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Neighborhood Racial Residential Segregation and Changes in Health or Death among Older Adults

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Abstract

We assessed relationships between neighborhood racial residential segregation (RRS), individual-level health declines and mortality using Health and Retirement Study data. We calculated the census-tract level Location Quotient for Racial Residential Segregation (LQRRS), and estimated adjusted relative risks (ARR) of LQRRS for declines in self-reported health or death 1992–2000, controlling for individual-level characteristics.

Of 6,653 adults, 3333 lived in minimal, 2242 in low, 562 in moderate, and 516 in high LQRRS tracts in 1992. Major decline/death rates were: 18.6%, 25.2%, 33.8% and 30.4% in minimal, low, moderate and high tracts, respectively. Adjusting for demographic characteristics, residence in low, moderate and high LQRRS census tracts was associated with greater likelihood of major decline/death compared to minimal LQRRS. Controlling for all variables, only moderate LQRRS predicted major decline/death, ARR=1.31 (95% CI 1.07, 1.59; p<.05).

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Keywords

segregation; census tracts; health status; contextual effects; health disparities; geography; United States

INTRODUCTION

Large disparities in health and high levels of racial residential segregation (RRS) are pervasive realities for many African Americans in the United States when compared to non-Hispanic whites (Massey and Denton, 1993; Williams, 1996, 1997, 1999). Several studies demonstrate a potential link between RRS and individual and community level health outcomes that may partially explain the basis for these disparities. For example, areas with higher levels of racial residential segregation are associated with higher rates of infant and adult mortality (LaVeist, 1993; Fang et al., 1998; Geronimus et al., 1996, 1999), cardiovascular disease (Diez Roux et al., 2001; Cooper, 2001), and poorer mental health (Aneshensel and Sucoff, 1996; Schulz et al., 2001), and these associations remain after controlling for individual level characteristics of residents such as socioeconomic status and health behaviors. Additionally, LaVeist found racial segregation to be associated with greater odds of death for African Americans and that older African American adults are more likely than other age groups to live in neighborhoods disadvantaged by racial segregation (LaViest, 2003).

What do we mean by segregation and how does RRS effect health outcomes? In the most general sense, segregation is the geographical separation of people on the basis of ethnicity or race (Kaplan and Holloway, 1998). Measures of RRS may capture exposure to factors deleterious to health, including higher levels of poverty, crime, incivility and social disorganization; poorer educational and occupational opportunities (Williams et al., 2010); poorer housing and the built environment, as well as poor role models for health behaviors. Notwithstanding what we know about the association of RRS and health outcomes, previous empirical work studying this relationship has notable gaps (White and Borrell, 2011). For example, the majority of studies investigating the relationships between segregation and health outcomes have focused on mortality outcomes including adult all-cause and infant mortality (White and Borrell, 2011; Fang, et al., 1998; Geronimus, et al., 1996, 1999). However, explanatory factors may not be uniform in their impact on different health outcomes, and therefore expanding outcomes to include declines in subjective health status may strengthen our understanding of the relationship between segregation and health.

Segregation is a phenomenon that can be meaningful at several geographic levels, such as counties, metropolitan areas, cities or neighborhoods. Traditional operational measures of segregation most prevalent in the health literature are calculated for large geographic areas (e.g., metropolitan areas, cities) and are typically used in the investigation of aggregate outcomes—e.g., rates of mortality and rates of low birth weight (White and Borrell, 2011). However, neighborhood factors have been suggested as particularly important determinants of health for older adults (Yao and Robert, 2007). Hence, these large area measures tell us relatively little about the extent to which *individuals* are exposed directly to segregation and how local areas or neighborhoods characterized by segregation might affect individual level health outcomes. Lastly, the use of cross sectional analyses limits the ability of many studies to understand the explanatory importance of individual variables influencing health. For example, cross sectional studies cannot discern whether disparities in outcomes have decreased or increased over time (Yao and Robert, 2007).

We designed our study to help address these important gaps. We assess the relationship between racial residential segregation and self-reported major declines in health or death in older adults using a small area measure of segregation, the Location Quotient for Racial Residential Segregation (LQRRS). The LQRRS measure can be considered as examining the hypothesis of relative deprivation (one's position relative to others in society is a health determinant) as put forth by Robert Merton (1938). He claimed that individual differences could be better studied by examining relative, rather than absolute differences. More recently, Wilkinson and Pickett (2007) have argued that social inequalities (including health status and mortality) are best studied by comparing the degree of relative differences between individuals and groups, rather than simply comparing absolute levels of social indicators. Following Merton (1938) we introduce a segregation measure that accounts for relative differences by comparison of smaller neighborhood units relative to the larger metropolitan area.

Figure 1 presents the conceptual model guiding this investigation. First, we conceptualize racial residential segregation and the three demographic variables of age, sex and race/ethnicity to be exogenous covariates and their unanalyzed association is indicated by a curved double arrowed connection. This model suggests racial residential segregation and demographics affect health outcomes both directly and indirectly, where the effects are mediated to some degree by individual level factors including socioeconomic status (educational attainment, income, health insurance coverage, net worth), health behaviors (smoking and alcohol consumption patterns), and health status (self-reported overall health, chronic health conditions). These individual factors are more proximate determinants of health declines and death (Link and Phelan, 1995). Our model also suggests that not all of the effects of segregation and demographics are mediated by individual level factors and we allow for direct effects of segregation and demographics on health.

METHODS

Data sources

For this study we use two data sources. The first includes Wave 1 (1992) and Wave 5 (2000) of the Health and Retirement Study (HRS), a longitudinal, nationally representative, multistage area probability sample of U.S. households. Supported by the National Institute on Aging and conducted by the University of Michigan's Institute for Social Research, the first wave of data collection targeted non-institutionalized persons in the contiguous U.S. ages 51–61 (born 1931–1941) and their spouses. For the initial interview, in-home, face-to-face interviews were conducted for 7,608 households yielding 12,652 individual respondents (an overall response rate of 82%). Subjects were subsequently interviewed every two years. Blacks, Hispanics, and Florida residents were over sampled. By design, the HRS staff provided sampling and analytical weights only for the targeted "age-eligible" respondents and their "age-eligible" spouses/partners to adjust for over sampling and non-response bias. A more detailed description of the overall study design and sampling methods are provided elsewhere (Heeringa and Connor, 1995). Complete details on the HRS are available online at http://hrsonline.isr.umich.edu. Our second data source is the 1990 U.S. Decennial Census (U.S. Census Bureau, 1990) from which we obtained the necessary population values at the Metropolitan Statistical Area (MSA) and census tract levels in order to compute our focal independent variable LQRRS. The U.S. Census data was then merged with HRS restricted baseline data gathered in 1992 that included subjects' census tract information.

Subjects

Because of the HRS complex survey design and our desire to produce nationally representative estimates for this age group in our final analysis, we were limited to using

those respondents for whom sampling and analysis weights were provided. By design, these were the targeted "age-eligible" respondents and spouses/partners mentioned above, ages 51–61 in 1992, numbering 9,824 individuals of the original 12,652 respondents, the balance of which were spouses of the age eligible respondents outside of the 51–61 age range. Next, 85 (0.9%) respondents had incomplete records for either the 1992 or 2000 interview and were excluded. An additional 1399 (14.2%) were lost to follow-up over the 8-year period. This left us with 8340 respondents initially available who had complete records in both waves of data collection or who had died during the period 1992–2000. Among these 8340 respondents we excluded an additional 1687 persons (17.1%) who were rural (non-MSA) residents. This left 5975 persons who had complete records plus 678 persons who died in the period 1992–2000 for a total study sample of 6653. We used both publicly available HRS data files and a restricted data file containing geographic identifiers for each respondent. Finally, because of the sensitive nature of the geographic identifiers, this study was approved by a local institutional review board and the staff of the Health and Retirement Study.

Major decline/death

Two health status indicators were combined to define our single outcome measure: major decline in self-reported overall health (SROH) between 1992 and 2000, and death (all cause mortality) between 1992 and 2000. Self reported overall health (SROH) or global self-rated health has been used as an important patient-derived outcome variable (Satariano, 1986; Shetterly et al., 1996; Idler and Benyamini, 1997). Previous work also documents that SROH is predictive of mortality in longitudinal studies (Onawola and LaVeist, 1998; Bowling, 1991), predicts medical care services use (Krauss et al., 1999), and is useful in predicting subsequent changes in health, physical functioning, disability, and distress (Farmer and Ferraro, 1997; Ferraro et al., 1997; Idler and Kasl, 1991).

First, death was determined using National Death Index and household contacts by the HRS staff and made available as a public dataset. Second, self reported overall health was assessed with the Excellent/Very Good/Good/Fair/Poor questionnaire response format at each interview. A major decline in SROH was defined as follows: 1) a decline from excellent/very good/good health in 1992 to fair/poor health in 2000; or 2) a decline from fair health in 1992 to poor in 2000 (Baker et al., 2001, 2006; Sudano and Baker, 2006). We also expanded this health status measure (major decline in heath) to include any individuals—regardless of 1992 health status—who died between 1992 and 2000. Thus we call our final outcome measure a major decline or death 1992 – 2000.

An Exposition of LQRRS: A Local (Small Area) Measure of Racial Residential Segregation

Racial residential segregation is typically measured across large areas, reflecting the ambient effects across a region, such as an MSA, county, or city. While traditional large scale measures such as the popular index of dissimilarity (or "D") are often used when analyzing aggregated rates of outcomes in a region, they fail to characterize the segregation level of the smaller constituent geographic units. Segregation levels across constituent units are not expected to be uniform; the level in each unit is likely to deviate from the aggregate level. Therefore, it is important to recognize that spatial variation among the constituent levels (typically census tracts) imposes different magnitudes of effects for residents in different parts of the region. Measures such as "D", which describes the overall segregation level of a region, are labeled as global measures, but local measures—with a value assigned to each constituent unit—are needed in order to more accurately depict the conditions experienced by individuals (O'Sullivan and Wong, 2007; Wong, 1996, 2002). Notwithstanding the debate on whether to use a spatial versus social or interactional definition of neighborhood (O'Campo, 2003), using census tracts has been the de facto method for approximating a

neighborhood unit in scores of studies (O'Campo, 2003; Saelens et al., 2003) and it is our approach in this study. We therefore use the terms "neighborhood" and "census tract" interchangeably.

We take the theoretical stance that variation in health outcomes can be explained by relative (rather than absolute) differences in the segregation of neighborhoods. In order to depict the segregation experience of individuals within a neighborhood, a conventional solution involves the proportion (or percentage) of minority members in a unit as a marker for the level of segregation (Myers, 2004; Kiel and Zabel, 1996). Even though this indicator is highly correlated with other measures of segregation and its calculation is straightforward, it has important limitations. While some have questioned the conceptual meaning of proportional measures, others have questioned construct validity and interpretation. Massey and Denton (1988) suggested five dimensions of segregation: evenness, isolation, concentration, centralization and clustering, and while the validity and interpretations of these five dimensions are beyond the scope of this article (interested readers can refer to Wong (2008)), simple proportions do not adequately characterize any of these varied dimensions of segregation. Some have suggested that measures of segregation should refer to "differences in the *distribution* [our emphasis] of social groups" and hence "only *dispersion* [our emphasis] measures are proper measures of segregation" (James and Taeuber, 1985). The evenness dimension, which is effectively captured by the dissimilarity index D, has been the standard segregation measure. However, this premise is only appropriate when one assesses the aggregated segregation pattern of the region. To properly account for the features of inequality operating on individuals at the neighborhood level, a relative comparison measure is more appropriate to reflect the experience of residents (Wong, 2002).

Rarely used to reflect racial residential segregation, the Location Quotient (LQ) has been commonly used by economic geographers and regional labor economists and is a standard tool to assess the level of specialization of a particular industry or type of economic activity in a subunit within a region (Isserman, 1977). It has also been used by demographers to characterize the distribution of a population with specific characteristics relative to the overall composition of the characteristic across a larger area (see http://www.bls.gov/cew/cewlq.htm for more details and a web tool for calculating various LQ's). In demography, LQ is regarded as a measure of relative concentration, but demographers use of "concentration" here is not identical to the meaning conveyed by the five dimensional categorization of segregation (James and Taeuber, 1985; Massey et al., 1996). For Massey, concentration refers to a ratio of occupied physical space or density (Massey and Denton, 1988). Our operationalization extends the work of Massey with a ratio that quantifies the relative racial homogeneity of each neighborhood within an MSA.

The LQ can be calculated simply as:

$$LQ_{im}=(x_{im}/X_i)/(X_m/X)$$

where LQ_{im} is the value for the ith unit or tract in a region or MSA for minority group m; x_{im} is the number of individuals from minority group m living in the ith tract; X_i is the total number of residents in the ith tract of the MSA; X_m is the total number of individuals from minority group m in the MSA; and X is the total number of residents in the MSA. Hence the final value consists of a ratio of two proportions in which the numerator is the proportion of minority residents in the tract and the denominator the proportion of minority residents in the larger region or MSA. As an example, a census tract with an LQ index of 5 means that the proportion of group M living in the tract is 5 times the proportion of group M in the

larger region or MSA as a whole. The LQ can be calculated for any two groups or any two characteristics so we therefore had to choose which groups to use in our measure of LQRRS. Because Hispanics are relatively under-represented in our sample compared to whites and blacks, we chose to focus this analysis on the relative distribution of non-Hispanic African-Americans compared to all others. Hence our LQRRS is more accurately a measure of Black/other segregation versus Black/White segregation.

Variables

To represent and to control for individual level factors important to health outcomes, we used an approach informed in part by Andersen's Behavioral Model for Healthcare Utilization (Anderson, 1995) and its subsequent expansion to include health outcomes (Anderson, 2000). In this framework, characteristics of the individual are organized into categories reflecting *predisposing* (generally demographic variables), *enabling* (generally socioeconomic variables) and *need*-related (health status and lifestyle variables) contributing to health care utilization and ultimately health outcomes. Previous work demonstrates that these factors are linked to the use of health care preventive services (Sudano and Baker, 2003), act as barriers to care (Baker et al., 2002), and are associated with declines in health and mortality (Sudano and Baker, 2006). Details on these variables follow below.

Demographics—Respondents' age in years (continuous) was recorded from the 1992 interview; sex was categorized as female or male (referent group); marital status was categorized as married (referent group), separated/divorced/widowed, or never married; race/ethnicity was categorized as white, black or Hispanic using self-reported data from respondents.

Socioeconomic Status—Educational attainment was measured in number of years of formal schooling completed. We computed an adjusted income measure for each respondent--an income-to-needs ratio (INR)-that incorporates total household income divided by the poverty guideline for a given size household. As an example, an INR of 3.0 is equivalent to an income 300% of the poverty guidelines for a given family size. Net worth as of 1992 was first measured as a continuous variable in units of US dollars. Both INR and net worth were collapsed into variables with 6 and 5 categories, respectively. INR values were <1.00, 1.00–1.49, 1.50–1.99, 2.00–2.99, 3.00–4.99 and 5.00 and greater. Net worth values were actually quintiles of the distribution with dollar amounts of <$20,200; $20,201-$69,000; $69,001-$138,000; $138,001-$286,000 and >$286,000. Both INR and net worth were entered into the equation as pseudo-continuous variables using their respective numerical values of 1–6 and 1–5. Finally, we used a measure of intermittent insurance status, first determining the existence of any kind of health insurance coverage (public or private) in 1992, 1994, and 1996, and then categorizing individuals as a) insured all 3 interviews (referent), b) 1–2 reports of being uninsured, or c) uninsured all 3 interviews.

Health Status—All multivariate models adjusted for 4 health status variables based on self-reports from the 1992 interview. These included self-reported overall health categorized as poor (referent), fair, good, very good and excellent; a count of total number of chronic diseases (hypertension, diabetes, health disease, chronic lung disease, cancer, arthritis, stroke, and visual difficulties) (Verbrugge et al., 1989), and a count of the number of physical limitations. Three sets of questions previously described by HRS investigators assess the number of physical limitations and include 4 items assessing difficulties with *mobility* (activities requiring large muscle strength), 6 items assessing difficulties with *agility* (activities required to perform instrumental activities of daily living), and 5 items assessing difficulties with *facility* (activities required to perform activities of daily living) (Fillenbaum, Burchett and Welsh, 1993; Baker et al., 2001). A report of any difficulty with

the activity was coded as 1 and no difficulty coded as 0. The total number of difficulties was summed and entered into the equations as a continuous variable.

Some of the respondents in the HRS reported fair or poor health status at baseline, and therefore were more likely to experience a health decline or death in subsequent waves. Conversely, others reported very good or excellent health, and were thus less likely to have a decline and more likely to survive over the study period. If in fact health status at baseline influences segregation, the estimates of the effect of segregation may be biased because they in some regard are reflections of baseline health status. To control for potential selection bias, in which baseline health status is related to segregation, we included along with the 3 measures detailed above another a measure of health status—self-reported health status trajectory in the past year, categorized as much worse (referent), somewhat worse, the same, somewhat better, and much better.

Health Behaviors—Health behaviors include a smoking behavior measure categorized as never smoked (referent), past and current smoker; past problem drinking measured using the CAGE index dichotomized as none or 1 indicator as referent versus 2 or more indicators (Mayfield et al., 1974); a measure of current drinking pattern based on number of drinks per day categorized as abstainer, moderate (referent), and heavy drinking; and body mass index (BMI) was categorized into quintiles, with the lowest quintile as referent.

Analytic scheme

We used the analytic and survey weights included in the data files to produce nationally representative point estimates and to account for the complex sampling design in the HRS. Nested multivariable logistic regression models estimated unadjusted and adjusted odds ratios of health declines (major decline in self-reported health or death 1992–2000) for categories of LQRRS, controlling for individuals' demographic characteristics, socioeconomic status, health status and health behaviors. Odds ratios were converted to adjusted relative risks using a published formula from Zhang and Yu (1998). We used STATA versions 9 and 10 (College Station, TX) for all analyses. A p value of 0.05 was used to determine statistical significance. In order to determine the necessity of accounting for clustering of individuals within census tracts, we used the *xtlogit* procedure in STATA to calculate the intraclass correlation coefficient (ICC) (reported as *rho* by xtlogit). The ICC was .02 and was not statistically significant. Research suggests that linear regression estimates are sufficient when the ICC < .05 and that there is no benefit to multilevel modeling when the ICC is not different from zero (Goldstein, 2003). We report only the logistic regression results here.

RESULTS

Study subjects lived in 85 MSA's in a total of 1303 census tracts. Whites resided in 78 MSA's and 1031 tracts, Blacks in 60 MSA's and 338 tracts, and Hispanics in 59 MSA's and 263 tracts. Distributions within tracts range from 1–58 respondents for Whites, 1–18 for Blacks and 1–19 for Hispanics, while means within tracts were similar at approximately 10 for each group.

Because the use of LQRRS as operationalized in our study is new (we know of no other study that has used it), there is no consensus on how to incorporate it into multivariable models. Other continuous measures of segregation at the global level are typically categorized in analyses to facilitate interpretation of effects and we follow this practice (Cutler et al., 1999). For example the "D" index has a possible range of 0.0–1.0 and is often categorized as low (>0.3), moderate (0.3–0.6), and high (>0.6) (Massey and Denton, 1993; Williams, 1996). We used methods suggested by Harrell (2006) (i.e., restricted cubic

splines) to establish empirically justifiable cut points for the LQRRS/health outcome relationship, and subsequently categorized LQRRS as minimal, low, moderate and high (cut points detailed below).

As mentioned above, the distribution of respondents by LQRRS was skewed, with 3,333 (50.1%) of the study population respondents living in minimally segregated neighborhoods (614 tracts with LQRRS values < 0.34); 2,242 (33.7%) living in low segregation neighborhoods (474 tracts with LQRRS values of 0.34–2.49); 562 (8.4%) living in moderately segregated neighborhoods (104 tracts with LQRRS values of 2.50–4.11); and 516 (7.8%) living in highly segregated neighborhoods (116 tracts with LQRRS values of >4.11) (Table 1).

Age was the only characteristic not associated with LQRRS in the bivariate analysis. There were higher percentages of females in moderate and high segregation neighborhoods. A higher percentage of blacks lived in moderate and highly segregated neighborhoods than in minimally segregated neighborhoods, while for whites higher percentages lived in minimally and low segregation neighborhoods, and the highest percentage of Hispanics lived in low segregated neighborhoods.

Living in a minimally segregated neighborhood was associated with higher socioeconomic status. In particular, at the bivariate level, average net worth in minimally segregated neighborhoods was 2.3 times higher than in highly segregated neighborhoods. Those in the most segregated neighborhoods had the lowest levels of income to needs. Respondents living in moderate and highly segregated neighborhoods had higher mean counts of chronic disease and physical limitations. Living in these neighborhoods was also associated with reporting lower self-rated health at baseline and experiencing a major decline or death between 1992 and 2000. The highest level of LQRRS was associated with worsening baseline self-reported health (health as opposed to 1-year ago) but also with improving self-reported health. Highly segregated neighborhoods had the highest percentage of current smokers and heavy drinkers, while moderately segregated neighborhoods had the highest percentage with a history of alcohol abuse and the highest percentage of obese residents.

Predicted probabilities from a logit analysis of the relationship between LQRRS and major health declines or death is displayed in Figure 2. The eight year probability of major decline or death is near zero in the minimal segregation category, increases rapidly in the low segregation category and is highest in the moderate and high segregation categories. Also notable is the slight decline in probability of major decline or death as the continuous LQRRS measure increases.

Table 2 presents the results of nested logistic regression analyses for the change in relative risk of major decline or death by LQRRS when adding demographics, socioeconomic status, baseline health status, and health behaviors to the logistic regression model. LQRRS has a strong and statistically significant association with major decline/death at low, moderate and high levels in the unadjusted model, with ARR's ranging from 1.32–1.86. In Model 2 the magnitude of the ARR's decreases but the same overall pattern of relationships is maintained.

Addition of the socioeconomic status variables in Model 3 severely reduces the effect of segregation on major decline/death for low and high LQRRS census tracts. For moderate LQRRS census tracts the effect of segregation on major health decline/death is also reduced but remains statistically significant. Results from models 4 and 5 indicate that controlling for individual baseline health status and health behaviors does not substantially reduce the effect of segregation on major health decline/death over and above the model that includes SES.

DISCUSSION

This study has overcome key limitations of previous studies of segregation and health, notably the reliance on only large-area measures of segregation, cross-sectional data, aggregate (non-individual) data, the absence of key indicators such as body mass index and substance use/misuse, and coarse measures of health status (White and Borrell, 2011; LaViest, 2003; Robert and Ruel, 2006). In this study of older adults in the United States, the results provide preliminary support for the conceptual model in Figure 1. Socioeconomic status explains much of the association between neighborhood racial segregation and health outcomes. Health status and health behaviors did not explain much of the association between segregation and health after controlling for socioeconomic status, and these individual level factors did not explain all of the effects of LQRRS for residents of moderately segregated neighborhoods.

These findings are consistent with previous research that has demonstrated the effect of RRS on health status to be mediated through individual characteristics. Communities with greater residential segregation can be characterized by lower community socioeconomic status (SES) including higher levels of poverty and unemployment, fewer job opportunities, fewer or restricted social and public services, poorer school systems, and higher proportions of deteriorated or abandoned housing stock (Cohen et al., 2003). Such observations have led many researchers to conclude that RRS is a “fundamental” or basic underlying “social” factor shaping the opportunity structure and life-world of individuals residing in segregated communities—communities with potentially damaging health consequences for many (Williams and Collins, 2001).

Ample evidence derived from cross-sectional studies suggests a relationship between RRS and unemployment levels (Cubbin et al., 2001) and proportion of residents living below poverty levels. Likewise, RRS has been linked to social factors such as higher crime levels (Kawachi and Kennedy, 1997), and higher rates of female headed households (Gee, 2002; LeClere et al., 1997, 1998). The physical environment of a community has also been associated with levels of segregation. Specifically, toxic dumps are more frequently located in or near areas of high RRS (Sexton and Anderson, 1993), and areas of high RRS often have extremely poor housing stock, which increase potential exposure to lead or other noxious substances. Each has serious health consequences including increased risks of cancer, cognitive disability, and asthma. Similarly, areas of high RRS are often sites of intense promotion of alcohol and tobacco consumption, fewer grocery stores stocking a full range of nutritious products, and more likely to have unsafe streets and few areas for physical exercise, leading to higher rates of obesity and inactivity. All of these factors may ultimately translate into increased risks for cancer, hypertension, diabetes, and cardiovascular disease. In short, all of this evidence suggests an association between RRS and community characteristics that plausibly leads to downstream effects on residents’ health (Grady and Ramirez, 2008; Kramer and Hogue, 2009).

Based on the descriptive results reported in Table 1, bivariate results in Figure 2 and the multivariate results in Table 2 we conclude that LQRRS is an effective way of operationalizing racial residential segregation. Our findings from a nationally representative panel study in the United States are similar to cross-sectional findings on relative deprivation by socioeconomic status in a European sample (Stafford and Marmot, 2003). By using LQRRS, a measure of the relative concentration of neighborhood racial segregation, our research is more consistent with the realities of geographic variation in inequality than prior studies. We do not assume that a specific proportion of minorities is responsible for health inequalities in all communities in the United States. Instead, our operational definition of LQRRS recognizes the importance of how segregated a person’s neighborhood

is as compared with other neighborhoods in a metropolis, recognizing the pervasive nature of localized status hierarchies.

Our research is an extension of prior empirical and theoretical understandings of the complexity of social inequality (Shulz and Mullings, 2006). Being female and having lower socioeconomic status were both associated with living in census tracts characterized by higher levels of segregation. Our multivariate analysis is supportive of a theoretical model in which health disparities are woven together into a race, class and gender triad of neighborhood health disadvantage.

Limitations and Directions for Future Research

This study has several important limitations. First, our results only represent the 1931–1941 age cohort and may not be generalizable to other age groups. Second, our operational definition of LQRRS is based on a comparison of the distribution of African Americans to all others at the census tract level. Future studies could estimate the potential for a non-uniform effect of our Afro-centric LQRRS measure on the health of other racial and ethnic minorities such as Hispanics and could compute separate segregation indices for different racial and ethnic groups. Cultural and ethnic homogeneity in some settings may offer residents with greater access to social capital and informal networks of support that promote health.

Third, to address attrition we compared characteristics of those included in our analyses with those excluded due to attrition and those excluded because of rural residence; no significant differences were found between the three groups in age, sex, net worth, insurance status, and health behaviors (data not shown). There were significant differences however in education (both excluded groups were slightly less educated); race/ethnicity (more rural white exclusions, fewer rural black exclusions, and more Hispanics lost to attrition); income (both excluded groups had between $5,000 to 15,000 less household income in 1992); and health status (rural exclusions more likely to be in poor or fair health status in 1992 compared to both other groups—27% vs. 19%, respectively. Although recent work using the Health and Retirement Study data found little evidence for attrition bias (Kapteyn et al., 2006) this attrition may or may not induce bias under various conditions (e.g., attrition completely at random, outcome dependent attrition, etc.) (Mirowsky and Reynolds, 2000).

Fourth, a healthy survivor effect (observed in past studies of smoking and obesity) is likely to weaken the association between residential racial segregation and health decline in longitudinal analysis (Koster et al., 2007; Ostbye and Taylor, 2004; Ostbye et al., 2002). Fifth, individuals may move over the study period, but they may move to very similar or very dissimilar census tracts. Any analysis that does not account for mobility tacitly assumes that the “exposure”—in an epidemiological sense—to LQRRS is constant throughout the study period. In an ancillary analysis (data not shown) we used an indicator variable for having moved between baseline and wave 5. The effect of moving on major death/decline was statistically significant (OR 2.33, $p<0.001$; CI 2.05–2.64), but its inclusion did not alter the magnitude or statistical significance of LQRRS.

We further acknowledge that our LQRRS measure is among the category of segregation measures commonly termed “aspatial” and hence is subject to some limitations. Most notably, LQRRS does not adequately characterize segregation levels of adjacent census tracts and cannot address the modifiable areal unit problem (Wong, 1997; Reardon and O’Sullivan, 2004). Hence future work will incorporate spatial measures at the census tract level to directly compare and contrast these alternative formulations of segregation.

Finally, the continued statistically significantly elevated risk for the moderate LQRRS category after all the controls have been included suggests that there are other processes as yet unidentified and unmeasured that may explain this finding. While our research is limited by the availability of individual level concepts in the HRS, other characteristics of neighborhoods, including environmental factors like noise, pollution, dilapidated housing, and neighborhood socioeconomic status indicators could be operationalized in a future study in order to give a more complete depiction of how neighborhood-level measures influence health outcomes.

Notwithstanding these limitations, our study has addressed several limitations identified in a recent review of research on segregation and health (White and Borrell, 2011). Our analysis extends prior work with evidence that LQRRS, a relative concentration segregation measure, has a substantial influence on the health declines and mortality of older adults as they age. Health inequalities are created by larger inequalities in society. The segregation of racial and ethnic minorities into disadvantaged neighborhoods is a persistent and lasting structural cause of health disparities (Williams and Collins, 1995; Williams et al., 2010). The results presented here lend further support to the theory that a person's relative position in society, including the relative concentration of minority group members in their neighborhood compared to other neighborhoods in a region, can influence health over time for older adults, and can reinforce the multiplicative structure of health and social inequality.

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- LQRRS is a newly developed aspatial local area measure of racial residential segregation.
- We use longitudinal data on older adults from the Health and Retirement Study.
- This new measure has a curvilinear association with major declines in health and mortality.

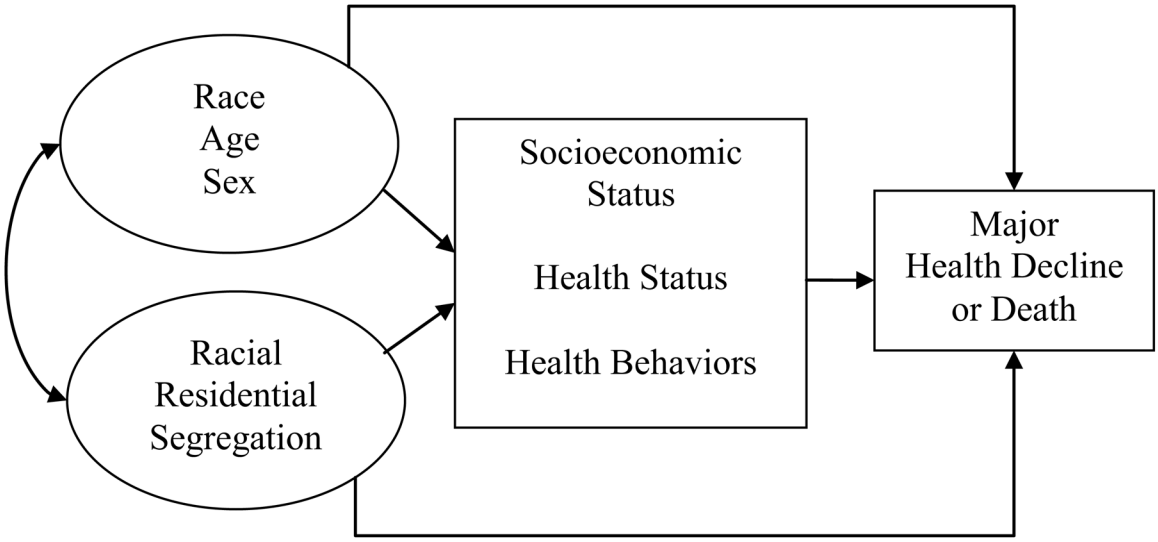

Figure 1.
Conceptual Model of Racial Residential Segregation, Individual Level Factors and Health Outcomes.

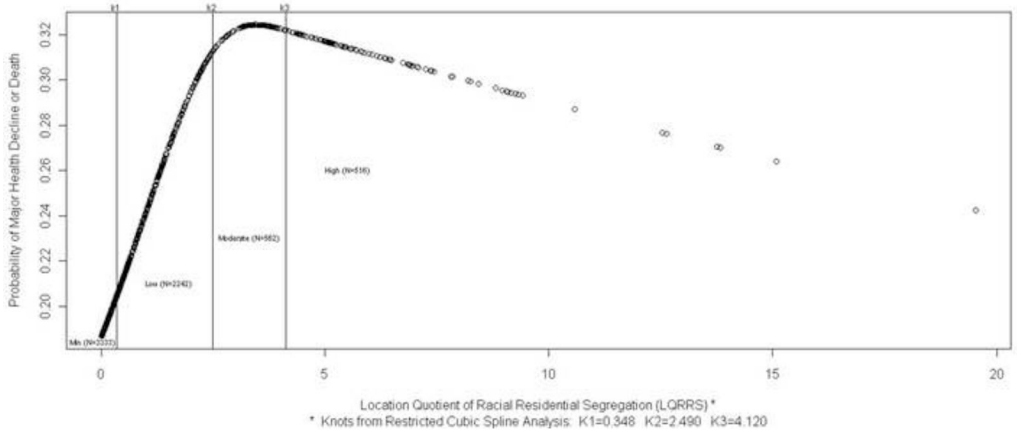

Figure 2.
LQRRS Cutpoints by Probability of Major Decline or Death 1992–2000 N=6653)

Table 1

Study Population Characteristics by LQRRS Category (N=6653)

	LQRRS Census Tract Levels				
Demographics	**Minimal m=610 n=3333**	**Low m=474 n=2242**	**Moderate m=104 n=562**	**High m=116 n=516**	**p**
Age, mean years (SD)	55.9 (3.2)	55.8 (3.1)	55.9 (3.1)	56.1 (3.2)	.263
Female Sex, %	51.0	51.7	60.2	56.3	.003
Racial/Ethnic Group, %					.000
White	94.7	79.7	25.8	22.4	
Black	10.7	10.8	69.6	74.3	
Hispanic	4.3	9.6	4.7	3.3	
Marital Status, %					.000
Never Married	3.1	4.9	7.7	7.7	
Separated, Divorced, Widowed	17.3	23.2	37.8	37.5	
Married	79.6	71.8	54.7	54.8	
Socioeconomic Status					
Education in years, mean (SD)	12.7 (2.9)	11.7 (3.6)	11.7 (3.1)	11.7 (3.0)	.000
Income-to needs ratio, mean (SD)	5.0 (1.4)	4.5(1.6)	4.1 (1.8)	4.0(1.8)	.000
Net Worth in thousands of $, mean (SD)	30.8 (59.4)	18.0 (36.5)	14.1 (52.7)	13.6 (43.8)	.000
Continuously Insured (1992–96) %	83.8	76.4	70.8	71.6	.000
Health Status					
Self-reported Overall Health, %					.000
Poor	5.6	8.4	10.6	12.7	
Fair	9.1	15.0	21.8	19.8	
Good	23.9	26.5	32.5	32.5	
Very Good	32.6	27.0	24.4	23.0	

	LQRRS Census Tract Levels				
Demographics	**Minimal m=610 n=3333**	**Low m=474 n=2242**	**Moderate m=104 n=562**	**High m=116 n=516**	**p**
Excellent	28.8	23.2	10.7	12.0	
Chronic Disease Count, mean (SD)	1.1 (1.1)	1.3 (1.3)	1.4 (1.3)	1.5 (1.3)	.000
Physical Limitations Count, mean (SD)	2.6 (3.0)	3.3 (3.5)	3.5 (3.6)	3.8 (4.0)	.000
Health Now as Opposed to 1-year Ago, %					.000
Much Worse	1.7	2.6	4.2	6.9	
Somewhat Worse	8.7	10.8	12.0	9.7	
The Same	74.7	70.5	66.6	67.8	
Somewhat Better	10.0	10.0	11.8	8.7	
Much Better	4.9	6.2	5.5	7.0	
Major Decline or Death 1992–2000, %	18.1	23.8	33.7	30.5	.000
Health Behaviors					
Smoking, %					.000
Never	36.1	32.2	39.0	31.3	
Past smoker	39.3	38.0	39.9	36.3	
Current smoker	24.6	30.0	31.2	32.3	
Baseline Alcohol Use Pattern, %					.000
Abstainer	29.7	39.1	43.0	40.9	
Moderate	64.6	56.0	50.7	52.0	
Heavy	5.7	4.9	6.3	7.1	
Problem Drinking History (CAGE), % >2	12.5	15.1	20.2	17.2	.000
BMI Quintiles, %					.000
1st (14.3–23.0)	19.5	21.6	14.3	16.4	
2nd (23.1–25.2)	12.4	19.5	18.6	16.3	
3rd (25.3–27.4)	19.6	19.3	17.4	18.2	

	LQRRS Census Tract Levels				
Demographics	**Minimal m=610 n=3333**	**Low m=474 n=2242**	**Moderate m=104 n=562**	**High m=116 n=516**	**p**
4th (27.5–30.6)	20.7	20.1	22.0	21.8	
5th (30.7–59.1)	16.8	19.4	27.7	27.4	

Notes: Results are from weighted analyses using survey estimation procedures in Stata 9 and 10. m=number of tracts in the LQRRS category; n=number of respondents in the LQRRS category. BMI=Body mass index (kg/m^2).

Significance tests for categorical variables are based on the Pearson χ^2 statistic corrected for survey design and the test for continuous variables are based on the t statistic. Income-to-needs ratio is based on household income in 1991 divided by the poverty guideline for a given household size. A value of 5.00 for example indicates a household income 5 times (or alternative, 500% of) the poverty guideline for a given household size.

Table 2

Nested Logistic Regression Results Showing Changes in Adjusted Relative Risk (ARR) of Major Decline or Death for Low, Moderate and High vs. Minimal LQRRS (N=6653).

		ARR by LQRRS (95% Confidence Intervals)			
Nested Models of Major Decline/Death as of 2000		**Minimal LQRRS Tracts N=3333**	**Low LQRRS Tracts n=2242**	**Moderate LQRRS Tracts n=562**	**High LQRRS Tracts n=516**
1	Unadjusted	Referent	1.32 *** (1.16–1.49)	1.86 *** (1.63–2.10)	1.69 *** (1.45–1.95)
2	Demographics[a]	Referent	1.25 *** (1.10–1.42)	1.57 *** (1.31–1.86)	1.37 ** (1.12–1.66)
3	Demographics, SES[b]	Referent	1.10 (0.96–1.26)	1.36 ** (1.12–1.64)	1.19 (0.95–1.46)
4	Demographics, SES, Health Status[c]	Referent	1.08 (0.93–1.25)	1.31 * (1.07–1.59)	1.11 (0.88–1.37)
5	Demographics, SES, Health Status, Health Behaviors[d]	Referent	1.07 (0.92–1.23)	1.31 * (1.07–1.59)	1.08 (0.86–1.36)

Notes. All statistical tests are compared to the referent group (Minimal LQRRS).

[a] Demographic variables include age, sex, racial/ethnic group.

[b] SES (socioeconomic status) variables include educational attainment, insurance status, income-to-needs ratio (total household income divided by the poverty guideline for a given size household) and net worth in quintiles (see methods section for details) as of the 1992 interview.

[c] Health status variables include: self-rated health (at baseline), self-rated health at baseline (as opposed to prior year), chronic diseases, and functional limitation.

[d] Health behavior variables include the following, as of the respondents' 1992 interview: smoking status, alcohol consumption pattern, CAGE score, and body mass index.

* = $p < 0.05$;

** = $p < 0.01$;

*** = $p < 0.001$