research study. *Am J Public Health.* 2019;109(1):132–139. doi:10.2105/AJPH.2018.304749.
32. Blue Bird Jernigan V, D'Amico EJ, Duran B, Buchwald D. Multilevel and community-level interventions with native Americans: challenges and opportunities. *Prev Sci.* 2020;21(Suppl 1):65–73. doi:10.1007/s11121-018-0916-3.
33. Cobb LK, Appel LJ, Franco M, Jones-Smith JC, Nur A, Anderson CA. The relationship of the local food environment with obesity: a systematic review of methods, study quality, and results. *Obesity.* 2015;23(7):1331–1344. doi:10.1002/oby.21118.
34. Palta M, Prineas RJ, Berman R, Hannan P. Comparison of self-reported and measured height and weight. *Am J Epidemiol.* 1982 Feb;115(2):223–30. doi:10.1093/oxfordjournals.aje.a113294. PMID: 7058781
35. Haynes-Maslow L, Andress L, Byker-Shanks C, et al. *Examining Food Insecurity in the Rural United States: A Qualitative Study.* Share Our Strength and Feeding America; 2020.
36. Harrison E, Gilbert B, Popkin SJ, Waxman E. *Tackling Food Insecurity by Bringing Data to Communities.* In. Washington, DC: Urban Institute; 2019
37. El Fakiri F, Bruijnzeels MA, Hoes AW. No evidence for marked ethnic differences in accuracy of self-reported diabetes, hypertension, and hypercholesterolemia. *J Clin Epidemiol.* 2007;60(12):1271–1279. doi:10.1016/j.jclinepi.2007.02.014.
38. Palta M, Prineas RJ, Berman R, Hannan P. Comparison of self-reported and measured height and weight. *Am J Epidemiol.* 1982;115(2):223–230. doi:10.1093/oxfordjournals.aje.a113294.