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Neighborhood context and ethnicity differences in body mass index: A multilevel analysis using the NHANES III survey (1988–1994)

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Abstract

A growing body of literature has documented a link between neighborhood context and health outcomes. However, little is known about the relationship between neighborhood context and body mass index (BMI) or whether the association between neighborhood context and BMI differs by ethnicity. This paper investigates several neighborhood characteristics as potential explanatory factors for the variation of BMI across the United States; further, this paper explores to what extent segregation and the concentration of disadvantage across neighborhoods help explain ethnic disparities in BMI. Using data geo-coded at the census tract-level and linked with individual-level data from the Third National Health and Examination Survey in the United States (U.S.), we find significant variation in BMI across U.S. neighborhoods. In addition, neighborhood characteristics have a significant association with body mass and partially explain ethnic disparities in BMI, net of individual-level adjustments. These data also reveal evidence that ethnic enclaves are not in fact advantageous for the body mass index of Hispanics—a relationship counter to what has been documented for other health outcomes.

Keywords

BMI; Weight; Obesity; NHANES; USA; Neighbourhood effects; Spatial analysis; Ethnicity; Social class

1. Introduction

A primary risk factor for cardiovascular disease and diabetes—obesity has become an epidemic in the U.S. and is poised to become the nation's leading health problem (Thom et al., 2006). Sixty-five percent of the U.S. adult population is either overweight or obese, leading to higher rates of overall mortality and elevated risks for specific causes of death (Thom et al., 2006; Rogers et al., 2003). Health problems linked to excessive weight are disproportionately felt by ethnic groups as Hispanics and non-Hispanic Blacks experience higher rates of overweight and obesity than non-Hispanic Whites (NCHS, 2006).[1] The ethnic differences in weight are only

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partially accounted for by individual-level socioeconomic status (Lakdawalla and Philipson, 2002), suggesting that examination of the causes and correlates of overweight and obesity ought to include the social and structural environment as possible contributing factors.

Studies linking residential context to health have found neighborhood characteristics to be significant predictors of various health outcomes and behaviors including mortality (Yen and Kaplan, 1999; Sloggett and Joshi, 1998; LeClere et al., 1998), infectious disease (Acevedo-Garcia, 2000, 2001), low birthweight (Morenoff, 2003; Roberts, 1997; O'Campo et al., 1997; Sastry, 2003), cigarette smoking (Kleinschmidt et al., 1995; Diez-Roux et al., 2003; Duncan et al., 1999), and consumption level of fruits and vegetables (Morland et al., 2002a), net of individual-level socioeconomic adjustments (c.f. Oreopoulos, 2003; Reijneveld and Schene, 1998; Sloggett and Joshi, 1994). However, there is some research that is critical of efforts to obtain causal estimates of neighborhood effects (Oakes, 2004, 2006; Durlauf, 2004; Blakely and Subramanian, 2006) due to issues of identification (Manski, 1995), selection or sorting into neighborhoods (Schelling, 1971; Tiebout, 1956), residual confounding (Becher, 1992) and the increased conceptual and modeling difficulties in recovering contextual effects (Hauser, 1974; Blalock, 1984; Blakely and Woodward, 2000). To address the well-known problem of self-selection, randomized control studies are commonly thought of as the “gold standard”. However, neighborhood social experiments are also subject to limitations in the dose and length of intervention and issues such as randomization and substitution bias and “interference” which may also undermine causal inferences (Sorensen et al., 1998; Heckman and Smith, 1995; Sobel, 2006; Rubin, 1986).

While acknowledgment that neighborhood characteristics may be correlated with unobserved individual characteristics (e.g. inherent propensity to engage in health promoting behaviors) is necessary and appropriate, the current evidence does suggest that neighborhood variables also capture structural and social context that influence health behaviors and outcomes that are not accounted for by individual-level adjustments. Consequently, understanding how neighborhoods are linked to weight may be crucial in stemming the obesity epidemic.

However, few neighborhood studies have used body mass index (BMI) or obesity as an outcome; fewer still have examined whether neighborhood context helps explain the ethnic differences in BMI, despite the recognition that neighborhood context systematically differs by ethnicity.[2] Given the growing evidence that neighborhood characteristics are associated with health (Robert, 1999;Pickett and Pearl, 2001;Kawachi and Berkman, 2003;Kling et al., 2005) and that Black and Hispanic minorities disproportionately reside in residential areas of concentrated disadvantage, accounting for these factors may provide further explanation of the determinants of ethnic disparities in BMI in the U.S.

2. Neighborhoods, body mass index, and obesity

Booth et al. (2005) documented a link between neighborhood environment and individual-level diet, physical activity, and BMI. Furthermore, both theory and evidence suggest that the concentration and availability of neighborhood resources condition and restrict individual lifestyle choices (Berkman and Kawachi, 2000; Rieker and Bird, 2005) that may have further, more direct, effects on weight. A review by Booth et al. (2005) on studies investigating the man-made environment and obesity revealed that, despite using differing methodologies, most studies have found that greater obesity risk was associated with some characteristics of residential areas including: resources, walk-ability, land use, sprawl, and level of deprivation. For example, accessibility of exercise facilities (e.g. parks and recreation centers) is positively

[1]For the sake of brevity, non-Hispanic Whites and non-Hispanic Blacks are henceforth referred to as “Whites” and “Blacks”, respectively.
[2]Throughout this paper, we use “ethnicity” to refer to both ethnicity and race.

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correlated with consuming a healthy diet and engaging in physical activity (Cheadle et al., 1991; Humpel et al., 2002). In addition, dangerous neighborhoods, or the perception of unsafe environments lower the rates of exercise (Molnar et al., 2004; Ross, 2000) and the presence of supermarkets carrying a larger selection of ‘healthy’ foods (Sallis et al., 1986) is linked negatively to BMI (Morland et al., 2006). Thus, a variety of neighborhood characteristics may contribute to residents' opportunities or constraints to engage in positive health behaviors, which in turn influence the risk of being overweight or obese.

Because the distribution of resources and environmental quality varies across neighborhoods according to their level of affluence/poverty, neighborhood socioeconomic level (e.g. neighborhood poverty rate) is commonly used as a global measure to capture aspects of the social and structural environment not routinely measured in survey research. As such, several studies have investigated the connection between neighborhood socioeconomic status and weight. For example, Ellaway et al. (1997) found that material deprivation; a composite measure comprised of car ownership, weekly household income and housing tenure, was significantly associated with higher BMI, waist circumference, and prevalence of obesity. Van Lenthe and Mackenbach (2002) demonstrated similar findings in the Netherlands, where an index of material deprivation was associated with increasing mean BMI and prevalence of overweight individuals. Using the data from the Third National Health and Nutrition Examination Survey (NHANES III), Cubbin et al. (2001) also found that material deprivation, measured through the Townsend Deprivation Index, was associated with cardiovascular disease risk behaviors, including physical inactivity and higher BMI.

Despite the growing evidence supporting a link between neighborhood context and weight, only a limited number of studies have investigated the relationship between neighborhood characteristics and BMI in the U.S. population, net of individual socioeconomic status (Orr et al., 2003; Morenoff et al., 2006; Komlos and Lauderdale, 2007; Burdette and Whitaker, 2005; Burdette et al., 2006). Still fewer studies have used nationally representative data and the few that have did find neighborhood socioeconomic and demographic factors to be associated with BMI (Robert and Reither, 2004; Boardman et al., 2005; Chang, 2006). For example, Chang (2006) found that racial residential segregation, as measured by the isolation index was positively associated with both BMI and greater odds of being overweight for Blacks. On the other hand, no association between the isolation index and weight was found for Whites. Boardman et al. (2005) found neighborhood poverty and obesity prevalence to be independent predictors for being obese. Robert and Reither (2004) found that community socioeconomic disadvantage and community income inequality, as measured by the Gini index, were significantly associated with BMI for women, net of individual socioeconomic adjustments. For men, however, neighborhood characteristics were not associated with BMI in that study.

Notably, results from a large-scale experimental study in the U.S. also support a positive relationship between neighborhood disadvantage and obesity. The Moving to Opportunity (MTO) study, a quasi-experimental study funded by the U.S. Department of Housing and Urban Development, was a quasi-experimental study in 5 large metropolitan areas that randomized, via a lottery drawing, over 4000 families with children in public housing into one of three groups: (1) the experimental, or MTO, group which received a Section 8 Housing Voucher which could be redeemed only if they moved to a low-poverty census tract (<10% poverty rate), as well as housing counseling; (2) the Section 8 group who received a Section 8 Housing Voucher that could be used in any neighborhood; (3) an in-place control group which remained eligible for public housing but did not receive any vouchers or housing counseling (Kling et al., 2004). At 4–7 years following randomization, various socioeconomic and health outcomes, including obesity, were measured. The MTO study found that the experimental group (those randomized to move into low-poverty neighborhoods) had a statistically significant 20% reduction in relative risk for being obese compared to the control group. The Section 8 group

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also had lower rates of obesity, although the estimated differences were only marginally significant.

3. Neighborhoods, body mass index, and ethnicity

It is important to realize that the opportunities and constraints present in residential environments that are linked to health outcomes are not equally distributed across ethnic groups (Fitzpatrick and LaGory, 2000). Ethnic minorities, particularly Blacks, are more likely to reside in disadvantaged neighborhoods, due to segregation, with fewer options for exercise, higher crime rates, as well as a greater prevalence of advertising for fast food (Popkin et al., 2005; Morland et al., 2002a,b), even after accounting for differences in socioeconomic status (Denton and Massey, 1988; South and Crowder, 1998; Massey and Fischer, 1999; Lewis et al., 2005; Morland et al., 2002a,b; Zenk et al., 2005).

Beyond the detrimental socioeconomic consequences of racial segregation that may lead to unfavorable health behaviors, the racial concentration of Blacks may engender cultural norms that mitigate the social disapproval of being overweight or obese, thereby decreasing the incentives to lose weight (Robert and Reither, 2004; Boardman et al., 2005). Differences in body image between Blacks and Whites, particularly among women, may be a factor contributing to the higher rates of obesity in Blacks (Flynn and Fitzgibbon, 1998). For example, Black women indicate less disapproval of overweight women than do White women (Hebl and Heatherton, 1998). Hence, residing in areas with high concentration of Blacks may engender certain social values and perceptions that more readily accepts being overweight or obese as a normative condition; the less disparaging image of obesity among Blacks may produce a decreased incentive to lose weight (Kumanyika, 1993).

In contrast, neighborhoods that are segregated by country of birth, resulting in immigrant enclaves, are thought to exhibit protective properties for health that may counteract or even surmount the effects of otherwise disadvantaged socioeconomic environments typically found in immigrant enclaves. Enclaves may confer benefits such as informational or social networks (Chiswick and Miller, 2005; Bartel, 1989). Such informational networks may contribute to the structural environment in that culturally appropriate foods may be more available. In addition, social networks among immigrants may provide childcare assistance or opportunities to join or be positively influenced by a group of individuals who engage in exercise within the neighborhood. Finally, given that immigrants are a self-selected subpopulation that tends to be healthier than their non-emigrating counterparts, residence among other healthy immigrants may ensure the maintenance of health through various protective practices and through a rejection of native practices that are health-threatening. That is, while segregation among the U.S. born is indicative of concentrated poverty and marginalization of racial minorities, the segregation of immigrants, in contrast, results in the concentration and maintenance of positive health behaviors and cultural and social support that are indicative of relatively healthy immigrant populations—particularly of Hispanic origin. However, the literature relating diet, physical activity and weight to neighborhood characteristics has not addressed the residential context of immigrants (Bartel, 1989).

In short, while several harmful characteristics of neighborhoods may affect BMI universally —these characteristics disproportionately affect ethnic minorities and the socio-economically disadvantaged, possibly contributing to ethnic differences in BMI. Yet, we are aware of only one study that has directly tested this hypothesis. Using The Americans' Changing Lives (ACL), Robert and Reither (2004) found that community socioeconomic disadvantage helped explain some of the differences in BMI between Black and White women, above adjustments for individual socioeconomic status. Furthermore, though not a focus in their study, Boardman et al. (2005) also found that the BMI difference between Blacks and Whites was attenuated

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once neighborhood conditions were included in the models.[3] In both studies, substantial differences remained. However, although these studies utilized nationally representative data, their analyses only examined the role of neighborhood context for Blacks and Whites; neither had sufficient sample size to include Hispanics in their analyses. Moreover, neither fully examined whether there were ethnicity differences in the association between neighborhood context and BMI.[4]

In light of the limited examinations into the associations of neighborhood context with BMI and ethnic differences in BMI, this study seeks to contribute to the literature by using nationally representative data to investigate the potential role that neighborhood context – specifically, neighborhood disadvantage, neighborhood educational concentration at the extremes, Black segregation, and Hispanic segregation – might play in influencing BMI and in generating racial disparities in BMI. Furthermore, we examine whether and to what extent the effect of neighborhood-level factors on BMI may differ by ethnicity.

4. Methods

4.1. Data

Our analysis is based on individual-level data from the NHANES III survey (1988–1994) linked with census-tract level data from the U.S. Census. The survey collected information on the health and nutritional status of individuals through at-home interviews and direct physical examinations at mobile examination centers (MECs).[5] The survey is a nationally representative, multiple-year-cross-sectional sample of the civilian non-institutionalized population. NHANES III over-sampled among Blacks and Mexican-Americans. Consequently, NHANES III provides a sufficient number of Black and Mexican-American minorities to examine possible differential relationships between BMI and neighborhood context across ethnicity.

To examine the relationship between neighborhood conditions and BMI, we use census tracts as neighborhood proxies.[6] Neighborhood contextual factors were derived from 1990 and 2000 Decennial Census data and linked to individual respondents in the sample via census tract identifiers.[7] These geo-coded identifiers reflect respondents' tract of residence at the time of the at-home interview. Neighborhood conditions between decennial census years in the sample (1991–1994) were estimated by linearly interpolating across decennial tract measures, assuming a constant rate of change in neighborhood conditions between decennial census years. For the years 1988–1990, 1990 neighborhood measures were used. Because tract boundaries change across decennial censuses, normalization of tract boundaries to 1990 tract definitions was conducted before any neighborhood tract-level measures were estimated.[8] This ensured that the noise in tract demographic variation due to boundary adjustments is minimized.

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[3]Boardman et al. (2005) did not stratify their analyses by gender.

[4]Robert and Reither (2004) tested interactions between ethnicity and community disadvantage measures and found no significant associations (results not shown in their paper). However, their small sample size (778 for Black women and 1481 for non-black women) may not have allowed sufficient power to detect these potential differences.

[5]Description and Public-Use Data Files of NHANESS III are available at http://www.cdc.gov/nchs/about/major/nhanes/nh3data.htm.

[6]At the time of delineation, census tract boundaries are designed to capture relatively homogenous properties with respect to residential characteristics, economic status, and living conditions. Census tracts are composed usually of 1000–8000 residents, with an average size of 4000 people. The spatial size of census tracts depends on housing density and thus varies widely. (U.S. Census Bureau: http://www.census.gov/geo/www/cob/tr_metadata.html, Accessed November 5, 2006).

[7]Tract identifiers are not publicly available and were obtained through special contract between the National Center for Health Statistics (NCHS) and the RAND Center for Health and Health Disparities (CHHD). The CHHD provided census tract level data to NCHS. Using restricted information on the addresses of NHANES III respondents, NCHS then merged the file to the public-use NHANES III data. Tract and county identification variables were randomly generated and do not reflect true geographic identifiers. The merged data was kept at the NCHS Research Data Center (RDC) and all analyses were conducted remotely. Information on the NCHS RDC is available at http://www.cdc.gov/nchs/r&d/rdc.htm. Information on the CHHD, including available spatially linked sociodemographic and built environment data offered through the Center, is available at http://www.rand.org/health/centers/pophealth/index.html.

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Tract locations of approximately 86% of the sample were identified via address or street intersection matches. The remaining 14% only had zip code or county locations and were excluded from the analyses. These excluded observations were predominately located in more rural areas. Consequently, our sample is comprised predominantly of residents within metropolitan statistical areas.[9] We further restricted our sample to individuals who were at least 20 years old and not pregnant during the time of the interview. The resulting sample consists of approximately 7500 female and 6700 male subjects.

4.2. Individual-level measures

Table 1 presents descriptions of all major variables by ethnicity and gender. Height and weight measurements were recorded by trained clinicians in the mobile examination center or at the respondent's home during the physical examination. Figs. 1 and 2 show county-level BMI distributions[10]; these indicate that there is more county-level variation in BMI for females than males, though neither level of variation is large.

Other individual-level variables include age, marital status (married, single, and other) employment status (employed, unemployed, not in the labor force), educational attainment (college, some college, high school, no high school), nativity (U.S. born versus foreign born), ethnicity (non-Hispanic White, non-Hispanic Black, Mexican-American, and Other) and family poverty income ratio (PIR). A PIR at or below 1.00 indicates that the respondent is a member of a family whose income is at or below the official poverty threshold.[11] Age and PIR are continuous measurements while the other individual-level variables are categorical.

4.3. Neighborhood context measures

We examine four neighborhood-level characteristics: neighborhood disadvantage, neighborhood educational concentration at the extremes, Black segregation, and Hispanic segregation. Each of these measures is computed at the level of the census tract. They are defined as follows.

Neighborhood disadvantage: to capture the notion of overall neighborhood deprivation, we adopt a modified version of Ricketts and Sawhill's (1988) composite measure of neighborhood disadvantage The composite measure is made up of the average of four deprivation indicators: proportion of individuals age 25 and over with no high school degree, proportion of individuals receiving public assistance, proportion of households with children headed by females, and the proportion of males age 16 and over who are unemployed.[12] The index ranges from 0 to 100, with a higher score reflecting a higher level of neighborhood disadvantage.

Education Index of Concentration at the Extremes: the second neighborhood variable, index of concentration at the extremes (ICE), was first introduced by Massey (2001) as an alternative

[8]The study used normalized 1990 tracts provided by RAND's CHHD Data Core. "In order to express 2000 census tracts in terms of 1990 geo-references, the Data Core utilized the 1990-2000 tract mapping product – Census Tract Relationship Files – that was developed by the Census Bureau…. The CPHHD Data Core has implemented a *population-based* methodology for reallocating all 2000 census tract measures into 1990-equivalent portions, then aggregating into fully apportioned 1990 geographies." (CHHD Data Core Users' Documentation, p. 4). Further documentation regarding tract normalization may be found at http://www.rand.org/health/centers/pophealth/index.html.

[9]MSAs are generally counties (cities and towns in New England) containing at least one city or urbanized area with a population of at least 50,000 and a total metropolitan population of at least 100,000 (75,000 in New England).

[10]County-level BMI figures are limited to the 35 counties that were identifiable in the public-use data. Data restrictions prohibited mapping all sampled counties and tract-level BMI distributions. The dependent variable, BMI, was calculated by dividing an individual's weight (in kilograms) by his height (in meters) squared.

[11]For example, the poverty threshold in 1990 for a four-person family with two children under 18 years is approximately US$ 13,300 (U.S. Census Bureau, http://www.census.gov/hhes/www/poverty/threshld/thresh90.html, Accessed October 18, 2006).

[12]This is a slight modification of Ricketts and Sawhill's definition which used 16–19 year olds who are not enrolled in school and are not high school graduates.

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to measuring the separate effects of concentrated affluence and poverty. Massey contended that, more so than the concentration of poverty or affluence, it is the proportional imbalance between affluence and poverty that really mattered and offered the “concentration at the extremes” index as a way to capture the proportional polarization of a neighborhood. Here, we apply the index to the educational capital of a neighborhood, expressed as $((C_i - \mathrm{NHS}_i)/T_i) \times 100$ where, C_i equals the number of individuals 25 or over who are college graduates, NHSi equals the number of individuals 25 or over without a high school degree, and T_i equals the total population of 25 or over in the neighborhood. The ICE ranges from −100 to +100, where negative 100 represents a neighborhood where all individuals 25 or older are uneducated and a positive 100 represents a neighborhood where all individuals 25 or older are highly educated. A zero reflects a neighborhood where the numbers of uneducated and highly educated are equally balanced.

Black and Hispanic segregation: we use the percentage of Blacks and the percentage of Hispanics in a neighborhood as a rough proxy for the level of Black residential segregation and degree of Hispanic enclaves, respectively. Descriptive characteristics for the four neighborhood-level measures are presented in Table 2 and plots showing the distribution of the disadvantage index and education ICE are presented in Figs. 3 and 4.

4.4. Statistical analysis

The sample consists of approximately 160 tracts nested within 81 counties. Over a third of the tracts contain at least ten male and female observations, with the average number of female and male respondents per tract numbering 48 and 42, respectively. The mean number of observations per county is 94 and 81 for the female and male samples, respectively. We therefore employ a 3 level (individual-, tract-, county-levels) hierarchal linear modeling framework which appropriately adjusts the standard errors to account for the nested structure of our dataset. Using SAS v9.1 Proc Mixed, a series of three-level random intercept models are conducted to investigate the relationship between neighborhood context and BMI.

In order to examine whether the association between neighborhood context and BMI differs across racial groups, a cross-level interaction term between ethnicity and neighborhood context are included in each model. That is, ethnicity is interacted with neighborhood context to allow for the relationship between neighborhood context and BMI to differ across ethnicity.

Our three level models can be formally expressed as:

Level1:

$$Y_{i\,\mathrm{jk}} = \delta_{o\,\mathrm{jk}} + \sum_{h=1}^{P} \delta_{h\,\mathrm{jk}} x_{\mathrm{hi\,jk}} + \sum_{m=p+1}^{n} \delta_{m\,\mathrm{jk}} \mathrm{ethnicity}_{\mathrm{mi\,jk}} + r_{i\,\mathrm{jk}}$$

Level2:

$$\delta_{o\,jk} = \alpha_{ook} + \alpha_{o\,1k}\mathrm{neighborhoodcontext}_{\,jk} + u_{o\,jk}$$

$$\delta_{h\,jk} = \alpha_{hok}$$

$$\delta_{m\,jk} = \alpha_{mok} + \alpha_{m\,1k}\mathrm{neighborhoodcontext}_{\,jk}$$

Level3:

$$\alpha_{ook} = \beta_{ooo} + v_{\,ook}$$

$$\alpha_{o\,1k} = \beta_{o\,1o}$$

$$\alpha_{hok} = \beta_{hoo}$$

$$\alpha_{mok} = \beta_{moo}$$

$$\alpha_{m\ 1k} = \beta_{m\ 1o}$$

where Y_{ijk} is the outcome variable, BMI, for person i residing in the tract j, in county k, and x_h is a vector of individual covariates (e.g. age and education level). The individual-level variable, ethnicity$_m$, is a series of dummy variables for each ethnicity category (i.e., Black, Mexican-American, and Other—White is the reference category) and the tract-level term, neighbor-hoodcontext, reflects the characteristic of the neighborhood that is being investigated/ estimated. The terms: r_{ijk}, u_{ojk}, v_{ook}, represent the error components at Level 1, Level 2, and Level 3, respectively.[13]

Substitution yields a more compact notation in which the cross-level interaction term (neighborhoodcontext × ethnicity) becomes more evident:

$$Y_{i\mathrm{jk}}=\beta_{\mathrm{ooo}}+\sum_{h=1}^{p}\beta_{\mathrm{hoo}}(x_{\mathrm{hi\,jk}})+\beta_{o1o}(\mathrm{neighborhoodcontext_{jk}})+\sum_{m=p+1}^{n}\beta_{\mathrm{moo}}(\mathrm{ethnicity_{mi\,jk}})$$
$$+\sum_{m=p+1}^{n}\beta_{m1o}(\mathrm{neighborhoodcontext_{jk}})(\mathrm{ethnicity_{mi\,jk}})+(r_{i\mathrm{jk}}+u_{o\mathrm{jk}}+v_{\mathrm{ook}})$$

The slope term, β_{m1o}, represents the difference in the relationship between neighborhood context and BMI for ethnic group m, compared to that for Whites.

Because many aspects of neighborhood conditions are highly correlated (see Table 3), our analytical strategy is to first conduct our analyses with the neighborhood context measures of interest entered individually in separate models (Models 2–5, Tables 4 and 5). We then attempt to tease out the effects of different neighborhood contexts by entering the neighborhood-level conditions simultaneously into a single model (Model 6, Tables 4 and 5).

All analyses are stratified by gender and include individual-level controls as well as year dummies for the year in which the respondent was examined to account for temporal factors (not reported here). All continuous variables at both the individual and neighborhood-levels are centered to the gender sub-sample mean (i.e., grand-mean centered). Since all models include ethnicity interactions, centering allows for the ethnicity coefficients to be directly interpreted as the racial difference in BMI at the gender specific sample mean of the neighborhood context being investigated.

5. Results

Model results for the female and male sub-samples are presented in Tables 4 and 5, respectively. Though we originally specified a three-level hierarchy, results from these models estimated county-level variances to be zero. We therefore present results from two-level (individuals nested within tracts) models. For both Tables 4 and 5, Models 1A and 1B adjust for individual socioeconomic characteristics only while Models 2–5 reflect results that include only a single neighborhood context in the model specification. Results for Models 6A and 6B reflect estimates that include simultaneously the four neighborhood context measures: disadvantage index, educational ICE, %Black, and %Hispanic. To directly interpret the coefficients as the change in BMI associated with a change in neighborhood context, the total neighborhood coefficients for Whites, Blacks, Mexican-Americans, and “Other ethnicity” are presented for each model in lieu of the interaction coefficients. Coefficients for neighborhood disadvantage,

[13]Even though we did not include county level measures in the models, we employed three-level models to adjust for the clustering of respondents within counties and to allow for county specific intercepts. (Including MSA-level cost-of-living-index (COLI) adjustments at the county level did not significantly alter results and because COLI information was not available for all counties in the dataset, COLI was dropped from further analyses.)

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proportion Black, and proportion Hispanic are based on a 10 percentage point change. Coefficients for the education ICE are based on a 10 point change.

5.1. Females

Model 1A (Table 4) shows that Black and Mexican-American females have higher BMI than White females, even after adjusting for individual-level socioeconomic factors. Estimates of the effects of individual-level predictors are in the expected direction, with higher socioeconomic status negatively associated with BMI. In addition, U.S. born individuals and married women have higher BMI, which is also consistent with other findings.

Models 2A–5A add neighborhood disadvantage, education ICE, proportion Black, and proportion Hispanic into the models separately. There are significant associations between each neighborhood context and BMI differing by ethnicity. All four neighborhood measures were significantly associated with BMI for Mexican-Americans, while no association was found for Blacks. For Whites, neighborhood disadvantage and education ICE coefficients were found to be significant.[14] Using the strongest findings as an example, living in more disadvantaged neighborhoods for Whites and Mexican-Americans increases BMI by the same magnitude as being unemployed (compared to being employed).[15] Another interpretation would be to consider an average height female; for a White female 1.63 m (5 ft 4 in.) in height, a 10 percentage point increase in the neighborhood disadvantage index is associated with a 1.68 kg (3.70 lbs) increase in weight (Fig. 5).[16] With respect to ethnic differences, accounting for neighborhood disadvantage reduces the ethnicity coefficient by approximately 9% for Blacks and 29% for Mexican-Americans.

When all four neighborhood variables were entered into the model simultaneously (Model 6A), many of the significant relationships were attenuated, as expected. Significant associations observed for neighborhood disadvantage index and Hispanic concentration in the previous models became statistically insignificant, as did the association between the neighborhood concentrations of Blacks for Mexican-Americans. However, the association between education ICE and BMI remained significant and slightly increased from −0.19 to −0.26 for Whites and from −0.21 to −0.26 for Mexican-Americans (comparing Model 3A to 6A). Moreover, neighborhood education ICE became significantly associated with lower BMI for Blacks. The increases indicate that the association between neighborhood educational ICE and BMI was to some extent confounded by the other neighborhood characteristics included in the model. Simultaneously adjusting for multiple neighborhood characteristics resulted in an increase in the ethnic differences in BMI, particularly for Mexican-Americans (1.4–1.6).

5.2. Males

Results of Model 1B (Table 5) for males indicate that income, labor force status, and educational attainment were not associated with BMI, reflecting the weaker link between socioeconomic status and weight for males, compared to females. Being US born and married were positively associated with BMI. Results also reveal that there exists a significant disparity in BMI for Mexican-Americans compared to Whites. Mexican-American males, net of individual-level socioeconomic controls, have a 1.11 higher BMI score than Whites. However, no differences were found in BMI between Black and White males after adjusting for socioeconomic characteristics. (This finding is consistent with the similar rates of obesity among Blacks and Whites found in NHANES III and NHANES 1999–2000 data (Flegal et al.,

[14]Because the “Other Ethnicity” subpopulation is likely to be a highly heterogeneous group, the results for this subpopulation are not discussed.

[15]The difference in the association between BMI and neighborhood disadvantage for Whites and Mexican-Americans was not statistically significant.

[16]Calculation: $(0.634\ kg/m^2) \times (1.63\ m)^2 = 1.68$ kg.

2002). In addition, Robert and Reither (2004), using the 1986 Americans' Changing Lives (ACL) study, also found no significant difference in age-adjusted BMI between Blacks and Whites.)

In terms of the relationship between neighborhood and BMI, generally weaker associations and a slightly different pattern emerged compared to those found for females. Again, the most consistent findings were found for Mexican-Americans; all neighborhood measures, except for proportion Black, were found to be significantly associated with BMI for Mexican-Americans. In contrast to no neighborhood association found for Black females, proportion Black and proportion Hispanic were found to be significant predictors of BMI for Black males, albeit only marginally.[17] For Whites, only education ICE was associated with BMI.

Again, neighborhood disadvantage was found to have strong association with BMI for Mexican-Americans; a 10 percentage point increase in the neighborhood disadvantage index was associated with a 0.26 increase in BMI (Model 2B) for them. Though the magnitude of this association between BMI and neighborhood disadvantage for males is less than half of that for females, it is comparable to the average difference in BMI between an employed and unemployed male. For a 1.70 m (5 ft 7 in.) Mexican-American male, a 0.26 increase in BMI translates into an increase of 0.77 kg (1.63 lbs) (Fig. 6).

When all four neighborhood predictors are included in the model (Model 6B), the significant association between education ICE and BMI did not persist as it did for females. Higher concentration of more educated individuals remained associated with lower BMI for Whites but not for Mexican-Americans. Moreover, the education ICE coefficient for Whites increased with the inclusion of the other neighborhood variables. For Blacks, neighborhood disadvantage and Black concentration have opposing associations; a disadvantaged environment was associated with lower BMI while a higher proportion of Blacks in a neighborhood was associated with higher BMI for Blacks. No significant association remained between any of the neighborhood contexts and BMI for Mexican-Americans.

Results of Model 6 also reveal that the association between neighborhood context and BMI, though generally stronger in females than males, explained more of the racial BMI disparity in males than females. The difference in BMI for Blacks compared to Whites is fully explained by individual-level factors. The BMI gap between White and Mexican-American males is moderately reduced by 15%, from 1.11 to 0.94, once multiple characteristics of the neighborhood are accounted for.

6. Discussion

Consistent with the limited previous research investigating the relationship between neighborhood characteristics and BMI (Robert and Reither, 2004; Morenoff et al., 2006), we find that there is significant variation in BMI at both individual- and neighborhood-levels—although no significant variation is found at the county-level.[18] While most of the variation in BMI is attributable to variation within neighborhoods, there is a significant correlation between neighborhood context and BMI, net of individual-level socioeconomic adjustments. In general, adjusting for neighborhood context resulted in a modest to moderate reduction of the observed ethnic disparity in BMI for men, with less consistent results for women. Significant differences in BMI across ethnicity persisted after adjustments for neighborhood context for both genders.

[17] However, these associations are only significant at the 10% level.

[18] Recall that respondents from more rural areas are underrepresented due to geocoding limitations.

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Our examination into whether there are racial differences in the association between neighborhood context and BMI reveals that the strength and pattern of the association do vary by ethnicity. A significant relationship between neighborhood context and BMI is found to be most consistent for Mexican-Americans. The only neighborhood characteristic examined that did not have a significant association to BMI for Mexican-Americans was proportion Black in a neighborhood for Mexican-American males. However, with the simultaneous inclusion of multiple neighborhood-level controls, only education ICE for Mexican-American females remained significant. The increase in BMI for Mexican-Americans associated with an increase in proportion of Hispanics in a neighborhood is somewhat surprising (Model 5A and 5B), given the literature on the salutatory health effects of ethnic enclaves. However, one anomalous trend to the pattern of advantaged health among immigrants has been the trend towards Type-II diabetes and obesity among Hispanic immigrants that may be the result of the adoption of American lifestyles in combination with childhood deprivation and dietary patterns. Though additional analyses (results not shown) allowing for differential effects between U.S. born and foreign born Hispanics did not change the direction of the association. One potential explanation for the direction of the relationship may be that because of the higher prevalence of obesity among Hispanics – particularly among Mexican-Americans (Thom et al., 2006) – being overweight may be viewed as a cultural norm and more socially acceptable in areas of high Hispanic concentration, leading to higher rates of obesity in those areas. Although this social model has been hypothesized for Blacks (Boardman et al., 2005; Robert and Reither, 2004), our results suggest that this psychosocial interaction may also extend to Hispanics as well.

With respect to gender differences, our findings of stronger neighborhood associations for females than males are consent with previous literature on BMI and on other health outcomes (e.g. Cubbin et al., 2001; Stafford et al., 2005; Robert and Reither, 2004). Several potential mechanisms for the differential relationship have been tested. For example, Cohen et al. (2006) found that men and women use local parks in Los Angeles differently; men are more likely to engage in physical activity in parks, whereas women are more likely to sit. Morenoff and Sampson (1997) report that land use types and street connectivity have differential impacts on walking for men and women in Chicago. Some researchers hypothesize that the neighborhood environment may be more important for women than for men because women traditionally spend more time in the home and are thus exposed to the neighborhood for a greater amount of time (Robert, 1999). The general persistence of education ICE to remain statistically significant for women, but not for men, also suggests that there is a stronger connection between the neighborhood educational capital for women then men. Perhaps women are more likely to use informal networking to obtain and share information regarding health and health risks than men. In sum, women may be more reliant on neighborhood resources or men are more influenced by extra-residential factors, or both. However, other studies have found stronger associations between composite measures of neighborhood disadvantage and mortality among men than among women (Sundquist et al., 2004; Nordstrom et al., 2004). Further exploration is required to ascertain mechanisms driving these differences.

In addition, simultaneously adjusting for multiple neighborhood contexts resulted in an increase in observed ethnic disparity for women, with a reduction for men. This is the opposite pattern to results from Morenoff et al.'s (2006) study which observed a reduction in ethnic BMI disparity for women and an increase for men with the inclusion of multiple neighborhood-level adjustments. Robert and Reither (2004) also observed a reduction in ethnic BMI disparity for women. This suggests a complex web of relationships between neighborhood characteristics, ethnicity, and BMI which may be particularly sensitive to the specific combination of neighborhood contexts that is being investigated.

Our study suggests that neighborhood factors work through both indirect (individual-level covariates) and direct pathways to influence the body mass of residents. Sensitivity analyses – results not presented – with different outcome specifications (e.g. log bmi, binary obesity, binary overweight) yielded the same pattern of findings; further, model diagnostics calculating Cook's Distances did not reveal any potential outliers that would greatly influence model results.[19] As such, the significance and pattern of results suggest that consideration of contextual risk factors, as well as individual-level characteristics, may be important in combating the obesity epidemic.

Although this study takes critical steps towards understanding the intersection between ethnicity, BMI, and space, it is not without its limitations. As previously mentioned, the NHANES III, with its over-sampling of Blacks and Hispanics, is especially well-suited to investigating the correlates of racial disparities in BMI. Although the NHANES III is a nationally representative sample of the U.S. population, missing geocode identifiers restricted our analysis sample which resulted in an under-representation of individuals residing in more rural areas. The importance of neighborhood characteristics may vary by degree of residential density and our findings may not be generalizable to more rural areas. It should also be noted that inferences from this study may also not be generalizable to other developed countries. In a recent review, Cummins and Macintyre (2006) concluded that, although there is consistent evidence for a relationship between neighborhood context and diet and obesity in the U.S., there is much weaker (and inconsistent) evidence for a relationship outside the United States.

Second, causal interpretations of our findings should be tempered. The inclusion of neighborhood-level measures may serve to reduce bias in the ethnicity coefficients, as it may capture additional compositional differences across areas; however, neighborhood estimates may be biased if the measures are correlated with omitted characteristics at the individual-level (e.g. preferences for physical activity) that can affect health. In addition to bias due to omission of individual characteristics, poorly measured and/or poorly specified individual-level factors that were included in the models, may also yield biased neighborhood estimates.

Moreover, the cross-sectional nature of our study precludes any causal inferences for neighborhood effects. Conducting randomized control studies, such as the MTO, are likely the most powerful strategy to recover causal estimates. However, short of costly large-scale experimental studies, survey data with multiple observations across individuals would better lend itself to causal modeling strategies (e.g. fixed-effect models). In addition, because temporal fluctuations in neighborhood context have been found to vary across ethnicity (Quillian, 2003; Timberlake, 2003; Do, 2006), longitudinal data that provide information on the length of exposure to neighborhood context may be especially valuable when investigating the causes and correlates of racial health disparity and teasing out the sources for the differences in neighborhood impact on BMI across ethnicity.

Lastly, census measures are used to characterize neighborhood conditions and resources (e.g. public exercise facilities) and are only rough proxies for theoretically causal neighborhood conditions and processes (e.g. grocery store quality, presence of parks, and walk-ability). The reliance on census data precludes us from testing potential mechanisms and mediators through which neighborhood disadvantage and racial composition affect BMI. Although the study was not designed to investigate mediators, the MTO experiment, for example, found that the experimental group reported consuming significantly higher amounts of fruits and vegetables

[19]We estimated linear probability models with overweight and obesity as outcomes. The pattern of results was generally consistent with the linear BMI results. We also log transformed the BMI outcome variable to transform the distribution towards a normal distribution. The kurtosis was reduced from 2.2 to 0.1 for the female sample and 4.0 to 0.8 for the male sample, reflecting an approximately normal distribution after transformation. We re-estimated the models with log BMI as the outcome. Again, the general pattern of results and inferences were consistent with the linear BMI models. Tract-level cook's distance estimates did not indicate any influential outliers.

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versus controls at follow-up (Kling et al., 2004). The change in diet may be a possible contributing factor in the decreased prevalence of obesity in the experimental group.

The finding that census-derived neighborhood measures only account for a small portion of observed ethnic disparities suggests that research on more specific and proximate neighborhood conditions/processes is warranted. Clearly, the high levels of segregation observed in these and other data, and the subsequent disproportionate allocation of toxic environments across social space, may tell us much about disparities in obesity and health—as evidenced by the ability of our rough proxies to explain even a small portion of these disparities. However, specific policy implications resulting from this study are unclear as our global measures of neighborhood disadvantage and racial segregation limit our understanding of the causal mechanisms underlying the connection between neighborhood context and BMI. Future research that examines possible causal mechanisms such as diet, exercise, and availability of exercise facilities, are needed to form policy recommendations and interventions.

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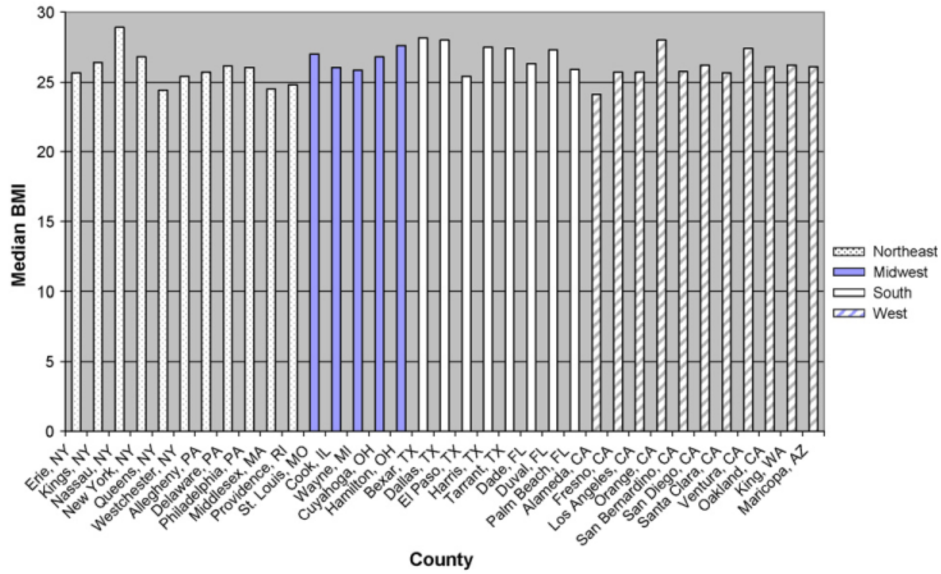

Fig. 1.
County-level BMI for females.

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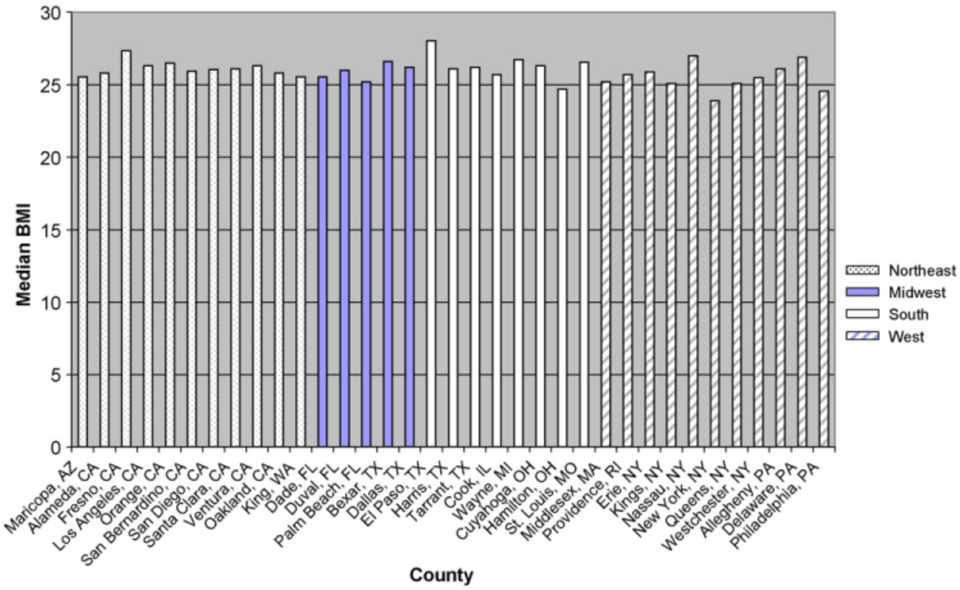

Fig. 2.
County-level BMI for males.

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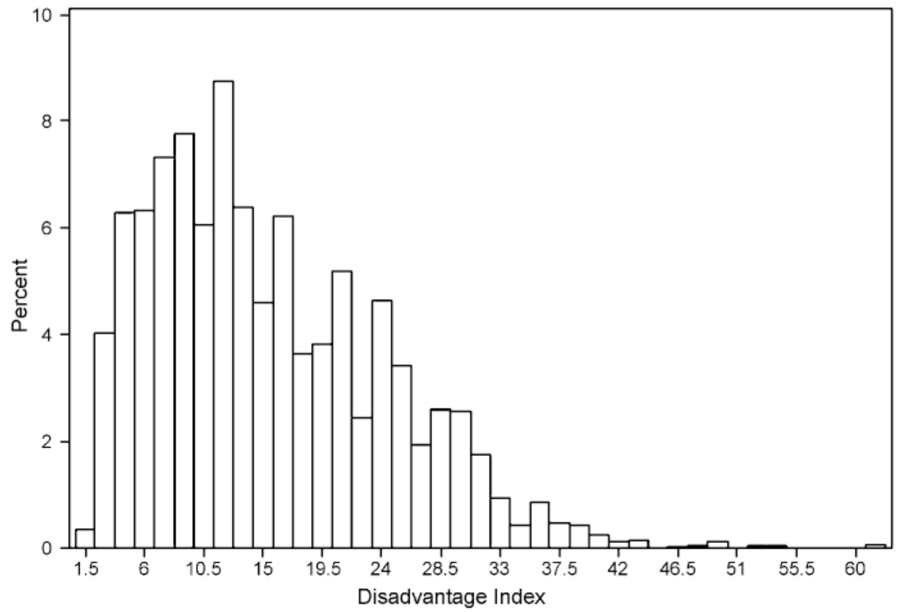

Fig. 3.
Sample distribution of disadvantage index.

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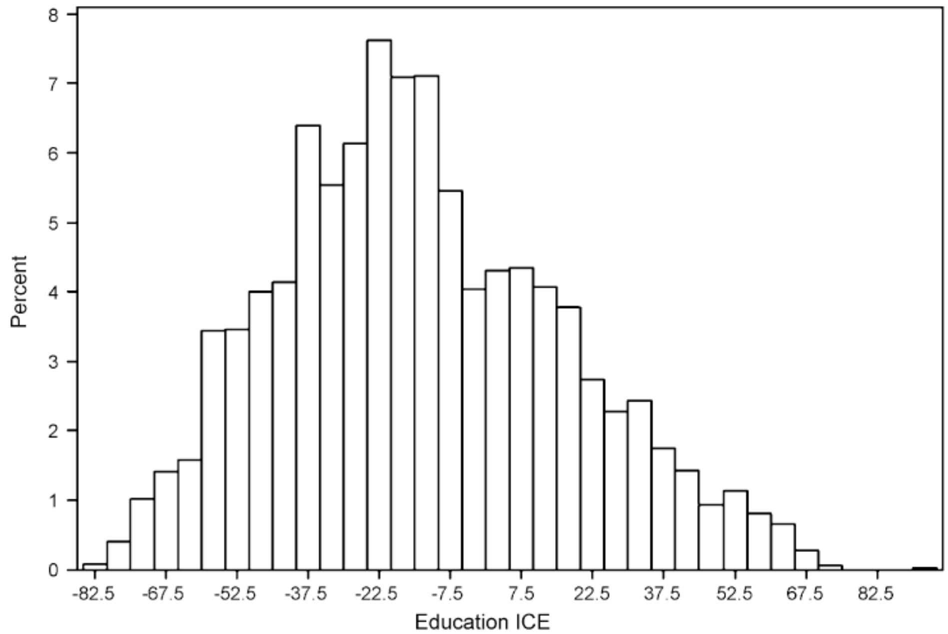

Fig. 4.
Sample distribution of education ICE.

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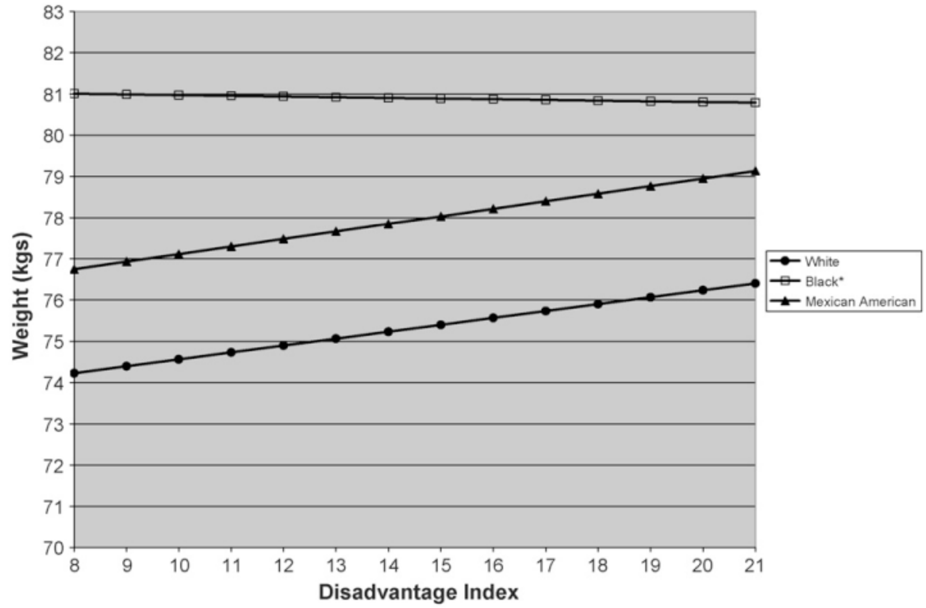

Fig. 5.
Female weight by neighborhood disadvantage. *Not statistically significant. Weight calculated for a 5 ft 4 in. female at female sample mean.

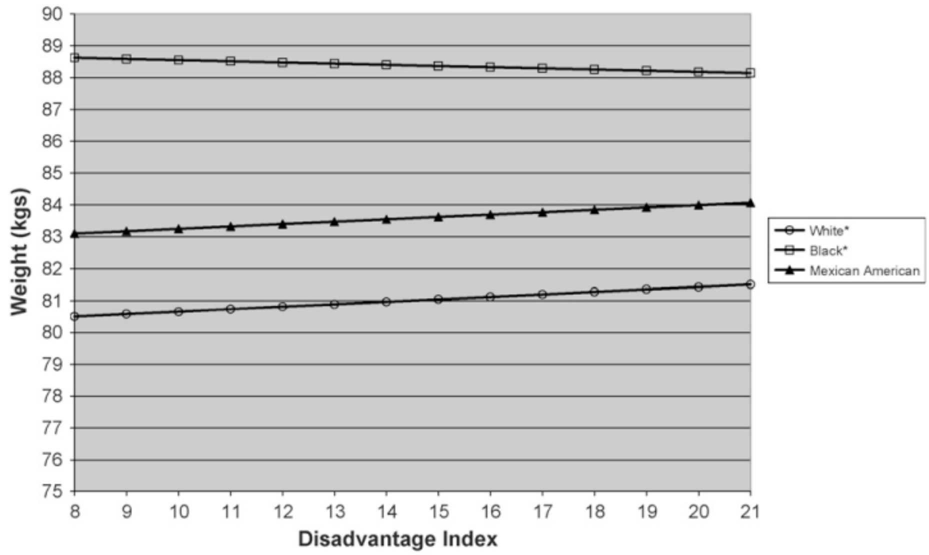

Fig. 6.

Male weight by neighborhood disadvantage index. *Not statistically significant. Weight calculated for a 5 ft 7 in. male at male sample mean.

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Table 1

Descriptive statistics for individual-level characteristics by ethnicity and gender

	White		Black		Mexican-American		Other ethnicity	
	Female	**Male**	**Female**	**Male**	**Female**	**Male**	**Female**	**Male**
N	2967	2526	2188	1854	1940	2033	365	279
Mean body mass index	26.25 (6.08)	26.42 (4.45)	28.99 (7.44)	26.44 (5.38)	27.99 (6.01)	26.94 (4.52)	26.65 (5.90)	25.46 (4.41)
Mean family poverty income ratio	3.06 (1.83)	3.37 (1.90)	1.91 (1.39)	2.19 (1.50)	1.76 (1.28)	1.89 (1.32)	2.00 (1.38)	2.20 (1.45)
Mean age	55.64 (20.44)	56.16 (20.13)	44.25 (17.33)	44.62 (17.47)	42.33 (17.27)	42.38 (17.52)	46.63 (17.65)	44.90 (18.39)
Employment status								
%Employed	43.51	57.52	53.61	60.41	44.48	69.80	44.11	65.59
%Unemployed	4.21	3.52	5.90	9.98	5.00	9.39	6.03	10.39
%Not in the labor force	52.28	38.95	40.49	29.61	50.52	20.81	49.86	24.01
Education level								
%Not a high school graduate	26.42	27.59	34.41	38.73	61.70	63.55	46.03	40.14
%High school graduate	35.86	27.32	36.93	34.09	23.61	20.02	22.74	24.37
%Some college	7.41	6.97	7.40	5.50	3.97	4.23	6.03	5.73
%College graduate	30.30	38.12	21.25	21.68	10.72	12.20	25.21	29.75
Nativity								
%Foreign born	6.17	6.33	6.54	7.12	48.04	55.04	82.47	80.65
%Us born	93.83	93.67	93.46	92.88	51.96	44.96	17.53	19.35
Marital status								
%Married	55.71	74.07	37.48	54.10	63.61	74.37	50.14	60.22
%Single	9.17	11.32	26.65	26.97	13.51	17.81	18.63	25.81
%Other	35.12	14.61	37.48	18.93	22.89	7.82	31.23	13.98

Note: Standard deviations in parenthesis.

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Table 2

Tract-level means by ethnicity and gender

	White		Black		Mexican-American		Other ethnicity	
	Female	**Male**	**Female**	**Male**	**Female**	**Male**	**Female**	**Male**
N	2967	2526	2188	1854	1940	2033	365	279
Disadvantage index	10 (5.6)	10 (5.6)	20 (9.7)	19 (9.1)	19 (8.2)	19 (8.2)	16 (8.7)	14 (8.4)
Education ICE index	1 (26.9)	2 (27.9)	−21 (25.2)	−19 (25.9)	−28 (29.1)	−28 (29.7)	−11 (30.7)	−6 (32.0)
%Black	8 (14.2)	8 (13.3)	51 (32.3)	51 (33.3)	7 (12.1)	7 (12.0)	11 (15.4)	10 (14.3)
%Hispanic	6 (11.8)	7 (12.6)	10 (16.6)	9 (16.2)	51 (28.7)	50 (29.1)	34 (27.6)	28 (25.8)

Note: Standard deviations in parentheses.

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Table 3

Correlation matrix of neighborhood predictors

	Disadvantage	Education ICE	%Black	%Hispanic	%White
Disadvantage	1.000				
Education ICE	−0.868	1.000			
%Black	0.478	−0.253	1.000		
%Hispanic	0.448	−0.510	−0.294	1.000	
%White	−0.760	−0.604	−0.565	−0.594	1.000

Note: All correlations are statistically significant at the 1% level

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Table 4

Neighborhood effects on BMI, U.S. women, 1988–1994

	Model 1A	Model 2A	Model 3A	Model 4A	Model 5A	Model 6A
Neighborhoood characteristics						
Disadvantage (for Whites)		0.634***				−0.324
Disadvantage (for Blacks)		−0.063				−0.468
Disadvantage (for Mexican-Americans)		0.691***				−0.003
Disadvantage (for other ethnicity)		0.937**				−0.081
Education ICE (for Whites)			−0.193***			−0.264***
Education ICE (for Blacks)			−0.058			−0.218**
Education ICE (for Mexican-Americans)			−0.207***			−0.256*
Education ICE (for other ethnicity)			−0.273**			−0.266
%Black (for Whites)				−0.003		−0.066
%Black (for Blacks)				−0.042		−0.024
%Black (for Mexican-Americans)				0.282***		0.230
%Black (for other ethnicity)				0.640***		0.574**
%Hispanic (for Whites)					0.078	−0.009
%Hispanic (for Blacks)					0.032	−0.010
%Hispanic (for Mexican-Americans)					0.095*	−0.068
%Hispanic (for other ethnicity)					0.079	−0.038
Individual-level socio-demographic characteristics						
Ethnicity [reference: White]						
Non-Hispanic Black	2.260***	2.048***	2.058***	2.406***	2.204***	2.353***
Mexican-American	1.399***	0.999***	1.023***	1.808***	1.060***	1.645***
Other ethnicity	0.271	0.052	0.192	0.928**	0.126	0.967*
Poverty income ratio	−0.332***	−0.284***	−0.2584***	−0.332***	−0.322***	−0.260***
Age	0.043***	0.044***	0.044***	0.045***	0.043***	0.045***
Age squared	−0.004***	−0.004***	−0.004***	−0.004***	−0.004***	−0.004***
Employment status [reference: unemployed]						
Employed	−0.675*	−0.6917**	−0.697**	−0.701**	−0.674**	−0.728**
Not in the labor force	0.041	−0.002	−0.002	0.022	0.031	−0.002
Education level [reference: no high school]						
High school graduate	−0.345*	—0.238	−0.213	−0.332*	−0.321*	−0.208
Some college	−0.504*	−0.401	−0.346	−0.503	−0.485	−0.347
College graduate	−1.123***	−0.989***	−0.882***	−1.107***	−1.103***	−0.846***
Nativity [reference: US born]						
Foreign born	−0.862***	−0.918***	−0.878***	−0.886***	−0.903***	−0.892***
Marital status [reference: married]						
Single	−0.086	−0.102	−0.068	−0.067	−0.105	−0.005
Other marital status	−0.212	−0.233	−0.204	−0.219	−0.217	−0.180
Random effects						
Level-two variance: var(u_{oj})	0.662**	0.550**	0.514**	0.614**	0.667**	0.481**
Level-one variance: var(r_{ij})	38.285***	38.242***	38.225***	38.248***	38.258***	38.155***
Fit statistic						
AIC	48529.3	48509.6	48500.1	48522.0	48533.0	48504.6

Note: N = 7460. Coefficients for neighborhood disadvantage, proportion Black, and proportion Hispanic are based on a 10 percentage point change. Coefficients for the education ICE are based on a 10 point change.

* $p < 0.10$.

** $p < 0.05$.

*** $p < 0.01$.

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Table 5

Neighborhood effects on BMI, U.S. men, 1988–1994

	Model 1B	Model 2B	Model 3B	Model 4B	Model 5B	Model 6B
Neighborhoood characteristics						
Disadvantage (for Whites)		0.268				−0.242
Disadvantage (for Blacks)		−0.128				−0.646**
Disadvantage (for Mexican-Americans)		0.256**				−0.033
Disadvantage (for other ethnicity)		0.377				−0.852
Education ICE (for Whites)			−0.089**			−0.138*
Education ICE (for Blacks)			0.032			−0.077
Education ICE (for Mexican-Americans)			−0.081**			−0.042
Education ICE (for other ethnicity)			−0.177**			−0.408**
%Black (for Whites)				−0.046		−0.069
%Black (for Blacks)				0.063*		0.150***
%Black (for Mexican-Americans)				−0.046		−0.000
%Black (for Other Ethnicity)				−0.037		−0.069
%Hispanic (for Whites)					0.048	0.007
%Hispanic (for Blacks)					−0.116*	−0.002
%Hispanic (for Mexican-Americans)					0.085**	0.063
%Hispanic (for Other Ethnicity)					0.075	−0.055
Individual-level sociodemographic characteristics						
Ethnicity [reference: White]						
Non-Hispanic Black	0.097	0.032	0.029	−0.046	−0.109	−0.161
Mexican-American	1.112***	0.951***	0.954***	1.095***	0.825***	0.940***
Other ethnicity	−0.030	−0.063	0.030	−0.026	−0.129	0.139
Poverty income ratio	0.040	0.055	0.066	0.040	0.048	0.062
Age	0.018***	0.018***	0.018***	0.018***	0.018***	0.017***
Age squared	−0.002***	−0.002***	−0.002***	−0.002***	−0.002***	−0.002***
Employment Status [Reference: Unemployed]						
Employed	−0.301	−0.287	−0.290	−0.292	−0.295	−0.306
Not in the labor force	−0.107	−0.084	−0.080	−0.116	−0.108	−0.079
Education level [reference: no high school]						
High school graduate	0.135	0.157	0.165	0.134	0.157	0.152
Some college	0.385	0.427	0.452*	0.389	0.413	0.457*
College graduate	0.026	0.088	0.151	0.030	0.055	0.154
Nativity [reference: US born]						
Foreign born	−1.174***	−1.214***	−1.203***	−1.158***	−1.194***	−1.183***
Marital status [reference: married]						
Single	−0.975***	−0.967***	−0.953***	−0.991***	−0.977***	−0.950***
Other marital status	−1.006***	−1.010***	−1.017***	−1.007***	−1.006***	−0.996***
Random effects						
Level-two variance: var(u_{oj})	0.07865	0.08092	0.07524	0.08617	0.08762	0.07659
Level-one variance: var(r_{ij})	21.0499***	21.0202***	21.0043	21.0283	21.0112	20.9461***
Fit statistic						
AIC	39451.6	39450.8	39444.0	39455.1	39450.1	39450.0

N = 6692. Coefficients for neighborhood disadvantage, proportion Black, and proportion Hispanic are based on a 10 percentage point change. Coefficients for the education ICE are based on a 10 point change.

* $p < 0.10$.

** $p < 0.05$.

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*** $p < 0.01$.