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Mortality disparities between Black and White Americans mediated by income and health behaviors

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ABSTRACT

Background: Race disparities in health outcomes including mortality risk are well known, but mediating mechanisms that link race to mortality risk have rarely been formally tested.
Methods: We analyzed public NHANES III data from 1988 to 1994 linked to mortality outcomes prospectively through 2015. Participants included 10,460 non-Hispanic Black (40.5%, n = 4233) and non-Hispanic White (59.5%, n = 6227) adults. Proportional hazards regression models examined mortality risk in association with race, demographics, income, and an index of risky health behaviors including smoking, poor diet and low physical activity. A mediation approach under the counterfactual framework was used to test effects of income and risky health behaviors as mediators between race and mortality risk.
Results: Considering only race, age and sex, Black participants had significantly higher mortality risk than Whites (HR = 1.46, 95% CI 1.35–1.58). When income and education were added, the race effect was lower but remained significant (HR = 1.15, 95% CI 1.02–1.30). In the subsequent model that also included risky behaviors the association between race and mortality was no longer significant (HR = 1.05, 95% CI 0.92–1.20); both higher income and healthier behaviors contributed to lower mortality risk. There was a significant indirect effect of race on mortality mediated through income, and the direct effect of race on mortality was not significant when the mediating effect of income was considered. Likewise, the risky behavior score significantly mediated the association between race with mortality, and the direct effect of race was not significant. In the separate models, income mediated 62% of the association between race and mortality and lifestyle mediated 61% of the relationship.
Conclusions: Efforts to reduce race-based mortality disparities may focus on policies to reduce income-based disparities and promote positive health behaviors that consider variations in socioeconomic resources and personal preferences.

1. Introduction

Racial disparities in life expectancy in the United States are well documented (Arias, 2016; Kochanek, Arias, & Anderson, 2013). In particular, Black Americans experience significantly shorter life expectancies than non-Hispanic White Americans, with higher mortality rates linked to relatively earlier mortality from diabetes, cancer, cardiovascular disease, homicide, and perinatal conditions (Firebaugh, Acciai, Noah, Prather, & Nau, 2014a, 2014b; Kochanek et al., 2013). These persistent race disparities contribute to the shorter life expectancies observed in the US relative to most other high-income countries (Collaborators, 2020; Li et al., 2018).

Mortality disparities experienced by Black Americans are potentially driven by multiple interrelated forces, including socioeconomic disadvantages, racial discrimination and segregation, poorer access to health care, greater environmental pollution exposures, worse access to health promoting amenities and practice of riskier health behaviors (Barnes et al., 2008; Chae et al., 2014, 2020; Elliott, Wang, Lowe, & Kleindorfer, 2004; Firebaugh & Acciai, 2016; Mode, Evans, & Zonderman, 2016; Nelson, 2002). Among these forces, lower income leads to poor health outcomes because it reduces access to healthier foods (Rao, Afshin, Singh, & Mozaffarian, 2013), cleaner and safer physical environments, and higher quality health care (Hood, 2005; Woolf et al., 2015).

Previous research has examined possible mediating variables that

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connect race or ethnicity to mortality or other outcomes. For example, Beydoun et al. (2016) studied how race/ethnicity disparities in all-cause mortality were altered when modeling effects of dietary factors, education and other variables. Sudano and Baker (2006) examined how health insurance, socioeconomic status (SES) and health behaviors contributed to racial and ethnic disparities to mortality and health declines. These studies employed multiple regression or proportional hazards approaches to examine associations between race or ethnicity and outcome, then added variables to subsequent models such as socioeconomic status, health insurance, lifestyle behaviors and others, and examined whether the regression coefficient for race remained significant or was substantially altered as these putative mediators were added. As an extension of this previous work, we employ a formal mediation analysis that allows for the estimation not only of whether a race association remains significant, or a mediator is significant when added to a model, but also allows a quantitative estimation of how much of the direct association between race and outcome persists when the indirect association of race operating through the mediator is estimated. In addition, the mediation analysis we conduct under a counterfactual framework allows for the interactions between race and potential mediators, which other studies have not included.

In addition to income, other possible mediating influences between race and mortality are health behaviors such as smoking, diet and physical activity. Black American adults smoke less than White adults but are more likely to die from smoking-related diseases (CDC, 2020). Previous evidence indicates that members of racial and ethnic minority groups including Black Americans engage in less physical activity than Whites (August & Sorkin, 2011; Zoeller, 2009). Satia (2009) observed that Black Americans and other minority groups experience diet-related disparities (poorer nutrient profiles and dietary behaviors) but suggested that these disparities are driven by socioeconomic status. As with income, however, formal quantitative tests of the role of health behaviors as an interaction-sensitive mediator of race-based mortality disparities have not been reported. The current study uses nationally representative data from the National Health and Nutrition Examination Survey (NHANES) linked prospectively with mortality outcomes to test income and health behaviors as formal mediators between race and mortality.

2. Methods

2.1. Design and data

We conducted a prospective analysis of direct and mediating associations between race (non-Hispanic Black or non-Hispanic White), other demographic and risk variables, and mortality. Baseline characteristics were obtained from the NHANES III data, collected between 1988 and 1994. The NHANES III was designed to obtain a nationally representative sample. NHANES data were linked to National Center for Health Statistics (NCHS) mortality data through 2015. Analyses used public, anonymous data sources and human subjects review was not required.

2.2. Study population

Among 13,696 non-Hispanic Black and non-Hispanic White adults aged 18 years or more, after excluding 1455 participants lost to follow-up and 1781 participants with missing values for major covariates including smoking, education, income, diet quality and BMI, 10,460 participants remained for final analysis. We compared baseline age and gender demographic characteristics among the participants who were lost to follow-up, excluded for missing data, or retained. We found that those lost to follow-up and those excluded were older on average than the retained participants (mean age: 58, 59, and 49, respectively) and that the three groups had similar gender distributions (female: 55%, 57% and 54%, respectively.)

2.3. Independent variables

The primary independent variable of interest was race, which included self-reported race as non-Hispanic Black or non-Hispanic White. Other key independent variables which also served as mediators included income and an index of risky lifestyle behaviors. Income was measured as household income in dollars (<$10,000, $10,000-<$30,000, $30,000-<$50,000, or $50,000 or more).

Risky lifestyle was measured from 0 to 6 as the sum of three behaviors each measured 0 to 2; the behaviors included smoking (never smoke: 0; former smoker: 1; and current smoker: 2); physical activity (active: 0; insufficiently active: 1; inactive: 2); and diet quality. The physically active group was defined as those who had leisure time moderate activity (METs ranging from 3 to 6) of five or more times per week or leisure time vigorous activity (MET >6) three or more times per week. The insufficiently active group was defined as those who were not inactive but did not meet the criteria for recommended levels of physical activity (Beddhu, Baird, Zitterkoph, Neilson, & Greene, 2009). Diet quality was assessed by the Healthy Eating Index (DHHS, 1999), originally scored 0–100, and grouped into thirds for the current study.

Additional covariates included age in years, sex, and years of education grouped into three categories (0–11, 12, or 13 or more). Body mass index (BMI) (kg/m^2) categories were included (normal: <25; overweight: 25 to <30; obese: ≥ 30), as was an index of social integration, using the measurement developed by Berkman and Syme (1979) and used in other prior research (Ford, Loucks, & Berkman, 2006). The social integration index included marital status; number of contacts with family, friends and neighbors; attendance at religious services; and participation in voluntary organizations.

2.4. Outcome

The outcome measure was mortality by the end of the follow up on December 31, 2015. Participants were followed until loss to follow-up, date of death or end of follow-up. Death records were obtained from the NCHS using ICD-10 codes and linked to the NHANES survey data (NCHS, 2021).

2.5. Analysis

We prepared a descriptive summary of study variables. Differences between Black and White participants on baseline characteristics were examined using chi-square tests for categorical variables and t-tests for continuous variables.

Next, we conducted a series of Cox proportional hazards multivariate regression models with survival time by the end of the follow-up as the dependent variable. The first model included only age, sex and race as independent variables. The second model added BMI, social integration, income and education. The third model further added the risky lifestyle index. One supplementary analysis estimated the models by both race and gender, and another considered additional covariates including urban/rural status, marital status (married or not), and health insurance (uninsured or not). The models accounted for the complex sampling design including sampling cluster, strata and weights as provided in the NHANES III data. Analyses were conducted using SAS software version 9.4 Proc SURVEYPHREG.

Finally, we conducted two mediation analyses under a counterfactual framework using the %mediation macro in SAS software version 9.4 (Valeri & Vanderweele, 2013). The analyses tested whether lower income or risky lifestyle index served as a mediator between race and mortality risk. These models contained the same covariates as the final regression models. Interactions between exposure and mediator were allowed. Results disaggregate the total association between race and outcome into direct effects and indirect effects operating through the mediator. The direct effect is defined as how much mortality would change when race changes from White to Black while the mediator is

kept at the level when race is White. The indirect effect is defined as how much mortality would change on average when race is Black, but the mediator was changed from the level it would take when race is White to the level when race is Black. The total effect is defined as how much mortality would change overall when race changes from White to Black.

The mediation analysis was first conducted overall, once for each mediator. Then, mediation analyses for each mediator were reanalyzed when stratified by the second mediator. Therefore, the analysis of income as a mediator was stratified by high (score ≥4) and low (score<4) risky lifestyle index; the analysis of risky lifestyle was stratified by low (<$50,000) and high (≥$50,000) income. This was done to gain a better sense of proportion mediated by each mediator independently.

3. Results

A summary of baseline participant characteristics is provided in Table 1. Differences between White and Black participants were significant for all variables. Black participants compared to White participants were younger, had fewer years of education and less income, higher current smoking rates but lower former smoking rates, less physical activity, scored lower on the Healthy Eating Index, higher on the risky lifestyle index, were more likely to be obese, and had lower social integration scores.

Over an average of 19 years (range 0–27 years) of follow-up, 4177 participants (39.9%) died. This included 2842 (45.6%) White participants and 1335 (31.6%) Black participants.

Table 2 presents the results of a set of multivariate-adjusted Cox proportional hazard models on the association between race and mortality. The table shows hazard ratios (HR) and 95% confidence intervals. Model 1 adjusted only for race, age and sex, and showed that Black participants had significantly higher mortality risk compared to White participants (HR = 1.46, 95% CI 1.35–1.58). Model 2 added BMI, social integration, income and education; the point estimate for the race effect was lower but remained significant (HR = 1.15, 95% CI 1.02–1.30). Higher income was related to lower mortality risk in a dose response pattern, and education was significant only at the highest level. Model 3 added the risky lifestyle index score; results from this model indicated that the association between race and mortality was no longer significant (HR = 1.05, 95% CI 0.92–1.20), that education was not significant, but that both higher income and healthier behaviors contributed to lower mortality risk. Based on these findings, analyses were undertaken to examine mediating effects of both income and risky lifestyle scores. Results (not shown) of the supplementary analysis by race and gender were very similar to those observed by race alone, as was the analysis that considered marital status, urban/rural status and lack of health insurance as additional covariates.

Results of the overall mediation analyses are provided in the left side of Table 3. Hazard ratios for income show that there was a significant indirect effect whereby the higher mortality risk associated with Black race was mediated through income, and that the direct effect of race on mortality was not significant when the mediating effect of income was considered. Likewise, the risky lifestyle index significantly mediated the association of race with mortality, and the direct effect of race was not significant. In the separate models, income mediated 62% of the association between race and mortality and lifestyle mediated 61% of the relationship.

The stratified mediation analysis results are shown in the middle and right-side columns of Table 3. The indirect effects for both income and risk lifestyle remain significant when stratified by the other mediator. Direct effects of race remain non-significant in all stratification conditions. The proportion of the association mediated by risky lifestyle is not influenced by low or high income. However, the proportion of the association mediated by income is reduced when stratified into both low and high risky lifestyle groups.

Table 1
Baseline characteristic of participants between non-Hispanic White and non-Hispanic Black American adults.

Variable label	Overall N = 10460	Non-Hispanic White N = 6227	Black N = 4233
Age at interview (years)	48.5 ± 19.9	52.9 ± 20.3	42.1 ± 17.5
Sex			
Male	4836 (46.2%)	2909 (46.7%)	1927 (45.5%)
Female	5624 (53.8%)	3318 (53.3%)	2306 (54.5%)
Education			
0–11 years	3231 (30.9%)	1715 (27.5%)	1516 (35.8%)
12 years	3712 (35.5%)	2140 (34.4%)	1572 (37.1%)
13 years or more	3517 (33.6%)	2372 (38.1%)	1145 (27.1%)
Income			
<$10,000	1907 (18.2%)	755 (12.1%)	1152 (27.2%)
$10,000-<$30,000	4444 (42.5%)	2518 (40.4%)	1926 (45.5%)
$30,000-<$50,000	2363 (22.6%)	1564 (25.1%)	799 (18.9%)
$50,000 or above	1746 (16.7%)	1390 (22.3%)	356 (8.4%)
Smoke			
Never	4945 (47.3%)	2773 (44.5%)	2172 (51.3%)
Former	2640 (25.2%)	1949 (31.3%)	691 (16.3%)
Current	2875 (27.5%)	1505 (24.2%)	1370 (32.4%)
Physical activity			
Inactive	2702 (25.8%)	1329 (21.3%)	1373 (32.4%)
Intermediate	3609 (34.5%)	2285 (36.7%)	1324 (31.3%)
Active	4149 (39.7%)	2613 (42.0%)	1536 (36.3%)
Healthy Eating Index score (0–100)	62.5 ± 13.5	64.9 ± 13.2	58.8 ± 13.0
Lifestyle Index	2.7 ± 1.6	2.5 ± 1.5	3.0 ± 1.5
Body Mass Index			
Normal weight (<25 kg/m^2)	4427 (42.3%)	2790 (44.8%)	1637 (38.7%)
Overweight (25-<30 kg/m2)	3429 (32.8%)	2118 (34.0%)	1311 (31.0%)
Obese (≥30 kg/m2)	2604 (24.9%)	1319 (21.2%)	1285 (30.4%)
Social Integration			
1	2192 (21.0%)	1132 (18.2%)	1060 (25.0%)
2	3497 (33.4%)	1954 (31.4%)	1543 (36.5%)
3	3249 (31.1%)	2063 (33.1%)	1186 (28.0%)
4	1522 (14.6%)	1078 (17.3%)	444 (10.5%)

4. Discussion

Although socioeconomic disadvantage is an established poor health outcome risk, and Black Americans on average experience poorer socioeconomic conditions than White Americans, results from the current study extend the knowledge base by quantifying the mediating effect of income between Black race and mortality risk, and by showing that a direct race disparity is reduced to non-statistical significance when accounting for income as a mediator. This is meaningful because it suggests that income-based interventions that target racial disparity in income levels may prove effective in reducing population mortality disparities.

Table 2
Hazard ratios and 95% confidence intervals between race and total mortality [a].

	Multivariate-adjusted model [b]	Multivariate-adjusted model [c]	Multivariate-adjusted model [d]
Race			
White	1	1	1
Black	1.34 (1.21 1.54)	1.13 (1.01 1.27)	1.04 (0.92 1.18)
Income			
<$10,000		1	1
$10,000–<$30,000		0.80 (0.70 0.91)	0.82 (0.72 0.93)
$50,000–<$30,000		0.67 (0.59 0.77)	0.71 (0.63 0.80)
$50,000 or above		0.53 (0.45 0.63)	0.60 (0.49 0.67)
Education			
0–11 years		1	1
12 years		1.00 (0.90 1.11)	1.04 (0.93 1.15)
13 years or more		0.83 (0.74 0.93)	0.92 (0.82 1.04)
Risky lifestyle index			1.19 (1.15 1.24)

[a] All models accounted for complex design in the NHANES.
[b] Model adjusted for age (continuous), sex.
[c] Model further adjusted for BMI, social integration, education and income.
[d] Model further adjusted for risky lifestyle index.

Income-based policy interventions do not necessarily indicate direct income support programs. Six policies to reduce economic inequality advocated by the UC Berkeley Othering and Belonging Institute include increasing the minimum wage, expanding the earned income tax credit, assisting low income families in saving for retirement and achieving home ownership, investing in early childhood education, adjusting capital gains tax rates to be in line with income tax rates, and ending racial segregation (Powell, 2021). The Organisation for Economic Cooperation and Development (OECD) has argued for policy efforts to reduce income inequality in three broad areas including education, job creation, and revising taxes and transfers to reduce disproportionate benefit to high earners (Keeley, 2015).

Our results are consistent with some previous research that has examined mediators of race disparities in health outcomes. Beydoun et al. (2016) conducted stratified Cox models by age, gender and income, making direct comparison to our study difficult, but generally they observed that differences in mortality between non-Hispanic Black and non-Hispanic White adults were usually not significant after adjusting for socioeconomic and behavioral factors. Our study adds nuance to this by allowing interactions between race and mediators and demonstrates significant mediator effects that render direct race effects non-significant. On the other hand, Sudano and Baker (2006) found that race-related mortality risk was not significantly influenced by SES or health behaviors after accounting for demographic and health status variables; our results suggest that such SES and health behavior variables are important mediators.

Income mediated 62% of the association between race and mortality. This indicates that other factors in addition to income are also important. Simultaneous mediating effects of income and risky behaviors were not modeled together and likely have correlated influences. Cohen et al. (Cohen et al., 2013) for example, found that levels of physical activity were similar among a sample of low-income Black and White adults. Mediation results of risky lifestyle stratified by income suggested that risky lifestyle is important regardless of income. Mediation of income stratified by risky lifestyle showed that the proportion of the association mediated by income is reduced compared to the overall model, suggesting that part of the income mediation effect in the overall model may overlap with pathways via lifestyle factors, but still has its additional contribution to racial difference in mortality beyond risky lifestyle. Other mediating influences not included in the present study may include racial discrimination leading to chronic stress and to inequities in access to housing, medical care or other amenities (Hood, 2005; Nelson, 2002; Woolf et al., 2015).

Risky lifestyle behaviors as a mediator between race and mortality highlights the importance of the contexts of engaging in healthy behaviors. Public health recommendations to exercise, eat a healthy diet and avoid smoking are well-intentioned and empirically grounded, but must be sensitive to life circumstances and to individual and cultural preferences (Joseph, Ainsworth, Keller, & Dodgson, 2015). Members of different race or ethnicity groups, for example, may prefer different forms of physical activity (Saint Onge & Krueger, 2011) and enjoy different culinary traditions (Slocum, 2010). Persons of limited economic means may struggle to access nutrient dense foods (Rao et al., 2013) and have more limited access to recreational equipment and amenities (Joseph et al., 2015). Recommendations from public health agencies and professionals cannot follow a one-size-fits-all approach but may more successfully achieve improved impact through approaches tailored to these contexts.

Beyond lifestyle interventions or income support policies, however, lies an additional, fundamental driver of race disparities in life expectancy. We refer here to lifelong institutional and structural racism that Black Americans experience, the "structural barriers, material hardships, and identity threats that comprise the Black experience" (Simons et al., 2021). According to the weathering hypothesis, race-related adversity has physiological impacts that result in accelerated biological aging, leading to earlier illness and mortality (Simons et al., 2021); this is consistent with evidence from Firebaugh that race disparities are

Table 3
Mediation analysis of racial disparities for overall mortality by income and risky lifestyle index. [a]

Mediator	Overall		Low risky lifestyle (Index score <4)		High risky lifestyle (Index score ≥4)	
	Hazard Ratio (95% CI)	Proportion mediated	Hazard Ratio (95% CI)	Proportion mediated	Hazard Ratio (95% CI)	Proportion mediated
Income (≥$50,000 vs <$50,000)		0.62		0.41		0.30
Natural direct effect	1.02 (0.95–1.10)		1.07 (0.97–1.17)		1.06 (0.95–1.19)	
Natural indirect effect	1.03 (1.01–1.05)		1.04 (1.01–1.07)		1.03 (1.002–1.05)	
Total effect	1.06 (0.99–1.13)		1.11 (1.02–1.22)		1.09 (0.97–1.21)	
	Overall		Low income (<$50,000)		High income (≥$50,000)	
	Hazard Ratio (95% CI)	Proportion mediated	Hazard Ratio (95% CI)	Proportion mediated	Hazard Ratio (95% CI)	Proportion mediated
Risky lifestyle index		0.61		0.62		0.59
Natural direct effect	1.03 (0.96–1.10)		1.02 (0.95–1.10)		1.07 (0.80–1.43)	
Natural indirect effect	1.04 (1.03–1.05)		1.04 (1.02–1.05)		1.10 (1.02–1.18)	
Total effect	1.07 (1.00–1.15)		1.06 (0.99–1.14)		1.18 (0.87–1.59)	

[a] Models adjusted for age, sex, education, income, lifestyle index, BMI and social integration except for the variable being assessed as a mediator.

not so much a question of different causes of death for Black versus White Americans, but of similar causes on an accelerated timeline (Firebaugh, Acciai, Noah, Prather, & Nau, 2014b). The focus on engaging in healthier behaviors, for example, becomes fundamentally more challenging when it must be accomplished under conditions of structural racism. This implies, importantly, that lifestyle interventions, no matter how well-tailored to cultural or racial identity, will not eliminate disparities and that policies that target and eradicate basic racial disparities are needed.

Strengths of the study include the long follow-up period, use of validated death records, a large and representative sample, and formal tests of mediating effects. However, several study limitations should be recognized. Outcomes were limited to overall mortality only and not to specific causes of mortality. Only one mediator at a time was modeled and mediators may have correlated influences. We had a measure of income but not of wealth, which may be important for older adults. Income was not adjusted for inflation over the six-year baseline period. Important covariates were included but it is possible that unmeasured confounds may influence the associations. Mediators were measured at the same time as baseline indicators. Possible changes in baseline measures after baseline and before mortality were not assessed. Data for most measures were dependent on self-report.

In conclusion, this study provides quantitative estimates of the contributions of low income, and health behaviors, in illuminating the relationship between race and mortality risk in the US. The direct effects of race on mortality are not significant when accounting for the mediating influences of income and of health behaviors. Efforts to reduce race-based mortality disparities may benefit from health behavior programs that are attuned to race differences in preferred methods of healthy behavioral practices. Reductions in income-based race disparities through policy initiatives offers a means to reduce mortality disparities and improve life expectancy. Finally, both of these objectives require efforts to eliminate underlying structural and institutional racism.

Author statement

Michael Hendryx: Conceptualization, investigation, methodology, project administration, supervision, visualization, writing – original draft. Juhua Luo: conceptualization, formal analysis, investigation, data curation, methodology, writing – review and editing. Fengge Wang: writing – review and editing, visualization.

Ethical statement

The research analyzed public anonymous data and human subjects review was not required.

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Declaration of interests

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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