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Racial/ethnic residential segregation: Framing the context of health risk and health disparities

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Abstract

An increasing body of public health literature links patterns of racial/ethnic residential segregation to health status and health disparities. Despite substantial new empirical work, meaningful understanding of the pathways through which segregation operates to influence health remains elusive. The literature on segregation and health was appraised with an emphasis on select conceptual, methodological and analytical issues. Recommendations for advancing the next generation of racial/ethnic residential segregation and health research will require closer attention to sharpening the methodology of measuring segregation, testing mediating pathways and effect modification, incorporating stronger test of causality, exploring factors of resilience in segregated areas, applying a life-course perspective, broadening the scope of the investigation of segregation to include nativity status in blacks and other racial/ethnic groups, and linkage with biological data.

Keywords

residential segregation; health disparities; race/ethnicity

Introduction

The persistence of racial/ethnic disparities, particularly black health disparities, across multiple measures of mortality and morbidity outcomes are widely documented (Keppel, 2007; Kramer and Hogue, 2009; Wong et al., 2002). While, the debate regarding the source of disparities continues to largely emphasize individual-level factors such as genetics, socioeconomic status, health behaviors, psychosocial factors, and access to care, a growing body of evidence suggests that these factors do not fully account for observed disparities (Finkelstein et al., 2004; Gorman and Sivaganesan, 2007; Kramer et al., 2004). Recently, neighborhood context has emerged as an important determinant that shapes the conditions that put individuals “at risk of risk” (Diez-Roux, 2003; Kawachi and Berkman, 2003).

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However, discussions of neighborhood context often lack a framework couched in broader spatial and social inequities, namely racial/ethnic residential segregation. Considered a spatial manifestation of institutionalized discrimination, racial/ethnic residential segregation (hereafter segregation) refers to the degree to which two or more groups live separately from one another in a geographic area (Massey and Denton, 1988). Although, the policies that created segregation are now illegal, the distinct historical, political, and social circumstances of segregation, particularly among blacks has profoundly shaped individual and community well-being and health (Massey and Denton, 1993).

Patterns of segregation among blacks **in the U.S.** remain the highest of all racial/ethnic groups and higher than levels of economic segregation (Massey et al., 2009). Recent national trends suggest that patterns of black/white segregation have declined between 1980 and 2000 (Iceland et al., 2002; Massey et al., 2009). However, the declines in segregation occurred in areas with small black populations, such as Portland, Oregon; whereas levels of high segregation in Northeastern and Midwestern metropolitan areas like New York City and Milwaukee have not abated over time. In fact, the level of segregation in some U.S. metropolitan areas for blacks parallel the levels of segregation in South Africa during the apartheid era (Massey and Denton, 1993). These high levels of segregation are typically viewed as a cornerstone of racial and urban inequality. For example, some of the consequences of segregation entail the concentration of poverty and the solidification of racial disparities in economic and educational opportunities (Williams and Collins, 2001). Thus, considered a marker of inequality, it is possible that patterns of segregation may provide additional insight into the greater burden of disease among blacks in the U.S.

The mechanisms through which segregation may influence health have been aptly described in prior work (Kramer and Hogue, 2009; Lee and Ferraro, 2007; Polednak, 1996a; Schulz et al., 2002; Williams and Collins, 2001). Briefly, it is postulated that segregation affects health by creating vastly different economic, physical, and social neighborhood environments and shaping health behaviors (Kramer and Hogue, 2009; Williams and Collins, 2001). Segregation can affect neighborhood environment as a result of the differential exposure to: 1) disadvantaged neighborhood physical environment and lower housing quality (Kramer and Hogue, 2009; Williams and Collins, 2001); 2) the concentration of poverty and (Kramer and Hogue, 2009; Schulz et al., 2002; Williams and Collins, 2001); 3) lack of access to economic and educational opportunity structures (Mays et al., 2007; Schulz et al., 2005; Schulz et al., 2002; Williams and Collins, 2001). The differential exposure to neighborhood stressors can in turn shape health behaviors. For example, neighborhoods where there is a shortage in the availability and affordability of healthy foods and the targeted advertisement of tobacco may very well influence poor dietary habits and smoking. Segregation has been coined a fundamental cause of racial/ethnic health disparities because of its role in shaping myriad factors important for promoting health and avoiding disease (Williams and Collins, 2001).

Research implicating segregation as a cause of health disparities has proliferated (Kramer and Hogue, 2009), creating a pressing need to take stock of the direction and progress in the field. Acevedo-Garcia and colleagues review of the literature highlighted the importance of a theoretical rationale linking segregation measures to health outcomes and the utility of incorporating a multilevel framework (Acevedo-Garcia et al., 2003). A recent systematic review discussed census **tracts** as proxies for neighborhoods, underscored potential pathways linking segregation to health, emphasized the utility of longitudinal data sources, and argued for housing policies to remedy segregation (Kramer and Hogue, 2009). Landrine and Corral's theoretical evaluation of the literature focused on the role of neighborhood disparities in healthcare quality, environmental exposures, and the built environment as central mediators between segregation and health disparities (Landrine and Corral, 2009).

This article differs from and extends the work of the aforementioned reviews by highlighting several important topics related to the investigation of segregation and health. Concerns related to consistency in the conceptualization **of segregation** (i.e. formal versus proxy measure) and methodological considerations such as specification of the macro-area scale to operationalize segregation have not been thoroughly discussed. Moreover, few studies have empirically tested mediating pathways linking segregation and health (Hutchinson et al., 2009; Yuan, 2008). Furthermore, studies exploring effect modification by perceived racial discrimination or neighborhood-level factors (i.e. poverty or social capital) have been limited. Improvements to study design and enhanced analytical methods, particularly in relation to stronger test of causality are needed. In light of these issues, the present review seeks to distinctly contribute to the discourse **on segregation and health** by focusing on select conceptual (operationalizing segregation as a formal versus proxy measure); methodological (macro-area unit of analysis used to measure segregation); and analytical (i.e. testing mediating pathways, effect modification, test of causality) concerns in empirical segregation and health research. Additionally, the review discusses future considerations for studies exploring segregation and health, specifically, **analyzing** the beneficial effects of segregation, integrating life-course theories, broadening the scope of segregation research to explore its impact by nativity status for blacks and other racial/ethnic groups, and **linking** with biological data.

Methods

Several databases, specifically the Web of Science, PsychINFO, and PubMed, were searched using the following keywords “racial/ethnic residential segregation”, “residential segregation”, “neighborhood racial concentration”, “racial concentration”, “neighborhood racial composition”, and “racial composition”. The search was restricted to studies conducted in the United States between 1950 and 2009, focused on the segregation patterns of blacks, investigated segregation as the primary exposure of interest, and examined a health outcome. The bibliographies of articles and reviews were additionally screened. We considered studies that examined the relation between segregation and 1) the magnitude of black/white or black/non-black health disparities and 2) variations of health status by degree of segregation. Studies that defined segregation using either a formal measure, with indices reflecting either exposure, evenness, concentration, centralization, or clustering (Massey and Denton, 1988) or proxy measure, defined as neighborhood racial composition, were considered. Additionally, only statistically significant associations were reported. Out of 1,121 articles, a total of 45 individual papers met the inclusion criteria. However, because papers could meet more than one inclusion criteria or may include more than one analysis, a paper may be counted more than once yielding a sample of 56 analyses considered.

Results

Table 1 **summarizes** published studies by macro-area unit of analysis and measure of segregation. Among the studies, there was considerable variation with respect to the macro-area unit of analysis and operationalization of segregation. Of the 56 analyses appraised in the 45 papers, 48% (27 out of 56) used metropolitan statistical area (MSA), 11% (6 out of 56) state, 25% (14 out of 56) city, and 9% (5 out of 56) used county as the macro unit of analysis. The table also shows the heterogeneity in the types of measures of segregation used. In general, formal measures of segregation predominated among larger macro-area units of analysis, namely MSA. For only one study, where MSA was the macro-unit of analysis, investigators used hypersegregation as a measure of segregation (Osypuk and Acevedo-Garcia, 2008). Among smaller macro-areas such as county and zip code, studies tended to use the proxy measure. Studies that employed formal measures were more likely to **find** a positive association between segregation and poorer health in comparison to proxy

measures when MSA, state, or city were used as the macro unit of analysis. For example, of the 9 studies that used city as the macro-unit of analysis and a formal measure of segregation, 8 studies consistently found a positive association between segregation and poorer health; while only 2 of 5 studies that used a proxy measure found a positive association.

Health outcomes and the direction of association (positive, negative, none) for segregation studies are presented in Table 2. A range of health outcomes have been examined; however, most of the evidence is derived from mortality outcomes (Bird, 1995;Collins and Williams, 1999;Cooper et al., 2001;Fang et al., 1998;Hart et al., 1998;Jackson et al., 2000; Laveist, [1989],[1993],[2003];Peterson and Krivo, 1999; Polednak, [1991],[1993],1996b;Rodriguez et al., 2007;Shihadeh and Flynn, 1996;Yankauer, 1950). The strongest **links** between segregation and poor health are documented among adult all-cause and infant mortality studies (Bird, 1995;Collins and Williams, 1999;Cooper et al., 2001;Guest et al., 1998;Hart et al., 1998;Jackson et al., 2000; Laveist, [1989],[1993],[2003];LeClere et al., 1997; Polednak, 1991,1993,1996b;Yankauer, 1950). However, four studies reported a protective relationship between segregation and mortality among blacks (Blanchard et al., 2004;Fang et al., 1998;Hutchinson et al., 2009;Inagami et al., 2006). It is possible that the differences in the associations may reflect variations in the operationalization of segregation or macro-unit of analysis employed. The four studies that reported a protective association employed a proxy measure to operationalize segregation and 3 out of the 4 studies used city as the macro-unit of analysis (Fang et al., 1998;Hutchinson et al., 2009;Inagami et al., 2006).

A range of morbidity outcomes was studied, where infant outcomes (i.e. low birthweight, preterm birth, fetal growth restriction) were the most common (Baker and Hellerstedt, 2006; Bell et al., 2006; Ellen, 2000; Grady, 2006; Grady and McLafferty, 2007; Grady and Ramirez, 2008; Osypuk and Acevedo-Garcia, 2008). The direction of the association between segregation and infant outcomes varied, where 7 out of 14 studies reported positive associations, 2 out of 14 studies reported a negative association, and 4 out of 14 studies reported no association. The majority of the studies adjusted for individual-level risk factors. The variation in findings may be partly attributable to the measure of segregation chosen and the macro-unit of analysis. Although **few** studies investigated the relationship between segregation and adult chronic diseases, the evidence suggest that residence in highly segregated neighborhoods is associated with poorer health outcomes (Acevedo-Garcia, 2001; Fabio et al., 2004; Haas et al., 2008; Morello-Frosch and Jesdale, 2006). The findings for self-reported health are mixed. Two out of 4 studies demonstrated a positive association between segregation and poorer self-rated health (Subramanian et al., 2005; White and Borrell, 2006); whereas three studies did not find an association (Mellor and Milyo, 2004; Robert and Ruel, 2006; Subramanian et al., 2005). Results from one study suggest that the measure of segregation may be important, where segregation operationalized as the isolation index was associated with poorer health and the index of dissimilarity did not have an association with health (Subramanian et al., 2005). Moreover, the inconsistency in results may reflect several factors including the point that different measures of segregation may conceptualize distinct pathways and causes of health, the choice of macro-unit of analysis, or differences in the individual-level risk factors adjusted for in the analyses.

A limited number of studies investigated the relation between segregation and health behaviors (Bell et al., 2007; Chang, 2006; Cooper et al., 2005; Landrine and Klonoff, 2000; Lopez, 2006). Two of these studies focused on smoking, specifically smoking behaviors and smoking during pregnancy, and both demonstrated a positive association between segregation and smoking. A study that assessed the association between segregation and physical activity found a differential effect by measure of segregation where increased physical activity was associated **with higher values of** the isolation index and **but not with**

values of the index of dissimilarity (Lopez, 2006). The study that examined segregation and injection drug use also showed that the association varied by measure of segregation (Cooper et al., 2005). Two studies focused on emotional well-being **and** both suggest a beneficial effect of residence in segregated neighborhoods (Postmes and Branscombe, 2002; Yuan, 2008).

Discussion

The majority of the reported findings to date identifies an association between residence in highly segregated areas and deleterious health outcomes, and to a lesser extent suggests a protective effect of segregation. The literature is fairly limited with regards to examining adult chronic diseases and health behaviors. Despite the relative consistency of a positive, independent effect of segregation, over and above individual sociodemographic factors, across various health outcomes and heterogeneity of segregation measures employed, substantive conceptual, methodological, and analytic gaps in the published literature **remain**.

Conceptualization of residential segregation

The review of the empirical evidence demonstrates that there have been two ways in which studies have conceptualized segregation: use of a formal measure of geographical segregation among racial groups or use of the proxy measure, black racial composition. Prior assessments of segregation and health have deemed the conflation of these two measures as a conceptual problem (Acevedo-Garcia and Lochner, 2003). The purpose of this section is to compare the two measures and discuss the implications of **their** use.

Formal measures

The formal measures of segregation are conceptualized using one of 5 geographic patterns and processes (Massey and Denton, 1988). A brief summary of each dimension is described below. *Evenness*, the most frequently used dimension of segregation, refers to the degree to which members of racial/ethnic groups are overrepresented or underrepresented across neighborhoods. *Concentration* refers to the relative amount of physical space occupied by a group. *Clustering* is the extent to which minority groups live disproportionately in contiguous areas (Iceland et al., 2002). *Centralization* indicates the degree to which a group is located near the center of an urban area (Iceland et al., 2002). *Exposure* (also referred to as isolation) measures the degree of potential contact between groups and reflects the degree to which groups share a common residential area. Although the five dimensions are correlated, they do not overlap completely and each **represents** a distinct geographic residential pattern (Bell et al., 2006). Further, hypersegregation is used to describe high levels of segregation on 4 of the segregation dimensions for one single residential area (Massey and Denton, 1989).

Proxy measure

Residential segregation has also been operationalized using a proxy measure, black racial composition, hereafter referred to as racial composition. Alternatively referred to as racial concentration, percent black, or racial/ethnic density, racial composition reflects the proportion of black individuals for a given geographic area. Racial composition has been interpreted as a measure of neighborhood racial context (White and Borrell, 2006; Zenk et al., 2005) and **higher values are** postulated to be related to lower exposure to discrimination, enhanced social cohesion, mutual social support, and a sense of community (Becares et al., 2009; Halpern, 1993; Hunt et al., 2007).

Formal versus proxy measure

Formal and proxy measures of segregation are **related and** often times used interchangeably. **Many** formal measures **are** in fact calculated by aggregating racial composition statistics for small geographic areas. However, the two types of segregation measures differ, affecting health in different ways, through different processes (Acevedo-Garcia and Lochner, 2003). For example, four studies operationalizing segregation as black racial composition within a local area (either a central city or county) documented a lower risk of mortality among blacks (Blanchard et al., 2004; Fang et al., 1998; Hutchinson et al., 2009; Inagami et al., 2006). In contrast, four other studies employing a formal segregation measure, with MSA as the macro-unit of analysis, documented higher mortality risk among blacks (Collins and Williams, 1999; Cooper et al., 2001; Hart et al., 1998; Polednak, 1993).

Future studies should attempt to examine the differences between formal versus proxy measures in relation to health outcomes for several reasons. First, formal measures of segregation reflect the **uneven geographic** distribution of a particular group **with**in a larger geographic area. The proxy measure **only partially represents** segregation because it measures the racial population composition of an area, not the relative locations of racial groups within the area. Therefore, it may not provide a true reflection of metropolitan-area or neighborhood segregation (Acevedo-Garcia and Lochner, 2003; Morello-Frosch and Lopez, 2006). For example, based on data from the 2000 **Census** and **measuring** segregation by the index of dissimilarity, the New York City MSA has a segregation value of 0.85 and the proportion of blacks is 26.6%; whereas, the Clarksville-Hopkinston, Tennessee MSA has a segregation value of 0.40 and the proportion of blacks is 23.2% (Williams and Collins, 2004). In New York City, the black population is highly concentrated geographically, whereas in Clarksville-Hopkinston the population is more evenly dispersed. This exemplifies that levels of segregation and the proportion of black residents in an area can be very different. Furthermore, prior studies reporting a correlation coefficient between formal and proxy **measures** of segregation **show that the correlation is** low, ranging from 0.062 to 0.28 (Mellor and Milyo, 2004).

Second, formal measures reflect the social processes and dynamics of racial inequality in education, housing, and labor markets (Schulz et al., 2002). Racial composition does not capture these complex processes of racial inequality (Acevedo-Garcia and Lochner, 2003; Morello-Frosch and Lopez, 2006; Wong, 2002). Third, formal measures of segregation, in theory, represent **potential** geographic and spatial interaction patterns between racial/ethnic groups. The use of neighborhood racial composition may not give a complete indication of the degree to which groups interact with one another. Further, unlike a formal measure of segregation, the use of a proxy measure does not recognize the degree to which neighborhood processes are affected by interconnections across boundaries. This is of particular import for health disparities research because the **connections** between segregation and inequalities in health are a function of the concentration of economic and social disadvantage, disinvestment of businesses from communities, and the absence of an infrastructure that promotes opportunity (Williams and Mohammed, 2009). And lastly, in regards to analytic considerations, several studies examining MSA-level segregation adjusted for racial composition of black residents and still reported robust associations between segregation and various health outcomes (Bell et al., 2006; Bell et al., 2007; Cooper et al., 2007; Osypuk and Acevedo-Garcia, 2008). This adjustment accounts for the fact that the proportion of black residents in an area has a tendency to increase as segregation increases. Further, the inclusion of both measures is not interpreted as an overspecification of the model. Future studies that operationalize segregation using the MSA as the macro-area and employ a formal measure of segregation should adjust for racial composition. In essence, the lack of differentiation between a formal and a proxy measure of segregation

could possibly underestimate associations as well as overlook potential policy opportunities for targeting health disparities.

Measurement

Spatial scale for measuring segregation—The calculation of a formal measure of segregation entails describing the distribution of individuals across micro-units within a larger macro area. Census tracts are typically used as the micro-unit in segregation and health research, although their use as proxies for neighborhoods has come under scrutiny (Diez-Roux, 2007; Kramer and Hogue, 2009; Krieger et al., 2003). Equally important is the choice of the macro-unit of analysis, which may have broader implications for describing and addressing health disparities, although, it has not received sufficient attention. Segregation can occur at a variety of geographic levels, for example, state, MSA, county, or city (Massey et al., 2009). However, there remains a considerable amount of heterogeneity in the macro-unit of analysis employed in segregation and health studies. It is possible that the effects of segregation may differ by geographical context. Most studies have used either the MSA or central city, and thus will be the focus of the following discussion.

Metropolitan Statistical Areas—The most common geographic macro-unit chosen to examine segregation and health is the MSA. Studies that have used MSA tend to focus on intercity comparisons of the effect of segregation. Defined by the Office of Management and Budget, MSA are comprised of at least one urbanized area with a population of 50,000 or more and adjacent communities that share a high degree of economic and social integration. MSA reflect housing and labor markets that are responsible for creating patterns of segregation (Bell et al., 2006; Morello-Frosch and Lopez, 2006; Osypuk and Galea, 2007). This feature makes MSA very attractive as a level of aggregation for modeling racial health disparities (Osypuk and Acevedo-Garcia, 2008). For example, transportation planning and industrial clusters determined at the metropolitan-level are important contextual factors driving environmental health disparities (Morello-Frosch and Lopez, 2006). Another advantage of using MSA is the minimization of selection bias. The forces operating to sort people into neighborhoods are less prominent between metropolitan areas as compared to within metropolitan areas (Osypuk and Galea, 2007). More specifically, people are less likely to move across MSA than they are to move within MSA. However, one of the limitations to using MSA is that cross-metropolitan analyses have the potential to obfuscate important patterns of within-MSA and local-level heterogeneity (Guest et al., 1998; O'Sullivan and Wong, 2007). For example, the size of census tracts in dense metropolitan area such as NYC can be as small as 0.25 square miles in comparison to 5 square miles of some census tracts in southern MSA (Mason et al., 2009). Secondly, datasets that sample populations based on MSA are not designed to take representative samples from neighborhoods within the MSA (Robert and Ruel, 2006). Further, it is possible that the processes necessary to understand the underlying spatial patterning by race/ethnicity may differ across metropolitan areas **and** operate through more proximal neighborhood-level factors.

Central city—A growing body of research explores the patterns of segregation within a specific local area, by limiting analyses to a single central city within an MSA. Cities have many advantages for analyzing the associations between segregation and health. It is possible that similar mechanisms (i.e. concentrated poverty, economic disinvestment, neighborhood conditions) that operate at the metropolitan level to influence health may very well operate at the city level. The use of city as the macro-unit of analysis may facilitate the ability to draw upon precise knowledge of neighborhood social, physical, political and historical attributes, providing a holistic understanding of the mechanisms underlying segregation and health disparities. For instance, studies can incorporate the influences of

specific provisions of municipal services, health regulations, or parameters for urban development (Osypuk and Galea, 2007). One of the major advantages of using this level of aggregation is that it captures the within-city variation and truer immediacy of social context that is lost in cross-metropolitan analyses (Guest et al., 1998). Moreover, the availability of data on the social and physical context of neighborhoods, which is not reflected in census-derived socioeconomic measures, may provide a detailed characterization of neighborhood context. Additionally, cities have a political structure of governance, unlike metropolitan statistical areas, where there is no corresponding political boundary (Osypuk and Galea, 2007). It is possible that the processes **influencing** spatial patterning by race/ethnicity may differ across metropolitan areas. For example, a census tract with a 10% minority population within a highly segregated metropolitan area may **represent a very different neighborhood context** from a similar census tract within a city that is not as segregated (Inagami et al., 2006).

The use of local formal measures of segregation have been developed (Chung and Brown, 2007; Reardon and O'Sullivan, 2004; Wong, 2002a) as a result of the growing concern that measures at the regional level may obscure spatial patterns within regions and central cities (Wong et al., 2007). Wong's local spatial index, based on the exposure dimension, models the potential for interaction between groups and takes into account that groups interact across contiguous neighborhood boundaries (Wong, 2002a). This local measure of segregation is the only alternative formal measure that has been used to examine segregation and health outcomes (Grady, 2006; Grady and McLafferty, 2007; Grady and Ramirez, 2008).

One key limitation, however, is the potential for introducing selection bias when using city, which does not account for the divide between the central city and the surrounding area (Acevedo-Garcia and Osypuk, 2008; Hearst et al., 2008; Osypuk and Acevedo-Garcia, 2010). For example, there may be key differences between people who are more likely to live in cities in comparison to those who are more likely to live in the suburbs. The criteria for choosing macro-level units should be primarily driven by the theoretical model guiding the research hypothesis (Acevedo-Garcia and Osypuk, 2008; Diez-Roux, 2007).

Implications of choice of unit of analysis (MSA versus central city)—

Segregation studies have not yet determined whether the magnitude of **health** disparities could be sensitive to different macro-area levels of geography. Testing the sensitivity of results to different spatial scales which may have implications for various social mechanistic pathways and different health outcomes has been suggested (Diez-Roux, 2007). Some of the evidence regarding the direction of association begs the question of whether the size of the geographic area has an impact on the magnitude and direction of residential segregation. For example, three studies that operationalized segregation using black racial composition within single central cities (i.e. two in New York City and one in Philadelphia) documented a lower risk of mortality among blacks (Fang et al., 1998; Hutchinson et al., 2009; Inagami et al., 2006). However, two studies that used black racial composition at the MSA-level observed a positive association between segregation mortality among blacks (Jackson et al., 2000; LeClere et al., 1997).

An issue underlying this question is the modifiable areal unit problem (MAUP), which refers to sensitivity of analytical results based on the definition of **areal** units and the level of aggregation of the data collected (Fotheringham and Wong, 1991; Openshaw, 1983). The MAUP is described in two components, the scale effect and the zoning effect. The scale effect refers to the level of aggregation of the **areal** units and the zoning **effect results from** the configuration of **area (zone) boundaries** (Fotheringham and Wong, 1991; O'Sullivan and Wong, 2007). The relationship between segregation measures and MAUP has been

previously discussed in the geography and sociology literature (Lee et al., 2008; O'Sullivan and Wong, 2007; Reardon and O'Sullivan, 2004; Wong, 2003, 2004). These issues of scale **and boundary effects** have implications for **measuring segregation and** interpreting **results about** the health consequences of segregation. For example, levels of segregation for a given metropolitan area and its central city may vary in regards to the size of the area and the racial diversity of the population (Reardon et al., 2008). This can lead to either the underestimation or the overestimation of health disparities in a particular area. Therefore, it is imperative to investigate the specific processes and scales through which residential segregation may influence health or contribute to disparities. The comparison of health disparities on different macro-geographic scales could be central for deciding the most effective level to intervene. This is important since there is a growing movement to **develop** neighborhood-level policies **to improve population health**. Thus, the reliability of segregation measures is critical for understanding the patterns and health consequences of segregation (Reardon and O'Sullivan 2004). Future studies to describe the effects of segregation at different levels of geography and to understand the influence of MAUP on segregation estimates should be a priority. Inconsistencies related to the choice in segregation measure (formal versus proxy) or the macro-unit of analysis (MSA versus city) used to operationalize segregation should be clarified to foster a more complete understanding and further elucidate the pathways and mechanisms by which segregation influences health.

Analytical

Testing mediating pathways—Distal causes of health, such as segregation, are mediated through individual-level and proximal causes (Osypuk and Galea, 2007). Therefore, enhancing the understanding of the pathways and mechanisms linking segregation to health requires empirically testing mediating pathways. Prior reviews have described the **mechanisms through which** segregation is postulated to influence health (Kramer and Hogue, 2009; Williams and Collins, 2001). However, few studies have empirically investigated the potential individual-level behavioral, psychosocial, or neighborhood-level medical, physical, environmental and social resources mediating segregation and health (Grady and Ramirez, 2008; Hutchinson et al., 2009; Yuan, 2008). Grady et al (2008) examined medical conditions hypothesized to mediate the relationship between segregation and low birth weight. Yuan (2008) tested individual-level social support and neighborhood-level social ties as potential mediators of the association between segregation and emotional well-being.

Testing for neighborhood-level mediation may be of importance because of the disparities in overall neighborhood and health care quality, built environment, and environmental exposures (Landrine and Corral, 2009). Several studies have examined the distribution and quality of nursing homes (Smith et al., 2007), fast food restaurant density (Kwate et al., 2009), and supermarkets (Moore and Diez Roux, 2006) in segregated areas. The presence or absence of such neighborhood characteristics can foster the development of health behaviors and influence the management of disease. Precise measurement and mapping of the **accessibility** of neighborhood resources by magnitude of segregation would be a complement to the segregation and health disparities discourse. For example, the application of geographic information system (GIS) mapping techniques could explicitly highlight the unequal distribution of neighborhood services and amenities, and can estimate an individual's access to or distance from neighborhood resources, which would in turn improve the understanding of how segregation impacts access to health resources. **Research**ers **have used** GIS to map the **spatial distributions** of social groups and **neighborhood resources and hazards in** metropolitan areas (Downey, 2003). These data have the promise to be very useful for testing specific intermediary mechanisms linking

segregation and health. Future studies investigating the role of residential segregation and its contribution to health risk and health disparities should test specific intermediary pathways at both the individual- and neighborhood-levels to improve understanding of the multiple pathways segregation operates to influence health and contribute to the allocation of resources.

Examining effect modification—Testing effect modification, where a measure of effect and/or association changes over the values of some other variable, in the segregation and health literature has been limited. Examining effect modification at the individual- or neighborhood-level can provide valuable insight into the complex relationships between segregation and health. For example, studies that have examined effect modification by race/ethnicity have uncovered mixed results where some studies show that whites, for instance, are harmed by segregation (Rodriguez et al., 2007; White and Borrell, 2006) and other studies demonstrate that white residents are not impacted (Bird, 1995; Chang, 2006; Hart et al., 1998). Far fewer analyses, however, have stratified on or tested for effect modification by individual-level characteristics such as age, gender, income or education.

Exploring the interaction between perceived discrimination and segregation may further **elucidate** the causes of racial/ethnic health disparities. Given the individual- and neighborhood-level pathways through which discrimination may influence health outcomes, there is however a paucity of studies examining the joint effect of perceived discrimination and segregation. **A hypothesized** mechanism **is that for blacks, the lesser** experience of racism in highly segregated or more concentrated neighborhoods may confer a protective effect given the social support and diminished exposure to discrimination. To our knowledge, only one study to date has looked at this issue. Becares et al. examined ethnic density and perceptions of discrimination among Africans, Caribbean Blacks, Pakastani, and Bangladeshi people in the UK (Becares et al., 2009). Although the interaction terms in this particular study were not statistically significant, **the** interaction **between segregation and discrimination** should be tested in the U.S. context.

Testing effect modification should not only be limited to individual-level characteristics, but also to neighborhood-level factors such as disadvantage and social capital. There is limited evidence of effect modification by neighborhood-level disadvantage (Mason et al., 2009; Pickett et al., 2005; Vinikoor et al., 2008). Segregation and neighborhood-level poverty are highly correlated (Williams and Collins, 2001) and most studies tend to treat it as a confounder. Of the studies that adjusted for area-level poverty, 63% (20 out of 32 studies) found a positive association between segregation and the health outcome of interest. However, it is possible that adjusting for poverty could lead to the underestimation of the effect of segregation since poverty may be on the causal pathway. Furthermore, **it** has been argued that segregation is an important factor in maintaining and perpetuating racial differences in socioeconomic status (Williams and Collins, 2001). Moreover, it is possible that other neighborhood-level factors such as social capital may be important. For example, the effect of neighborhood racial composition varied according to level of social capital, where neighborhoods that were predominantly black **and had** high social capital had lower black mortality (Hutchinson et al., 2009). Uncovering the differential effect of segregation by neighborhood characteristics should be **a high priority in** future studies.

Test of causality—High quality data and analytical techniques are needed to improve the estimation of the effect of segregation on health outcomes. Common to the neighborhood effects literature (Diez-Roux, 2007), studies in this review were mostly cross-sectional. The reliance upon cross-sectional studies makes it difficult to establish temporality **and** avoid bias related to endogeneity and reverse causation, and masks the dynamic nature of neighborhoods. It is possible that longitudinal studies could disentangle the relation between

frequency and duration of residence in segregated neighborhoods and the lag time between the exposure and onset of disease (Collins and Williams, 1999; Grady and McLafferty, 2007). In addition, longitudinal designs hold promise of illuminating the cumulative impact of segregation on health.

Analytic techniques, chiefly, multilevel or hierarchical analyses, have been used in more recent studies of segregation and health and more generally to identify causal effects of neighborhood environment on health. The motivation for using hierarchical statistical models is congruent with the hypothesized multilevel mechanisms between segregation and health. However, this analytical approach has drawn criticism related to the selection and the estimation of an independent causal effect of neighborhood context and structural confounding (Messer et al., 2008; Oakes, 2004). In light of **these** criticisms, propensity score matching has been used to account for some of the self-selection factors. One study examining the effect of segregation on preterm birth utilized propensity score methods (Hearst et al., 2008). However, this highlighted other methodological considerations related to selection bias and the estimation of causal effects given the non-overlapping distribution of neighborhood environments, (Acevedo-Garcia and Osypuk, 2008; Osypuk and Acevedo-Garcia, 2010). Because of segregation, there is limited overlap in the distribution of neighborhoods between blacks and whites where these groups tend to live in separate neighborhoods (Acevedo-Garcia and Osypuk, 2008). Secondly, this may constrain the identification of exchangeable groups and result in off-support inferences based on sparse data cells (Messer et al., 2010; Osypuk and Acevedo-Garcia, 2010). These two issues are important for causal inference and may in fact lead to the instability of estimates of disease occurrence and imprecision in the magnitude of disparities.

Instrumental variable (IV) analyses may alternatively be considered as an analytic approach to estimate the causal effect of segregation. IV analyses can be used to reduce or eliminate bias related to selection and unmeasured confounding for a given exposure by choosing a variable or instrument that is associated with the exposure but not associated with the outcome except through its association with the exposure (Angrist et al., 1996; Greenland, 2000). In the economics literature, IV analyses have been used to examine the effects of segregation on employment and earnings outcomes for blacks (Cutler and Glaeser, 1997; Weinberg, 2000). However, the validity of using IV analyses **rests** in finding the most appropriate instrument or variable. Methods to improve the estimation of segregation and health should broadly encompass a variety of research methods including qualitative and quantitative approaches, and spatial analytic techniques to foster the identification of temporal trends between segregation, health status, and health disparities.

Future research considerations

Beneficial health effects of segregation—Although **most health and** segregation **studies** document poorer health outcomes **in highly segregated areas**, **some** studies observed protective effects. Only a few studies have been able to capitalize on better understanding these mechanisms by empirically examining a full pathway between segregation and health outcomes (Hutchinson et al., 2009; Yuan, 2008). Studies exploring experiences of discrimination, social capital, and social support are needed. For example, numerous reports have provided persuasive evidence demonstrating an association between experiences of discrimination and poorer health outcomes (Schulz et al., 2006; Taylor et al., 2007; Wise et al., 2007). Further, findings from a recent study suggest that residents of highly segregated neighborhoods were more likely to be protected from experiences of discrimination (Hunt et al., 2007). Although high segregation often connotes poor access to resources, **some** evidence points to resilient features of segregated neighborhoods. For instance, black mortality was lower among residents of predominantly black neighborhoods

in Philadelphia with high neighborhood social capital in comparison to their counterparts living in predominantly white neighborhoods (Hutchinson et al., 2009). Moreover, there is some formative research which considers the role of neighborhood institutions such as churches as resource brokers – organizations that have ties to businesses, nonprofits, and government agencies **that are** rich in resources (Small, 2006). **These resource brokers** may provide information and services that buffer individuals against material disadvantage. Subjective perceptions of one's neighborhood environment may also be important for understanding the beneficial effects of neighborhoods. Qualitative work has demonstrated that people in black neighborhoods identify positive aspects of the neighborhoods such as cultural resources and faith institutions (Mullings and Waith, 2001). It is important that future studies determine the health outcomes and behaviors and factors associated with resilience that may buffer against and compensate for material deprivation of segregated communities.

Integrating a life-course framework—Among the most prominent concerns of neighborhood effects and segregation research are issues related to length of residence and exposure to the environment and the relationship to a relevant disease etiologic period. Due to limitations in the availability of data, it is challenging for studies to determine either the date or length of time an individual has lived in a particular area. As a consequence, relatively little attention has been paid to the time frame necessary for neighborhood conditions to affect health (Diez-Roux, 2007). More specifically, studies are unable to differentiate between individuals who have been exposed to segregation for long periods of time versus those with a relatively brief exposure. Hence, it has yet to be established whether the effects of segregation are cumulative or cross-sectional. The integration of a lifecourse framework, for example, the cumulative pathways perspective, may prove most promising for attempting to address these issues. Cumulative pathways approach posits that chronic stress can cause wear and tear on the body, leading to declines in health and function over time (Glymour and Manly, 2008). Relatedly, the weathering hypothesis underscores the role of early differential risk and cumulative social and environmental disadvantage on racial/ethnic disparities in health (Geronimus, 1992). **Understanding** how the reproduction of social and economic inequalities in neighborhood persists across generations (Sharkey, 2008) and across one's lifecourse **is** an important **topic for** segregation and health research.

A handful of studies have investigated lagged health effects of segregation over the lifecourse. Researchers have examined whether the racial composition of one's environment during childhood and adolescence affect later health outcomes (Landrine and Klonoff, 2000; LaVeist, 2003; Postmes and Branscombe, 2002). Another study has looked at the effect of segregation among the elderly (Robert and Ruel, 2006). Studies have largely examined infant and adult outcomes. Although these studies provide an important start, a more systematic approach is needed. It is not clear whether particular lifecourse stages may be more sensitive to the influence of segregation on health. Documenting the relationship between segregation and health at varying stages of the lifecourse would be a significant methodological contribution.

Black nativity status and other racial/ethnic groups—The U.S. continues to become an increasingly multiracial and multiethnic nation with individuals immigrating from other countries. Although, the historical development and patterns of segregation among foreign-born blacks, Hispanics and Asians are qualitatively different from U.S. born-blacks, the investigation of segregation may provide important clues about patterns of health status. The U.S. black population represents a heterogeneous group where the numbers of foreign-born blacks from the Caribbean and the continent of Africa have nearly doubled over the past 20 years and represent one-fourth of the black population in major metropolitan areas (Kent, 2007). Though the data on the health of foreign-born blacks

residing in the U.S. is limited, research findings in general report that they have better health outcomes than their U.S. born counterparts (Singh and Siahpush, 2002). However, there is evidence which suggest that the health profiles of foreign-born blacks diminish as the length of residence in the U.S. increases (Borrell et al., 2008). If this is true, it is possible that **for foreign-born** blacks, **neighborhood context in the U.S.** may influence **health** outcomes and lead to **the deterioration of** health over time. **Despite** the high levels of segregation among foreign-born blacks **in the U.S.** (Scopilliti and Iceland, 2008), **only a few** studies **have** explored the role of nativity status in the segregation and health literature (Baker and Hellerstedt, 2006; Grady and McLafferty, 2007). The comparison of the effect of segregation by nativity status could illuminate processes regarding timing between exposure and the occurrence of disease. Investigating the influence of segregation by black nativity status should be another priority for segregation and health research.

Hispanics are among the fastest growing subgroup of the population and the second-most segregated group in the U.S. (Iceland et al., 2002). Although a prior review of the segregation literature recommended studies to further examine segregation among Hispanics (Acevedo-Garcia et al., 2003), studies among Hispanics are still limited. The few studies to date have investigated health outcomes ranging from self-rated health (Patel et al., 2003), physical health symptoms (Lee and Ferraro, 2007), body mass index (Park et al., 2008), cancer tumor stage and size (Reyes-Ortiz et al., 2008), mortality (Inagami et al., 2006), and mental health (Lee, 2009; Ostir et al., 2003; Sheffield and Peek, 2009). These studies have largely operationalized segregation using the **proxy** measure. Overall, the findings from these studies are mixed and do not provide conclusive evidence on the impact of segregation on Hispanic health. Moreover, the evidence suggests heterogeneity of the patterns and effect of segregation within this population (Lee and Ferraro, 2007; Lee, 2009). For example, neighborhood segregation is significantly associated with poorer mental health among Mexican Americans, but the association between segregation and mental health was not observed among Puerto Ricans (Lee, 2009). Also, there is data suggesting that segregation may vary by generational status (Lee and Ferraro, 2007). Future studies should examine how health status may be shaped by segregation among Hispanics.

Though patterns of segregation are believed to play a lesser role in explaining health disparities among Asians, the studies examining segregation have documented **an** association with health problems. One study found that segregation among Asian Americans was associated with an increased risk of exposure to carcinogenic agents (Morello-Frosch and Jesdale, 2006), whereas segregation was only marginally associated with lower psychological symptom scores (Gee, 2002). Additional studies examining the contribution of institutionalized discrimination to the health risk of Asian Americans should be explored.

Linkage with biological data—There is a dearth of studies linking segregation to biological and physiological pathways. The majority of studies of segregation and health have primarily relied upon death and birth certificates as well as self-reported data. Although, we recognize the significance of this type of data, there are major gaps **in understanding** the relationship **of segregation** with the earlier onset of illness, more severe disease, and disease management. For example, research exploring the relationship between segregation and inflammatory biomarkers such as C-reactive protein may provide additional clues to the biological embodiment of discrimination. Moreover, there are a dearth of studies examining segregation and a range of chronic disease health outcomes such as hypertension and diabetes. The challenge of developing datasets with precise measurements of the neighborhood environment and **incorporating** biological data, including epigenetic or gene expression data, are crucial to furthering the mechanisms by which segregation influences health outcomes and the management of disease.

Conclusion

In summary, patterns of segregation shape health risk among blacks and racial/ethnic health disparities. Although there are studies that demonstrate a protective effect of living in segregated areas, the magnitude and persistence of black disparities across various disease and health outcomes warrants continued interest and further investigation. A singular focus on individual-level strategies to improve health and ameliorate health disparities has been ineffective. Moreover, recent evidence suggests that the incorporation of neighborhood or **placed-based** effects can significantly attenuate health disparities (Do et al., 2008). Therefore, elucidating the effect of segregation can have substantial implications for disease prevention and identifying key points of intervention. At the core, residential segregation reflects neighborhood differences in access to economic, medical, environmental, and political resources that may constrain the ability to improve health (Schulz et al., 2002); although there is some evidence suggesting that there are social resources within segregated neighborhoods that may mitigate against the material disadvantage. Strong theoretical frameworks have provided a rationale for why segregation is a fundamental cause of health disparities; however, there is a paucity of studies empirically testing the complex ways in which segregation influences health. This discussion highlighted key conceptual, methodological, and analytical issues **while offering** future directions such as exploring factors of resilience, applying a lifecourse perspective, broadening the scope of segregation to encompass black nativity and other racial/ethnic groups, and linkage with biological data. **These investigations** will further our understanding of **the diverse impacts of** residential segregation on health risk and health disparities.

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Table 1

Summary of the macro-area unit[a] of analysis and type of segregation measured used in the published research, 1950-2009

Macro unit of analysis	Segregation dimension	# of publications	# (%) of positive association
MSA	Formal:		
	Evenness	13	
	Exposure/isolation	6	
	Concentration	1	
	Clustering	2	
	Centralization	1	
	Hypersegregation	1	
	Total	24	21 (87.5%)
	Proxy:		
	Racial composition	3	
	Total	3	1 (50%)
State	Formal:		
	Evenness	1	
	Exposure/isolation	1	
	Concentration	1	
	Total	3	3 (100%)
	Proxy:		
	Racial composition	3	
	Total	3	1 (33%)
City	Formal:		
	Evenness	2	
	Exposure / Isolation	4	
	Wong's local index	3	
	Total	9	8 (88.8%)
	Proxy:		
	Racial composition	5	
	Total	5	2 (40%)
County	Formal		
	Evenness	2	
	Exposure/isolation	1	
	Total	3	1 (33.3%)
	Proxy:		
	Racial composition	2	
	Total	2	1 (50%)
Census **tract**	Proxy:		
	Racial composition	1	
	Total	1	1 (100%)
Individual[b]	Proxy:		

Macro unit of analysis	Segregation dimension	# of publications	# (%) of positive association
	Racial composition	3	
	Total	3	2 (66.6%)

Note: A single study may examine multiple segregation measures for a specific health outcome or multiple health outcomes for a specific measure of segregation. Therefore, some studies may be listed more than once or have two different associations for a single outcome.

Abbreviations: Metropolitan Statistical Area (MSA)

[a] Some studies that used racial composition as a measure of segregation were not included in this table since a macro-area unit of analysis is not specified.

[b] Creation of measure based on assessing racial/ethnic composition across various context over lifecourse.

Table 2

Summary of the directionality of association in published studies[a] on residential segregation and health disparities, 1950-2009

	Positive association[b]	Negative association[c]	No association
MORTALITY			
Adult all-cause	7	4	
CVD / heart disease	1		
Homicide	3		
Cancer	1		
End-stage renal disease			1
Infant mortality	6		1
MORBIDITY			
Infant health			
Low birth weight	5		1
Preterm birth	2	1	2
Fetal growth restriction	1	1	1
Chronic disease in adults			
Tuberculosis	1		
Cancer			
Stage diagnosis		1	
Risk[d]	2		1
Intentional injury	1		
Self-reported health	2		2
HEALTH BEHAVIOR			
Injection drug use	1		1
Physical activity			1
Smoking	2	1	
Weight status	1		
OTHER HEALTH STATUS			
Emotional well-being		2	
Adolescent child-bearing	1		

[a] Some studies may be listed more than once or have two different associations for a specified health outcome because multiple measures of segregation or multiple measures of health were accessed.

[b] Defined as residence in highly segregated area/neighborhood associated with higher levels of poorer health

[c] Defined as residence in highly segregated area/neighborhood associated with lower levels of poorer health and may also include conditional associations (only under some condition).

[d] Includes exposure to ambient air toxic