Macro Level Influences of Income on Individual Mortality Risk:

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ABSTRACT

We investigate whether income distribution affects odds of death beyond economic deprivation, while controlling for individual-level demographics. We also test whether contextual economic attainment has cross-level effects rooted in race: do contextual measures of income, poverty and inequality differentially affect white and non-white mortality rates? We analyze county-level influences of income, poverty, and income inequality on personal mortality risk using hierarchical linear modeling (HLM). A unique analytic method is applied to the Compressed Mortality File in that mortality is treated as a dichotomous variable and contextual measures from the U.S. Bureau of the Census are used to indicate environmental factors. In fact, income inequality does have more deleterious effects on non-white mortality than it does on mortality of whites, controlling for age, race and gender. The contextual effects of income inequality completely diminish the race-based demographic effect on differential mortality risk. This finding needs to be further explored with data that can also control individual health behaviors.

KEYWORDS

United States; mortality; income inequality, racial disparities, county-level analysis

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INTRODUCTION

Individual and Contextual Effects of Income on Health

A long tradition of studying the effects of income on individual health (Schnittker, 2004; Adler & Newman, 2002; House et al., 1990) reveals a clear gradient advantageous to individuals with high levels of income. People with greater economic resources report better health on three major indictors, disability (Maddox & Clark, 1992), morbidity (Ross & Mirowsky, 1999), and mortality (Hummer et al., 1998; Christenson & Johnson, 1995). The findings are robust to various measures of economic attainment, including per capita income (Hummer et al., 1998; House et al., 1990), poverty (Geronimus et al., 1990; Hahn et al., 1996), and income inequality (Wilkinson, 1997).

Another research trajectory assesses the relationship between ecological measures of economic attainment (income inequality) and individual health at the state level (Muller, 2002; Kawachi et al., 1997), county level (James & Cossman, 2006; Franzini et al., 2001) and across Metropolitan Statistical Areas (Shi & Starfield, 2001; Lynch et al., 1998). Several explanations link population level income inequality to mortality, including a breakdown of social cohesion (Kawachi & Kennedy, 1999), lack of investment in societal resources and institutions (Kawachi & Kennedy, 1999), underinvestment in human resources (Smith, 1996), and a reflection of individual level income and health (Lynch et al., 2000). More recent research has shown that these ecological factors are contextual and that these effects are different for various demographic groups (e.g., Yao & Robert, 2008).

Racial disparities in health and mortality are established at the (1) individual, (2) ecological, and (3) contextual levels. At the individual level, the explanations of mortality disparities include behavioral factors such as smoking, drinking, diet and exercise (Krueger, et al., 2011), which are also known to vary by education and income levels (Kimbro et al., 2008). At the ecological level research has shown that income inequality (LeClere & Soobader, 2000), poverty, and residential segregation (Kershaw et al., 2011) play a role in explaining variations in county-level mortality rates. When you examine both the individual and the context in which they live, it is clear that health outcomes and risk of death are due to both personal and contextual/ecological factors. It is not clear how individual and community characteristics interact with one another in assessing mortality risk. Our research attempts to answer this question.

Race is a confounding factor in research investigating mortality consequences of high inequality areas. After accounting for the proportion of the population that is black, the association between income inequality and mortality disappears in some studies (Deaton & Lubotsky, 2009; McLeod et al., 2004; Deaton & Lubotsky, 2003). In places with a high proportion of blacks, white income is higher and black income is lower, indicating a strong, positive correlation between income inequality and race (Deaton & Lubotsky, 2009), but not necessarily between income inequality and mortality. This provides evidence that the inequality and mortality relationship may be spurious, it may operate through indirect pathways, and/or it may have a unique effect on different racial groups.

METHODS

A great deal of mortality research is conducted at the MSA or state level, but we choose county as a unit of analysis for three important reasons. First, income based disparities in health are salient in rural America and of interest to the authors, thus the scope of our research is beyond MSAs. Similarly, not all rural counties are created equal so it is important to study each county as a unit rather than grouping them together as non-MSAs in the form of a rural-urban study of disparities. Residential patterns within counties are also largely determined by income and race, indicating important county-level variation in the two primary independent variables. Second, sub-state inequality produces variation in health infrastructure and relative well-being and many people view the county as an important economic and social unit (McLaughlin & Stokes, 2002). Third, the county is frequently the creating, organizing, and decision making unit for local levels of infrastructure including health care, education, civic, and other opportunities, meaning that the structure of counties is very important for determining access to care, health, and mortality (McLaughlin & Stokes 2002). The organization of this structure, including the process of maneuvering the health care system, may be the foundation for disparities in mortality.

Individual and County Level Data

Mortality data were obtained from the Compressed Mortality File (CMF), which is released by the Centers for Disease Control's National Center for Health Statistics. Our dependent variable assesses risk of death. The Compressed Mortality File, while representing the population, offers very few demographic details. We analyzed deaths that occurred in 2005, permitting a lag between our measures of income and income inequality, which are from Census

2000. The file lends itself to spatial analysis of deaths, but includes measures only of age at death, race, sex and cause of death (in addition to county of residence at time of death) (NCHS, 2009).

The United States Census Bureau data (2009) were used to complete the dependent variable measure. Since our HLM is estimating risk, we needed to input the population estimates by age, race and sex – these were taken from U.S. Census 2005 estimates. The Gini coefficients were calculated using data from the 2000 U.S. Census summary files and median household income was also calculated using this data.

Area Resource File (ARF) data includes per capita income (in thousands of dollars) and the percent of the population living in poverty (2000). We also noted the percentage of the county population that is living in rural areas, percentage of the county population that is black and the percent non-white were also retrieved from the Area Resource File.

Dataset Construction

The Compressed Mortality File has a unique construction in that each line of data is neither for an individual nor for a county, but for a specific age-race-sex category (for each county). To indicate what the data look like, see Figure 1. For any given county, each age-sex-race group has one line of data that indicate how many deaths (from each cause, but here we collapse the causes into one). For HLM analysis, this is the level one data and it is multiplied by the population that fall into that age-sex-race category to be treated as individual level data. The level two data are county level data that the statistical software links to each age-sex-race group death data within each county. The software is then predicting risk of death controlling for age (mid-point of the age group), race (black, non-black) and sex (male; female). The model then

predicts risk of death by age, sex and race and permits for contextual effects as well as cross-level interactions.

FIGURE 1 GOES ABOUT HERE

HLM software was used to estimate hierarchical linear models. A poisson model was estimated and overdispersion was controlled to account for the distribution of county level deaths. The variable exposure to risk of death due to county size was controlled using the county's population.

RESULTS

The descriptive statistics for the data are presented in Table 1. At level one, the number of deaths are reported for each age, sex and race group; so the mean of 20.16 indicates that, on average, each age-sex-race group (of which there are 52) in each county (of which there are 3,098) experienced 20.16 deaths in 2005. The standard deviation for this is exceedingly large because very populated counties would have much higher raw numbers, which also skews the mean up. The mean age for these age-sex-race categories across all counties was 58.18. The population—even across age-sex-race categories was evenly divided into male and female. Also, 30% of all age-sex-race categories were black. For level two indicators, the average percent rural for the counties was 60.59 and median county-level household income was just more than $36,000. The average county has 8.6 percent of its residents who were black. The average county Gini coefficient is 43.39 (on a 100 point scale).

TABLE 1 GOES ABOUT HERE

TABLE 2 GOES ABOUT HERE

The results from the HLM analysis are presented in Table 2. Model 1 is an individual level model only. This indicates, as would be expected, that with each additional year of age risk of death increases by 9.2%, that men are 39.4% more likely to die than women and that blacks are 31.8% more likely to die than whites. Keeping in mind that this is population data, these are not estimates; so the statistical significance is not of real importance. This also verifies the method of testing; so that when we add contextual effects we can be assured of the validity of the original model.

Model 2 adds county-level effects for rurality, percent black, Gini, and median household income (in 1000s). The level one coefficients are unchanged with the addition of the county-level effects; mortality continues to increase and with the same magnitude for age, race and sex, as in Model 1. Additionally, for each percent increase in the black population mortality risk increases slightly (0.1%); for each point on the Gini Index mortality decreases slightly (0.2%); and for each $1,000 increase in the median household income, mortality risk decreases slightly (0.8%). Though these effects seem of small magnitude, differences across counties can be large. This means that a county with 10% black has a .01 increase in mortality risk compared to one with no black population. For each $10,000 difference in median income, the risk of death decreases by 0.08.

Model 3 adds cross-level interactions with race. These measures indicate how the effect of being black (in level one) varies by each of the measures in level two. Model 3 includes cross-level interactions with race and the two demographic measures—rurality and percent black—and the two measures of income—income inequality and median household income. Results from Model 3 indicate that cross-level effects mediate the main effect of race substantially (the effect is 1.32 in Model 1 and 0.58 in Model 3). *The main effect of one's race*

on mortality risk reverses when the context is interacted with the individual's race. That is, being black becomes protective when interacted with measures of income inequality and contextual demographics. So, African Americans living in areas with high median income, low income inequality, and in more rural areas actually have a lower risk of mortality than whites in those same areas.

One cross-level interaction has a negative mediating relationship (reducing the effect of race on mortality): rurality, while the others exacerbate the effect of race on mortality (Gini and median household income). Again, although these effects might seem small, keep in mind that variations across counties in these measures can be substantial, leading to rather large effects overall.

Concerned about the validity of county-level estimates of race, we re-tested all models without percent black in them and the findings were robust. We were also concerned with how these effects might change with age, testing the model for people older than 35, older than 45 and older than 55. No statistically robust changes were seen until we were only considering the elderly (65+) population.

To depict the cross-level interaction graphically, we estimated odds of death at each age race and sex combination, and in low- average- or high-Gini contexts. White males in high Gini counties have the highest odds of death and black males who live in areas of low income inequality have the lowest odds of death (in analysis not shown). Including the context in the model, white men have higher odds of death than black men—in all contexts.

The same is true for women in that when controlling for the income inequality in a person's county of residence, the odds of death shift from being in favor of whites to being in favor of blacks (in analysis not shown). The odds of death remain lower for women than for

men and for younger adults than older adults, but the main effect for race (that blacks have higher odds of death than whites) reverses when context is examined in concert with individual demographics.

FIGURE 2 GOES ABOUT HERE

Figure 2 depicts this relationship even more clearly. When examining the odds of death, using white men in areas with high income inequality as the measuring stick, white men in average areas of income inequality have the next highest odds of death, followed by white men in areas with low income inequality. White women and black men, regardless of income inequality context, experience odds of death that are about 50-60% of white men in high income inequality counties. The lowest odds of death are uniformly experienced among black women. Regardless of context, black women are experiencing odds of death at about one-third that of white men in high inequality counties.

DISCUSSION

Income Inequality and Health Disparities

Existing research, as outlined above, indicates that blacks have higher morbidity, disability and mortality than whites – in all instances. Our research uncovers an unexpected reversal to the existing evidence on disparities in mortality. At the individual level, our results mirror those of other studies suggesting that blacks have much higher odds of death than whites. The results remain largely unchanged with the introduction of contextual measures, including county-level income, inequality, rurality, and demographic composition. However, the introduction of cross-level interactions completely changes the largely agreed upon relationship between race, context, and mortality. In counties that are not largely rural, black, poor, or unequal; blacks exhibit a

mortality advantage compared to whites. The associated implications are many. First, it appears that blacks living in advantaged conditions have favorable outcomes. Consequently, racial disparities in mortality cannot be reduced simply to individual factors as context clearly plays a critical role. This emphasizes the importance of aggregate factors as health determinants, beyond that of individual health behaviors. The finding also illustrates a protective effect for blacks in the advantaged contexts. Explanations for this finding are purely speculative at this point, but may speak to the positive benefits of access to care, healthy food, and avoiding exposure to harmful environmental agents in the natural and built environments. However, none of these reasons explicitly address the black advantage compared to whites as much as it does compared to blacks in less advantaged contexts. The most fundamental explanation may be that blacks lead healthier lives and engage in healthier behaviors than whites, but this finding certainly would not be supported with individual level data and, even if that were the case, these positive characteristics are overshadowed by the negative contexts in which many blacks live. Considering that context for blacks in the United States is rooted in historical circumstances including discrimination and unequal access to vital resources, context clearly matters. For those who are able to overcome the problem of context, health becomes a comparative advantage rather than a disadvantage.

Limitations

The data used in this research has two important limitations. First, the level one dataset includes only a few basic demographic and socioeconomic variables. As a result, we are unable to disentangle the role of health behaviors in racial mortality differentials. Future studies should incorporate individual level diet, smoking, drinking, and exercise measures when assessing the

cross level interactions of context with individual health predictors. A second limitation of our research is that we provide only one snapshot of the population in time. Our results are generated using 2005 data, however, we have the capability to create level one datasets as early as 1968 and as late as 2008, and every year in between. Census estimates from non-decennial census years are publicly available and can easily be used as level two datasets. Future analyses may study this topic in previous years to detect when the black advantage in mortality first appeared. Finally, this is a new technique to explore racial differences in the role of income inequality (and context in general) on individual mortality outcomes. Further testing is needed to continue to improve this and other methods used to study mortality and risk of death in hierarchical models. The advantage of the data used in this manuscript is that it is population level data—so these are not statistical estimates, but actual relationships.

Conclusions

The relationship between race and context is obviously complicated and needs much further research. Context can be assessed in a variety of ways, one of the most prominent being income inequality. Previous research has debated the significance of income inequality as a viable predictor of health at the aggregate level, and our findings add a new element to the debate by uncovering the reversal of the white mortality advantage. These data indicate that blacks who live in more economically sound areas have improved risk of death – to the extent that their risk of death is lower than that for whites in those same areas. What is killing blacks at a higher rate than whites, according to this data and without controls for health behaviors, is the severe economic inequality in which they live. Although economic inequality has long been suspected as an important factor in health and the creation of disparities, no previous research has

suggested that the elimination of this barrier reveals a black mortality advantage. Further studies should investigate the processes at the individual and contextual levels that create positive mortality outcomes leading to a black mortality advantage.

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Table 1. Descriptive Statistics

Level One			
Variable	**N**	**Mean**	**Standard Deviation**
Number of Deaths	116619	20.16	83.90
Median Age	116619	58.18	29.08
Male (Female =0)	116619	0.50	0.50
Black (Non-Black =0)	116619	0.30	0.46
Level Two			
Percent Rural	3098	60.59	30.52
Percent Black	3098	8.60	14.34
Gini (1 -100)	3098	43.39	3.75
Median Household Income in 2000s	3098	36.34	8.97
Weight			
County Population	116619	1660.21	8125.94

National Center for Health Statistics, 2009

Table 2. Events Rate Ratios for Non-Linear Log Link Function, Population Average Model Weighted for County Population

	Model 1		Model 2		Model 3	
Level 1 (Individual)						
Intercept	0.000	**	0.000	**	0.000	**
Median Age	1.092	**	1.092	**	1.092	**
Male (Male=1, Female=0)	1.394	**	1.394	**	1.394	**
Black (Black=1, Other=0)	1.318	**	1.316	**	0.581	**
Level 2 (County)						
Percent Rural			1.000	*	1.000	
Percent Black	--		0.001	**	1.002	**
Gini (0-100)	--		-0.002	*	0.996	**
Median Household Income (in 1000s)	--		-0.008	**	0.992	**
Cross-Level Interactions with Race						
Percent Rural					0.998	**
Percent Black					1.006	
Gini (0-100)					1.017	**
Median Household Income (in 1000s)					1.002	**

** = p < 0.05, ** = p < 0.001*

National Center for Health Statistics, 2009

Figure 1. Compressed Mortality File Data Structure

Age[a]	**Race**	**Sex**	**Number of Deaths**
Age under 1	Black	Male	X
Age under 1	Black	Female	X
Age under 1	Non-Black	Male	X
Age under 1	Non-Black	Female	X
…			
Age 85 and up	Black	Male	X
Age 85 and up	Black	Female	X
Age 85 and up	Non-Black	Male	X
Age 85 and up	Non-Black	Female	X

a – Intermediate age groups are 1-4, 5-9, 10-14, 15-19, 20-24, 25-34, 35-44, 45-54, 55-64, 65-74, 75-84

Figure 2. Comparison of Odds of Death