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# The Hispanic paradox in the prevalence of obesity at the county-level

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## Abstract

**Objective:** The percentage of Hispanics in a county has a negative association with prevalence of obesity. Because Hispanic individuals are unevenly distributed in the United States, this study examined whether this protective association persists when stratifying counties into quartiles based on the size of the Hispanic population and after adjusting for county-level demographic, socioeconomic, healthcare, and environmental factors.

**Methods:** Data were extracted from the 2018 Robert Wood Johnson Foundation County Health Rankings. Counties were categorized into quartiles based on their percentage of Hispanics, 0%–5% ($n = 1794$), 5%–20% ($n = 962$), 20%–50% ($n = 283$), and >50% ($n = 99$). For each quartile, univariate and multivariate regression models were used to evaluate the association between prevalence of obesity and demographic, socioeconomic, healthcare, and environmental factors.

**Results:** Counties with the top quartile of Hispanic individuals had the lowest prevalence of obesity compared to counties at the bottom quartile ($28.4 \pm 3.6\%$ vs. $32.7 \pm 4.0\%$). There was a negative association between county-level percentage of Hispanics and prevalence of obesity in unadjusted analyses that persisted after adjusting for all county-level factors.

**Conclusions:** Counties with a higher percentage of Hispanics have lower levels of obesity, even after controlling for demographic, socioeconomic, healthcare, and environmental factors. More research is needed to elucidate why having more Hispanics in a county may be protective against county-level obesity.

**KEYWORDS**
health disparities, Hispanic paradox, obesity

# 1 | INTRODUCTION

Hispanics are the largest and fastest growing minority group in the United States.[1–4] Compared with non-Hispanic Whites (NHWs), Hispanics generally experience higher levels of poverty, lower education and are more likely to be uninsured.[1,3–6] These factors are associated with adverse health outcomes in the general population, but several studies have shown that Hispanics experience unexpectedly lower rates of coronary heart events and cardiovascular disease (CVD) mortality when studied in aggregate.[3,4,7] This epidemiological phenomenon has been coined the "Hispanic paradox," and it is postulated that geography may play a role in explaining this observation.[1,2,4–6,8] When compared to non-Hispanic whites and African Americans, Hispanics have a lower CVD mortality, but similar or greater cardiovascular risk burden.[9,10] Recent findings have shown that Hispanics have similar or greater rates of hypertension and hypercholesterolemia when compared to non-Hispanics whites and African Americans.[9] Hispanics have higher rates of obesity, similar to those seen in African Americans, when compared with NHWs.[11–15] However, there is some controversy about the Hispanic paradox due to the growing heterogeneity of the US Hispanic population in terms of country of origin and acculturation. e.g., Hispanics of Puerto Rican background have higher obesity rates than African American and NHWs, but Hispanics of South American background have lower obesity rates than NHWs.[9,10]

Various studies examining regional heterogeneity in prevalence of obesity have found a Hispanic paradox by reporting a negative association between counties with a higher percentage of Hispanics and county-level obesity.[16,17] Prior work has demonstrated that the lowest county-level prevalence of obesity was found in the Southwest and Western region of the country, areas that have high Hispanic populations.[16–18]

This study aims to understand why Hispanic ethnic density is negatively associated with county-level obesity and to determine if this is explained by other county-level factors. Because Hispanics are unevenly concentrated in certain counties of the United States, it is important to consider how the association between Hispanic population and obesity differ across counties based on the underlying size of the Hispanic population by county.[19] Analyses of the association between percentage of Hispanics and county-level obesity that examine all counties together risk detecting spurious or no effect driven largely by the low percentage of Hispanics in most counties. The objectives of this study were to investigate the following: (1) whether there is an association between the percent of Hispanics living in a county and county-level prevalence of obesity after stratifying counties based on the size of the Hispanic population, and (2) if an association exists, does it persist after adjusting for county-level demographics, socioeconomic, healthcare, and environmental factors. The a priori hypothesis was that there would be a negative association between percentage of Hispanics and prevalence of obesity at the county-level, and this effect would persist after adjusting for a county-level demographics, socioeconomic, healthcare, and environmental factors.

# 2 | MATERIALS & METHODS

## 2.1 | Data sources

County-level data were extracted from the 2018 Robert Wood Johnson Foundation County Health Rankings (CHR). Based on previous studies, several variables were identified to be important predictors of county-level prevalence of obesity.[17] The CHR is compiled annually, based on a collection and interpolation of data from the Behavioral Risk Factor Surveillance System (BRFSS), the Dartmouth Institute, American Community Survey, Centers for Disease Control and Prevention (CDC) Diabetes Interactive Atlas, CDC WONDER mortality data, Centers for Medicare & Medicaid Services National Provider Identification, US Census, US Department of Agriculture Food Environment Atlas, and the US Department of Education. Details of CHR dataset are at (https://www.countyhealthrankings.org/explore-health-rankings/rankings-data-documentation). Briefly, the CHR county-level factors include demographic (population, percentage rural, percentage female, percentage younger than 18 years, percentage of 65 years and older, percentage African American, percentage Hispanic, percentage Asian, percentage American Indian/Alaskan Native, and percentage Native Hawaiian/Other); socioeconomic (median household income, percentage with some college education, percentage of food insecure, percentage unemployed, and percentage with severe housing problems); healthcare (percentage of adults uninsured and primary care physician [PCP] rate); and environmental (percentage with access to exercise opportunities and Food Environment Index) factors. A detailed list of all factors, their definitions, and their original data sources is available in Table 1. Because county Hispanic population is skewed, counties were categorized into quartiles so that each quartile had a minimum of 99 counties based on the percentage of Hispanics: 0%–5% ($n = 1794$), 5%–20% ($n = 962$), 20%–50% ($n = 283$), and >50% ($n = 99$). A sensitivity analysis was conducted using different cutoffs with qualitatively similar univariate results.

The CHR data were merged with 2018 Federal Information Processing Standards Code US Census data to match counties to their corresponding region. This study was based on publicly available and unidentifiable data and was thus determined by Stanford's institutional review board to be exempt from review; informed consent was waived.

The 2018 CHR used data from CDC's BRFSS 2013–2015 and the US Census Bureau to obtain county-level estimates for prevalence of obesity. The BRFSS is an ongoing monthly, state-based telephone and cellphone based survey that samples using random-digit-dialed. County-level prevalence of obesity is based on survey respondents (age 20 and older) whose self-reported height and weight correspond to a BMI of 30 kg/m$^2$ or greater.[20] For the majority of US counties, the BRFSS captures small sample sizes, which prevents reliable county-level estimates. To address this limitation, BRFSS data from 2013, 2014, and 2015 were pooled and a Bayesian multilevel model was used to estimate prevalence of obesity for all US counties. Estimates were restricted to adults aged 20 years or older to be consistent with the population estimates from the US Census Bureau.

**TABLE 1** Definition of variables

| Variables | Description | Sources of Data | Year | Category |
|---|---|---|---|---|
| **Outcome** | | | | |
| Adult obesity | Percentage of adults that report a BMI of 30 or more | CDC Diabetes Interactive Atlas | 2014 | Outcome |
| **Selected variables** | | | | |
| Population | Number of persons | Census Population Estimates | 2016 | Demographics |
| % Rural | Urban areas are defined as having 50,000 or more people. Rural encompasses all population, housing, and territory not included within an urban area. | Census Population Estimates | 2010 | Demographics |
| % Females | Number of females in county | Census Population Estimates | 2016 | Demographics |
| % below 18 years of age | Number of persons less than 18 years old | Census Population Estimates | 2016 | Demographics |
| % 65 and older | Number of persons at or greater than 65 years old | Census Population Estimates | 2016 | Demographics |
| % Non-Hispanic white | Persons self-identifying as non-Hispanic white | Census Population Estimates | 2016 | Demographics |
| % Non-Hispanic African American | Persons self-identifying as non-Hispanic African-American | Census Population Estimates | 2016 | Demographics |
| % Hispanic | Persons self-identifying as Hispanic | Census Population Estimates | 2016 | Demographics |
| % Asian | Persons self-identifying as Asian | Census Population Estimates | 2016 | Demographics |
| % American Indian and Alaskan Native | Persons self-identifying as American Indian/Alaskan Native | Census Population Estimates | 2016 | Demographics |
| % Native Hawaiian/Other Pacific Islander | Persons self-identifying as Native Hawaiian/Other | Census Population Estimates | 2016 | Demographics |
| Region | Census regions are groupings of states and the District of Columbia that subdivide the United States for the presentation of census data. The Census Bureau defines four census regions and identifies each one with a single-digit census code- Northeast,[1] Midwest,[2] South,[3] and West[4] | US Census | 2016 | Demographics |
| Median household income | Median Household Income is the income where half of households in a county earn more and half of households earn less. | Small Area Income and Poverty Estimates | 2016 | Socioeconomic |
| Some college | Percentage of adults ages 25–44 with some post-secondary education | American Community Survey, 5-year estimates | 2012–2016 | Socioeconomic |
| Food Insecurity | Food Insecurity is the percentage of the population who did not have access to a reliable source of food during the past year. | Map the Meal Gap | 2015 | Socioeconomic |
| Unemployment | Percentage of population ages 16 and older unemployed but seeking work | Bureau of Labor Statistics | 2016 | Socioeconomic |
| Severe housing problems | Percentage of households with at least 1 of 4 housing problems: Overcrowding, high housing costs, or lack of kitchen or plumbing facilities | Comprehensive Housing Affordability Strategy (CHAS) data | 2010–2014 | Socioeconomic |
| Uninsured | Percentage of population under age 65 without health insurance | Small Area Health Insurance Estimates | 2015 | Healthcare |
| Primary care physicians | Ratio of population to primary care physicians | Area Health Resource File/American Medical Association | 2015 | Healthcare |

| Variables | Description | Sources of Data | Year | Category |
|---|---|---|---|---|
| Access to exercise opportunities | Percentage of population with adequate access to locations for physical activity | Business Analyst, Delorme map data, ESRI, and US Census Tigerline Files | 2010 & 2016 | Environmental |
| Food environment index | Index of factors that contribute to a healthy food environment, 0 (worst) to 10 (best) | USDA Food Environment Atlas, Map the Meal Gap from Feeding America | 2015 | Environmental |

Abbreviations: CDC, Centers for Disease Control and Prevention; ESRI, Environmental Systems Research Institute; USDA, United States Department of Agriculture.

## 2.2 | Statistical analysis

For each pair of county-level factors that had a pairwise linear correlation greater than or equal to 0.8, the one with the weaker association with prevalence of obesity by univariate regression was excluded.[17] County-level population and median household income were log normalized and scaled to have maximum values of 100. County-level primary care physician (PCP) rate was scaled to have a maximum value of 100. For the counties in each quartile, univariate, and multivariate regression models were used to evaluate the association between prevalence of obesity and demographic, socio-economic, healthcare, and environmental factors. A statistical measure of variation explained by a regression model, $R^2$, was used to compare models. The Kruskal–Wallis test was used for between-group comparisons. In order to determine the degree of spatial autocorrelation, the tendency for counties that are geographically close together to have correlated values, a Local Indicators of Spatial Association (LISA) analysis was conducted using a "queen" weights matrix that uses shared borders to define each county's neighboring counties.[21,22] The Moran's I statistic was used to identify statistically significant geographic clusters of counties with similar prevalence of obesity and percentage of Hispanics.[21,22] The Moran's $I$ statistic varies from −1 (perfect negative spatial autocorrelation) to +1 (perfect positive spatial autocorrelation). To adjust for spatial autocorrelation (i.e., the significant clustering of counties with similar obesity levels), a spatial lag term was used to ensure that results are not biased by shared similarities in the prevalence of obesity among neighboring counties.[21,22] The spatial lag was calculated as the average of the dependent variable, prevalence of obesity, among a county's neighbors. All analyses were performed using RStudio Version 1.2.5019. Statistical significance was determined using 2-sided $p < 0.05$.

## 3 | RESULTS

The percentage of Hispanics differed across the quartiles of US counties; 1794 of US counties had <5% Hispanics and 99 counties had a >50% Hispanics (Table 2). Compared to counties at the bottom quartile of Hispanic percentage, counties at the top quartile of Hispanic percentage had the lowest prevalence of obesity (28.4 ± 3.6% vs. 32.7 ± 4.0%), lowest median household income ($43,910 ± $9461 vs. $47,120 ± $11,048), lowest percentage of population with some

college education (46.2 ± 9.0% vs. 56.9 ± 11.4%), lowest primary care physician ratio (41.5 ± 21.9 vs. 53.1 ± 36.2), highest percentage of uninsured (19.8 ± 6.1% vs. 10.7 ± 4.2%), and highest percentage of unemployed (7.2 ± 3.4% vs. 5.4 ± 2.0%; $p < 0.0001$).

When compared to counties at the bottom quartile of Hispanic percentage, counties at the top quartile of Hispanic percentage were less likely to be rural (36.6 ± 30.2% vs. 68.5 ± 27.2%), had a higher percentage of persons less than 18 years of age (26.7 ± 4.3% vs. 21.7 ± 3.1%), and a lower percentage of 65 years and older (14.9 ± 4.2% vs. 19.3 ± 4.0%) ($p < 0.0001$). Counties with the highest percentage of Hispanics were primarily in the South and West regions (Figure 1). Summary statistics of all other demographic, socioeconomic, health care, and environmental factors appear in Table 2.

In unadjusted analyses, the percentage of Hispanics living in a county was negatively associated with county-level obesity rates (Figure 2). In univariate regression analyses, the percentage of Hispanics was inversely associated with prevalence of obesity in counties with the lowest percentage of Hispanics (<20%). The top three factors that explained the greatest variation in county-level prevalence of obesity, as measured by unadjusted $R^2$ in univariate regression, differed by percentage of Hispanics. In quartile 1 (Hispanic percentage <5%), the greatest variation in county prevalence of obesity was explained by percent food insecure (25.6%), median household income (23.7%), and percent some college (19.8%). In quartile 4 (Hispanic percentage >50%), the greatest variation in prevalence of obesity was explained by percentage younger than 18 years (30.9%), percentage 65 years and older (24.7%), and the percentage of individuals with some college education (18.0%). Univariate regression results for all demographic, socioeconomic, health care, and environmental factors are shown in Table 3.

After adjusting for all county-level factors, the percentage of Hispanics remained inversely associated with county-level prevalence of obesity in counties with a Hispanic percentage over 5%. Socioeconomic and healthcare factors including household income, percentage of individuals with some college, percent uninsured, and PCP rate were negatively associated with county-prevalence of obesity after adjusting for all other factors in all Hispanic ethnic density quartiles except counties in quartile 4 (Hispanic percentage >50%). Details of the multivariate regressions for all factors are shown in Table 4.

To compare the different Hispanic quartiles, a linear regression with Hispanic quartiles as an indicator variable was conducted. Hispanic quartiles with higher percentages of Hispanics showed a

**TABLE 2** County-level demographic, socioeconomic, healthcare, and environmental factors by Hispanic density quartiles

| | Percent of Hispanic population | | | | |
| --- | --- | --- | --- | --- | --- |
| | [0%–5%] (n = 1794) | (5%–20%] (n = 962) | (20%–50%] (n = 283) | >50% (n = 99) | |
| Variable | Mean (SD) | | | | p-value |
| Demographic factors | | | | | |
| Population | 10,548 (21,361) | 36,595 (71,030) | 89,078 (259,923) | 46,562 (121,605) | <0.0001 |
| Rural, % | 68.5 (27.2) | 47.0 (31.6) | 42.7 (33.2) | 36.6 (30.2) | <0.0001 |
| Female, % | 50.0 (1.9) | 50.0 (2.4) | 49.3 (2.8) | 48.6 (3.5) | <0.0001 |
| Percent < 18 | 21.7 (3.1) | 22.6 (3.5) | 23.9 (3.7) | 26.7 (4.3) | <0.0001 |
| Percent 65 and over | 19.3 (4.0) | 17.5 (4.9) | 16.7 (5.0) | 14.9 (4.2) | <0.0001 |
| Hispanic, % | 2.6 (1.1) | 9.7 (4.0) | 31.0 (8.3) | 65.8 (13.4) | <0.0001 |
| African-American population, % | 9.4 (16.1) | 9.7 (12.7) | 5.9 (6.8) | 2.8 (3.8) | <0.0001 |
| Asian, % | 0.8 (1.0) | 2.3 (3.8) | 3.1 (5.1) | 1.5 (1.9) | <0.0001 |
| American Indian/Alaskan Native, % | 2.2 (8.7) | 2.4 (6.9) | 2.3 (3.8) | 2.1 (2.2) | <0.0001 |
| Native Hawaiian/Other Pacific Islander, % | 0.1 (1.2) | 0.2 (0.7) | 0.2 (0.2) | 0.1 (0.1) | <0.0001 |
| Non-Hispanic White, % | 83.7 (17.9) | 74.1 (14.9) | 57.1 (11.5) | 28.4 (12.2) | <0.0001 |
| East region | 136 (62.7)[b] | 64 (29.5)[b] | 16 (7.4)[b] | 1 (0.4)[b] | <0.0001 |
| Midwest region | 793 (75.2)[b] | 233 (22.1)[b] | 27 (2.6)[b] | 2 (0.2)[b] | |
| South region | 753 (53.0)[b] | 463 (32.6)[b] | 140 (9.8)[b] | 66 (4.6)[b] | |
| West region | 112 (25.2)[b] | 202 (45.5)[b] | 100 (22.5)[b] | 30 (6.8)[b] | |
| Socioeconomic factors | | | | | |
| Median household income[a] | 47,120 (11,048) | 53,500 (14,680) | 53,056 (13,850) | 43,910 (9461) | <0.0001 |
| Some college, % | 56.9 (11.4) | 59.9 (11.3) | 53.9 (11.1) | 46.2 (9.0) | <0.0001 |
| Food insecure, % | 14.5 (4.4) | 14.1 (3.8) | 13.1 (3.7) | 10.3 (3.1) | <0.0001 |
| Unemployed, % | 5.4 (2.0) | 4.9 (1.4) | 4.8 (1.4) | 7.2 (3.4) | <0.0001 |
| Severe housing problems, % | 13.5 (4.5) | 15.3 (4.4) | 16.5 (5.6) | 17.9 (6.3) | <0.0001 |
| Health care factors | | | | | |
| Uninsured, % | 10.7 (4.2) | 12.4 (4.7) | 16.4 (5.9) | 19.8 (6.1) | <0.0001 |
| Primary care physician (PCP) rate[a] | 53.1 (36.2) | 58.9 (34.2) | 55.8 (31.5) | 41.5 (21.9) | <0.0001 |
| Environmental factors | | | | | |
| Access to exercise opportunities, % | 58.8 (22.8) | 69.2 (21.8) | 68.6 (23.9) | 63.3 (25.1) | <0.0001 |
| Food Environment Index | 7.4 (1.2) | 7.4 (1.1) | 7.4 (1.2) | 7.7 (1.2) | 0.0122 |
| Obese, % | 32.70 (4.0) | 30.4 (4.8) | 28.6 (4.5) | 28.4 (3.6) | <0.0001 |

[a]Variables were log normalized and scaled to have a maximum value of 100.

[b]Reported values indicate the number and percent of counties within each region and Hispanic quartile.

significant negative association between percentage of Hispanics and prevalence of obesity at the county-level compared to counties with the least percentage of Hispanics (Table 5).

The LISA analysis revealed a positive spatial autocorrelation in prevalence of obesity at the county-level (Moran's $I = 0.59$; $p < 0.01$) and a positive autocorrelation in percentage of Hispanics at the county-level (Moran's $I = 0.81$; $p < 0.01$). A LISA map of spatially significant clusters of counties with high prevalence of obesity in the South and clusters of counties with low prevalence of obesity in the West are shown in Figure 1A. A LISA map of spatially significant clusters of counties with a high percentage of Hispanics are shown in Figure 1B. A regression analysis that included a spatial lag term to adjust for spatial autocorrelation in prevalence of obesity at the county-level showed a significantly negative association ($p < 0.01$) between prevalence of obesity and percentage of Hispanics at the county-level (Table 6).
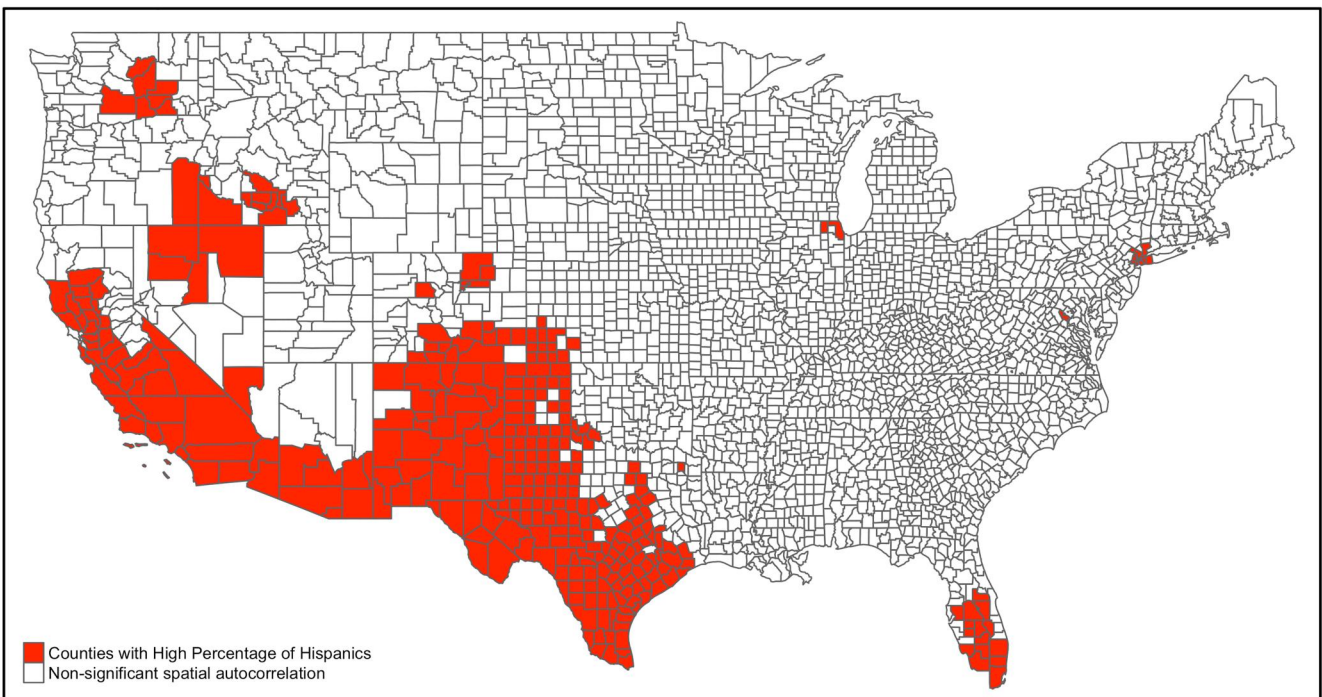
**(A)**
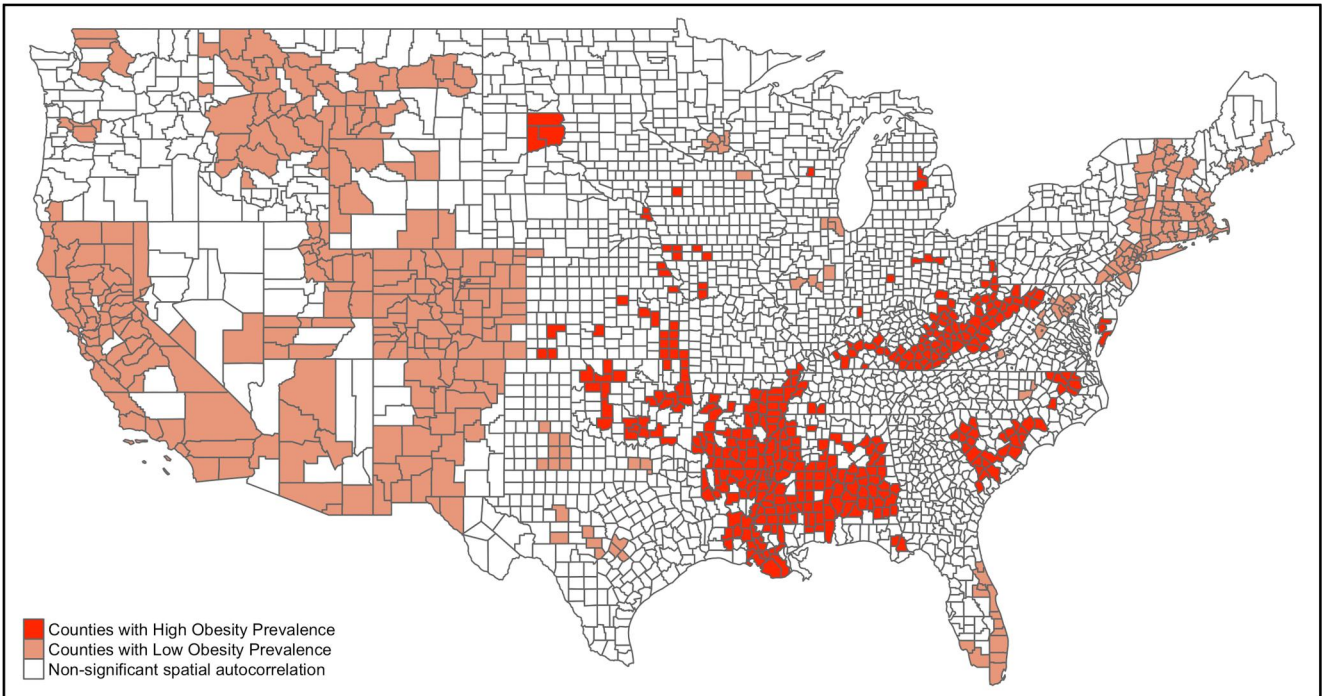


**(B)**



**FIGURE 1** Local Indicators of Spatial Association (LISA) map of significant concentrations of prevalence of obesity and Hispanic population at the county-level. (A), Moran's $I = 0.59$; $p < 0.01$. Red counties are a geographic cluster with significantly ($p < 0.05$) higher prevalence of obesity than would be expected if county spatial distribution were random. Orange counties are a geographic cluster with significantly ($p < 0.05$) lower prevalence of obesity than would be expected if county spatial distribution were random. (B), Moran's $I = 0.81$; $p < 0.01$. Red counties are a geographic cluster with significantly ($p < 0.05$) a higher percentage of Hispanics than would be expected if county spatial distribution were random
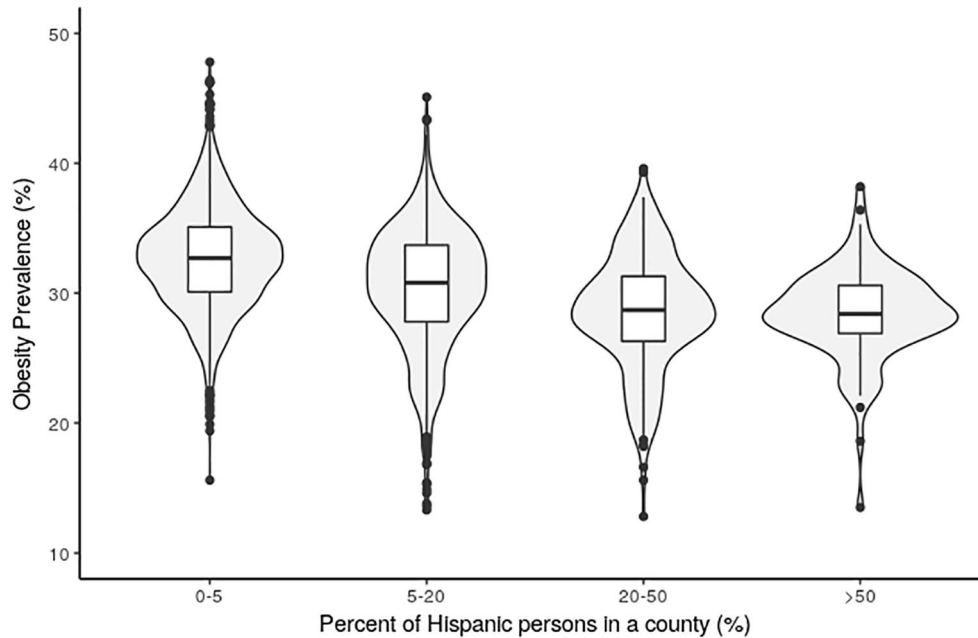
**FIGURE 2** Violin plots of prevalence of obesity stratified by Hispanic population at the county-level. Violin plots show the distribution of county-level prevalence of obesity by percent of Hispanic persons within each quartile. The box plots inside the violin plot show median prevalence of obesity (IQR) for each Hispanic quartile: 0%–5% (32.1 [27.1, 37.1]), 5%–20% (30.8 [24.9, 36.7]), 20%–50% (28.7 [23.7, 33.7]), >50% (28.4 [24.7, 32.1]). IQR, interquartile range

## 4 | DISCUSSION

Using contemporary nationally representative data, this cross-sectional study documented a negative association between the percentage of Hispanics in a county and county-level obesity. This association persisted after adjusting for demographic, socioeconomic, healthcare, and environmental factors and across quartiles of Hispanic ethnic density. These findings support the Hispanic paradox in county-level prevalence of obesity. Demographic and socioeconomic factors explained most of the variation in county-level obesity for all Hispanic ethnic density quartiles, but there was significant heterogeneity in the factors that accounted for the variation based across these quartiles. In contrast to the other quartiles, the variation in prevalence of obesity in quartile 4 (Hispanic percentage >50%) was largely explained by demographic factors. Quartile 4 counties tended to have a younger population with a higher percentage of younger than 18 years and lower percentage of 65 years and older compared to other quartiles.

Previous county-level studies have similarly found a negative association between percentage of Hispanic population and prevalence of obesity.[16–18,23] These authors hypothesized that these associations may be because Hispanic populations are dense in regions associated with lower prevalence of obesity (e.g., Southwest and West). This study corroborated these findings by documenting geographic clusters of Hispanics in similar US regional clusters with lower prevalence of obesity. However the Hispanic population is growing the fastest in regions associated with high prevalence of obesity (e.g., Midwest and South).[16] One possible explanation for this contradictory observation

is that baseline Hispanic population density has been associated with a lower change in prevalence of obesity over time, but an increase in Hispanic population over time was associated with increased prevalence of obesity.[16] This study found that despite adjustment for demographic, socioeconomic, healthcare, and environmental factors, the percentage of Hispanics in a county was associated with lower rates of obesity across US counties.[18,24–26]

Prior work seeking to understand the Hispanic paradox has shown mixed results for the protective role of residential enclaves on various health outcomes. Since the Hispanic population is highly segregated in the United States, it is possible that living in ethnically homogenous areas results in higher availability of social support, decreased discrimination, and lower acculturation—factors that have been associated with improved health status across diverse communities.[1,27,28] A protective role against obesity has been documented for Hispanic immigrants living in ethnically homogenous communities, but this effect diminished in higher poverty neighborhoods. There was no association observed for US-born Hispanics.[29] On the other hand, Hispanic ethnic density has been associated with increased CVD mortality, challenging the protective role of ethnically homogenous enclaves.[1] In agreement with previous county-level studies, this study found a negative association between Hispanic population and prevalence of obesity.[16,23] In the context of a highly segregated Hispanic population in the U.S., a strength of the present analysis is that the counties were stratified based on the size of Hispanic population and found that this negative association persists across Hispanic ethnic density quartiles. This association persisted after adjusting for spatial autocorrelation in prevalence of obesity and percentage of Hispanics at the county-level.

**TABLE 3** Univariate regression analysis of county-level prevalence of obesity by demographic, socioeconomic, healthcare, and environmental factors stratified by Hispanic density quartiles

| | Percent of Hispanic population | | | | | | | |
| | [0%–5%] (n = 1794) | | [5%–20%] (n = 962) | | [20%–50%] (n = 283) | | >50% (n = 99) | |
| Variable | Coefficient (SE) | $R^2$ | Coefficient (SE) | $R^2$ | Coefficient (SE) | $R^2$ | Coefficient (SE) | $R^2$ |
|---|---|---|---|---|---|---|---|---|
| **Demographic factors** | | | | | | | | |
| Population | −0.001 (0.011) | 0.0000 | −0.068 (0.014)[a] | 0.0273 | −0.094 (0.018)[a] | 0.1099 | 0.019 (0.029) | 0.0005 |
| Rural, % | 0.012 (0.003)[a] | 0.0074 | 0.029 (0.005)[a] | 0.0515 | 0.036 (0.008)[a] | 0.0990 | −0.027 (0.012)[b] | 0.0253 |
| Female, % | 0.174 (0.048)[a] | 0.0072 | −0.026 (0.063) | 0.0011 | −0.072 (0.095) | 0.0005 | −0.103 (0.102) | 0.0161 |
| Percent < 18 | 0.321 (0.029)[a] | 0.0627 | 0.441 (0.041)[a] | 0.1165 | 0.579 (0.063)[a] | 0.2185 | 0.437 (0.072)[a] | 0.3092 |
| Percent 65 and over | −0.197 (0.023)[a] | 0.0405 | −0.094 (0.031)[a] | 0.0131 | −0.110 (0.053)[b] | 0.0053 | −0.465 (0.072)[a] | 0.2465 |
| Hispanic, % | −0.516 (0.084)[a] | 0.0205 | −0.248 (0.037)[a] | 0.0015 | −0.009 (0.032) | 0.0000 | 0.006 (0.027) | 0.0002 |
| African-American population, % | 0.099 (0.005)[a] | 0.1620 | 0.101 (0.012)[a] | 0.0766 | 0.057 (0.039) | 0.0067 | 0.094 (0.094) | 0.0102 |
| Asian, % | −1.122 (0.088)[a] | 0.0837 | −0.345 (0.038)[a] | 0.0546 | −0.308 (0.050)[a] | 0.1291 | −0.057 (0.195) | 0.0259 |
| American Indian/Alaskan Native, % | 0.039 (0.011)[a] | 0.0071 | 0.124 (0.022)[a] | 0.0082 | 0.005 (0.070) | 0.0009 | −0.469 (0.158)[a] | 0.0741 |
| Native Hawaiian/Other Pacific Islander, % | −0.234 (0.079)[a] | 0.0049 | −0.671 (0.210)[a] | 0.0080 | −1.521 (1.146) | 0.0069 | −4.113 (2.812) | 0.0113 |
| East region | 29.5 (3.8)[a,c] | | 27.1 (3.4)[a,c] | | 26.4 (4.8)[a,c] | | 30.0 (NA)[a,c] | |
| Midwest region | 32.2 (2.9)[a,c] | | 32.3 (3.2)[a,c] | | 33.3 (3.4)[a,c] | | 35.3 (4.1)[a,c] | |
| South region | 34.5 (3.8)[a,c] | | 31.7 (4.0)[a,c] | | 29.7 (3.2)[a,c] | | 29.2 (2.2)[a,c] | |
| West region | 27.9 (4.0)[a,c] | | 26.1 (5.1)[a,c] | | 26.1 (4.7)[a,c] | | 26.0 (4.5)[a,c] | |
| **Socioeconomic factors** | | | | | | | | |
| Median household income | −1.003 (0.043)[a] | 0.2366 | −1.076 (0.064)[a] | 0.2429 | −0.618 (0.121)[a] | 0.1282 | 0.272 (0.197) | 0.0116 |
| Some college, % | −0.155 (0.007)[a] | 0.1982 | −0.198 (0.012)[a] | 0.2726 | −0.192 (0.021)[a] | 0.2185 | −0.140 (0.038)[a] | 0.1802 |
| Food insecure, % | 0.450 (0.018)[a] | 0.2560 | 0.307 (0.039)[a] | 0.0586 | −0.016 (0.073) | 0.0002 | −0.202 (0.116) | 0.0302 |
| Unemployed, % | 0.741 (0.044)[a] | 0.1343 | 0.828 (0.103)[a] | 0.0531 | 0.077 (0.192) | 0.0040 | −0.027 (0.107) | 0.0015 |
| Severe housing problems, % | 0.062 (0.021)[a] | 0.0049 | −0.279 (0.034)[a] | 0.0779 | −0.325 (0.043)[a] | 0.1864 | −0.045 (0.057) | 0.0279 |
| **Health care factors** | | | | | | | | |
| Uninsured, % | 0.160 (0.022)[a] | 0.0287 | 0.256 (0.031)[a] | 0.1315 | 0.264 (0.043)[a] | 0.1122 | 0.185 (0.056)[a] | 0.1198 |
| Primary care physician (PCP) rate | −0.128 (0.012)[a] | 0.0660 | −0.235 (0.019)[a] | 0.1498 | −0.270 (0.036)[a] | 0.1849 | −0.273 (0.076)[a] | 0.1214 |
| **Environmental factors** | | | | | | | | |
| Access to exercise opportunities, % | −0.053 (0.004)[a] | 0.0930 | −0.084 (0.006)[a] | 0.1477 | −0.057 (0.011)[a] | 0.1047 | 0.010 (0.014) | 0.0003 |
| Food Environment Index | −1.211 (0.072)[a] | 0.1388 | −0.911 (0.135)[a] | 0.0426 | −0.423 (0.227) | 0.0194 | 0.682 (0.290)[b] | 0.0216 |

[a]$p < 0.01$.
[b]$p < 0.05$.
[c]Categorical geographical variable show mean (SD) of prevalence of obesity.

There are several limitations that may affect the interpretation of the results. The CHR data were based on self-reported, sampled randomly from the population, and statistically interpolated. Self-reported data are often imprecise due to recall and social desirability bias.[30,31] However, recent research has demonstrated that the use of multivariable regression modeling controlling for self-reported biases associated with sociodemographic characteristics can result in reliable estimates similar to those from directly measured anthropometric data.[32–34] These methodological studies add strength and reliability to these findings. Since this dataset lacked BMI measurements linked to race/ethnicity, the authors were unable to analyze county-level analysis of obesity rates disaggregated by race/ethnicity subgroups. Subsequent work should disaggregate Hispanics further by nativity status, country of origin, and degree of acculturation. Further study is necessary of individual-level response to surveys such as the BRFSS to evaluate potential shortcomings in the analysis of aggregate-level data.

**TABLE 4** Multivariate regression analysis of county-level prevalence of obesity by demographic, socioeconomic, healthcare, and environmental factors stratified by Hispanic density quartiles

| | Percent of Hispanic population | | | |
|---|---|---|---|---|
| | [0%–5%] (n = 1794) | (5%–20%] (n = 962) | (20%–50%] (n = 283) | >50% (n = 99) |
| Variable | Coefficient (SE) | | | |
| Demographic factors | | | | |
| Population | 0.028 (0.016) | −0.012 (0.017) | 0.037 (0.031) | 0.151 (0.053)[a] |
| Rural, % | 0.001 (0.004) | −0.017 (0.006)[a] | −0.009 (0.011) | 0.004 (0.022) |
| Female, % | 0.010 (0.046) | 0.016 (0.064) | 0.059 (0.111) | −0.377 (0.213) |
| Percent < 18 | 0.161 (0.039)[a] | 0.272 (0.050)[a] | 0.567 (0.099)[a] | 0.613 (0.231)[a] |
| Percent 65 and over | −0.093 (0.031)[a] | −0.067 (0.037) | 0.003 (0.076) | 0.030 (0.255) |
| Hispanic, % | −0.108 (0.073) | −0.115 (0.028)[a] | −0.073 (0.026)[a] | −0.151 (0.067)[b] |
| African-American population, % | 0.031 (0.008)[a] | 0.061 (0.012)[a] | 0.027 (0.038) | −0.134 (0.178) |
| Asian, % | −0.452 (0.090)[a] | 0.072 (0.042) | −0.031 (0.049) | −0.152 (0.208) |
| American Indian/Alaskan Native, % | 0.079 (0.013)[a] | 0.107 (0.017)[a] | 0.062 (0.050) | 0.060 (0.153) |
| Native Hawaiian/Other Pacific Islander, % | 2.915 (0.689)[a] | −0.028 (0.170) | 1.683 (0.943) | −2.487 (3.786) |
| East region | - | - | - | - |
| Midwest region | 1.804 (0.298)[a] | 2.183 (0.479)[a] | 1.609 (1.013) | −1.187 (5.046) |
| South region | 2.027 (0.303)[a] | 0.695 (0.483) | 0.243 (1.025) | −3.661 (4.660) |
| West region | −1.756 (0.449)[a] | −2.157 (0.482)[a] | −3.290 (0.918)[a] | −8.140 (4.682) |
| Socioeconomic factors | | | | |
| Household income | −0.407 (0.079)[a] | −0.725 (0.093)[a] | −0.712 (0.157)[a] | −0.509 (0.344) |
| Some college, % | −0.033 (0.010)[a] | −0.105 (0.016)[a] | −0.099 (0.029)[a] | −0.042 (0.051) |
| Food insecure, % | 0.218 (0.050)[a] | −0.067 (0.061) | −0.139 (0.100) | −0.243 (0.212) |
| Unemployed, % | 0.110 (0.053)[b] | 0.285 (0.091)[a] | 0.048 (0.168) | 0.251 (0.147) |
| Severe housing problems, % | −0.172 (0.023)[a] | −0.188 (0.033)[a] | −0.113 (0.052)[b] | −0.071 (0.096) |
| Health care factors | | | | |
| Uninsured, % | −0.150 (0.025)[a] | −0.093 (0.036)[a] | −0.136 (0.065)[b] | −0.125 (0.109) |
| Primary care physician (PCP) rate | −0.024 (0.010)[b] | −0.069 (0.017)[a] | −0.067 (0.033)[b] | −0.105 (0.079) |
| Environmental factors | | | | |
| Access to exercise opportunities, % | −0.011 (0.004)[a] | −0.017 (0.007)[a] | −0.024 (0.011)[b] | 0.011 (0.021) |
| Food Environment Index | 0.019 (0.118) | 0.077 (0.167) | −0.245 (0.233) | −0.379 (0.436) |

[a]$p < 0.01$.
[b]$p < 0.05$.

| | Percent of Hispanic population | | | |
|---|---|---|---|---|
| | [0%–5%] (n = 1794) | (5%–20%] (n = 962) | (20%–50%] (n = 283) | >50% (n = 99) |
| Variable | Coefficient (SE) | | | |
| Obese, % | - | −2.351 (0.170)[a] | −4.142 (0.272)[a] | −4.316 (0.4392)[a] |

[a]$p < 0.01$.

**TABLE 5** Linear regression analysis of county-level prevalence of obesity by Hispanic quartile

**TABLE 6** Spatial lag regression analysis compared to univariate linear regression analysis of prevalence of obesity at the county-level

| Univariate linear regression | |
| --- | --- |
| | Coefficient (SE) |
| Hispanic, % | −0.289 (0.017)[a] |
| Spatial lag regression | |
| Hispanic, % | −0.064 (0.013)[a] |

[a]$p < 0.01$.

## 5 | CONCLUSIONS

Counties with a higher percentage of Hispanics have lower levels of obesity, even after controlling for demographic, socioeconomic, healthcare, and environmental factors. Future work is needed to elucidate why the percentage of Hispanics in a county may be protective against obesity.

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### REFERENCES

1. Rodriguez F, Hu J, Kershaw K, et al. County-level Hispanic ethnic density and cardiovascular disease mortality. *J Am Heart Assoc.* 2018;7:e009107.
2. Rodriguez CJ, Allison M, Daviglus ML, et al. Status of cardiovascular disease and stroke in Hispanics/Latinos in the United States: a science advisory from the American Heart Association. *Circulation.* 2014;130:593-625.
3. Sorlie PD. Mortality by Hispanic status in the United States. *J Am Med Assoc.* 1993;270:2464.
4. Medina-Inojosa J, Jean N, Cortes-Bergoderi M, Lopez-Jimenez F. The Hispanic paradox in cardiovascular disease and total mortality. *Prog Cardiovasc Dis.* 2014;57:286-292.
5. Ruiz JM, Steffen P, Smith TB. Hispanic mortality paradox: a systematic review and meta-analysis of the longitudinal literature. *Am J Publ Health.* 2013;103:e52-e60.
6. Ruiz JM, Hamann HA, Mehl MR, O'Connor M-F. The Hispanic health paradox: from epidemiological phenomenon to contribution opportunities for psychological science. *Group Process Intergr Relat.* 2016;19:462-476.
7. Virani SS, Alonso A, Benjamin EJ, et al. Heart disease and stroke statistics-2020 update: a report from the American Heart Association. *Circulation.* 2020;141:e139-e596.
8. Markides KS, Eschbach K. Aging, migration, and mortality: current status of research on the Hispanic paradox. *J Gerontol B Psychol Sci Soc Sci* 2005;60:68–75 Spec No 2.
9. Daviglus ML, Pirzada A, Talavera GA. Cardiovascular disease risk factors in the Hispanic/Latino population: lessons from the Hispanic community health study/study of Latinos (HCHS/SOL). *Prog Cardiovasc Dis.* 2014;57:230-236.
10. Isasi CR, Ayala GX, Sotres-Alvarez D, et al. Is acculturation related to obesity in Hispanic/Latino adults? Results from the Hispanic community health study/study of Latinos. *J Obes.* 2015;2015:186276.
11. Flegal KM, Kruszon-Moran D, Carroll MD, Fryar CD, Ogden CL. Trends in obesity among adults in the United States, 2005 to 2014. *J Am Med Assoc.* 2016;315:2284-2291.
12. Frisco ML, Van Hook J, Hummer RA. Would the elimination of obesity and smoking reduce U.S. racial/ethnic/nativity disparities intotal and healthy life expectancy? *SSM Popul Health.* 2019;7:100374.
13. Powell-Wiley TM, Ngwa J, Kebede S, et al. Impact of Body Mass Index on heart failure by race/ethnicity from the get with the guidelines-heart failure (GWTG-HF) registry. *JACC Heart Fail.* 2018;6:233-242.
14. Holzer J, Canavan M, Bradley E. County-level correlation between adult obesity rates and prevalence of dentists. *J Am Dent Assoc.* 2014;145:932-939.
15. Ward ZJ, Bleich SN, Cradock AL, et al. Projected U.S. State-level prevalence of adult obesity and severe obesity. *N Engl J Med.* 2019;381:2440-2450.
16. Myers CA, Slack T, Martin CK, Broyles ST, Heymsfield SB. Change in obesity prevalence across the United States is influenced by recreational and healthcare contexts, food environments, and Hispanic populations. *PLoS One.* 2016;11:e0148394.
17. Scheinker D, Valencia A, Rodriguez F. Identification of factors associated with variation in US county-level obesity prevalence rates using epidemiologic vs machine learning models. *JAMA Netw Open.* 2019;2:e192884.
18. Myers CA, Slack T, Martin CK, Broyles ST, Heymsfield SB. Regional disparities in obesity prevalence in the United States: a spatial regime analysis. *Obesity.* 2015;23:481-487.
19. Bureau USC. *The Hispanic Population: 2010.* Suitland, MD: US Census Bureau; 2011.
20. Remington PL, Catlin BB, Gennuso KP. The county health Rankings: rationale and methods. *Popul Health Metrics.* 2015;13:11.
21. Chi G, Zhu J. Spatial regression models for demographic analysis. *Popul Res Policy Rev.* 2008;27:17-42.
22. Schabenberger O, Gotway CA. Spatial regression models. *Statistical Methods for Spatial Data Analysis.* Boca Raton, FL: Chapman & Hall; CRC Taylor & Francis Group; 2017:299-404.
23. Slack T, Myers CA, Martin CK, Heymsfield SB. The geographic concentration of US adult obesity prevalence and associated social, economic, and environmental factors. *Obesity.* 2014;22:868-874.
24. Dwyer-Lindgren L, Freedman G, Engell RE, et al. Prevalence of physical activity and obesity in US counties, 2001–2011: a road map for action. *Popul Health Metrics.* 2013;11:1-11.
25. von Hippel P, Benson R. Obesity and the natural environment across US counties. *Am J Publ Health.* 2014;104:1287-1293.
26. Hales CM, Fryar CD, Carroll MD, Freedman DS, Aoki Y, Ogden CL. Differences in obesity prevalence by demographic characteristics and urbanization level among adults in the United States, 2013-2016. *J Am Med Assoc.* 2018;319:2419-2429.
27. Osypuk TL, Diez Roux AV, Hadley C, Kandula NR. Are immigrant enclaves healthy places to live? The Multi-ethnic Study of Atherosclerosis. *Soc Sci Med.* 2009;69:110-120.
28. Abraído-Lanza AF, Chao MT, Flórez KR. Do healthy behaviors decline with greater acculturation? Implications for the Latino mortality paradox. *Soc Sci Med.* 2005;61:1243-1255.

29. Do DP, Frank R. The diverging impacts of segregation on obesity risk by nativity and neighborhood poverty among Hispanic Americans. *J Racial Ethn Health Disparities.* 2020.

30. Flegal KM, Ogden CL, Fryar C, Afful J, Klein R, Huang DT. Comparisons of self-reported and measured height and weight, BMI, and obesity prevalence from national surveys: 1999-2016. *Obesity.* 2019;27:1711-1719.

31. Maukonen M, Männistö S, Tolonen H. A comparison of measured versus self-reported anthropometrics for assessing obesity in adults: a literature review. *Scand J Publ Health.* 2018;46:565-579.

32. Stommel M, Schoenborn CA. Accuracy and usefulness of BMI measures based on self-reported weight and height: findings from the NHANES & NHIS 2001-2006. *BMC Publ Health.* 2009;9:421.

33. Ng CD. Biases in self-reported height and weight measurements and their effects on modeling health outcomes. *SSM Popul Health.* 2019;7:100405.

34. Mozumdar A, Liguori G. Corrective equations to self-reported height and weight for obesity estimates among U.S. Adults: NHANES 1999-2008. *Res Q Exerc Sport.* 2016;87:47-58.