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Racial/ethnic residential segregation and cardiovascular disease risk

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Abstract

A growing body of research has examined whether racial/ethnic residential segregation contributes to health disparities, but recent findings in the literature, particularly with respect to cardiovascular disease (CVD) risk, have not been summarized. This review provides an overview of findings from studies of racial/ethnic residential segregation of non-Hispanic blacks and Hispanics with CVD risk published between January 2011 and July 2014. The majority of studies of black segregation showed higher segregation was related to higher CVD risk, although relationships were less clear for certain outcomes. Relationships among Hispanics were more mixed and appeared to vary widely by factors such as gender, country of origin, racial identity, and acculturation. Implications for research on racial/ethnic disparities in CVD and lingering gaps in the literature are discussed as well.

Keywords

racial; ethnic; residential segregation; ethnic enclave; immigrant enclave; cardiovascular disease

Introduction

The burden of cardiovascular disease (CVD) risk factors and outcomes remains high in the U.S. Approximately 83.6 million American adults have 1 or more types of CVD – over 1 in 3 adults [1]. In addition, just 17% of adults meet ≥ 5 of the 7 criteria for the American Heart Association's (AHA) concept of “ideal” cardiovascular health [1]. However, this burden is not distributed equally across race/ethnic groups. Non-Hispanic black adults are more likely to have hypertension and to have had a stroke than non-Hispanic whites [1]. In addition, both blacks and Hispanics are more likely to be obese and have diabetes than their white counterparts [2]. A growing body of research suggests the residential environment

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Compliance with Ethics Guidelines

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contributes to CVD risk, independent of traditional individual-level risk factors [3-5]. In particular, racial/ethnic residential segregation, the systematic separation of individuals into different neighborhoods by race/ethnicity, may represent an important determinant of sociocultural and environmental conditions that are believed to influence CVD risk, particularly in minorities [6-8].

Racial residential segregation is largely thought to be the product of housing discrimination and discriminatory lending practices, but it has also been part of the racial/ethnic assimilation process in the U.S. [6, 9]. As such, most immigrant groups have experienced some form of segregation in the U.S. For blacks, segregation in the Northeast and Midwest started with the great migration of blacks out of rural areas in the South between 1890 and 1940. This period paralleled the pattern of most new immigrant groups, resulting largely from a desire of newcomers to live with other newcomers. Living in predominantly black neighborhoods offered opportunities for job leads, connections to cultural and religious institutions, and social support. The process of segregation typically subsides within a generation as upward mobility leads to fuller integration with whites. However, for black Americans, segregation increased throughout much of the 20th century due to a long period of institutional discrimination, leading to constrained opportunities for economic and residential mobility [10]. Segregation of the black community is thought to have social, economic, and health implications as a result of concentration of poverty and limited access to health-promoting resources. For these reasons, segregation has been deemed a fundamental cause of black-white health disparities [9].

Among Hispanics, segregation from non-Hispanic whites is much less prevalent than among blacks. However, Hispanic segregation is on the rise in the U.S.., paralleling the rapid increases of the Hispanic population in the US [11]. Whether segregation has implications for the health of Hispanics is less clear. One of the reasons is that the processes that contribute to Hispanic segregation are thought to be different than those operating for blacks. While both blacks and Hispanics have been subject to discrimination in housing markets, Hispanic segregation is thought to also reflect the residential preferences of Hispanic immigrants to live among co-ethnics, facilitating access to culturally specific resources to ease in the adjustment to U.S. society [12]. However, it is unclear whether these structural and social resources are sufficient to offset the high levels of poverty that are also associated with Hispanic segregation. Moreover, as Hispanics acculturate to U.S. norms, the degree to which they are able to integrate with non-Hispanic whites has been shown to depend on factors such as race and country of origin [11]. Thus, residence in Hispanic ‘enclaves’ among long-term immigrants or U.S.-born Hispanics may reflect blocked upward mobility with negative consequences for health.

The goals of this review are to summarize recent findings in the segregation and cardiovascular health literature for blacks and Hispanics, to discuss the implications of these findings for racial/ethnic CVD disparities, and to identify gaps in our current knowledge. We focus on blacks and Hispanics because CVD risk burden is high in these two groups, and because the majority of segregation studies in the literature focuses on one or both of these populations.

Identification of Relevant Studies

We conducted a comprehensive review of articles published between January 2011 and July 2014 using MEDLINE, PsychINFO, and Web of Science. We utilized keywords that included both segregation-related terms (e.g., residential segregation, racial composition, ethnic density) and CVD-related terms (e.g., heart disease, blood pressure, smoking). We included studies on the seven factors that make up the AHA's concept of cardiovascular health (smoking, diet, and physical activity, BMI, hypercholesterolemia, diabetes, and hypertension) and cardiovascular outcomes (stroke and coronary heart disease). An initial search retrieved 486 articles, dissertations, and book chapters. From these, titles and abstracts were reviewed, and only studies published in a journal or book that contained relevant data to this review were retained. After excluding duplicates (n=215), irrelevant topics (n=229), and dissertations (n=4), 38 articles were selected for further analysis. Of these 38 articles, we excluded studies of Asian segregation [13], other segregation measures not specific to blacks or Hispanics [14], children [15-17], and those conducted outside the U.S. [18-22], yielding a total of 28 individual papers. However, because some papers included multiple outcomes or examined both Hispanic/Latino and black segregation indices in the same paper, a total of 19 papers for black segregation (Table 1) and 16 papers for Hispanic segregation (Table 2) were included.

Racial/Ethnic Residential Segregation Across the Continuum of CVD Risk

Assessing Residential Segregation—Two important features to consider when assessing residential segregation and its impact on CVD risk are geographic scale and measurement. Segregation and health studies fall into two broad categories: metropolitan area-level segregation and neighborhood-level segregation. Metropolitan area-level segregation and health studies (which may include segregation measured at the metropolitan area, county, and city level) posit that living in a segregated area impacts health regardless of the level of segregation experienced in an individual's actual neighborhood. In these studies, health outcomes are compared across metropolitan areas in the U.S. Neighborhood-level segregation and health studies, on the other hand, are part of the general neighborhood effects literature and suggest there is something about living in a segregated neighborhood that influences health [23]. Examining segregation at the neighborhood level offers greater spatial resolution, but it is susceptible to the same methodological drawbacks of other neighborhood-level studies such as off-support inference and selection bias. Segregation studies at the metropolitan level are less susceptible to these issues, but they cannot capture the health impact of different levels of segregation experienced by individuals within metropolitan areas.

Several measures have been used to examine associations of metropolitan- and neighborhood-level segregation with health. In the recent literature reviewed in this paper, the most commonly used measure of metropolitan-level segregation is the isolation index. The isolation index is a measure of exposure, one of the five dimensions of segregation discussed in Massey and Denton's seminal paper published in 1988 [24]. The exposure dimension refers to the degree of potential contact between groups within neighborhoods of a metropolitan area. The isolation index in particular represents the percentage of the population that is a certain race/ethnic group in the neighborhood (usually defined as a

census tract) in which the average person in that race/ethnic group lives. Scores range from approximately 0 to 1, with a higher score indicating greater racial/ethnic isolation (i.e., greater likelihood of only being exposed to individuals of their own race/ethnicity).

Racial/ethnic composition was the most commonly used measure of neighborhood-level segregation. Largely viewed in the literature as a proxy for segregation [6, 8], the advantages of this measure are that it is readily available in U.S. Census data (using census tracts or block groups as proxies for neighborhoods) and it is easy to interpret. However, this measure has limitations. One is that it does not provide any information on how racial/ethnic groups are distributed in space. Another is that it does not take into account the racial composition of the larger surrounding area. For example, a neighborhood that is 30% black means something different in Chicago, which is 32.9% black, than in San Francisco, which is 6.1% black [25]. A cutpoint of 60% is generally used to indicate high segregation [9], but as described below, this cutpoint is not always adopted.

Studies of Black Residential Segregation—There were 19 papers published within the last three years that examined associations of black residential segregation with CVD risk. Studies were largely cross-sectional or ecologic in design – only one study was prospective. In addition, most studies, except for one [26], used self-reported data to measure obesity and biological CVD risk factors. Overall, findings from these recent studies suggest higher metropolitan-level black segregation is associated with worse CVD risk. The majority of neighborhood-level segregation studies also showed higher segregation was related to worse CVD risk, but findings were more mixed. Potential explanations for this include differences in the cutpoints used to assess segregation, characteristics of the cities/regions included in the studies, and the way the outcome was measured.

Lifestyle Factors: Four studies focused on lifestyle factors recognized to be associated with CVD risk including smoking, diet, and physical activity. The only study of smoking found, in a nationally- representative sample, that black women living in more segregated counties (measured using the black:white interaction index, a measure of the exposure dimension that assesses the extent to which blacks are exposed to white residents) were more likely to smoke during pregnancy than black women living in less segregated counties [27]. The only study to include a diet-related outcome found no difference in consumption of ≥ 5 servings of fruits/vegetables per day between blacks living in high (isolation index ≥ 0.6) compared with low (isolation index < 0.5) segregation metropolitan areas throughout the U.S. [28]. However, those living in moderate segregation areas were more likely to eat ≥ 5 servings of fruits/vegetables per day than their counterparts in low segregation areas. Findings were mixed for the 2 studies of physical activity/exercise. A national study of metropolitan-level segregation found no association with exercise (defined as any in the past month) [28]. In contrast, a North Carolina study found blacks living in more segregated neighborhoods engaged in more minutes of walking and moderate to vigorous physical activity per week [29].

BMI/Obesity: There were six studies that focused on BMI/obesity; two measured segregation at the metropolitan level and four measured segregation at the neighborhood level. Two nationally-representative studies of metropolitan-level segregation (both

measured using the black isolation index) and BMI/obesity found higher segregation was related to higher BMI/obesity, though one study only found this significant association in women [26, 28]. Consistent with this, a New York City neighborhood-level segregation study found blacks living in higher percent black neighborhoods were more likely to be obese [30]. A national prospective study found black women living in a predominantly black neighborhood (highest quartile) were more likely to become obese over the follow-up period than those living in low segregation neighborhoods (lowest quartile); this difference was only significant for those who remained in the most segregated neighborhoods over follow-up [31]. In contrast, two studies of neighborhood-level segregation and obesity, one in southeastern Pennsylvania [32] and another throughout the U.S. [33], found that living in high segregation neighborhoods (defined in both studies as neighborhoods that are ≥ 25% black) was not associated with obesity in blacks. The cutpoint used to categorize segregation in these two studies is one potential explanation for these divergent findings.

Biological CVD Risk Factors and Outcomes: Six studies examined associations of racial residential segregation with biological CVD risk factors, three for hypertension and three for diabetes. Two nationally-representative studies of metropolitan-level segregation and hypertension found adults living in more segregated areas were more likely to be hypertensive [34, 35]; in one study this association held for blacks but not whites [35]. The only study of neighborhood-level segregation and hypertension found older (≥ 65 years) foreign-born blacks living in high segregation neighborhoods in New York City were less likely to be hypertensive than their counterparts living in low segregation neighborhoods [36]. Segregation was not associated with hypertension among U.S.-born blacks or younger foreign-born blacks. A metropolitan-level segregation study of the 50 most populous U.S. cities found higher segregation was correlated with larger black-white disparities in age-adjusted diabetes mortality [37], and a neighborhood-level segregation study found higher percent black was correlated with higher age-adjusted diabetes mortality rates in Chicago [38]. However, a national study of neighborhood-level segregation found living in a predominantly black neighborhood (>65% black) was not associated with diabetes prevalence [39].

The few recent studies that have evaluated relationships of segregation with cardiovascular outcomes have focused on mortality or self-reported prevalence, and findings are mixed. A metropolitan-level segregation study of all U.S. metropolitan areas with at least 5,000 non-Hispanic black residents found higher segregation (measured using black isolation index) was related to higher age-adjusted heart disease death rates among black adults 35 and older and white adults aged 65 years and older; segregation was not associated with heart disease death rates in younger whites [40]. Higher segregation was associated with higher age-adjusted stroke mortality rates in younger blacks but not older blacks or whites in both age categories. In contrast, a national study of county-level segregation found higher segregation (measured using black isolation index) was associated with lower coronary heart disease mortality among blacks [41]. This finding is consistent with a study of black adults aged 65 years and older that found those living in counties with a higher percent black were less likely to have prevalent CVD [42].

Two studies have evaluated associations of neighborhood-level segregation with age-adjusted stroke mortality rates. A Chicago study found living in community areas with a higher percent black was correlated with higher stroke mortality rates [43]. Consistent with this, an Atlanta study found more racially isolated younger adults had higher stroke mortality rates [44]. However, this study also found stroke mortality rates were lower for adults 65 and older living in high vs. low segregation neighborhoods.

Studies of Hispanic/Latino Residential Segregation—As with black segregation studies, of the 16 Hispanic segregation studies included in this review, only one was longitudinal in design [45]. In addition, except for studies that examined mortality, all but one study relied on self-reported measures for outcomes [26]. Overall, the body of evidence from studies published in the last three years is mixed, and highly dependent on the outcome studied, and on factors such as gender, nativity, race (among Hispanics), and measurement strategies.

Lifestyle Factors: Among the behavioral CVD risk factors, only smoking and diet have been studied in relation to Hispanic segregation in literature published in the last three years. Of the three smoking studies, two examined relationships of county-level segregation with maternal smoking using national natality data [27, 46]. One study found higher Hispanic segregation (using the Hispanic:non-Hispanic white interaction index) was associated with lower odds of maternal smoking among Hispanic women [27]. The other maternal smoking study assessed the impact of Hispanic segregation on smoking in *non-Hispanic* white and black women, reporting an inverse association between county-level % Hispanic and maternal smoking [46]. The authors suggest this indicates that the health benefits of living in Hispanic enclaves may extend across race/ethnic lines. In contrast to these findings, a neighborhood-level segregation study in Los Angeles found living in uppermost quartile of %Latino immigrant composition was not associated with smoking among Hispanic women, but it was positively, marginally associated with smoking among Hispanic men [47]. The authors note that these results are inconsistent with theories regarding the health benefits of immigrant enclaves. However, a direct comparison of results across studies is difficult given the differences in measurement of segregation, and in the ethnicity and immigrant status of the study populations.

Only one study examined the association between neighborhood-level Hispanic segregation and diet [48]. A New York City study found living in a more linguistically isolated neighborhood (defined as % Spanish-speaking families in which no person aged 14 years and older spoke English very well) was associated with significantly greater adherence to a healthy dietary pattern and with lower adherence to an energy-dense dietary pattern, though the latter association was not significant.

BMI/Obesity: Eight of the 16 studies reviewed examined BMI/obesity as an outcome and all but one [26] relied on self-reported measures of height and weight. In general, findings between Hispanic segregation and obesity were mixed with most studies reporting null or positive associations, and one reporting a negative association. However, there was considerable variation in terms of how segregation was measured. Moreover, most studies considered Hispanics as a single homogenous group without disaggregation by key health-

relevant social factors such as gender, nativity, country of origin, acculturation, or race. Findings from studies that did consider such heterogeneity among Hispanics suggested that associations between segregation and obesity may depend on these factors.

For example, a nationally-representative metropolitan-level segregation study found that living in high (isolation index > 0.6) compared to low (isolation index ≤ 0.3) Hispanic segregation areas was associated with a lower prevalence of obesity among Mexican-American women but not among Mexican-American men [26]. Another nationally-representative metropolitan-level segregation study of Hispanics also showed null associations among men [49]. In this same study, while the relationship between the metropolitan-level Hispanic isolation index and obesity was also null in women after accounting for individual-level factors, there was evidence of a statistically significant interaction between segregation and race among Hispanic women. Specifically, there was a negative association between segregation and obesity among Hispanic black women, a positive association among Hispanic white women, and a null association among Hispanic women identifying as 'other race.' These findings are consistent with the gendered nature of the results from the study among Mexican-Americans, but they are also distinct given that the direction of the association among Hispanic women depended on race. A direct comparison between the two studies is difficult given the differences in the populations under study (Mexican-Americans vs. Hispanics). Nevertheless, these studies suggest that social heterogeneity is important to consider when examining associations between segregation and health among Hispanics. The only other study in our review that utilized the metropolitan-level Hispanic isolation index to characterize Hispanic segregation found a positive association with obesity using national data on Hispanics [50]. However, the authors did not examine heterogeneity by gender, race, or any other factors among Hispanics.

The five additional BMI/obesity studies used percent measures (% Hispanic or % immigrant) to measure segregation. Two neighborhood-level segregation studies (1 nationally-representative, and 1 using data from Utah) reported positive associations between segregation and obesity [33, 51], and three studies (two neighborhood-level studies in Los Angeles and New York City; and one county-level study in Texas) reported null associations [30, 45, 52]. Two considered potential heterogeneity. The Utah study found a positive association between % Latino and obesity prevalence [51]. However, there was also a negative association between % immigrant concentration and obesity. In the Texas segregation study, there was no association between county-level % Hispanic and county-level obesity prevalence [52]. However when the authors investigated differences by county-level socioeconomic indicators (education and poverty), they found an association between living in 'high' % Hispanic counties (25.1%) and lower obesity only in counties with high education or low poverty. Finally, in the one study that was longitudinal in design, the Los Angeles study found no association between neighborhood-level % Hispanic or % immigrant and change in weight over time [45].

Biological CVD Risk Factors and Outcomes: Only four recent studies have examined Hispanic segregation in relation to biological CVD risk factors and outcomes, and all found inverse associations with Hispanic segregation. A neighborhood-level segregation study in

Chicago reported an inverse association between % Hispanic immigrant neighborhoods and odds of self-reported hypertension[53]. However, among hypertensives, living in these neighborhoods was also associated with lower odds of seeing a doctor or taking medications for hypertension. While the first set of results are consistent with theories of health benefits of living in immigrant enclaves, the second set of findings also point to the potential for deleterious consequences, particularly with regard to healthcare access. Two other neighborhood-level segregation studies, also in Chicago, found inverse associations of % Hispanic composition with age-adjusted stroke- and diabetes-related mortality rates [38, 43]. Finally, a county-level segregation study of Mexican-Americans in 5 Southwestern states found higher percent Hispanic was inversely associated with self-reported prevalent CVD [42].

Implications for Racial/Ethnic Disparities in Cardiovascular Disease

Few studies have directly examined the extent to which racial segregation accounts for black-white disparities in CVD risk, but there is some evidence in the literature that points to the presence of smaller disparities in more integrated communities. For example, two papers from this review showed larger racial disparities in hypertension prevalence [35] and age-adjusted diabetes mortality [37] for those living in more segregated areas. In addition, findings from the Exploring Health Disparities in Integrated Communities study showed that blacks and whites living in integrated communities in Baltimore with similar income levels had more similar hypertension, diabetes, and obesity prevalence compared with black and whites in national studies [54-56].

Two strategies have been adopted to address the negative health consequences of racial residential segregation in blacks: moving residents of segregated neighborhoods to better quality neighborhoods and improving the health-harming aspects of segregated neighborhoods. Public housing policy interventions such as housing voucher programs that give residents in segregated, high poverty neighborhoods the opportunity to move into better quality neighborhoods have been shown to offer some long-lasting benefits including reduced exposure to crime and decreased neighborhood social disorder [57]. Though findings for health outcomes are limited, one notable health-related study, the Moving to Opportunity Study [58], found participants (low income women, predominantly minority) who received vouchers to move into low poverty neighborhoods between 1994 and 1998 were less likely to be morbidly obese and had lower glycated hemoglobin levels than the control group (those who did not receive vouchers to move) in 2008-2010.

Evidence from the built-environment CVD risk literature suggests that altering health-relevant features of segregated neighborhoods may also be a means to improve the health of minorities [5, 59-61]. However, these studies are largely cross-sectional, so it remains unclear the extent to which altering the built environment will reduce cardiovascular health disparities. Indeed, findings from the few longitudinal studies and natural experiments that have capitalized on the opening of grocery stores in resource-poor communities suggest that such interventions alone may not be sufficient to change the behavior of residents [62, 63]. Further empirical work is needed to better understand if and how these two approaches can reduce racial/ethnic disparities in CVD.

Given the inconsistency of findings related to segregation and cardiovascular health in Hispanics, it is difficult to determine the role segregation has in contributing to Hispanic-white disparities in CVD. On the one hand, Hispanic segregation has been linked to access to healthier foods, as well as to social and cultural norms that reinforce healthier behaviors [12, 64]. On the other hand, such areas have also been linked to high poverty, high crime, fewer resources to support physical activity, and less access to healthcare [64, 65]. Additional research is warranted to better understand the reasons underlying the inconsistency of results related to Hispanic segregation and to better identify specific causal mechanisms amenable to intervention.

Conclusions

In contrast to earlier years where studies of segregation and CVD risk focused primarily on mortality, the majority of studies published since 2011 have focused CVD risk factor prevalence. This broader focus on CVD risk factors helps move the field forward by identifying the pathways linking segregation to disparities in cardiovascular outcomes. It also allows for the use of more sophisticated modeling approaches like multilevel and marginal models, as opposed to solely relying on ecologic designs. However, several gaps remain. One, more prospective studies of segregation and CVD risk are needed, particularly to understand how persistent exposure to segregation, as well as changes in exposure over the lifecourse, influences CVD risk. Second, more objective measurement of CVD risk will help strengthen the validity of study findings. However, it is worth noting that given most population-based datasets collect self-reported data, this increased validity may come at the expense of generalizability of findings. Third, better integration of social theory is needed to support the measures chosen to assess segregation. Doing so would encourage the formulation of testable hypotheses and would guide researchers in the conceptualization of potential causal pathways. Finally, there is a need to consider heterogeneity of associations within race/ethnic groups. Classification of Hispanics, but also blacks, as a single group assumes homogeneity of risk, despite the potential for differences across a range of social factors. Accounting for this heterogeneity would help elucidate how and why segregation has implications for cardiovascular health.

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Table 1

Summary of recent research linking black residential segregation to cardiovascular-associated risk factors and outcomes

Study	Sample	Design	Geographic scale	Measure of segregation (geographic unit (neighborhood unit))	Outcome variable	Covariates	Findings*
Yang et al., Apr 2014 [27]	Women who had a live birth in the US (2008)	Cross-sectional	County	Black-white interaction index (county (census tract)) - continuous	Self-reported smoking during pregnancy	Individual-level	Positive association
Corral et al., Apr 2012 [28]	Black participants of the Behavioral Risk Factor Surveillance System (2000)	Cross-sectional	Metropolitan area	Black isolation index (metropolitan area (census tract)) - categorized as high (≥ 0.6), medium, and low (<0.5)	Exercise (any in the past month) Eating behavior (≥ 5 servings of fruits/ vegetables per day) Overweight/obesity using self-reported height and weight	Individual-level Metropolitan area-level	Null association for exercise Negative association for fruit/vegetable intake Positive association for overweight/obesity
Armstrong-Brown et al., May 2014 [29]	Black participants of the Action through Churches in Time to Save Lives of Wellness project in Piedmont, North Carolina (2007-2009)	Cross-sectional	Neighborhood	Percent black (census tract) - dichotomized at ≥ 0.5	Minutes moderate-vigorous physical activity/week Meeting 2008 physical activity guidelines Minutes walking/week MET-hours/ week	Individual-level Neighborhood-level	Negative association
Kershaw et al., Feb 2013 [26]	Black participants of the National Health and Nutrition Examination Surveys (1999-2006)	Cross-sectional	Metropolitan area	Black isolation index (metropolitan area (census tract)) - categorized as high (> 0.6), medium, and low (≤ 0.3)	Obesity using measured height and weight	Individual-level Metropolitan area-level Neighborhood-level	Positive association for women No association for men
Li et al., Jan 2014 [32]	Black and white adults in southeastern Pennsylvania (2006 and 2008)	Cross-sectional	Neighborhood	Percent black (census tract) - dichotomized at ≥ 25% black	Obesity using self-reported height and weight	Individual-level Neighborhood-level	Null association for black men, black women, and white men Positive association for white women
Kirby et al., Aug 2012 [33]	Participants of the Medical Expenditure Panel Survey (2002-2007)	Cross-sectional	Neighborhood	Percent black (census block group) - dichotomized at ≥ 25% black	BMI and obesity using self-reported height and weight	Individual-level Neighborhood-level	Null association for all race/ethnic groups

Study	Sample	Design	Geographic scale	Measure of segregation (geographic unit (neighborhood unit))	Outcome variable	Covariates	Findings*
Lim et al., Mar 2014 [30]	New York City Community Health Survey participants (2002-2004)	Cross-sectional	Neighborhood	Percent black (zip code) - continuous	Obesity using self-reported height and weight	Individual-level Neighborhood-level	Positive association
Cozier et al., Apr 2014 [31]	Black Women's Health Study participants (1997-2009)	Cohort	Neighborhood	Percent black (census block group)	Obesity using self-reported height and weight	Individual-level Neighborhood-level	Positive association (only statistically significant for women who consistently lived in segregated neighborhoods over follow-up)
Kershaw et al., Sep 2011 [35]	Black and white participants of the National Health and Nutrition Examination Surveys (1999-2006)	Cross-sectional	Metropolitan area	Black isolation index (metropolitan area (census tract)) - continuous	Hypertension using measured blood pressure	Individual-level Neighborhood-level	Positive association for blacks Null association for whites
Jones, Jul 2013 [34]	Behavioral Risk Factor Surveillance System participants (2005)	Cross-sectional	Metropolitan area	Hypersegregation: number of segregation dimensions for which score was ≥0.6 (metropolitan area (census tract)) - 4 categories	Self-reported hypertension	Individual-level Metropolitan area-level	Positive association
White et al., Aug 2011 [36]	US- and foreign-born blacks in New York City (2002 and 2005)	Cross-sectional	Neighborhood	Spatial isolation index (United Hospital Fund neighborhood designation (census tract)) - dichotomized at score ≥ 0.55	Self-reported hypertension	Individual-level Neighborhood-level	Null association for all US-born and younger foreign-born blacks Negative association for older foreign-born blacks
Rosenstock et al., Feb 2014 [37]	Blacks and whites in 50 most populous cities (2005-2007)	Ecologic	City	Percent population black (city) - continuous Isolation index (city (census tract)) - continuous	Age-adjusted diabetes mortality rates	None	Positive association (only statistically significant for percent population black)
Gaskin et al., Nov 2013 [39]	Black and white participants of the National Health and Nutrition Examination Survey (1999-2004)	Cross-sectional	Neighborhood	Percent black, percent white, and percent other (census tract) - eight categories combining individual race and neighborhood racial composition (>65% cutpoint for	Diabetes using measured fasting plasma glucose and HbA1c	Individual-level Neighborhood-level	Null association comparing blacks in predominantly black neighborhoods to whites in predominantly white neighborhoods

Study	Sample	Design	Geographic scale	Measure of segregation (geographic unit (neighborhood unit))	Outcome variable	Covariates	Findings*
				predominantly black/white/other) predominantly black/white/other)			
Hunt et al., Feb 2014 [38]	Non-Hispanic blacks, non-Hispanic whites, and Hispanics in Chicago (2006-2008)	Ecologic	Neighborhood	Percent black (community area) - continuous	Age-adjusted diabetes mortality rate	None	Positive association
Gebreab et al., Sep 2012 [41]	Blacks and whites in the US (1996-2006)	Ecologic	County	Black isolation index (county (census tract)) - continuous	Age-adjusted coronary heart disease mortality rates	County-level	Negative association for blacks Null association for whites
Alvarez et al., Dec 2012 [42]	Black participants of the Established Populations for Epidemiologic Studies of the Elderly (1982)	Cross-sectional	County	Percent black (county) - categorized as high (≥0.5), medium, and low (<0.25)	Self-reported cardiovascular disease	Individual-level	Negative association
Greer et al., Jun 2014 [40]	Non-Hispanic black and white residents of metropolitan statistical areas with at least 5,000 non-Hispanic black residents (2010)	Ecologic	Metropolitan area	Black isolation index (metropolitan statistical area (census tract))	Age-adjusted heart disease mortality rates Age-adjusted stroke mortality rates	County-level	Heart disease: Positive association for older whites and all blacks Null association for younger whites Stroke: Positive association for younger blacks Null association for older adults and younger whites
Greer et al., Fall 2011 [44]	Non-Hispanic black and white Atlanta residents (2000-2006)	Ecologic	Neighborhood	Spatial black isolation index (census tract (50m×50m grid cell and all cells within a 500m radius) - categorized as high (≥ 0.7), medium (0.3-<0.7), and low (<0.3)	Age-adjusted stroke mortality rates	Neighborhood-level	Positive association for younger adults (35-64) Negative association for older adults
Hunt et al., Jul 2014 [43]	Non-Hispanic blacks, non-Hispanic whites, and Hispanics in Chicago (2006-2008)	Ecologic	Neighborhood	Percent black (community area) - continuous	Age-adjusted stroke mortality rate	None	Positive association

*A positive (negative) association is defined as residence in highly segregated area/neighborhood associated with poorer (better) health.

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Table 2

Summary of recent research linking Hispanic residential segregation to cardiovascular-associated risk factors and outcomes

Study	Sample	Design	Geographic scale	Measure of segregation (geographic unit (neighborhood unit))	Outcome variable	Covariates	Findings *
Cantrell, May 2014 [47]	Hispanics in Wave 1 of the Los Angeles Family and Neighborhood Survey (2000-2001)	Cross-sectional	Neighborhood	Factor score for Hispanic immigrant composition (census tract) - categorized into quartiles	Self-reported smoking	Individual-level Neighborhood-level	Positive association for men No association for women
Yang et al., Apr 2014 [27]	Women who had a live birth in the US (2008)	Cross-sectional	County	Hispanic-white interaction index (county (census tract)) - continuous	Self-reported smoking during pregnancy	Individual-level	Negative association among Hispanics
Shaw et al., Jun 2013 [46]	Non-Hispanic black and white women who had a livebirth in the US (2000)	Cross-sectional	County	Percent Hispanic (county) - categorized as >=50%, 15-49.99%, 5-14.99%, 1-4.99%, <1%	Self-reported smoking during pregnancy	Individual-level Neighborhood-level	Negative association
Park et al., Sep 2011 [66]	Hispanic female guardians of Head Start children in NYC (2003-2006)	Cross-sectional	Neighborhood	Percent linguistic (Spanish) isolation (community district) - continuous	Healthy dietary pattern and energy-dense dietary pattern	Individual-level Neighborhood-level	Positive association with healthy dietary pattern Negative but not significant association with energy-dense diet
Corral et al., Apr 2014 [67]	Hispanics participants of the Behavioral Risk Factor Surveillance System (2000)	Cross-sectional	Metropolitan area	Hispanic isolation index (metropolitan area (census tract)) - categorized as high (≥ 0.6), medium, and low (<0.5)	Obesity using self-reported height and weight	Individual-level Metropolitan area-level	Positive association
Salinas et al., Apr 2012 [52]	Participants in the Texas Behavioral Risk Factor Surveillance System (2000-2009)	Ecologic	County	Percent Hispanic (county) - continuous and dichotomized at median (25.1%)	Obesity using self-reported height and weight	County-level	No association overall. Negative association only for counties with high % bachelor's degree (above median) or low poverty (below median).
Ullman et al., Aug 2013 [45]	Participants in Waves 1 and 2 of the Los Angeles Family and Neighborhood Survey (2000-2001 and 2006-2008)	Cohort	Neighborhood	Percent Hispanic (census tract) - categorized as 'predominantly Hispanic'>=75%, 'high Hispanic'>=35%	Annual weight change in kilograms (self-reported)	Individual-level Neighborhood-level	No association

Study	Sample	Design	Geographic scale	Measure of segregation (geographic unit (neighborhood unit))	Outcome variable	Covariates	Findings*
Kershaw et al., Mar 2014 [49]	Hispanics participants of the Behavioral Risk Factor Surveillance System survey (2003-2008)	Cross-sectional	Metropolitan area	Hispanic isolation index (metropolitan area (census tract)) - continuous	Obesity using self-reported height and weight	Individual-level Metropolitan area-level	Positive association for Hispanic white women, negative association for Hispanic black women, and no association among Hispanic 'other race' women. No association for men.
Kershaw et al., Feb 2013 [26]	Mexican-American participants of the National Health and Nutrition Examination Surveys (1999-2006)	Cross-sectional	Metropolitan area	Hispanic isolation index (metropolitan area (census tract)) - categorized as high (> 0.6), medium, and low (≤ 0.3)	Obesity using measured height and weight	Individual-level Metropolitan area-level Neighborhood-level	Negative association for women No association for men
Kirby et al., Aug 2012 [33]	Participants of the Medical Expenditure Panel Survey (2002-2007)	Cross-sectional	Neighborhood	Percent Hispanic (census block group) - dichotomized at ≥ 25% Hispanic	BMI and obesity using self-reported height and weight	Individual-level Neighborhood-level	Positive association for Hispanics and non-Hispanic Whites.
Wen et al., Dec 2011 [68]	Driver license records from Hispanics and non-Hispanic whites in Utah (1999-2008)	Cross-sectional	Neighborhood	Percent Latino (census tract) - continuous; percent immigrant (census tract) - continuous	Obesity using self-reported height and weight	Individual-level Neighborhood-level	Positive association with % Latino for Hispanic and white men and women. Negative association with immigrant concentration for men and women.
Lim et al., Mar 2014 [30]	New York City Community Health Survey participants (2002-2004)	Cross-sectional	Neighborhood	Percent Hispanic (zip code) - continuous	Obesity using self-reported height and weight	Individual-level Neighborhood-level	No association
Viruell-Fuentes et al., Dec 2012 [69]	Hispanics from the Chicago Community Adult Health Study (2001-2003)	Cross-sectional	Neighborhood	Percent Hispanic immigrant (neighborhood cluster) - continuous	Self-reported hypertension, utilization of hypertension-related healthcare, and being treated for hypertension	Individual-level Neighborhood-level	Negative association with odds of hypertension. Among hypertensives, negative association with hypertension care and treatment.
Hunt et al., Feb 2014 [38]	Non-Hispanic blacks, non-Hispanic whites, and Hispanics in Chicago (2006-2008)	Ecologic	Neighborhood	Percent Hispanic (community area) - continuous	Age-adjusted diabetes mortality rate	None	Negative association

Study	Sample	Design	Geographic scale	Measure of segregation (geographic unit (neighborhood unit))	Outcome variable	Covariates	Findings*
Hunt et al., Jul 2014 [43]	Non-Hispanic blacks, non-Hispanic whites, and Hispanics in Chicago (2006-2008)	Ecologic	Neighborhood	Percent Hispanic (community area) - continuous	Age-adjusted stroke mortality rate	None	Negative association
Alvarez et al., Dec 2012 [42]	Mexican-Americans in the Hispanic Established Populations for Epidemiologic Studies of the Elderly (1993)	Cross-sectional	County	Percent Hispanic (county) - categorized as high (≥0.5), medium, and low (<0.25)	Self-reported cardiovascular disease	Individual-level	Negative association

*A positive (negative) association is defined as residence in highly segregated area/neighborhood associated with poorer (better) health.