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Racial Residential Segregation and Disparities in Obesity among Women

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ABSTRACT *The high rate of obesity among black women in the USA is a significant public health problem. However, there is limited research on the relationship between racial residential segregation and disparities in obesity, and the existing evidence is limited and results are mixed. This study examines the relationship between racial residential segregation and obesity among black and white women. We conducted this cross-sectional study by joining data from the 1999–2004 National Health and Nutrition Examination Survey with data from the 2000 US Census. Multilevel logistic regression models found that for every one-point increase in the black isolation index, there was a 1.06 (95 % confidence interval (CI)=1.01, 1.11) times higher odds of obesity for black women. In order to address the disparately high rates of obesity among black women, health policies need to address the economic, political, and social forces that produce racially segregated neighborhoods.*

KEYWORDS *Health disparities, Racial residential segregation, Obesity, Cardiovascular risk, Woman, Black or African American*

INTRODUCTION

Obesity in the USA is a leading public health problem because of high prevalence and because it is a precursor to serious medical conditions including diabetes, heart disease, cancer, and stroke. In 2007–2008, the age-adjusted obesity rate was 33.8 % for all Americans, 32.2 % for men and 35.5 % for women.[1] The causes of obesity are complex and multifactorial, but upstream social determinants of health are gaining attention for their contribution, especially to health disparities seen in obesity. Racial and ethnic disparities in obesity are significant, especially in women. In 2007–2008, the prevalence of obesity was 33.0 % for non-Hispanic white women, 43.0 % for Hispanic women, and 49.6 % for non-Hispanic black women,[1] disparities which persist even after controlling for socioeconomic and other demographic factors.[2]

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Racial residential segregation is a social determinant of health that has been cited as a fundamental cause of health disparities and is defined as the "physical separation of the races in residential contexts."[3] The concept of segregation can be applied broadly, but racial residential segregation has typically been written about in terms of the African American experience. While many minority groups experience residential segregation in the USA, the experience of African Americans is viewed as "an institutional manifestation of racism."[3] Residential segregation is thought to produce different social and environmental exposures for blacks and whites and, in turn, lead to disparities in health.[3–5] It is conceptualized as having an indirect effect on health with more proximate neighborhood level socio-environmental factors acting as mediators. Residential segregation may increase African Americans' exposure to environmental risks and reduce access to community resources, quality jobs, education, public safety, and social networks, all of which limit healthy behaviors and are associated with poor health.[3,6–8] Additionally, racial residential segregation is thought to act indirectly through the concentration of poverty in neighborhoods.[6,9] It is known that racially segregated minority neighborhoods are more likely to be economically disadvantaged,[10] and this intersection makes it difficult to know if it is racial composition *or* neighborhood poverty or if it is racial composition *and* neighborhood poverty that account for the high rates of obesity in African Americans.[11] Disentangling racial composition and neighborhood poverty will advance our understanding of health disparities.

While several studies have explored the relationship between segregation and disparities in obesity, the findings are mixed. Some studies have found positive relationships in which more highly segregated neighborhoods have higher rates of obesity.[12–14] This includes one study that found black women living in racially integrated neighborhood had a similar odds of obesity compared to whites living in the same integrated neighborhood.[15] Other studies have found no association;[16–18] however, one study[17] simultaneously controlled for a variety of characteristics of the physical environment. Nearly all of these studies used the percent of black residents living in a census tract as the measure of segregation. Only one study[13] used an index of segregation[19] which are broadly used and accepted as standard indicators of segregation. All but one study[19] used as cross-sectional design, and all but one[18] used self-reported height and weight as the measure of BMI. Studies on both sides also suffer from small areas of geographic representation,[14,15,17] failure to stratify analysis by gender[12,13,16], and use of data sources from the 1980s.[14,16,17]

This study aims to investigate the relationship between racial residential segregation and obesity and the independent effect of neighborhood poverty in a nationally representative sample of urban dwelling black and white women. The analysis is limited to black and white women because of the disproportionately high prevalence of obesity seen among black women and because prior work suggests that individual demographic effects on weight status vary by race,[20] and neighborhood level effects on weight status are more prominent in women.[13,14,16]

METHODS

Data Sources

National Health and Nutrition Examination Survey. National Health and Nutrition Examination Survey (NHANES) is a continuous, annual survey released in 2-year increments. The cross-sectional survey is nationally representative of the civilian non-

institutionalized US population. There was oversampling of low-income individuals, children ages 12 to 19 years, adults ages 60 years and older, blacks, and Mexican Americans. The sampling design for each panel of NHANES was a complex, stratified multistage probability sample.[21] Data were collected from respondents in two phases. First, an in-home interview was conducted to gather health history, health behaviors, health utilization, and risk factors. At the conclusion of the in-home interview, respondents were invited to participate in a physical examination at a mobile examination center.[22] NHANES was approved by the NCHS Research Ethics Review Board, and all participants provided informed consent. This study used data from the 1999–2004 NHANES and were limited to female respondents 20 years and older who self-identified their race as non-Hispanic white or non-Hispanic black/African American. The full sample consisted of 4,330 participants, 1,319 black women, and 3,011 white women.*Census Bureau*. Data were obtained from the 2000 US Census Population and Housing Summary Files 1 and 3.

Measures

Area Level Variables. Census tracts were used to measure neighborhoods, and all area level covariates were reported for participant census tracts. Residential segregation is conceptualized using five dimensions: unevenness, isolation, centralization, concentration, and clustering.[19] In keeping with previous studies on segregation and weight status,[13,14] this study measured segregation using the black isolation index[19] taken from the 2000 US Census which calculates an index score for every Metropolitan Statistical Area (MSA) in the USA. The black isolation index measures the degree to which blacks inhabit the same space as other blacks by taking into account the number of black residents in proportion to the total population. The index ranges from 0 to 1, where 0 means that blacks are completely integrated and 1 means that blacks are completely isolated from whites. The mathematical equation is:

$$\text{Isolation index}={}_xP^*{}_y = \sum\nolimits_{i=1}^{n} \left[\frac{x_i}{X}\right]\left[\frac{x_i}{t_i}\right],$$

where x_i is the number of blacks in tract i, t_i is the total population in tract i, and X is the number of blacks in the MSA. The proportion is summed across all census tracts in the MSA. To allow for more easily interpreted results, it was multiplied by 10 to create a 0–10 scale.

A neighborhood poverty variable was taken from the 2000 US Census report of the percent of population in a census tract with a family income equal to or less than the Federal Poverty Line (FPL). Census tracts were categorized as urban if the 2000 US Census identified it as part of a MSA. Census tracts were assigned one of four geographic regions, Northeast, Midwest, South, or West, based on 2000 US Census categorization.*Individual Level Variables*. Obesity, the dependent variable of interest, was calculated with a measured height in centimeters and weight in kilograms from respondents who participated in the physical examination. BMI was calculated using the formula (kg/m^2) and a binary variable created so those with a BMI of greater than or equal to 30.0 kg/m^2 were categorized as obese.

Individual level covariates came from NHANES in-home interview data. Using the highest level of school completed, analysis was conducted using five education categories; however, college graduate was the only significant educational level in all

models. Therefore, all other categories were collapsed resulting in a binary educational status variable of college graduate or less than college graduate. Annual family income was reported as it relates to the FPL. Initially, a five-category income variable was used; however, income less than FPL was the only significant category in all models, so all other categories were collapsed resulting in a binary variable which defined poor as those with income less than the FPL and non-poor as those with income equal to or greater than the FPL. Marital status was categorized as married or living as married, separated or divorced, widowed, or never married. Age was a five-level categorical variable of 10-year increments from 20 to 59 years old and the final category of participants 60 years and older. The Institutional Review Board at Johns Hopkins Bloomberg School of Public Health approved this study.

Analysis

Multilevel logistic regression models were run using a generalized linear latent and mixed models (GLLAMM) program[23] to explore the association between obesity and various area level variables. Multilevel models account for the non-independence of participants sharing geographic proximity. Two-level random intercept models with a random intercept for county were fitted using 4,330 black and white women nested within 1,358 census tracts and 51 counties. Random intercepts for census tract and MSA were not included because there were too few participants per census tract (2.24 black participants/tract and 3.02 white participants/tract), and the majority MSAs were made up of just one (25 %) or two (67 %) counties. There was an average 30.67 black participants per county and 59.04 white participants per county.

Model 1 included only individual covariates, age, education, family income, and marital status. Model 2 added segregation, model 3 added geographic region, and model 4 added neighborhood poverty. Sample weights were applied for the differential probability of being selected and non-response to the interview or physical exam. Standard errors were adjusted for the multistage sampling design using Taylor linearization methods. NHANES geographic variables, state, county, and census tracts were used but are restricted; therefore, all data were merged, accessed, and analyzed at the Research Data Center in Hyattsville, Maryland using Stata version 11.0 software.

RESULTS

Descriptive Summary Statistics

Table 1 presents demographic and neighborhood characteristics of the sample stratified by race. Black women were obese at nearly twice the rate of white women, 45.1 and 26.3 %, respectively (Table 1). The largest age group for black women was 30–39 years (24.7 %) compared to 60 years and older for white women (27.4 %). The largest percent of white and black women was married or living as married, 63.3 % of whites compared to 35.7 % of blacks. More white (27.4 %) than black (13.8 %) women had a college degree or greater. More than a quarter of the black women (27.6 %) reported family income below the FPL, while 9.8 % of white women reported family income below the FPL. On average, the isolation index of the MSAs where black women live was higher than the isolation index for the MSAs where white women live, 6.95 and 5.17, respectively. For black women, an average 22.1 % of residents in their census tract were living in poverty, whereas, for white

TABLE 1 Demographic and neighborhood characteristics of 1,319 black and 3,011 white female NHANES participants, 1999–2004 (weighted)

	Black women	White women
	15.4 %	84.6 %
Obese, %	45.1	26.3
Age, %		
20–29	18.0	14.8
30–39	24.7	19.3
40–49	23.8	22.1
50–59	14.3	16.5
≥60	19.1	27.4
Marital status, %		
Married or living as married	35.7	63.3
Widowed	11.5	10.7
Separated or divorced	23.1	13.3
Never married	29.8	12.6
Education, %		
Less than college graduate	86.21	72.65
College graduate or greater	13.8	27.4
Family income, %		
Non-poor	72.36	90.24
Poor	27.6	9.8
Neighborhood (MSA) black isolation index, mean	6.95	5.17
Percent neighborhood (census tract) poverty, mean	22.1	9.2
Region, %		
Northeast	19.5	23.1
Midwest	22.6	25.5
South	51.7	32.4
West	6.3	19.1

women, an average of 9.2 % of residents in their census was living at or below the FPL. The majority of black women lived in the South (51.7 %), whereas white women were more evenly distributed throughout regions, but the largest percent (32.4 %) of white women also lived in the South.

Regression Analysis

Table 2 presents the odds of obesity among the black women. In model 1, two individual level predictors of obesity were identified as significant for black women. Black woman ages 40–49 years had a 1.63 (95 % confidence interval (CI)=1.11–2.39) times higher odds of obesity than those 20–29 years, and those who were divorced or separated had a 1.56 (95 % CI=1.16–2.11) times higher odds of being obese compared to those who were married or living as married after adjustment for other individual level variables. In model 2, where the black isolation index was added, there was a positive statistically significant relationship between the black isolation index and obesity; for every one-point increase in the index, there was a 1.06 (95 % CI=1.01, 1.11) times higher odds of obesity for black women after adjustment for age, family income, marital status, and education. The 40–49-year age group was no longer a significant predictor of obesity, but those living in poverty had decreased odds of obesity (odds ratio (OR)=0.61, 95 % CI=0.39–0.94), and those who were never married had increased odds of obesity (OR=1.65, 95 % CI=1.19–2.27). After adjustment for geographic region in model 3, the odds ratio

TABLE 2 Odds of obesity in 1,319 black female NHANES participants, 1999–2004 (weighted)

	Model 1	Model 2	Model 3	Model 4
	OR (95 % CI)	OR (95 % CI)	OR (95 % CI)	OR (95 % CI)
Age				
20–29	Ref	Ref	Ref	Ref
30–39	1.10 (0.73–1.65)	1.39 (0.86–2.25)	1.37* (0.84–2.23)	1.31 (0.79–2.17)
40–49	1.63* (1.11–2.39)	1.53 (0.86–2.72)	1.54 (0.86–2.76)	1.46 (0.79–2.67)
50–59	1.26 (0.75–2.11)	1.46 (0.68–3.14)	1.49 (0.70–3.18)	1.35 (0.61–2.97)
≥60	1.14 (0.66–1.97)	1.23 (0.68–3.14)	1.16 (0.51–2.63)	1.10 (0.47–2.53)
Family income				
Non-poor	Ref	Ref	Ref	Ref
Poor	0.77 (0.59–1.01)	0.61* (0.39–0.94)	0.59* (0.38–0.92)	0.56* (0.34–0.90)
Marital status				
Married/living as married	Ref	Ref	Ref	Ref
Widowed	1.07 (0.70–1.62)	1.42 (0.78–2.58)	1.42 (0.78–2.57)	1.33 (0.71–2.51)
Divorced/ separated	1.56* (1.16–2.11)	1.73* (1.21–2.68)	1.77** (1.14–2.73)	1.63* (1.02–2.63)
Never married	1.25 (0.89–1.76)	1.65** (1.19–2.27)	1.68** (1.21–2.33)	1.44* (1.06–1.97)
Educational level				
Less than college	Ref	Ref	Ref	Ref
College or greater	0.71 (0.47–1.02)	0.71 (0.41–1.23)	0.69 (0.40–1.20)	0.75 (0.44–1.26)
Black isolation index		1.06* (1.01–1.11)	1.35** (1.29–1.41)	1.25** (1.16–1.35)
Region				
Northeast			Ref	Ref
Midwest			1.14* (1.00–1.29)	1.51** (1.28–1.79)
South			1.20* (1.03–1.40)	1.16** (0.98–1.37)
West			1.06 (0.89–1.25)	3.57** (2.57–4.96)
% living in poverty				1.02 (0.99–1.04)

*$P \leq 0.05$, **$P \leq 0.01$

for the isolation index increased so that for every one-point increase in the isolation index, there was a 1.35 (95 % CI=1.29,1.41) times higher odds of obesity in black women adjusted for age, poverty, marital status, education, and geographic region. Black women living in the Midwest (OR=1.14, 95 % CI=1.00–1.29) and the South (OR=1.20, 95 % CI=1.03–1.40) had significantly higher odds of obesity compared to those in the Northeast controlling for age, family income, marital status, education, and black isolation index. After adjusting for neighborhood poverty in model 4, the odds ratio for the isolation index decreased but remained significant (OR=1.25, 95 % CI=1.16, 1.35) among black women. However, the neighborhood poverty was not associated with obesity in black women after controlling for other variables in the model.

Table 3 presents the models in the sample of white women. Model 1 finds a statistically significant stepwise increase in the odds of obesity for 20- to 59-year-olds so that with every 10-year increase in age, there is a 2 to more than 3.5 times higher odds of obesity. Poor women had a significantly increased odds of obesity (OR=1.67, 95 % CI=1.25–2.23), and those with a college education or more had a significantly lower odds of obesity (OR=0.47, 95 % CI=0.34–0.66). Model 2 added the black isolation index which was not significantly associated with obesity. When region was added in model 3, back isolation was negatively associated with obesity

TABLE 3 Odds of obesity in 3,011 white female NHANES participants, 1999–2004 (weighted)

	Model 1	Model 2	Model 3	Model 4
	OR (95 % CI)	OR (95 % CI)	OR (95 % CI)	OR (95 % CI)
Age, years				
20–29	Ref	Ref	Ref	Ref
30–39	2.01** (1.34–3.01)	2.28* (0.92–5.64)	2.18 (0.83–5.75)	2.16 (0.79–5.90)
40–49	2.50** (1.56–4.01)	2.52* (1.05–6.03)	2.49 (0.98–6.31)	2.50 (0.96–6.52)
50–59	3.60** (2.18–5.94)	5.13** (1.88–13.98)	4.86** (1.73–13.64)	4.74** (1.68–13.34)
≥60	2.13** (1.45–3.13)	2.81* (1.17–6.74)	2.71* (1.11–6.62)	2.65* (1.07–6.57)
Family income				
Non-poor	Ref	Ref	Ref	Ref
Poor	1.67** (1.25–2.23)	1.78* (1.05–3.02)	1.74* (1.00–3.02)	1.81* (1.01–3.23)
Marital status				
Married/living as married	Ref	Ref	Ref	Ref
Widowed	0.97 (0.64–1.46)	1.05 (0.58–1.92)	1.05 (0.57–1.94)	1.06 (0.57–1.96)
Divorced/ separated	1.00 (0.70–1.44)	0.93 (0.48–1.79)	0.91 (0.46–1.78)	0.93 (0.48–1.79)
Never married	1.27 (0.91–1.78)	1.78* (1.08–2.93)	1.80* (1.09–2.96)	1.77* (1.04–3.00)
Educational level				
Less than college	Ref	Ref	Ref	Ref
College or greater	0.47** (0.34–0.66)	0.31** (0.18–0.55)	0.32** (0.18–0.55)	0.31** (0.17–0.54)
Black isolation index		1.00 (0.98–1.03)	0.94** (0.91–0.97)	0.94** (0.89–0.98)
Region				
Northeast			Ref	
Midwest			1.84** (1.52–2.24)	1.32** (1.08–1.62)
South			0.93 (0.71–1.22)	0.94 (0.70–1.25)
West			0.81 (0.64–1.02)	0.82 (0.62–1.08)
% living in poverty				0.99 (0.95–1.02)

*$P \leq 0.05$, **$P \leq 0.01$

among white women so for every one-point increase in black isolation, there was a 6 % (OR=0.94, 95 % CI=0.91, 0.97) lower odds of obesity. The Midwest was the only region with a significantly different odds of obesity compared to the Northeast (OR=1.84, 95 % CI=1.52–2.24) after controlling for individual level variables and black isolation index. Model 4 added percent living in poverty which was not associated with obesity nor did it change the negative association between the black isolation and obesity in white women.

DISCUSSION

Understanding the upstream social and neighborhood etiologies of obesity is fundamental to curbing the obesity epidemic and reducing racial disparities in obesity. Our study demonstrates that living in a metropolitan area where blacks are more highly segregated is a risk factor for obesity in black women, but it is protective against obesity in white women, after controlling for individual and neighborhood socioeconomic factors. Similarly, Chang[13] found higher levels of black isolation to be associated with higher rates of obesity in blacks but not associated in whites; however, the sample included both men and women. Another

study found that higher black racial isolation was positively associated with BMI in women but not men, regardless of race[14]. Our findings are able to show the unique relationships between segregation and obesity in black versus white women. Our finding of a significant positive relationship in black women and negative relationship in white women suggests that within a highly isolated MSA where whites and blacks live in separate communities, that even with similar poverty rates, there are different levels of community investment based on race.

The positive association found between segregation and obesity among black women is a particularly important finding because of the high rate of obesity in black women and the pervasive nature of segregation in the USA. However, the relationship is complex, and segregation may affect weight through various pathways for black women. Notably, while neighborhood poverty was not an independent predictor of obesity, adding it to a model with segregation weakened the relationship between segregation and obesity. In another study, neighborhood poverty also attenuated the effect of racial composition, measured by percent non-Hispanic black; however, in contrast to our findings, neighborhood poverty was a significant predictor of obesity.[12] In a recent study from the Move to Opportunity demonstration project, residents that moved from high to low poverty neighborhoods had a reduced incidence of obesity compared to a control group.[24] Additional research should be conducted to investigate whether neighborhood poverty is in the pathway between segregation and obesity.

The influence of individual level factors was different in black and white women. In white women, all of the individual level covariates were significantly associated with obesity, while for black women, only family income and marital status were significant in their associations with obesity. In black women, being poor was protective against obesity, whereas in white women, poverty was a risk factor for obesity. The lack of typical associations with these demographic covariates in black women is supported in previous research.[20] One plausible explanation is that social norms related to the acceptability of being overweight within black communities may exert such powerful effects on population weight status that it overrides typical individual level demographic associations.[12,16]

There are several limitations to this study. Due to the cross-sectional nature of the data, the directionality of associations cannot be certain. However, it seems unlikely that a person's weight status would determine where they live, especially in light of relevant socioeconomic factors which were adjusted for in this study. The study is limited to differences between black and white women; therefore, findings are not generalizable to men or to other racial/ethnic groups, some of which also experience disparities in obesity rates. The use of BMI as a measure of obesity has limitations. While BMI is correlated with percentage of body fat, it does not distinguish between fat mass versus lean body mass, and blacks tend to have higher lean mass and lower fat mass compared to whites.[1] Finally, using a measure of segregation at the MSA level may introduce an aggregation bias, whereas a larger geographic area results in a larger associations, and this may explain the large effect size.

This study adds to a growing body of research that supports the association between racial residential segregation and obesity in blacks; however, questions remain. For instance, while there is an association between segregation and obesity, it is not clear if a change in the level of segregation would result in less obesity among black women. In addition, more work is needed to describe the specific characteristic of segregated neighborhoods that put residents at risk. It is likely that a woman's weight status is influenced by a complex web of social, familial,

psychological, economic, behavioral, and environmental phenomena, but to reduce health disparities for obesity, policies need to focus on upstream interventions that change the lived experience of minorities and allow opportunities to engage in healthy behaviors. Associations found in this study support the assertion that communities with higher concentrations of black residents lack health-promoting characteristics that in turn impacts the health of residents. The elimination of racial disparities in obesity will require public health polices and interventions that take aim at structural forces which underlie racial disparities and promote policies to eliminate institutional racism, especially those which lead to the residential segregation of blacks.

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