Published in final edited form as:
Soc Forces. 2009 June 1; 87(4): 2063–2092. doi:10.1353/sof.0.0188.

Neighborhood Racial Isolation, Disorder and Obesity

Virginia W. Chang,
University of Pennsylvania

Amy E. Hillier, and
University of Pennsylvania

Neil K. Mehta
University of Pennsylvania

Abstract

Recent research suggests that racial residential segregation may be detrimental to health. This study investigates the influence of neighborhood racial isolation on obesity and considers the role of neighborhood disorder as a mediator in this relationship. For the city of Philadelphia, we find that residence in a neighborhood with high black racial isolation is associated with a higher body mass index and higher odds of obesity among women, but not men, highlighting important sex differences in the influence of neighborhood structure on health. Furthermore, the influence of high racial isolation on women's weight status is mediated, in part, by the physically disordered nature of such neighborhoods. Disorder of a more social nature (as measured by incident crime) is not associated with weight status.

The influence of neighborhood context on health has been the subject of considerable research interest over the past decade, and racial segregation is increasingly a focus of attention. Racial segregation is well known to affect the social and economic well-being of the segregated minority group (Massey 1990), and recent research suggests that it can also affect health, with detrimental effects on general outcomes such as mortality (Collins and Williams 1999; Jackson et al. 2000; LeClere, Rogers and Peters 1997) and overall health status (Subramanian, Acevedo-Garcia and Osypuk 2005). Little is known, however, about how segregation might affect obesity, a specific health outcome that may function as an intermediary link between segregation and more general health measures. Obesity is associated with various morbidities, disability and mortality (Alley and Chang 2007; Calle et al. 1999; Must et al. 1999).

A study by Chang (2006) found that racial segregation, as measured by the black isolation index, is positively associated with BMI and the risk of being overweight among non-Hispanic blacks. For example, an increase of one standard deviation in the isolation index was associated with a 14 percent increase in the odds of being overweight. In keeping with most prior work on segregation, this study measured segregation at the level of the metropolitan statistical area and compared residence across different MSAs. An MSA-level measure of racial isolation, however, *averages* neighborhood conditions within an MSA. Hence, individual outcomes were not linked to individual neighborhoods, and this work was not able to directly assess whether those with higher BMIs actually lived in the more racially isolated neighborhoods of a given MSA. In the current study, we scale down the analysis to measure racial isolation at the neighborhood level, which permits a more direct examination of whether residence in a more segregated neighborhood increases the risk of being overweight.

Direct correspondence to Virginia W. Chang, Department of Medicine, University of Pennsylvania School of Medicine, 1233 Blockley Hall, 423 Guardian Dr., Philadelphia, PA 19104-6021. vwchang@mail.med.upenn.edu.

We also consider neighborhood disorder as a potential mediator in the relationship between segregation and weight status. While the literature on segregation and health has increased significantly in recent years, it has been limited by a lack of attention to specific mediators. Poor, racially isolated neighborhoods are more likely to be disordered, and disorder could affect weight status by discouraging physical activity and generating chronic stress, which can promote weight gain via both physiological and behavioral mechanisms. With respect to behavioral responses, chronic stress can lead to overeating as a coping mechanism, especially among women (Jackson and Knight 2006). Prior work has shown that residents of disordered neighborhoods have worse health as indexed by self-reported health, physical functioning and chronic conditions (Ross and Mirowsky 2001).

Neighborhood Segregation and Disorder

Poor, racially isolated neighborhoods are more likely to be disordered. Neighborhood disorder, or neighborhood *incivilities*, generally refers to observable indicators of social and physical disarray ranging from criminal or uncivil behavior on the streets (e.g., harassment, loitering, etc.) to the degeneration of physical capital, marked by a decline in the appearance, maintenance or functionality of properties and physical structures (e.g., graffiti, vacant lots, abandoned or burned-out housing and unkempt or dilapidated properties). With higher poverty rates among the segregated minority group, racial segregation acts to concentrate poverty in space creating a distinctive social and economic milieu that is short on the resources needed to maintain an orderly public environment (Massey 1990). Poor, racially isolated neighborhoods are weak on collective efficacy, which emphasizes mutual trust and solidarity among neighbors and a willingness to intervene for the common good or active social control of public space (Sampson and Groves 1989; Sampson, Raudenbush and Earls 1997). As a whole, the community is not able to realize the common values of its residents with effective social controls. Additionally, segregation can lead to the development of alternative status and values schemes, which compensate for a disjuncture between dominant socioeconomic goals and structured opportunities. These schemes often reflect a deliberate inversion or disavowal of mainstream counterparts and can inspire disorderly and unlawful behaviors (Anderson 1990; Shihadeh and Flynn 1996; Wilson 1997). Furthermore, concentrated poverty and crime contribute to a self-perpetuating process of disinvestment and eventual withdrawal by landlords, business owners and homeowners alike, resulting in progressive physical dilapidation (Massey 1990). Overall, the lack of both social and economic resources can combine to produce a somewhat menacing local space that is marked by incivility, crime and physical decay (Ross and Mirowsky 2001).

Neighborhood Segregation, Disorder and Weight Status

Neighborhood disorder could affect weight status through a variety of pathways. Work in sociology and criminology demonstrates that neighborhood disorder strongly contributes to fear and the perceived risk of crime (LaGrange, Ferraro and Supancic 1992; Perkins and Taylor 1996; Skogan 1990), and a concern for personal safety is often proposed as a barrier to physical activity (Humpel, Owen and Leslie 2002). The perception of disorder can serve as a heuristic device, providing visual cues to an underlying state of social disorganization with a breakdown of acceptable norms of behavior and the failure of both formal and informal agencies to maintain control (Lewis and Salem 1986; Perkins and Taylor 1996; Skogan 1990). Disorder inspires fear not only by signaling a lack of regard for public order but also by indicating that law enforcement is limited in its ability to maintain order (Taylor and Hale 1986). Residents of neighborhoods with a higher degree of disorder and crime may be less likely to spend leisure time outdoors and, therefore, be less physically active because they fear victimization or harassment. As the fear of crime is rather loosely coupled to actual victimization, such fear may be more reflective of broader conditions in the community such as physical disorder than of direct experiences with crime (LaGrange, Ferraro and Supancic 1992; Lewis and Maxfield 1980; Perkins and Taylor 1996).

In addition to fear and the perception of crime risk, neighborhood disorder is linked to a belief or feeling of powerlessness among residents (Ross, Mirowsky and Pribesh 2001). Powerlessness bears considerable overlap with the concept of self-efficacy from behavioral models based on social cognitive theory (Bandura 1986), and empirical evidence suggests that self-efficacy is an important determinant of physical activity (Dishman, Sallis and Orenstein 1985; Sallis, Hovell and Hofstetter 1992). Communal physical disorder also has an impact on the aesthetic qualities of one's immediate environment. A high proportion of abandoned houses and vacant lots, for example, not only detracts from informal community surveillance but also diminishes the aesthetic quality of the walking and recreational environment. Studies on physical activity show that the perception of positive aesthetic features in one's neighborhood, such as enjoyable scenery, can be associated with increased activity (Ball et al. 2001; Brownson et al. 2001).

Living in a disordered environment also contributes to chronic stress from a variety of sources as residents are confronted on a daily basis with a noxious and distressing local environment characterized by run-down and unkempt properties, vacancies, crime and other visual cues that both formal and informal social control are weak and unreliable (Ross 2000; Ross and Mirowsky 2001). Such chronic exposures to stress may, in turn, have physiological consequences that promote weight gain. The human neuroendocrine system responds to stress by releasing glucocorticoids, steroid hormones that are well known to be associated with weight gain and fat accumulation with chronic exposure (Dallman et al. 2003; Kuo et al. 2007). Indeed, abdominal fat may function as an anatomically localized indicator of prolonged exposure to high levels of glucocorticoids from chronic stress (Kahn et al. 1998).

Stress can also lead to overeating as a coping mechanism, and women in particular are apt to turn to food as a coping response (Jackson and Knight 2006). While this is a psychological response, there is actually a complex interplay between psychological and physiological pathways. Stress and glucocorticoids stimulate appetite and motivate the ingestion of "comfort foods," which are palatable foods containing high levels of fat, sugar and carbohydrates relative to bland foods (Dallman et al. 2003). In fact, the consumption of such foods can assist in curbing the chronic stress response, and the affective experience of anxiety, by initiating a feedback loop that reduces circulating cortisol levels (Dallman et al. 2003; Jackson and Knight 2006). Hence, there is a physiological basis for overeating as a coping response to stress. Lastly, stress may also lead to staying home and sedentary behaviors as a coping mechanism.

There is relatively little prior work on the relationship between racial isolation (or racial segregation more generally) and obesity. As previously noted, Chang (2006) found that segregation, as measured by an MSA-level black isolation index, is positively associated with BMI and the risk of being overweight among non-Hispanic blacks. Robert and Reither (2004) examined the relationship between community percent black and BMI, but did not find a significant association. Work by Boardman et al. (2005), on the other hand, found that neighborhood percent black is significantly associated with an increased risk of obesity, and that this relationship may be mediated by the proportion of co-residents who are obese. None of these studies considered the role of neighborhood disorder and crime as potential mediators. Moreover, there is little empirical data on the relationship between disorder and obesity.

The Present Study

The objective of this study is to investigate the influence of neighborhood racial isolation on weight status and to examine the role of neighborhood disorder as a key mediator in this

NIH-PA Author Manuscript

NIH-PA Author Manuscript

relationship. Specifically, we hypothesize that living in a racially isolated neighborhood is associated with a higher BMI and risk of obesity, and that these relationships will be attenuated after accounting for neighborhood differences in disorder. We combine individual-level data on weight outcomes in Philadelphia with neighborhood-level data on racial composition, physical disorder and social disorder (as measured by crime data). Disorder variables are based on a rich array of objectively measured data collected from multiple municipal agencies in the city of Philadelphia, taking advantage of a unique opportunity to study the influence of objective measures of neighborhood context on obesity.[1] Subjective, self-reported measures of neighborhood context are well known to run the risk of spurious correlations with study outcomes (Duncan and Raudenbush 1999). In this case, for example, persons who are more prone to fear or anxiety (quite independently of actual disorder or crime) may be both more likely to perceive or report neighborhood problems and less likely to engage in outdoor activity (than less fearful persons). We avoid this problem by using disorder data that is objective and acquired independently of study participants.

We also consider the mediating role of a variety of other neighborhood characteristics, including access to park space, recreation centers and supermarkets, as well as the presence of billboards and commercial land use. While the literature on segregation and health continues to grow, less attention has been devoted to the study of potential mediators. Prior work on segregation and obesity has largely relied on census data to assess context, and this has limited the ability to examine mediators such as disorder and other more nuanced neighborhood features. We also consider the extent of potential bias from *unmeasured* confounding in our models. Lastly, we examine the extent to which individual-level racial disparities in weight status can be attributed to neighborhood differences. Despite considerable increases in obesity over the past three decades among all major race/ethnic groups in the United States, disparities between groups have persisted over time, particularly among women. For example, recent estimates show that the prevalence of obesity among non-Hispanic white women is 30 percent, compared to 54 percent among non-Hispanic black women (Ogden et al. 2006). As with other health outcomes, such racial disparities persist despite adjustments for individual socioeconomic differences (Chang and Lauderdale 2005), and there is now increasing attention to the influence of neighborhood environment on obesity.

Methods

Individual-Level Data and Measures

Data on weight status and other individual-level variables are from the 2002 and 2004 *Southeastern Pennsylvania Household Health Survey*, a cross-sectional, population-based telephone survey collected semi-annually by the Philadelphia Health Management Corporation to examine the health of persons living in southeastern Pennsylvania. It serves as the largest and most comprehensive survey of the region's health, and the sample is designed to be representative of the underlying population. We focus on adults (18 and older) residing in the city of Philadelphia, the area for which we have data on neighborhood disorder.

Weight status is assessed with body mass index (BMI: weight [kg]/height [m]^2) based on self-reported height and weight, and respondents were asked to report values without shoes. To correct for potential reporting error in the self-reported measures, we used data from the 1999–2004 *National Health and Examination Survey* to estimate the association between self-reported and measured values (Cawley 2000). The NHANES contains measured values for

[1]Outdoor activity occurs year-round in Philadelphia, as the winters are relatively temperate. Over 2002–2004 (the years pertaining to our individual-level data), average temperatures for the three coldest months (December–February) ranged from 34–39 °F, and average daily highs ranged from 39–45 °F (The Franklin Institute 2008). Philadelphia also gets a limited amount of snow. For the months of December–February, total snowfall averaged 2.96 inches per month for 2002 and 2004 (The Franklin Institute 2008).

height and weight from physical exams as well as self-reported values (also without shoes). Using the NHANES data, we regressed measured weight on self-reported weight, the square of self-reported weight and age. In similar fashion, we regressed measured height on self-reported height and its squared value, adjusting for age. As preliminary analyses suggested some degree of variation by sex, race/ethnicity and age, analyses were stratified by race-sex groups and all models included an interaction between self-reported values and age. We then used the coefficients from these regressions to predict measured height and weight from self-reported values in the SPHHS data. In this manner, weight status calculated from the predicted values is adjusted for self-reporting error. The race/ethnic groups used were non-Hispanic white, non-Hispanic black and Mexican American in the NHANES data. Sample sizes in the NHANES were not adequate for separate analyses of Asians, so self-reported values for Asians in the SPHSS were adjusted using the coefficients estimated for whites. Adjusted values for weight status are used throughout the paper. Regression results are very similar to models estimated using self-reported weight status and key study findings did not differ in any meaningful fashion. We examine BMI as a continuous outcome as well as obesity (BMI ≥ 30).[2]

Key covariates at the individual level include age, sex, race/ethnicity, education, household income, marital status and survey year (2002 vs. 2004). Age is modeled as a continuous variable and includes a squared term given a well-known curvilinear relationship between age and weight status. All other covariates are modeled as categorical variables with dichotomous indicators, as outlined in Table 1. Household income includes a missing category for those who refused or could not answer the survey item. Sensitivity analyses using regression-based imputation did not show any substantive changes to our findings, so we elect to leave these respondents coded as missing. Findings were also robust to two additional sensitivity tests: one where regressions were repeated with all such persons assigned to either the lowest or the highest income category, and a second where regressions were repeated with a separate variable denoting federal poverty status included along with the income variables. For all other variables, data are missing for less than 2 percent of respondents, and missing cases are deleted.

Neighborhood-Level Data and Measures

Racial Isolation—Data on neighborhood-level racial composition, economic status and population size are based on census tract data from the 2000 U.S. Census SF3 files. Residential segregation has been conceptualized along five well known dimensions: unevenness, isolation, centralization, concentration and clustering (Massey and Denton 1988). We focus on the isolation dimension, which is in keeping with several prior studies on segregation and health (Chang 2006; Collins and Williams 1999; Jackson et al. 2000; Robert and Reither 2004; Subramanian, Acevedo-Garcia and Osypuk 2005). At the level of the metropolitan statistical area, the black isolation index is computed as the average percentage of blacks per census tract in the MSA, weighted by the proportion of blacks that live in each tract (Massey and Denton 1988). Because we are able to conduct our analyses at the census tract level, we can focus directly on the percentage of blacks in each tract, permitting a direct analysis of individual neighborhoods rather than relying on an average of neighborhood conditions at the MSA level. Black racial isolation is measured by the percentage of non-Hispanic blacks within a given census tract and is divided into three categories (high: > 60 percent, medium: 20–60 percent and low: < 20 percent), which are modeled with indicator variables. Hispanic racial isolation is also considered, though our primary focus is on black isolation because most neighborhoods in Philadelphia have a very low percentage of Hispanic residents (median 2.7 percent, mean

[2]The SPHHS does not include information on whether or not women were pregnant at the time of the survey, and pregnancy alters weight status. To assess whether our results might be biased by the inclusion of pregnant women, we re-ran all of our models excluding women under the age of 45. Findings for models of BMI as well as obesity were not altered in any meaningful fashion and our study conclusions were unchanged.

7.7 percent). Poverty concentration is measured by the percentage living below the federal poverty line within a given tract.

Physical Disorder—Data on neighborhood disorder are from the University of Pennsylvania's Cartographic Modeling Lab. The *CML's Neighborhood information System* integrates data from 10 different municipal agencies, creating a unique data warehouse on the spatial distribution of physical structures within the city of Philadelphia. An index of physical disorder was created for each census tract based on the following data elements from the years 2000–02: vacant residential properties, vacant lots, housing code violations, fires on property, residential properties owned by the Philadelphia Housing Authority and median residential sales price (Table 2). These variables index the degeneration of physical capital or the material aspects of one's surroundings, i.e., a decline in the appearance, maintenance and functionality of properties and physical structures. With the exception of median sales price, the raw data for each variable took the form of an absolute count and was adjusted for the number of parcels or housing units per census tract (see Table 2). Data across the three years were averaged for each variable, and all variables were log-transformed to reduce skew. A principal components factor analysis confirmed that these variables load on a single factor with loadings of .70–.93. A score for physical disorder was computed by summing the z-scores (standardized values) for each of the six variables, and the index shows good internal consistency with an alpha reliability of .90. Median residential sales price was reverse-coded in creating the score.

Social Disorder - Crime—Data pertaining to crime and social incivilities is also provided by the CML, which formed a research partnership with the Philadelphia Police Department to access incident-level data for crimes. An index of crime and social disorder was created based on the following data from 2000–02: serious crimes against people (e.g., robbery and aggravated assault), serious crimes against property (e.g., burglary, theft, auto theft), criminal mischief and vandalism, disorderly conduct, curfew violations and minor disturbances (Table 2). Each variable was adjusted for the number of persons per census tract, and we averaged data from the years 2000–02. Variables were log-transformed, and a principal components analysis confirmed that they load on a single factor with loadings of .79–.93. A score for social disorder/crime was computed by summing the z-scores for each of the six variables with an alpha reliability of .93. The correlation between the scores for physical and social disorder/crime is .67.[3]

Other Neighborhood Covariates and Potential Mediators—Lastly, we consider adjustments for a variety of other neighborhood factors using data from the CML. We took all available data into consideration and focused on neighborhood characteristics that: (1. are potentially correlated with neighborhood disorder or isolation and (2. could have a plausible influence on weight status. Given the data at hand, we were able to create variables relating to five additional domains: park space, recreation centers, supermarkets, commercial land use and billboards (Table 2). Access to parks and recreation centers can affect physical activity (Humpel, Owen and Leslie 2002); access to supermarkets can affect food choices (Morland, Wing and Diez Roux 2002); commercial and other non-residential land use has been associated with walking and cycling (Hoehner et al. 2005;Saelens, Sallis and Frank 2003); and billboard advertising could encourage the consumption of unhealthy foods. Recent empirical work suggests that billboard and other outdoor advertisements for high calorie/low nutrient products (e.g., fast food and sugar beverages) are more prevalent in black and low income neighborhoods (Hillier et al. forthcoming). The number of recreation centers, supermarkets and billboards were adjusted for census tract area-size. Adjustments for number of persons rather than area

[3]When the variables for physical disorder and crime/social disorder are pooled together, factor analysis with oblique rotation confirms that there are two factors with good separation, and that each variable loads primarily on the expected factor. Prior to rotation, 73 percent of the variance is accounted for by the two factors.

did not meaningfully alter our results. We also considered models where access to parks, recreation centers and supermarkets is operationalized as whether or not the tract centroid (or edge) is within various distances of these factors (e.g., half, three-quarters or 1 mile), and conclusions were again unchanged. All variables are log-transformed to reduce skew.

Analyses

As depicted in the following equation, two-level hierarchical linear regression is used to model the effect of neighborhood-level racial composition and disorder on individual-level BMI, adjusting for covariates at each level.

$$BMI_{ij}=\beta_{0j}+\sum_{k=1}^{K}\beta_{kj}X_{kij}+\sum_{m=1}^{M}\gamma_m Z_{mj}+e_{ij}+u_{0j}$$

Individuals (i) at level one are nested within census tracts/neighborhoods (j) at level two. BMI_{ij} is the body mass index for person i in tract j; X_{ij} are 1, …, K individual-level covariates (e.g., age, education, etc.); Z_j are 1, …, M neighborhood-level covariates (e.g., racial isolation, disorder); and e_{ij} is the individual-level error term. A random effect (u_{0j}) for the level-one intercept (β_{0j}) models between-neighborhood variance in BMI and accounts for the non-independence of persons clustered within the same census tract. Our sample consists of 6,698 persons nested within 348 neighborhoods, with a mean of 19.2 and a median of 18 persons per neighborhood. Analyses with obesity as the outcome variable are similarly modeled using hierarchical generalized linear regression models.

Given prior work suggesting that contextual effects on health may vary by sex, particularly for weight status (Chang and Christakis 2005; Miles 2006; Robert and Reither 2004), we test for interactions between neighborhood variables and sex. Moreover, as noted above, women, and perhaps black women in particular, are more likely to respond to stress by consuming comfort foods as a coping mechanism (Jackson and Knight 2006). Men, on the other hand, may be more likely to engage in substance use (e.g., drugs, tobacco, alcohol) as a coping response to stress (Williams 2003). These responses can have varying implications for weight status. Interactions between neighborhood variables and individual-level race are also considered, as well as interactions between individual-level sex and race. Statistical analyses were conducted with STATA 9.2 and HLM 6.04 software.

Despite adjustments for a large number of *observed* covariates as (discussed above), we further test our results for sensitivity to *unmeasured*, residual confounding. Here, we adapt methods of external adjustment (Lin, Psaty and Kronmal 1998; Schneeweiss 2006) to examine how our estimates of the association between disorder and obesity would be changed by adjusting for a hypothetical confounder with various characteristics. The extent of bias from unmeasured confounding will depend in predictable ways on the prevalence of the putative confounder, its association with obesity, and its association with disorder. We vary these characteristics and quantify the effect of hypothetical confounding on our estimates. In this manner, we get an approximation of what such a confounder would have to be like and how much hidden bias would have to be present to “explain away” our estimates and alter study conclusions (Rosenbaum 1991). We conduct these analyses on our model with obesity as the outcome variable.

Results

Descriptive statistics for individual- and neighborhood-level variables are shown in tables 1 and 2. In our Philadelphia sample, 37 percent of census tracts have a relatively high proportion of black residents (> 60 percent), and 44 percent of tracts have a relatively low proportion (< 20 percent). The average concentration of poverty is 23 percent. Scores for physical and social disorder/crime exhibit a wide range and are approximately normally distributed across tracts. A one-way ANOVA model with BMI as the dependent variable and a random effect for the intercept demonstrates significant variation ($p < .01$) between neighborhoods in BMI with an estimated variance component of 1.91 and an intraclass correlation coefficient of 5 percent. As expected, and consistent with the range of values reported in previous studies on weight status (Boardman et al. 2005;Robert and Reither 2004), the between-area variance is small relative to the within-area variance. A small ICC, however, does not rule out large and meaningful effect sizes associated with differences in neighborhood characteristics (Duncan and Raudenbush 1999).

Body Mass Index

Table 3 displays the results for multivariate regression models for BMI. Statistically significant ($p < .05$) and substantive interactions were found between sex and individual-level race, as well as between sex and specific neighborhood-level variables (racial isolation and physical disorder). Therefore, the coefficients for individual-level race, neighborhood racial isolation and neighborhood physical disorder are listed separately for men and women to facilitate interpretation. Model 1 estimates individual-level racial disparities in BMI, adjusting for individual-level age, sex, education, income, marital status and survey year. Despite adjusting for differences in socioeconomic status, BMI is, on average, significantly higher for black and Latino women relative to white women. In contrast, BMI is significantly lower for Asian women. Among men, such racial differences are in the same direction but much smaller in magnitude and statistically significant only for Asian men.

Model 2 includes the black racial isolation as a neighborhood-level predictor variable. Among women, increasing racial isolation is associated with a monotonic increase in BMI. Living in a neighborhood with high (vs. low) racial isolation is associated with a .992 unit increase in BMI ($p < .01$), despite adjustments for individual differences in age, race, SES and marital status. As points of reference, this difference in BMI is comparable to the difference in estimated BMI between a high school graduate vs. a college graduate (.946 from Model 2, not shown in table), as well as the difference between having < $15,000 vs. ≥ $70,000 in household income (.707 from Model 2). Living in a neighborhood with medium (vs. low) isolation is associated with a .564 unit increase in BMI ($p < .05$). In contrast to women, there is no significant association between BMI and racial isolation among men. No significant interactions were found between racial isolation and individual-level race (i.e., the influence of neighborhood racial isolation on weight status did not vary by the race of the individual resident). Also, no significant effects were found for Hispanic racial isolation, and the findings for black isolation were not sensitive to adjustments for Hispanic isolation.

Model 3 further adjusts for neighborhood poverty levels and population size. Among women, the coefficient for high racial isolation is slightly attenuated (to .956) but remains significant ($p < .01$), suggesting that racial isolation has effects on weight status that are independent of those relating to the concentration of poverty. The estimate for medium (vs. low) isolation is not significant. Model 4 adds physical disorder to the model. As previously noted, there is a statistically significant interaction between sex and physical disorder, so a separate coefficient for physical disorder is listed for each sex. Disorder variables are scaled so that the coefficients represent the change in BMI estimated for an increase from the 25^{th} to 75^{th} percentile of disorder (the inter-quartile range). Physical disorder is significantly associated with BMI among women but not among men. Among women, an inter-quartile increase in physical disorder is associated with a 1.024 unit increase in BMI ($p < .01$). Furthermore, the coefficient for high racial isolation among women is attenuated by ~50 percent and is no longer significant in Model 4, supporting the hypothesis that the effect of neighborhood racial isolation on weight status is mediated by neighborhood physical disorder. Finally, Model 5 further adds social disorder/crime to the model. In contrast to physical disorder, social disorder/crime is not significantly associated with BMI, and this remains the case even if physical disorder is excluded from the model. No significant interactions were found between sex and social disorder or between race and either disorder variable. In comparing Model 1 with Model 5, individual-level racial disparities for black and Latino women are attenuated by adjusting for neighborhood characteristics, but significant disparities remain. The difference between black vs. white women is reduced by 26 percent, and the difference between Latino vs. white women is reduced by 18 percent.

In Table 4, we consider whether our main model is sensitive to the addition of variables for five other selected neighborhood-level factors: parks, recreation centers, supermarkets, commercial land use and billboards. Model 1 is simply the final model from Table 3. In models 2 through 6 we consider the additional neighborhood covariates, one at a time and without disorder. Here, we see that none of the variables is significantly associated with BMI and, furthermore, that none has much influence on the estimate for racial isolation among women. Finally, in Model 7 of Table 4, we add all the new variables simultaneously to Model 1 and show that our estimate for physical disorder is robust to the addition of several key neighborhood controls. Moreover, the addition of such controls does not add much with respect to the attenuation of the isolation estimate.[4]

Obesity

Table 5 displays models that examine obesity, rather than BMI, as the outcome, and the results show a similar pattern. In Model 1, high racial isolation is associated with a 35 percent increase in the odds of being obese among women ($p < .01$), adjusting for neighborhood poverty and population size, as well as all individual-level covariates. Model 2 adds the variables for physical and social disorder/crime to the model, as well as the five other selected neighborhood factors. Our sensitivity analysis of unmeasured confounding (see next section) requires a categorical independent (exposure) variable of interest. Hence, Model 2 shows physical disorder modeled with quartiles to provide baseline estimates for our sensitivity analysis. The effect of racial isolation is no longer significant in Model 2, and physical disorder shows a monotonic, positive relationship with obesity. Those in the 4^{th} (highest) quartile have 78 percent higher odds of obesity relative to the 1^{st} (lowest) quartile ($p < .01$), and those in the 3^{rd} quartile have 57 percent higher odds ($p < .01$). Social disorder/crime and the other neighborhood covariates are again not significant with the exception of percent commercial parcels, which is associated with lower odds of obesity. Lastly, findings for models of BMI and obesity were not changed in any meaningful fashion by excluding underweight (BMI < 18.5) persons from the sample or by adjusting for smoking status.

Sensitivity Analyses for Unmeasured Confounding

Despite adjustments for a large number of *observed* covariates, we further consider the sensitivity of our results to adjustment for a *hypothetical unmeasured* confounder (Lin, Psaty and Kronmal 1998; Schneeweiss 2006). Table 6 shows how estimates from Model 2 of Table 5 for the association between physical disorder and obesity among women (ORs for 3^{rd} and 4^{th} quartiles of disorder vs. 1^{st} quartile) would be influenced by adjusting for a hypothetical confounder (C) with various characteristics. We vary the strength of the association between

[4]The SPHHS has three questions on “neighborhood” food access. It asks respondents about the ease of finding fruit; the quality of grocery stores; and whether they have to travel outside the neighborhood for a supermarket. In keeping with our results using the objective measure of supermarket access, the inclusion of these self-reported variables did not attenuate the association between segregation and weight status.

C and obesity (OR C-obesity: 1.50 to 2.00) as well as the prevalence of C (.0 to .6) in the disorder category (quartile) under consideration. Additionally, we assume that the prevalence of C is 50 percent higher in the disorder category under consideration relative to the base category (1^{st} quartile). As expected, the estimates for the association between disorder and obesity are unchanged when the prevalence of the confounder is 0 (see table). Here, the ORs for the association between physical disorder and obesity are the same as in Model 2 of Table 5: 1.57 for the 3^{rd} (vs. 1^{st}) quartile, and 1.78 for the 4^{th} (vs. 1^{st}) quartile. As the strength of the association between C and obesity increases, and as the prevalence of C increases, the *adjusted* ORs between disorder and obesity decrease. The ORs remain above 1.00, however, at all combinations. Furthermore, all estimates remain significant ($p < .05$). Hence, our estimates are highly robust to bias from an unobserved confounder, and we are not able to "explain away" our estimates. Moreover, an OR of 2.00 for C-obesity is in excess of all observed ORs between obesity and the measured covariates of our models, including individual-level factors.

Discussion

This study investigates the influence of segregation, specifically neighborhood racial isolation, on weight status and considers the hypothesis that neighborhood disorder is a mediator in this relationship. Among women, we find that residence in a neighborhood with high (vs. low) black isolation is associated with higher weight status and an increased risk of being obese, despite adjustments for neighborhood poverty and individual-level socioeconomic factors. Hence, women experience a higher risk of obesity when living in a more racially isolated neighborhood, above and beyond the influence of personal disadvantages such as those relating to education and income. Racially isolated neighborhoods are more likely to be disordered, and we find that physical disorder mediates the relationship between racial isolation and weight status. Moreover, the association between disorder and weight status was robust to adjustments for a variety of other key neighborhood characteristics (e.g., access to park space, recreation centers and supermarkets), as well as a sensitivity analysis for unmeasured confounding. With respect to individual-level racial disparities in weight status, significant differences remain despite adjustments for both individual- and neighborhood-level characteristics.

We use objectively measured data on neighborhood disorder collected from multiple municipal agencies in Philadelphia, avoiding the risk of bias incurred by self-reported disorder. Physical disorder refers to observable indicators of physical disarray, including degeneration and decline in the appearance and functionality of surrounding properties (e.g., vacant lots, abandoned or burned-out properties, unkempt or dilapidated housing, etc.). Such a state of disorder can act as a heuristic device, providing visual clues to the failure of both formal and informal agencies to maintain social control. As such, living in a disordered environment may lead to chronic stress with increased cortisol secretion, a sense of fear and powerlessness, overeating, and a reluctance to engage in outdoor activity, all of which can have effects on weight status. Furthermore, in the context of prior work linking segregation to an increased risk of mortality and poor health, as well as prior work linking disorder to poor health (Ross and Mirowsky 2001), unhealthy weight status may function as an intermediary outcome in these relationships.

Interestingly it is *physical* rather than social disorder that is relevant to weight status in our study. Social disorder, as indexed by incident crime data, was not significantly associated with BMI or obesity. Hence, it may be the case that physical disorder is more pertinent to weight-related outcomes than markers of social disorder such as crime. As previously noted, the fear of crime is somewhat loosely coupled to actual victimization, so such fear may be more reflective of broader local conditions such as physical disorder than of direct experiences with crime. Physical disorder also detracts from the aesthetic qualities of one's environment, which further lessens any motivation for outdoor activity. It may also be the case, however, that it is social incivilities of a more informal nature, i.e., those that are not well-captured by official crime data, that are important to our outcomes.

Another key finding is that both segregation and disorder are positively associated with weight status for women but not men. While an explanation for this difference is not readily apparent, there are various possibilities. First, disorder may precipitate a greater quantity, or perhaps different quality, of psychological stress among women. Moreover, coping responses to stress are known to vary by sex. For example, women are more apt to engage in overeating as a coping mechanism for stress (Jackson and Knight 2006). Jackson and Knight (2006) argue that among black women, overeating is learned early in life as a culturally acceptable behavior and antidote to chronic stress. Women may also be more likely to restrict their outdoor activity in response to fear. Men, on the other hand, are generally more physically active than women and are more likely to engage in substance use (e.g., drugs, tobacco, alcohol) as a coping response to stress (Williams 2003). While overeating typically leads to weight gain, smoking and substance abuse can be associated with weight loss. Overall, the sex differences we find may reflect highly gendered responses to stress and coping (Williams 2003).

Second, men may be more likely to leave the neighborhood for work, thereby experiencing less isolation and exposure to neighborhood Stressors. Third, given that weight status is correlated with both rate and poverty (Chang and Lauderdale 2005), the status of being obese; is probably fast approaching the norm in hyper-segregated urban enclaves, and women may be more likely to calibrate personal weight standards relative to community norms. Women are more likely than men to compare themselves to others (particularly other women) with respect to appearance (Graziano et al. 1993), and shifting local weight standards may act to mitigate the broader social stigma of obesity. Indeed, recent empirical work has shown that obesity is positively associated with the proportion of one's neighbors who are obese, and supports the hypothesis that racial isolation affects weight status through an influence on local weight norms (Boardman et al. 2005). Additionally, many studies have shown that blacks tend to be more tolerant than whites of heavier weights (Kumanyika 1998), and racial isolation would act to concentrate such standards, again shifting the overarching community norm away from mainstream counterparts.

Other studies on weight status and residential context have also suggested that contextual effects may be stronger for women than men (Chang and Christakis 2005; Robert and Reither 2004). Along with the current study, these findings suggest that there can be important sex differences in the relationship between the structured environment and health. As a whole, studies on the role of neighborhood factors in conditioning health tend to focus on poverty and race, potentially overlooking the fact that men and women may experience certain neighborhood elements quite differently. Indeed, such sex differences may contribute, to some degree, to the observation of larger racial disparities in weight status among women. In our study, however, significant racial disparities remained despite adjustments for multiple individual- and neighborhood-level factors.

In keeping with prior work finding that weight status is positively associated with racial isolation measured at the MSA level (Chang 2006), we find that this relationship is preserved when isolation is measured at the neighborhood level and persons are linked to individual neighborhoods. Our findings differ, however, from those of a study by Robert and Reither (2004) where community percent black was not associated with BMI. While their study used data from the 1980s, this study uses data from the 2000s, and the bulk of recent and dramatic shifts in the population-level distribution of weight status occurred during this interval (Chang and Lauderdale 2005; Ogden et al. 2006). Given the large number of environmental changes that are thought to contribute to such shifts, as well as a concomitantly changing cultural context, the various weight-promoting pathways relating to segregation may be more salient now than they were in the past.

The influence of racial isolation and disorder on weight status did not vary by the race of the individual resident, which is largely in keeping with prior expectations as well as work on other outcomes at the neighborhood level. LeClere, Rogers and Peters (1997), for example, find that neighborhoods with a high concentration of blacks confer a greater risk of mortality for blacks but also for whites and Mexican Americans. The broader material and structural disadvantages that are precipitated by racial isolation and the concentration of black poverty can have a negative influence on all residents of a given neighborhood regardless of race. We had no prior reason, for example, to expect neighborhood physical disorder to have a greater effect on one group vs. another. In contrast, prior work by Chang (2006) found that racial isolation, as measured by an MSA isolation index, was associated with weight status for blacks but not whites. This finding is not inconsistent with those of the current study because an MSA isolation index *averages* neighborhood conditions across a given MSA. Specifically, the black isolation index is computed as the average percentage of blacks per census tract in the MSA, weighted by the proportion of blacks that live in each census tract. Hence, while blacks may suffer greater disadvantage in MSAs with a higher isolation index, whites may fare better in such cities because they are more isolated or buffered from the correlates of black poverty. In short, the expectation of racial differences can be highly dependent on how isolation is measured (e.g., neighborhood-level percent black vs. MSA-level isolation index).

Limitations

There are limitations to this study. First, we did not have access to sufficiently detailed measures on individual-level mediators such as diet, physical activity and stress. Adjusting for such factors using the somewhat crude measures available in our data did little to attenuate the association between neighborhood disorder and weight status. Given the limited number of pathways by which differences in weight status can be produced, this lack of attenuation suggests that our behavior and stress variables are insufficiently detailed to capture relevant physiological differences. It is well known that very small caloric imbalances (e.g., 100 calories/day) can lead to significant weight changes over time (Cutler, Glaeser and Shapiro 2003), and our measures are simply not designed to capture such differences.

Second, this study is cross-sectional and cannot rule out the possibility that weight status may influence place of residence. It seems unlikely, however, that a person's weight status would have any major effect on place of residence over and above well known determinants of residential mobility such as race, education and income, all of which are adjusted for in our analyses. Also, our findings were robust to sensitivity analyses where we restrict the sample to persons who have been living in the same neighborhood for at least five years. Furthermore, the hypothesis that neighborhood can have a causal influence on obesity is supported by recent findings from Moving to Opportunity, a large-scale randomized experiment wherein some families living in high-poverty housing projects were offered vouchers to move to lower poverty neighborhoods (experimental group), while others were not offered vouchers (Kling, Liebman and Katz 2007). The experimental group subsequently had a lower risk of obesity relative to the control group. Lastly, we note that there is racial and ethnic variation in the percentage of body fat associated with a given BMI (Deurenberg, Yap and van Staveren 1998). Hence, the use of a single, standard cut-point for obesity may not suit all groups, especially when used to establish thresholds of health risk.

Conclusions

In sum, we find that neighborhood racial isolation is positively associated with weight status and the risk of obesity among women (but not men), and that this relationship is mediated by

NIH-PA Author Manuscript

NIH-PA Author Manuscript

the physically disordered nature of segregated neighborhoods. We advance prior work in this area by scaling the analysis down to a neighborhood level and by using more recent data. Furthermore, this is the first study to examine the intermediary role of neighborhood disorder. We find that the presence of physical disorder may be more relevant to weight status than the presence of crime-related social disorder. Lastly, our findings highlight important sex differences in the influence of neighborhood structure on health.

While it has long been noted by social scientists that segregation and disorder can have a remarkable impact on the social fabric of urban life, our findings contribute further evidence that there are specific effects on health as well. Hence, health behaviors at the individual level are ultimately conditioned by risk factors organized at a spatial level, and differences between places are an important component to consider in health promotion and policy efforts. For example, public health campaigns that encourage exercise may be irrelevant to persons in disadvantaged neighborhoods with little opportunity and multiple disincentives to engage in such activity. Finally weight status can go on to affect individual status attainments for women. Empirical evidence suggests that being overweight or obese can have a negative influence on education, wages and occupational attainment, as well as marital mobility (Gortmaker et al. 1993; Pagan and Davila 1997). Hence, if segregation really does increase the risk of a normatively undesirable weight outcome, then the *body itself* may play a non-trivial role in the overall cycle of segregation and individual poverty and dislocation among women in the United States.

Acknowledgments

This research was supported by grant RWJF ID #052210 from the Robert Wood Johnson Foundation Active Living Research Program and grant K12-HD043459 from the National Institute of Child Health and Human Development. We are grateful to Jason Schnittker, Theodore Iwashyna and three anonymous reviewers for their constructive comments and suggestions. We also thank Mikko Myrskylä for assistance with portions of the analysis. Early versions of this paper benefited from presentations at the Department of Sociology Colloquium Series at the University of Pennsylvania, the Department of Health Studies Seminar Series at the University of Chicago, the Wagner Research Colloquium at New York University and the American Sociological Association Annual Meeting in 2008. Chang is with the Philadelphia Veterans Affairs Medical Center and the Departments of Medicine and Sociology at the University of Pennsylvania.

References

Alley, Dawn E.; Chang, Virginia W. The Changing Relationship of Obesity and Disability, 1988–2004. JAMA 2007;298(17):2020–27. [PubMed: 17986695]

Anderson, Elijah. Streetwise: Race, Class, and Change in an Urban Community. University of Chicago Press; 1990.

Ball, Kylie; Bauman, Adrian; Leslie, Eva; Owen, Neville. Perceived Environmental Aesthetics and Convenience and Company Are Associated with Walking for Exercise among Australian Adults. Preventive Medicine 2001;33(5):434–40. [PubMed: 11676585]

Bandura, Albert. Social Foundations of Thought and Action: A Social Cognitive Theory. Prentice Hall; 1986.

Boardman, Jason D.; Saint Onge, Jarron M.; Rogers, Richard G.; Denney, Justin T. Race Differentials in Obesity: The Impact of Place. Journal of Health and Social Behavior 2005;46(3):229–43. [PubMed: 16259146]

Brownson, Ross C.; Baker, Elizabeth A.; Housemann, Robyn A.; Brennan, Laura K.; Bacak, Stephen J. Environmental and Policy Determinants of Physical Activity in the United States. American Journal of Public Health 2001;91(12):1995–2003. [PubMed: 11726382]

Calle, Eugenia E.; Thun, Michael J.; Petrelli, Jennifer M.; Rodriguez, Carmen; Heath, Clark W, Jr. Body-Mass Index and Mortality in a Prospective Cohort of U.S. Adults. New England Journal of Medicine 1999;341(15):1097–105. [PubMed: 10511607]

Cawley, John. Working Paper No. 7841. Cambridge, MA: National Bureau of Economic Research; 2000. Body Weight and Women's Labor Market Outcomes.

Chang, Virginia W. Racial Residential Segregation and Weight Status among US Adults. Social Science & Medicine 2006;63(5):1289–1303. [PubMed: 16707199]

Chang, Virginia W.; Christakis, Nicholas A. Income Inequality and Weight Status in US Metropolitan Areas. Social Science & Medicine 2005;61(1):83–96. [PubMed: 15847964]

Chang, Virginia W.; Lauderdale, Diane S. Income Disparities in Body Mass Index and Obesity in the United States, 1971–2002. Archives of Internal Medicine 2005;165(18):2122–28. [PubMed: 16217002]

Collins, Chiquita A.; Williams, David R. Segregation and Mortality: The Deadly Effects of Racism? Sociological Forum 1999;14(3):495–523.

Cutler, David M.; Glaeser, Edward L.; Shapiro, Jesse M. Why Have Americans Become More Obese? Journal of Economic Perspectives 2003;17(3):93–118.

Dallman, Mary F.; Pecoraro, Norman; Akana, Susan F.; la Fleur, Susanne E.; Gomez, Francisca; Houshyar, Hani; Bell, ME.; Bhatnagar, Seema; Laugero, Kevin D.; Manolo, Sotara. Chronic Stress and Obesity: A New View of 'Comfort Food.'. Proceedings of the National Academy of Sciences of the United States of America 2003;100(20):11696–701. [PubMed: 12975524]

Deurenberg P, Yap M, van Staveren WA. Body Mass Index and Percent Body Fat: A Meta Analysis among Different Ethnic Groups. International Journal of Obesity 1998;22(12):1164–71. [PubMed: 9877251]

Dishman, Rod K.; Sallis, James F.; Orenstein, Diane R. The Determinants of Physical Activity and Exercise. Public Health Reports 1985;100(2):158–71. [PubMed: 3920714]

Duncan, Greg J.; Raudenbush, Stephen W. Assessing the Effects of Context in Studies of Child and Youth Development. Educational Psychologist 1999;34(1):29–41.

Gortmaker, Steven L.; Must, Aviva; Perrin, James M.; Sobol, Arthur M.; Dietz, William H. Social and Economic Consequences of Overweight in Adolescence and Young Adulthood. New England Journal of Medicine 1993;329(14):1008–12. [PubMed: 8366901]

Graziano, William G.; Jensen-Campbell, Lauri A.; Shebilske, Laura J.; Lundgren, Sharon R. Social Influence, Sex Differences, and Judgments of Beauty: Putting the *Interpersonal* Back in Interpersonal Attraction. Journal of Personality and Social Psychology 1993;65(3):522–31.

Hillier, Amy; Cole, Brian L.; Smith, Tony E.; Yancey, Antronette K.; Williams, Jerome D.; Grier, Sonya; McCarthy, William. Forthcoming. "Clustering of Unhealthy Outdoor Advertisements around Child-Serving Institutions: A Comparison of Three Cities". Health & Place.

Hoehner, Christine M.; Brennan Ramirez, Laura K.; Elliott, Michael B.; Handy, Susan L.; Brownson, Ross C. Perceived and Objective Environmental Measures and Physical Activity Among Urban Adults. American Journal of Preventive Medicine 2005;28(2S2):105–16. [PubMed: 15694518]

Humpel, Nancy; Owen, Neville; Leslie, Eva. Environmental Factors Associated with Adults' Participation in Physical *Activity*. American Journal of Preventive Medicine 2002;22(3):188–99. [PubMed: 11897464]

Jackson, James S.; Knight, Katherine M. Race and Self-Regulatory Health Behaviors: The Role of the Stress Response and the HPA Axis in Physical and Mental Health Disparities. In: Schaie, K Warner; Carstensen, Laura L., editors. Social Structures, Aging, and Self-Regulation in the Elderly. Springer; 2006. p. 189-208.

Jackson, Sharon A.; Anderson, Roger T.; Johnson, Norman J.; Sorlie, Paul D. The Relation of Residential Segregation to All-Cause Mortality: A Study in Black and White. American Journal of Public Health 2000;90(4):615–17. [PubMed: 10754978]

Kahn, Henry S.; Tatham, Lilith M.; Pamuk, Elsie R.; Heath, Clark W, Jr. Are Geographic Regions with High Income Inequality Associated with the Risk of Abdominal Weight Gain? Social Science & Medicine 1998;47(1):1–6. [PubMed: 9683373]

Kling, Jeffrey R.; Liebman, Jeffrey B.; Katz, Lawrence F. Experimental Analysis of Neighborhood Effects. Econometrica 2007;75(1):83–119.

Kumanyika, Shiriki K. Obesity in African Americans: Biobehavioral Consequences of Culture. Ethnicity and Disease 1998;8(1):93–6. [PubMed: 9595252]

Kuo, Lydia E.; Kitlinska, Joanna B.; Tilan, Jason U.; Li, Lijun; Baker, Stephen B.; Johnson, Michael D.; Lee, Edward W.; Burnett, Mary Susan; Fricke, Stanley T.; Kvetnansky, Richard; Herzog, Herbert; Zukowska, Zofia. Neuropeptide Y Acts Directly in the Periphery on Fat Tissue and Mediates Stress-Induced Obesity and Metabolic Syndrome. Nature Medicine 2007;13(7):803–11.

LaGrange, Randy L.; Ferraro, Kenneth F.; Supancic, Michael. Perceived Risk and Fear of Crime: Role of Social and Physical Incivilities. Journal of Research in Crime and Delinquency 1992;29(3):311–34.

LeClere, Felicia B.; Rogers, Richard G.; Peters, Kimberley D. Ethnicity and Mortality in the United States: Individual and Community Correlates. Social Forces 1997;76(1):169–98.

Lewis, Dan A.; Maxfield, Michael G. Fear in the Neighborhoods: An Investigation of the Impact of Crime. Journal of Research in Crime and Delinquency 1980;17(2):160–89.

Lewis, Dan A.; Salem, Greta. Fear of Crime: Incivility and the Production of a Social Problem. Transaction; 1986.

Lin DY, Psaty BM, Kronmal RA. Assessing the Sensitivity of Regression Results to Unmeasured Confounders in Observational Studies. Biometrics 1998;54(3):948–63. [PubMed: 9750244]

Massey, Douglas S. American Apartheid: Segregation and the Making of the Underclass. American Journal of Sociology 1990;96(2):329–57.

Massey, Douglas S.; Denton, Nancy A. The Dimensions of Residential Segregation. Social Forces 1988;67(2):281–315.

Miles, Rebecca. Neighborhood Disorder and Smoking: Findings of a European Urban Survey. Social Science & Medicine 2006;63(9):2464–75. [PubMed: 16904800]

Morland, Kimberly Steve Wing; Roux, Ana Diez. The Contextual Effect of the Local Food Environment on Residents' Diets: The Atherosclerosis Risk in Communities *Study*. American Journal of Public Health 2002;92(11):1761–67. [PubMed: 12406805]

Must, Aviva; Spadano, Jennifer; Coakley, Eugenie E.; Field, Alison E.; Colditz, Graham; Dietz, William H. The Disease Burden Associated with Overweight and Obesity. JAMA 1999;282(16):1523–9. [PubMed: 10546691]

Ogden, Cynthia L.; Carroll, Margaret D.; Curtin, Lester R.; McDowell, Margaret A.; Tabak, Carolyn J.; Flegal, Katherine M. Prevalence of Overweight and Obesity in the United States, 1999–2004. JAMA 2006;295(13):1549–55. [PubMed: 16595758]

Pagan, Jose A.; Davila, Alberto. Obesity Occupational Attainment, and Earnings. Social Science Quarterly 1997;78(3):756–70.

Perkins, Douglas D.; Taylor, Ralph B. Ecological Assessments of Community Disorder: Their Relationship to Fear of Crime and Theoretical Implications. American Journal of Community Psychology 1996;24(1):63–107. [PubMed: 8712188]

Robert, Stephanie A.; Reither, Eric N. A Multilevel Analysis of Race, Community Disadvantage, and Body Mass Index among Adults in the US. Social Science & Medicine 2004;59(12):2421–34. [PubMed: 15474198]

Rosenbaum, Paul R. Discussing Hidden Bias in Observational Studies. Annals of Internal Medicine 1991;115(11):901–5. [PubMed: 1952480]

Ross, Catherine E. Neighborhood Disadvantage and Adult Depression. Journal of Health and Social Behavior 2000;41(2):177–87.

Ross, Catherine E.; Mirowsky, John. Neighborhood Disadvantage, Disorder, and Health. Journal of Health and Social Behavior 2001;42(3):258–76. [PubMed: 11668773]

Ross, Catherine E.; Mirowsky, John; Pribesh, Shana. Powerlessness and the Amplification of Threat: Neighborhood Disadvantage, Disorder, and Mistrust. American Sociological Review 2001;66(4):568–91.

Saelens, Brian E.; Sallis, James F.; Frank, Lawrence D. Environmental Correlates of Walking and Cycling: Findings From the Transportation, Urban Design, and Planning Literatures. Annais of Behavioral Medicine 2003;25(2):80–91.

Sallis, James F.; Hovell, Melbourne F.; Hofstetter, C Richard. Predictors of Adoption and Maintenance of Vigorous Physical Activity in Men and Women. Preventive Medicine 1992;21(2):237–51. [PubMed: 1579558]

Sampson, Robert J.; Groves, W Byron. Community Structure and Crime: Testing Social-Disorganization Theory. American Journal of Sociology 1989;94(4):774–802.

Sampson, Robert J.; Raudenbush, Stephen W.; Earls, Felton. Neighborhoods and Violent Crime: A Multilevel Study of Collective Efficacy. Science 1997;277(5328):918–24. [PubMed: 9252316]

Schneeweiss, Sebastian. Sensitivity Analysis and External Adjustment for Unmeasured Confounders in Epidemiologic Database Studies of Therapeutics. Pharmacoepidemiology and Drug Safety 2006;15 (5):291–303. [PubMed: 16447304]

Shihadeh, Edward S.; Flynn, Nicole. Segregation and Crime: The Effect of Black Social Isolation on the Rates of Black Urban Violence. Social Forces 1996;74(4):1325–52.

Skogan, Wesley G. Disorder and Decline: Crime and the Spiral of Decay in American Communities. Free Press; 1990.

Subramanian SV, Acevedo-Garcia Dolores, Osypuk Theresa L. Racial Residential Segregation and Geographic Heterogeneity in Black/White Disparity in Poor Self-Rated Health in the US: A Multilevel Statistical Analysis. Social Science & Medicine 2005;60(8):1667–79. [PubMed: 15686800]

Taylor, Ralph B.; Hale, Margaret. Testing Alternative Models of Fear of Crime. Journal of Criminal Law and Criminology 1986;77(1):151–89.

The Franklin Institute. Philadelphia Weather Data. 2008. Available at: http://www.fi.edu/weather/data/index.html

Williams, David R. The Health of Men: Structured Inequalities and Opportunities. American Journal of Public Health 2003;93(5):724–31. [PubMed: 12721133]

Wilson, William J. When Work Disappears: The World of the New Urban Poor. Vintage Books; 1997.

Table 1

Descriptive Statistics for Individual-Level Variables

Variable	Mean (SD) or %
BMI	27.3 (6.4)
Obese (BMI ≥ 30)	26.6
Age (years)	46.5 (18.2)
Female	65.8
Race/Ethnicity	
White	42.9
Black	38.3
Latino	7.8
Asian	9.0
Other	2.0
Education	
Less than HS (0–11 yrs)	14.3
HS Graduate (12 yrs)	36.3
Some College (13–15 yrs)	21.1
College Graduate (16 yrs)	17.3
Post College (> 16 yrs)	11.1
Household Income	
< $15,000	18.8
$15,000 < $30,000	18.9
$30,000 < $50,000	13.0
$50,000 < $70,000	14.4
$70,000 or More	16.8
Don’t Know/Missing	18.3
Married	40.9
Survey Year	
2002	51.8
2004	48.2

Note: N = 6,698.

Table 2

Descriptive Statistics for Neighborhood Variables

Variables	Mean (SD) or %	Units
% Non-Hispanic Black		
High (> 60)	37.4	
Medium (20–60)	19.0	
Low (< 20)	43.7	
% Hispanic	7.7 (14.8)	
% Below the Federal Poverty Line	22.8 (14.7)	
Population Size	4.29 (2.25)	1000 persons
Physical Disorder		
Vacant Residential Properties	5.67 (7.16)	# per 100 residential parcels
Vacant Lots	7.94 (10.25)	# per 100 parcels
Housing Code Violations	18.45 (23.94)	# per 100 occupied housing units
Fires on Property	.57 (.57)	# per 100 parcels
PHA-owned Residential Properties	1.73 (5.30)	# per 100 residential parcels
Median Residential Sales Price	8.04 (9.49)	$10,000
Score (IQ range:−4.10–3.63)	.00 (4.87)	
Social Disorder/Crime		
Serious Crimes Against Persons	1.37 (1.12)	# per 100 persons
Serious Crimes Against Property	6.45 (6.91)	# per 100 persons
Criminal Mischief and Vandalism	1.61 (1.18)	# per 100 persons
Disorderly Conduct	.44 (1.00)	# per 100 persons
Curfew Violations	1.27 (1.33)	# per 100 persons
Minor Disturbances	6.70 (4.53)	# per 100 persons
Score (IQ range: −3.09–2.83)	.00 (5.21)	
Other Covariates		
% Park Area	4.81 (8.65)	
Recreation Centers	2.00 (3.46)	# per square mile
Supermarkets	1.68 (3.57)	# per square mile
% Commercial Parcels	4.81 (5.29)	
Billboards	15.91 (21.60)	# per square mile

Notes: Mean and SD reflect the distribution across census tracts in our sample. Disorder data are per year and averaged across the years 2000–02. Scores for each dimension of disorder were computed by summing the z-scores (standardized values) for each of the six component variables. Residential sales price was reverse-coded in creating the score. PHA: Philadelphia Housing Authority. IQ: inter-quartile range. N = 348.

Table 3

Models for Body Mass Index

	Coefficient (z)				
	Model 1	**Model 2**	**Model 3**	**Model 4**	**Model 5**
Neighborhood-level					
Racial Isolation					
Estimates for Women:					
% Non-Hispanic Black					
> 60		.992** (3.53)	.956** (3.32)	.509 (1.66)	.480 (1.53)
20–60		.564* (2.04)	.518 (1.83)	.365 (1.28)	.350 (1.22)
< 20		–	–	–	–
Estimates for Men:					
% Non-Hispanic Black					
> 60		−.100 (−.26)	−.141 (−.36)	.177 (.41)	.142 (.33)
20–60		−.126 (−.34)	−.168 (−.45)	.081 (.21)	.063 (.16)
< 20		–	–	–	–
% Below Poverty			.052 (.79)	−.151(−1.44)	−.147 (−1.41)
Population Size			.006 (.17)	.034 (.91)	.031 (.84)
Physical Disorder					
Estimate for Women				1.024** (3.63)	1.089** (3.52)
Estimate for Men				−.147 (−.44)	−.076 (−.21)
Social Disorder/Crime					−.073 (−.52)
Individual-Level					
Race/Ethnicity					
Estimates for Women:					
Black	3.037** (14.81)	2.381** (8.63)	2.357** (8.50)	2.249** (8.08)	2.244** (8.06)
Latino	2.586** (7.11)	2.397** (6.49)	2.343** (6.24)	2.112** (5.57)	2.113** (5.58)
Asian	−3.718** (−9.46)	−3.847** (−9.73)	−3.877** (−9.76)	−3.892** (−9.80)	−3.885** (−9.77)
White or Other	–	–	–	–	–

	Coefficient (z)				
	Model 1	Model 2	Model 3	Model 4	Model 5
Neighborhood-level					
Estimates for Men:					
Black	.205 (.70)	.274 (.71)	.259 (.67)	.367 (.95)	.367 (.95)
Latino	.742 (1.44)	.764 (1.46)	.721 (1.38)	.977 (1.85)	.974 (1.84)
Asian	−2.864** (−7.06)	−2.837** (−6.83)	−2.868** (−6.87)	−2.750** (−6.58)	−2.740** (−6.55)
White or Other	–	–	–	–	–
Male	.338 (1.45)	.522* (2.11)	.520* (2.10)	−.059 (−.20)	−.058 (−.20)
Age	.404** (16.95)	.402** (16.92)	.402** (16.91)	.401** (16.88)	.401** (16.89)
Age2	−.004** (−16.07)	−.004** (−16.07)	−.004** (−16.05)	−.004** (−16.01)	−.004** (−16.02)
Education					
Less than HS (0–11 yrs)	2.207** (6.72)	2.255** (6.87)	2.230** (6.76)	2.160** (6.54)	2.170** (6.56)
HS Graduate (12 yrs)	1.409** (5.20)	1.447** (5.34)	1.438** (5.30)	1.388** (5.11)	1.394** (5.13)
Some College (13–15 yrs)	.959** (3.36)	.988** (3.46)	.987** (3.45)	.951** (3.33)	.953** (3.34)
College Graduate (16 yrs)	.483 (1.67)	.501 (1.74)	.506 (1.75)	.484 (1.68)	.485 (1.68)
Post College (> 16 yrs)	–	–	–	–	–
Household Income					
< $15,000	.745* (2.58)	.707* (2.45)	.671* (2.29)	.637* (2.18)	.643*(2.20)
$15,000 < $30,000	.394 (1.44)	.374 (1.37)	.349 (1.27)	.332 (1.21)	.338 (1.23)
$30,000 < $40,000	.254 (.89)	.232 (.81)	.215 (.75)	.224 (.78)	.229 (.80)
$40,000 < $70,000	.456 (1.68)	.431 (1.59)	.422 (1.55)	.414 (1.53)	.419 (1.54)
Don't Know Missing	.576* (2.08)	.558* (2.02)	.539 (1.94)	.527 (1.90)	.530 (1.91)
$70,000 or More	–	–	–	–	–
Married	−.242 (−1.48)	−.223 (−1.36)	−.217 (−1.32)	−.230 (−1.40)	−.230 (−1.41)
Survey Year 2004 (vs. 2002)	−.116 (−.77)	−.126 (−.83)	−.124 (−.82)	−.129 (−.86)	−.129 (−.86)

Notes: Model includes interaction terms between sex and the following variables, neighborhood racial isolation (as measured by the percentage of residents who are non-Hispanic black), neighborhood physical disorder, and individual-level race. Hence, the coefficients for these variables are listed separately for women and men. The coefficient for male above is the main effect of sex. Disorder variable are scaled so that an increase of one unit represents an increase from 25^{th} to the 75^{th} percentile of disorder (the inter-quartile range). Percent below poverty is scaled so that one unit represents 10 percentage points. Population size is scaled so that one unit represents 1,000 persons.

* $p < .05$

** $p < .01$. N = 6,698.

NIH-PA Author Manuscript

NIH-PA Author Manuscript

Table 4

Models for Body Mass Index with other Selected Neighborhood Covariates

	Coefficient (z)						
	Model 1	**Model 2**	**Model 3**	**Model 4**	**Model 5**	**Model 6**	**Model 7**
Neighborhood-Level							
Racial Isolation							
Estimates for Women:							
% Non-Hispanic Black							
> 60	.480 (1.53)	1.008** (3.47)	.950** (3.30)	.927** (3.21)	.926** (3.17)	.988** (3.42)	.474 (1.47)
20–60	.350 (1.22)	.527 (1.86)	.510 (1.80)	.511 (1.80)	.498 (1.75)	.534 (1.88)	.330 (1.15)
< 20	–	–	–	–	–	–	–
Estimates for Men:							
% Non-Hispanic Black							
> 60	.142 (.33)	−.088 (−.22)	−.151 (−.38)	−.168 (−.43)	−.177 (−.44)	−.106 (−.27)	.116 (.26)
20–60	.063 (.16)	−.167 (−.45)	−.174 (−.47)	−.169 (−.45)	−.191 (−.51)	−.152 (−.41)	.022 (.06)
< 20	–	–	–	–	–	–	–
% Below Poverty	−.147 (−1.41)	.053 (.80)	.057 (.87)	.074 (1.10)	.069 (.96)	.038 (.56)	−.137 (−1.30)
Population Size	.031 (.84)	.006 (.17)	.005 (.13)	.001 (.03)	.000 (.01)	.008 (.22)	.021 (.55)
Physical Disorder							
Estimate for Women	1.089** (3.52)						1.119** (3.59)
Estimate for Men	−.076 (−.21)						−.026 (−.07)
Social Disorder/Crime	−.073(−.52)						.005(.03)
% Park Area		.205(1.31)					.221(1.32)
Recreation Centers			−.110(−.86)				−.225(−1.62)
Supermarkets				−.179(−1.40)			−.092(−.69)
% Commercial Parcels					−.0.66(−.62)		−.163(−1.26)
Billboards						.178(1.18)	.231(1.40)

Note: All models adjust for individual age, race, education, income, marital status and survey year. Models include interaction terms between sex and the following variables: individual-level race, neighborhood racial isolation, and neighborhood physical disorder. Variables for disorder, park area, recreation centers, supermarkets, commercial parcels, and billboards are scaled so that a change of one unit represents an

NIH-PA Author Manuscript
NIH-PA Author Manuscript

increase from the 25th to the 75th percentile (the inter-quartile range). Percent below poverty variable is scaled so that a change of one unit represents an increase of 10 percentage points. Population size is scaled so that one unit represents 1,000 persons.

*p < .05

**p < .01. N = 6,698.

Table 5

Models for Obesity: Neighborhood-Level Estimates

	Model 1			Model 2		
	Coeff. (z)		OR	Coeff. (z)		OR
Racial Isolation						
Estimates for Women:						
% Non-Hispanic Black						
>60	.298	(2.77)	1.35**	.109	(.89)	1.11
20–60	.181	(1.65)	1.20	.106	(.93)	1.11
<20	—	—	—	—	—	—
Estimates for Men:						
% Non-Hispanic Black						
>60	.098	(.61)	1.10	.150	(.83)	1.16
20–60	−.065	(−.40)	.94	.008	(.05)	1.01
<20	—	—	—	—	—	—
% **Below Poverty**	.050	(1.95)	1.05	−.024	(−.60)	.98
Population Size	−.011	(−.78)	.99	−.007	(−.45)	.99
Physical Disorder in Quartiles						
Estimates for Women:						
4^{th} Quartile				.576	(3.16)	1.78**
3^{rd} Quartile				.452	(3.08)	1.57**
2^{nd} Quartile				.211	(1.90)	1.24
1^{st} Quartile (lowest)				—	—	—
Estimates for Men:						
4^{th} Quartile				.070	(.31)	1.07
3^{rd} Quartile				−.080	(−.42)	.92
2^{nd} Quartile				.016	(.11)	1.02
1^{st} Quartile (lowest)				—	—	—
Social Disorder/Crime				.057	(.88)	1.06
% Park Area				.017	(.26)	1.02

	Model 1		Model 2	
	Coeff. (z)	**OR**	**Coeff. (z)**	**OR**
Recreation Centers			−.005 (−.08)	1.00
Supermarkets			.022 (.41)	1.02
% Commercial Parcels			−.114 (−2.22)	.89*
Billboards			.061 (.92)	1.06

Note: All models adjust for individual age, race, education, income, marital status and survey year. Models include interaction terms between sex and the following variables: individual-level race, neighborhood racial isolation, and neighborhood physical disorder. Percent below poverty variable is scaled so that a change of one unit represents an increase of 10 percentage points. Variables for social disorder, park area, recreation centers, supermarkets, commercial parcels, and billboards are scaled so that a change of one unit represents an increase from the 25th to the 75th percentile (the inter-quartile range). Population size is scaled so that one unit represents 1,000 persons.

* p < .5

** p < .01.

N = 6,698.

Table 6

Sensitivity Analysis of the Effect of Unmeasured Confounding on the Association between Physical Disorder and Obesity among Women

(C = Confounder)		OR Disorder-Obesity Adjusted for Confounder[c]	
OR C-Obesity[a]	Prevalence C in Disorder Category[b]	3rd Quartile	4th Quartile
1.50	.0	1.57**	1.78**
1.50	.2	1.52**	1.72**
1.50	.4	1.48**	1.68**
1.50	.6	1.45*	1.64**
1.75	.0	1.57**	1.78**
1.75	.2	1.50**	1.70**
1.75	.4	1.45*	1.64**
1.75	.6	1.41*	1.59*
2.00	.0	1.57**	1.78**
2.00	.2	1.48**	1.68**
2.00	.4	1.42*	1.61**
2.00	.6	1.37*	1.56*

Notes:

[a]Odds ratio (association) between the hypothetical confounder and obesity.

[b]Prevalence of the hypothetical confounder in the disorder category under consideration (3rd quartile or 4th quartile).

[c]Odds ratios for the association between physical disorder and obesity (3rd quartile disorder [vs. 1st] and 4th quartile [vs. 1st]) after adjusting for the hypothetical confounder.

The prevalence of the hypothetical confounder is assumed to be 50 percent higher in the disorder category under consideration than in the base category (1st quartile disorder).

* $p < .05$

** $p < .01$.