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# The Association Between Educational Attainment and Mortality: Examining Absolute and Relative Effects by Race/Ethnicity

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**Objectives:** To determine whether the association between educational attainment and mortality varies by race/ethnicity on the absolute and relative scales, including among understudied races/ethnicities.

**Methods:** Data were obtained from the US National Longitudinal Mortality Study (1983-1984). Hazard models for adults aged ≥25 years (n=725,756) with race/ethnicity by educational interaction terms were used to test relative interaction; linear binomial models were used to test for absolute interaction.

**Results:** For the most part, educational gradients in mortality did not differ across race/ethnicity on the multiplicative scale. Conversely, additive interactions appear to be significant. Blacks gained more in terms of reduced mortality rates for each additional year of schooling. The educational gradient in Whites is also notable as the lowest educated Whites have similar absolute numbers of expected deaths as Blacks similarly educated. At higher levels of education, Whites gain substantially in terms of longer longevity. The educational gradient in Asians, Hispanics, and Native Americans is narrower compared to both Whites and Blacks.

**Conclusions:** The association between educational attainment and mortality does not function uniformly across race/ethnicity.
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**Keywords:** Race; Ethnicity; Health; Mortality; Education

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## Introduction

The association of higher educational attainment with longer life expectancy has been observed in a variety of settings[1] Although poorer longevity among the lower educated has been well-documented, less understood is whether the association between education and mortality is similar for groups disadvantaged by other factors, such as minority race/ethnicity. The concept of intersectionality acknowledges that social categorizations, such as race, class, and gender, are interconnected and can lead both groups and individuals to experience multiple forms of overlapping advantage and disadvantage. Thus, combinations of social categories may interact and influence health differently from markers of social status examined in isolation.[2] This topic has particular relevance because, although racial and ethnic diversity continues to increase in the United States, mortality gradients in certain race/ethnicities, particularly Asians and Native Americans, remain understudied.

In theory, the intersection of race/ethnicity, education, and mortality could work in different directions. More education may provide advantages that buffer minorities from racial disadvantage and thereby confer larger mortality gains within otherwise disadvantaged groups compared to Whites.[3] Conversely, the diminishing returns hypothesis suggests racial disadvantages may limit the health advantages gained with more education within certain race/ethnic groups.[4] There are very few theories that generate specific empirical predictions, and these dynamics may vary by race/ethnicity.

A variety of mechanisms could underlie differences in the relationship between education and mortality by race/ethnicity. Interpersonal racism may lead similarly educated persons of different races/ethnicities to experience differing levels of discrimination at school and in the workplace, reducing mental and ultimately physical health status. However, structural racism, defined as the ways in which racism is manifested and reinforced at the macrolevel, has been shown to be detrimental to health from very early in the life course.[5] Structural racism may work through a variety of mechanisms. First, quality of schooling varies across racial groups.[6] After schooling is completed, discrimination in the labor market may lessen the economic returns, and ultimately health and mortality benefits for equiva-

lently educated minorities relative to Whites.[7] Non-economic factors may also overshadow educational benefits. Contextual contingency or competing demands on time may be more acute for members of some race/ethnicity groups. For example, caregiving roles are often a large burden among minority women,[8] and minority men are more likely to be at risk of incarceration compared to Whites.[9] Finally, chronic conditions, such as asthma, are linked to early-life negative exposures such as poor housing quality, and Blacks and Native Americans suffer from greater lifelong health problems than Whites of similar ages.[10]

However, the effects of structural racism are not fully understood. For example, despite having relatively low socioeconomic position, Hispanics have better health and mortality compared to Whites.[11] Hispanics of low education have been shown to have mortality patterns similar to better educated Whites.[12]

## Existing Literature

Overall, existing studies have found that educational differentials in mortality in Blacks are similar to or slightly narrower than those found in Whites.[1,13-16] Only a handful of studies using data from the US National Health Interview Study (NHIS), or vital statistics data, have examined education-mortality associations for Hispanics and have found mixed results.[12,17,18] Very little empirical work has been conducted on the interplay of education and early life conditions among Asians and Hispanics and the situation may be more complex. Asian and Hispanics have higher rates of immigration compared to other racial/ethnic groups in the United States, and immigrants tend to be healthier than the native born for most health conditions, a phenomenon known as the healthy migrant effect.[19] Limited evidence suggests that educational disparities may be lesser in immigrants as those in the lowest educated groups fare better than expected.[20]

However, previous research has had two major limitations: First, comparisons have mostly been limited to Blacks and Hispanics compared to Whites, despite the fact that racial and ethnic diversity continues to increase in the United States. It is not known whether health returns of education are similar in other groups such Asians and Native Americans, which have very different educational and mortality patterns compared to other races/ethnicities. A second limitation of studies on this topic is that they have formally examined effect measure modification by race/ethnicity solely on the relative scale.

*The primary aim was to test whether the association between educational attainment and mortality is modified by race/ethnicity of understudied racial/ethnic groups in the United States.*

One of the great difficulties in effect measure modification research is that when both exposures are associated with the outcome, there will automatically be a statistically significant interactive effect on either the relative or absolute scales or both.

To complicate matters further, the relative and absolute scales often do not agree.[21] It is therefore vital for an analyst to be explicit about the meaning of such tests for interaction in these contexts.[22] Absolute interaction effects have greater public health importance because they reflect the number of deaths related to an exposure in each subgroup. As highlighted by Ward et al, another important consideration for interactions in racial disparities analyses is the prevalence of exposure and outcome in each subpopulation.[23] In an example from the social sciences, the association between several key demographic and behavioral risk factors, such as gender, race/ethnicity, education, and obesity, appear to decline with age on the relative scale, but the absolute number of deaths between advantaged and disadvantaged groups increases throughout the life course.[21] Strengthening the Reporting of Observational studies in Epidemiology (STROBE)[24] guidelines recommend presenting both absolute and relative interaction effects. However, how to interpret each, particularly when they differ in magnitude or even direction can be difficult and dependent on both research goals and an understanding of the topic under study. Absolute interactive effects are particularly important when examining racial health disparities for three reasons: 1) mortality rates vary

widely between races/ethnicities, with Blacks suffering a far greater burden of premature death; 2) educational composition differs significantly between races/ethnicities; and 3) a key health priority is identifying vulnerable populations with excess deaths.

The present analysis examines the association of education and mortality using a dataset, the National Longitudinal Mortality Study (NLMS), with a sample size large enough to examine differences across race/ethnicity. The primary aim was to test whether the association between educational attainment and mortality is modified by race/ethnicity on either the relative or absolute scale including understudied racial/ethnic groups in the United States. This analysis contributes to the literature by analyzing all major race/ethnicities and by providing a more thorough examination of interactive effects on both scales.

## Methods

### Sample

The National Longitudinal Mortality Study (NLMS) is a representative sample of the non-institutionalized population of the United States designed to study mortality differentials in demographic and socioeconomic groups. Deidentified data may be obtained by contacting the National Longitudinal Mortality Study.

Baseline data were obtained from the Annual Social and Economic Supplements covering the period from March 1973 to March 2002; Current Population Surveys (CPS) for February 1978, April 1980, August 1980, December 1980, and September 1985; and one 1980 Census cohort. CPS respondents were matched using probabilistic methods based on personal identifiers to National Death Index data for up to 11 years, which is maintained by the National Center for Health Statistics. Matching of CPS data to death data has been found to be largely effective at capturing all deaths in each study cohort.[25]

To maintain confidentiality of participants, baseline interview dates were not disclosed, and April 1, 1983, has been denoted as the starting point for all records. All socioeconomic and demographic data was self-reported and collected one time only. The public-use data file for the study currently includes data on 1,222,344 persons with more than 112,375 identified mortality records. Respondents aged <25 years were excluded from this analysis because educational attainment may not be completed before this age (n= 441,883). All respondents missing any covariate data were also excluded (n=54,705).

### Outcome

The outcome measure in this analysis was all-cause mortality determined via death certificate data throughout 11 years of follow up from baseline.

### Exposure

CPS was the data source for educational attainment in NLMS. The education variable in NLMS attempts to translate post-1991 data, which measures highest degree earned, into equivalent years of school to maintain consistency. This analysis classifies education into four mutually exclusive categories: less than high school (less than 12 years), high school only (exactly 12 years), some college (13-15 years), and bachelor's degree or higher (16+ years).

### Covariates

Self-reported race and ethnicity were also collected in the CPS as White, Black, American Indian or Eskimo, Asian or Pacific Islander, and other, non-White. Hispanic origin was recorded as Mexican, other Hispanic, or non-Hispanic. In this analysis, racial categories were mutually exclusive; all Hispanics were classified as Hispanic, regardless of race chosen. Potential confounders of the association between education and mortality were included in the analysis. All were collected via CPS and Census records. Sex is categorized as male or female. Age at time of interview was top coded at 90. Urban vs rural status was determined via the 1970, 1980, or 1990 Census. An urban area consists of all places of 2,500 or more inhabitants. Marital status was classified as divorced, married, never married, separated, or widowed. Family income was measured as percent of poverty level in 1990 and dichotomized as at or less than poverty and above poverty level. Immigration status was coded as either born in the United States or not. Finally, employment status was defined as employed; employed but absent from work; unemployed; disabled, unable to work; and not in labor force because retired, student, homemaker, or other reason. All confounders were identified a priori via a literature review.

### Statistical Analysis

Descriptive characteristics for the analytical sample were stratified by

race/ethnicity. Multivariable analysis was performed using Cox proportional hazards. The proportional hazard assumption was not met for all covariates. However, because the present dataset's large sample size would produce many significant results for even small deviations from the proportionality assumption, Schoenfeld residuals were also plotted and examined. Thus, it was determined the proportionality assumption was reasonable. Relative interaction effects were assessed by testing an interaction term. Models were then stratified by race/ethnicity. Cox proportional hazards models were adjusted for age and sex and then a full set of covariates.

Absolute interaction was assessed by calculating predicted rates for each education group using a linear binomial model as suggested by Thompson[26] because it assesses departures from additivity by estimating risk difference. A Poisson distribution was assumed to address model non-convergence as suggested by Spiegelman and Herzmark.[27] The linear binomial regression model, using an identity link, is advantageous because it allows for direct estimation of probabilities, differences in probabilities and of the interaction contrast. Because it is calculated on the additive scale, effect measure modification can be assessed using an interaction term. Additive models were adjusted by age and then a full set of covariates. Sex was not included as a covariate and other race was excluded in linear binomial models due to model non-convergence. All code was completed in SAS and available by contacting the author of this article.

All procedures were in accordance with the ethical standards of the responsible committee on human experimentation (institutional and national) and with the Helsinki Declaration of 1975, as revised in 2000. Informed consent was obtained from all participants included in the study.

## Results

The final analytic sample included 725,756 participants with a total of 7,446,796 person years of follow up. Full descriptive characteristics of the sample are shown in Table 1. The study included 604,344 non-Hispanic Whites, 61,019 non-Hispanic Blacks, 42,910 Hispanics, 12,106 non-Hispanic Asians, and 4,994 non-Hispanic Native Americans, and 383 other race. Those with more education were more likely to be male, non-Hispanic White, and urban. Slightly more decedents were male, and Blacks had the highest proportion of deceased status (16.5%). The largest educational attainment group was those with high school only (38.1%) followed by those with less than high school (27.2%).

In the age- and sex-adjusted Cox proportional hazards multivariable analysis, Asians had the lowest rate of death compared to Whites (HR:.57, 95%CI: .54, .61), followed by Hispanics (HR: .59, 95%CI: .57, .61). Native Americans had a slightly lower risk of mortality compared to Whites (HR: .86, 95%CI: .80, .94). Blacks had the highest risk of mortality compared to Whites (HR: 1.07, 95%CI: 1.05, 1.10). Higher educational attainment was associated with lower hazards of mortality for all groups. Although the overall interaction term was statistically significant (P<.001), the only race/ethnicity*educational attainment pair that was statistically significant was Black*less than high school. Results were qualitatively similar in the age- and sex-adjusted and full models (data not shown). The relative difference in mortality hazards from high to low education were similar across most race/ethnicities as can be most clearly seen in Figure 1.

In contrast to these results, large race/ethnicity differences in absolute mortality across educational categories were observed, and the race*education interaction term was significant at the P<.001 level. The racial groups with the highest baseline mortality had the highest absolute educational mortality differentials. Blacks had the highest predicted mortality for almost every educational category. For instance, Blacks with less than a high school diploma experienced 7,842 (95%CI: 7,644, 8,041) excess deaths compared to college educated Whites in the age-adjusted model. Blacks also had wide mortality differentials for each additional level of education. Whites also had wide mortality differentials by education. Increased mortality was most pronounced among the least educated Whites, and for this group, mortality risk differences were similar to comparatively educated Blacks. Whites experienced a steep decline in mortality with greater educational attainment, but risk differences remained higher than Asians and Hispanics with some college or at least a Bachelor's degree. Both Hispanics and Asians had lower baseline mortality and had the lowest mortality for each educational group. The mortality differentials for both

**Table 1. Descriptive characteristics of the National Longitudinal Mortality Study (n=725,756) by race/ethnicity 1983 to 1994**

| | Total | | American Indian or Eskimo, N=4,994 | | Asian, N=12,106 | | Hispanic, N=12,106 | | Non-Hispanic Black, N=61,109 | | Non-Hispanic White, N=604,344 | | Other nonWhite, N=383 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | N | % | N | % | N | % | N | % | N | % | N | % | N | % |
| Educational attainment | | | | | | | | | | | | | | |
| College | 133579 | 18.4 | 296 | 5.9 | 3825 | 31.6 | 3780 | 8.8 | 5874 | 9.6 | 119677 | 19.8 | 127 | 33.2 |
| High school only | 276293 | 38.1 | 1748 | 35.0 | 3729 | 30.8 | 12812 | 29.9 | 19970 | 32.7 | 237936 | 39.4 | 98 | 25.6 |
| Some college | 118805 | 16.4 | 776 | 15.5 | 1886 | 15.6 | 5307 | 12.4 | 8496 | 13.9 | 102277 | 16.9 | 63 | 16.4 |
| Less than high school | 197079 | 27.2 | 2174 | 43.5 | 2666 | 22.0 | 21011 | 49.0 | 26679 | 43.7 | 144454 | 23.9 | 95 | 24.8 |
| Age | | | | | | | | | | | | | | |
| 25-34 | 202102 | 27.8 | 1778 | 35.6 | 4028 | 33.3 | 15347 | 35.8 | 18608 | 30.5 | 162178 | 26.8 | 163 | 42.6 |
| 35-44 | 153456 | 21.1 | 1203 | 24.1 | 3108 | 25.7 | 10801 | 25.2 | 13188 | 21.6 | 125063 | 20.7 | 93 | 24.3 |
| 45-54 | 120816 | 16.6 | 854 | 17.1 | 2149 | 17.8 | 7342 | 17.1 | 10258 | 16.8 | 100165 | 16.6 | 48 | 12.5 |
| 55-64 | 114554 | 15.8 | 602 | 12.1 | 1550 | 12.8 | 5220 | 12.2 | 8996 | 14.7 | 98130 | 16.2 | 56 | 14.6 |
| 65-74 | 85301 | 11.8 | 379 | 7.6 | 906 | 7.5 | 2809 | 6.5 | 6573 | 10.8 | 74617 | 12.3 | 17 | 4.4 |
| 75-84 | 40582 | 5.6 | 145 | 2.9 | 303 | 2.5 | 1168 | 2.7 | 2747 | 4.5 | 36215 | 6.0 | [a] | [a] |
| 85+ | 8945 | 1.2 | 33 | .7 | 62 | .5 | 223 | .5 | 649 | 1.1 | 7976 | 1.3 | [a] | [a] |
| Sex | | | | | | | | | | | | | | |
| Female | 388053 | 53.5 | 2653 | 53.1 | 6418 | 53.0 | 22934 | 53.4 | 35634 | 58.4 | 320220 | 53.0 | 194 | 50.7 |
| Male | 337703 | 46.5 | 2341 | 46.9 | 5688 | 47.0 | 19976 | 46.6 | 25385 | 41.6 | 284124 | 47.0 | 189 | 49.3 |
| Nativity status | | | | | | | | | | | | | | |
| Immigrant | 47733 | 6.6 | 40 | 0.8 | 6868 | 56.7 | 18768 | 43.7 | 1754 | 2.9 | 20092 | 3.3 | 211 | 55.1 |
| Native born | 678023 | 93.4 | 4954 | 99.2 | 5238 | 43.3 | 24142 | 56.3 | 59265 | 97.1 | 584252 | 96.7 | 172 | 44.9 |
| Marital status | | | | | | | | | | | | | | |
| Divorced | 57355 | 7.9 | 584 | 11.7 | 582 | 4.8 | 3584 | 8.4 | 6933 | 11.4 | 45651 | 7.6 | 21 | 5.5 |
| Married | 514376 | 70.9 | 3167 | 63.4 | 9159 | 75.7 | 30607 | 71.3 | 30324 | 49.7 | 440851 | 72.9 | 268 | 70.0 |
| Never married | 71503 | 9.9 | 643 | 12.9 | 1555 | 12.8 | 4501 | 10.5 | 10576 | 17.3 | 54170 | 9.0 | 58 | 15.1 |
| Separated | 17629 | 2.4 | 192 | 3.8 | 155 | 1.3 | 1895 | 4.4 | 5803 | 9.5 | 9566 | 1.6 | 18 | 4.7 |
| Widowed | 64893 | 8.9 | 408 | 8.2 | 655 | 5.4 | 2323 | 5.4 | 7383 | 12.1 | 54106 | 9.0 | 18 | 4.7 |
| Income | | | | | | | | | | | | | | |
| Above poverty level | 640336 | 88.2 | 3364 | 67.4 | 10779 | 89.0 | 33834 | 78.8 | 43026 | 70.5 | 549033 | 90.8 | 300 | 78.3 |
| At or less than poverty level | 85420 | 11.8 | 1630 | 32.6 | 1327 | 11.0 | 9076 | 21.2 | 17993 | 29.5 | 55311 | 9.2 | 83 | 21.7 |
| Employment status | | | | | | | | | | | | | | |
| Employed, not working | 24016 | 3.3 | 124 | 2.5 | 406 | 3.4 | 1200 | 2.8 | 2218 | 3.6 | 20059 | 3.3 | 9 | 2.3 |
| Unemployed, looking for work | 25927 | 3.6 | 429 | 8.6 | 402 | 3.3 | 2388 | 5.6 | 4157 | 6.8 | 18537 | 3.1 | 14 | 3.7 |
| In school | 247208 | 34.1 | 1827 | 36.6 | 3290 | 27.2 | 13691 | 31.9 | 19868 | 32.6 | 208416 | 34.5 | 116 | 30.3 |
| Not in labor force, housekeeping | 12769 | 1.8 | 141 | 2.8 | 133 | 1.1 | 871 | 2.0 | 2107 | 3.5 | 9510 | 1.6 | 7 | 1.8 |
| Employed | 415836 | 57.3 | 2473 | 49.5 | 7875 | 65.1 | 24760 | 57.7 | 32669 | 53.5 | 347822 | 57.6 | 237 | 61.9 |
| Urbanicity | | | | | | | | | | | | | | |
| Rural | 231550 | 31.9 | 3079 | 61.7 | 1835 | 15.2 | 5765 | 13.4 | 10330 | 16.9 | 210464 | 34.8 | 77 | 20.1 |
| Urban | 494206 | 68.1 | 1915 | 38.3 | 10271 | 84.8 | 37145 | 86.6 | 50689 | 83.1 | 393880 | 65.2 | 306 | 79.9 |
| Death status | | | | | | | | | | | | | | |
| Alive | 622702 | 85.8 | 4402 | 88.1 | 11258 | 93.0 | 39331 | 91.7 | 50980 | 83.5 | 516378 | 85.4 | 353 | 92.2 |
| Not alive | 103054 | 14.2 | 592 | 11.9 | 848 | 7.0 | 3579 | 8.3 | 10039 | 16.5 | 87966 | 14.6 | 30 | 7.8 |

a. Some cells not shown for other race due to small n.

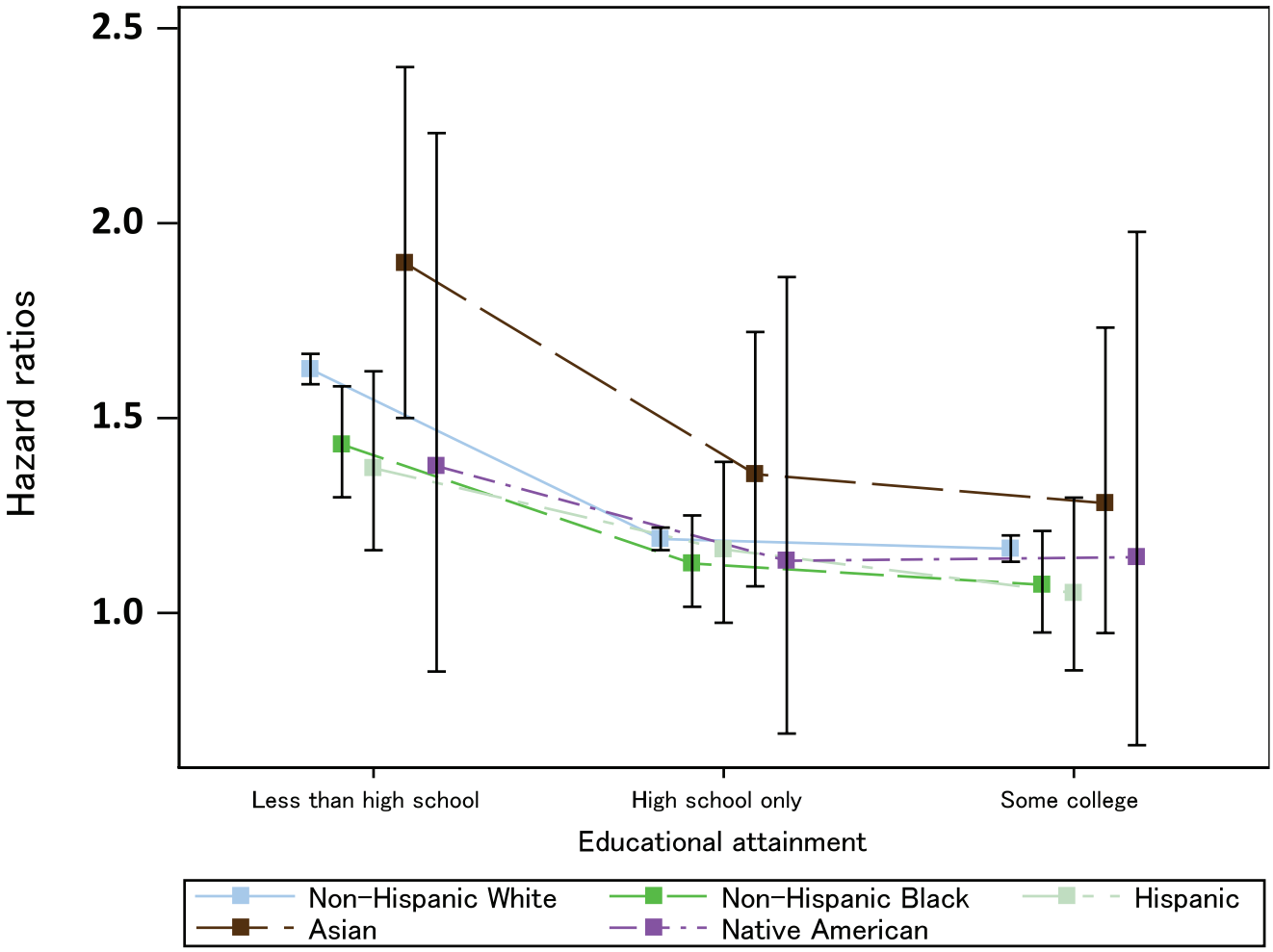


**Figure 1. Adjusted hazard ratios for death stratified by race/ethnicity in the National Longitudinal Mortality Study, 1983 to 1994**
Other race not shown due to small n. Reference=College educated. Adjusted by age, sex, urban/rural status, marital status, employment status, immigration status, and poverty level

groups were narrower than Blacks, Whites, and Native Americans. Native Americans had a steeper mortality differential than Asians and Hispanics, but narrower than Whites and Blacks. Native Americans experienced fewer excess deaths in the less than high school group than Whites, but more excess deaths in the high school only and some college groups (Table 2).

These patterns can be seen most clearly in Figure 2. Deaths per 100,000 were highest in the least educated Black and Whites but declined more steeply by educational category for Whites. Deaths were lower in Asians and Hispanics, and the differences between the highest and lowest educated were smaller in these groups.

## Discussion

Higher educational attainment was associated with lower mortality across all race/ethnicities, consistent with a wide body of literature.[28-31] On the relative scale, limited interaction was observed between educational attainment and race/ethnicity, meaning that the relative risk of death from high to low education is for the most part similar within each group. On the absolute scale however, the difference in the death rate between low and high educational attainment varied greatly by race/ethnicity. Specifically, Blacks and Whites had both the highest rates of death among

**Table 2. Risk differences per 100,000 in mortality by race/ethnicity and educational attainment in the National Longitudinal Mortality Study 1983 to 1994**

| | Model 1: Risk differences (95% CI) | Model 2: Risk differences (95% CI) |
|---|---|---|
| Race/ethnicity * education | | |
| Non-Hispanic White * less than high school | 7842 (7644, 8041)[a] | 5620 (5422, 5818)[a] |
| Non-Hispanic Black*less than high school | 8117 (7683, 8551)[a] | 5433 (4999, 5867)[a] |
| Hispanic*less than high school | 1108 (817.4, 1398)[a] | 506.8 (173.9, 839.7)[a] |
| Asian*less than high school | 875.8 (14.6, 1737)[a] | 470.3 (-435, 1375) |
| Native American*less than high school | 4117 (2925, 5310)[a] | 2093 (869.1, 3316)[a] |
| Non-Hispanic White*high school only | 849.7 (736.6, 962.8)[a] | 570.3 (451.4, 689.2)[a] |
| Non-Hispanic Black *high school only | 2740 (2414, 3067)[a] | 1542 (1226, 1859)[a] |
| Hispanic*high school only | 702.1 (400.4, 1004)[a] | 513.5 (190.8, 836.2)[a] |
| Asian*high school only | 575.7 (-46, 1198) | 580.4 (-63, 1224) |
| Native American*high school only | 2196 (1198, 3194)[a] | 874.3 (-83, 1832) |
| Non-Hispanic White*some college | 563.2 (431.9, 694.4)[a] | 418.2 (280.3, 556)[a] |
| Non-Hispanic Black*some college | 1957 (1527, 2387)[a] | 1037 (632.4, 1442)[a] |
| Hispanic*some college | 234.2 (-154, 622.9) | 277.4 (-144, 699.2) |
| Asian*some college | -268 (-822, 286.1) | 53.3 (-540, 646.9) |
| Native American*some college | 927.7 (-223, 2078) | -36 (-980, 908.4) |
| Non-Hispanic Black*college | 1189 (711.7, 1666)[a] | 760.1 (303, 1217)[a] |
| Hispanic*college | -6 (-458, 446.2) | 205.6 (-282, 693.3) |
| Asian*college | -671 (-989, -353) | 106.1 (-337, 549.4) |
| Native American*college | 1058 (-1004, 3120) | 733.5 (-1414, 2881) |

a. P ≤.05
Other race not shown due to small n.
The reference category for all risk differences is college-educated White.
Model 1 is age adjusted.
Model 2 is adjusted by age, urban/rural status, marital status, employment status, immigration status, and poverty level. Sex is not included in model 2 due to model non-convergence.

the least educated and the steepest mortality gradients by education, although even at the highest levels of educational attainment, mortality remained elevated among Blacks compared to other racial groups. Notably, the highest educated Blacks had predicted mortality rates similar to the least educated Asians and Hispanics. Asians and Hispanics experienced much narrower education-mortality gradients compared to Blacks and Whites. Education-mortality gradients among Native Americans were narrower than those found in Whites and Blacks but wider than those found in Asians and Hispanics.

Similar to the present findings, previous work on this topic found that among minorities, educational-mortality disparities were similar or slightly "narrower" compared to Whites on the relative scale.[28-31] This suggests educational attainment provides similar or only modestly smaller mortality gains in Blacks compared to Whites. Conversely, the health literature has shown more evidence for the diminishing returns hypothesis on the relative scale.[32,33] It is unclear why the interactive effects of education and race/ethnicity would work differently for health than mortality. One possible explanation may be that previous researchers did not thoroughly investigate interaction on both the absolute and relative scales. Specifically, a limited number of studies have examined these associations on the additive scale. One other study examined the interactive effects of educational attainment and race/ethnicity on mortality and found effects on the multiplicative but not the additive scale using NHANES data but did not include Hispanics, Asians, or Native Americans.[34]

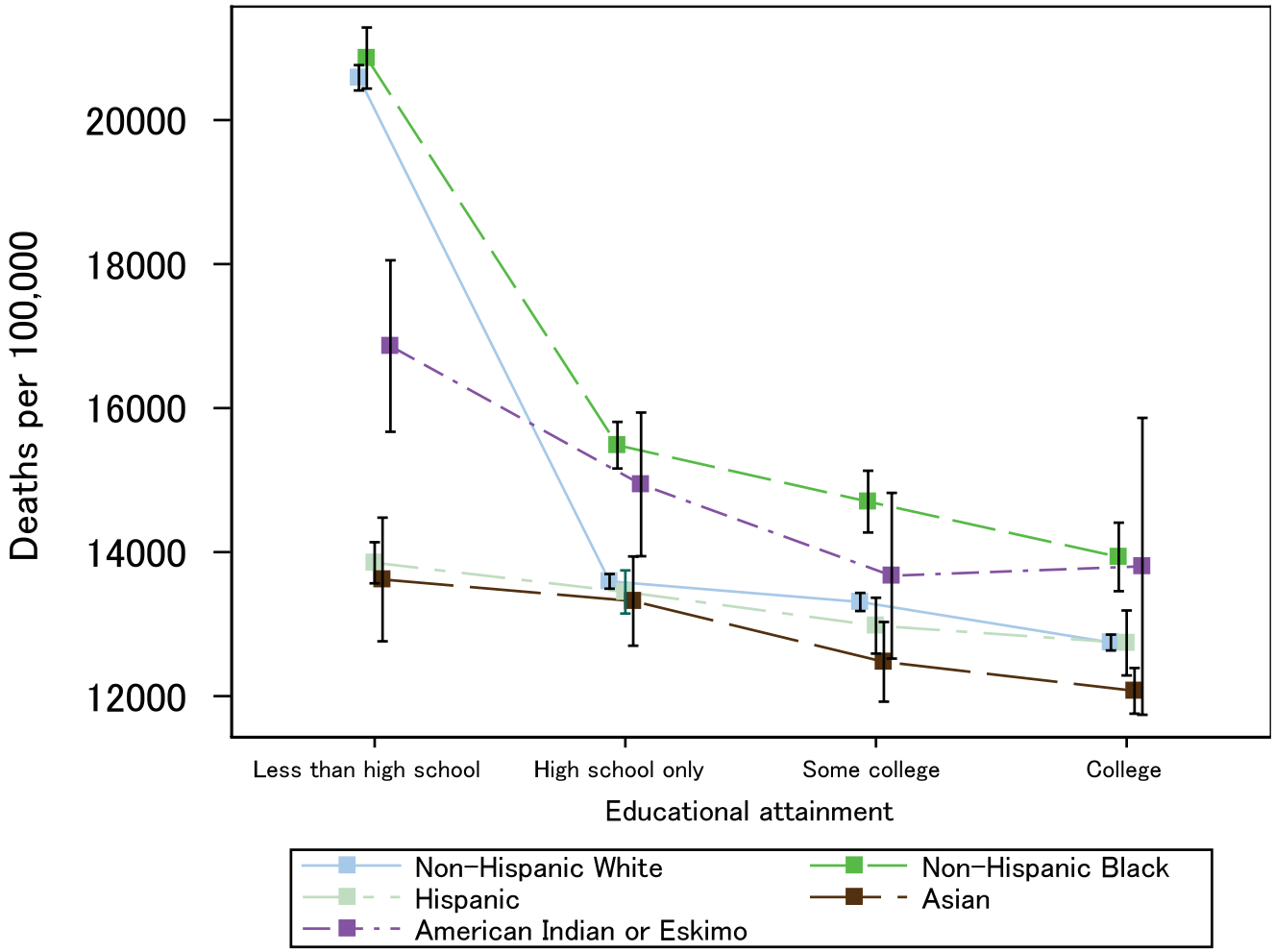


**Figure 2. Age-adjusted expected deaths per 100,000 in the National Longitudinal Mortality Study by race/ethnicity, 1983 to 1994**
Other race not included due to model non-convergence

The choice of testing interactive effects on the relative vs absolute scale is not an obvious one and rarely explicitly justified, despite the fact that the different scales often give contradictory answers as to the presence of interaction.[21] In many cases of social patterning of disease, baseline levels of both exposure and disease differ substantially across groups such that relative comparisons may not be as informative as comparisons on an absolute scale. For instance, health returns to education could be conceived as either relative or absolute gains from additional years of education within each race/ethnicity. A lack of interaction on the relative scale could be interpreted as similar returns to education for Black vs Whites, but the absolute results tell a very different and more relevant story. While Blacks gain in terms of mortality improvement as they go up the educational ladder, they still have much higher levels of mortality at equivalent levels of education, which aligns with the theory of diminished returns in that education is not converted into the same level of health for Blacks compared to Whites.

The finding that the least educated Whites suffered disproportionate mortality compared to their better educated counterparts is in agreement with previous work on this topic. Case and Deaton hypothesize this is due to deaths of despair among marginalized Whites.[35] However, this

group has changed in composition substantially over recent decades as Whites have become better educated, so much so that selection effects could also play an important role.[36]

The differences for Asians and Hispanics compared to Whites on both the absolute and relative scales were smaller; and, for those with a less than high school diploma, Whites suffered far greater mortality.

*Blacks and Whites had both the highest rates of death among the least educated and the steepest mortality gradients by education, although even at the highest levels of educational attainment, mortality remained elevated among Blacks…*

Anti-Blackness is a specific form of racism in which Blacks are subjected to greater racial discrimination than other minorities, who are perceived to be closer to Whiteness. Theoretically, this could lead to less labor market discrimination and other disadvantages for these groups compared to Blacks, allowing them to fully realize the health benefits of education.

In addition, higher levels of social cohesion in immigrant communities may be protective of health by reducing everyday stressors and producing positive affect,[11] though the fully adjusted models in this study included immigration status. Importantly, the lower levels of overall mortality for Asians and Hispanics compared to Whites may also account for these findings. Taken together, these results suggest that the interplay between race/ethnicity and education is complex and may not be consistent by racial and ethnic group.

### Study Limitations and Strengths

This study has several limitations that should be noted. First, data are only available for a limited number of cohorts and a relatively narrow time frame. Many of these dynamics may be evolving over time as both the demographic composition and mortality patterns in the United States are rapidly changing. In addition, these data are self-reported, though it is unlikely misreporting would be different by race/ethnicity. Finally, although this dataset contained a rich set of covariates, unmeasured confounding may be present. The present analysis also has a number of strengths, including a very large cohort, allowing for the examination of racial/ethnic groups that would not be possible with a smaller sample size. In addition, NLMS contains complete mortality data obtained from death certificates. Finally, the statistical approach used in this analysis allows for direct calculation of absolute differences in mortality and interactive effects.

## Public Health Implications

Assessing the interactive effects of educational attainment and race/ethnicity on mortality is an important topic in social science research, particularly for understanding the intersectionality of social identities on lifetime health advantage and ultimately mortality. This analysis thoroughly examined both absolute and relative interaction and found that when one group, in this case Blacks, suffers disproportionate baseline mortality, assessing relative interaction may not be sufficient and may belie important mortality disparities. In the present study, Blacks experienced greater absolute mortality at each level of education, and even at the highest levels of education, they experience mortality rates higher than their lower educated counterparts of other races/ethnicities. This suggests the health benefits of education may not outweigh the social disadvantages of racial discrimination. This same pattern was not observed in other disadvantaged minorities, such as Hispanics and Asians. Further research is needed to understand why the benefits of educational attainment on mortality do not function uniformly across race/ethnicity.

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**References**

1. Everett BG, Rehkopf DH, Rogers RG. The nonlinear relationship between education and mortality: an examination of cohort, race/ethnic, and gender differences. *Popul Res Policy Rev*. 2013;32(6):893-917. https://doi.org/10.1007/s11113-013-9299-0 PMID:24288422

2. Bowleg L. The problem with the phrase women and minorities: intersectionality-an important theoretical framework for public health. *Am J Public Health*. 2012;102(7):1267-1273. https://doi.org/10.2105/AJPH.2012.300750 PMID:22594719
3. Wilson G. Racialized life-chance opportunities across the class structure: the case of African Americans. *Ann Am Acad Pol Soc Sci*. 2007;609(1):215-232. https://doi.org/10.1177/0002716206295331
4. Hughes M, Thomas ME. The continuing significance of race revisited: A study of race, class, and quality of life in America, 1972 to 1996. *Am Sociol Rev*. 1998;63(6):785-795. https://doi.org/10.2307/2657501
5. Bell CN, Owens-Young JL. Self-rated health and structural racism indicated by county-level racial inequalities in socioeconomic status: the role of urban-rural classification. *J Urban Health*. 2020;97(1):52-61. https://doi.org/10.1007/s11524-019-00389-7
6. Margo RA. *Race and Schooling in the South, 1880-1950: An Economic History*. Chicago, IL: University of Chicago Press; 1990. https://doi.org/10.7208/chicago/9780226505015.001.0001
7. Pager D, Western B, Bonikowski B. Discrimination in a low-wage labor market: A field experiment. *Am Sociol Rev*. 2009;74(5):777-799. https://doi.org/10.1177/000312240907400505 PMID:20689685
8. Chen F, Mair CA, Bao L, Yang YC. Race/ethnic differentials in the health consequences of caring for grandchildren for grandparents. *J Gerontol B Psychol Sci Soc Sci*. 2015;70(5):793-803. PMID:25481922
9. Pettit B, Western B. Mass imprisonment and the life course: race and class inequality in US incarceration. *Am Sociol Rev*. 2004;69(2):151-169. https://doi.org/10.1177/000312240406900201
10. Brown TH, O'Rand AM, Adkins DE. Race-ethnicity and health trajectories: tests of three hypotheses across multiple groups and health outcomes. *J Health Soc Behav*. 2012;53(3):359-377. https://doi.org/10.1177/0022146512455333 PMID:22940814
11. Ruiz JM, Steffen P, Smith TB. Hispanic mortality paradox: a systematic review and meta-analysis of the longitudinal literature. *Am J Public Health*. 2013;103(3):e52-e60. https://doi.org/10.2105/AJPH.2012.301103 PMID:23327278
12. McKinnon SA, Hummer RA. *Education and Mortality Risk among Hispanic Adults in the United States. The Health of Aging Hispanics*. New York, NY: Springer; 2007:65-84.
13. Masters RK, Hummer RA, Powers DA. Educational differences in U.S. adult mortality: a cohort perspective. *Am Sociol Rev*. 2012;77(4):548-572. https://doi.org/10.1177/0003122412451019 PMID:25346542
14. Jemal A, Ward E, Anderson RN, Murray T, Thun MJ. Widening of socioeconomic inequalities in U.S. death rates, 1993-2001. *PLoS One*. 2008;3(5):e2181. https://doi.org/10.1371/journal.pone.0002181 PMID:18478119
15. Zajacova A, Hummer RA. Gender differences in education effects on all-cause mortality for White and Black adults in the United States. *Soc Sci Med*. 2009;69(4):529-537. https://doi.org/10.1016/j.socscimed.2009.06.028 PMID:19589633
16. Assari S, Lankarani MM. Race and urbanity alter the protective effect of education but not income on mortality. *Front Public Health*. 2016;4:100. https://doi.org/10.3389/fpubh.2016.00100 PMID:27242992
17. Miech R, Pampel F, Kim J, Rogers RG. The enduring association between education and mortality: The role of widening and narrowing disparities. *Am Sociol Rev*. 2011;76(6):913-934. https://doi.org/10.1177/0003122411411276 PMID:26937041
18. Turra CM, Goldman N. Socioeconomic differences in mortality among U.S. adults: insights into the Hispanic paradox. *J Gerontol B Psychol Sci Soc Sci*. 2007;62(3):S184-S192. https://doi.org/10.1093/geronb/62.3.S184 PMID:17507594
19. Argeseanu Cunningham S, Ruben JD, Narayan V. Health of foreign-born people in the United States: a review. *Health & Place*. 2008;14(4):623-635. https://doi.org/10.1016/j.healthplace.2007.12.002
20. Kimbro RT, Bzostek S, Goldman N, Rodríguez G. Race, ethnicity, and the education gradient in health. *Health Aff (Millwood)*. 2008;27(2):361-372. https://doi.org/10.1377/hlthaff.27.2.361 PMID:18332490
21. Mehta NK, Zheng H, Myrskylä M. How do age and major risk factors for mortality interact over the life-course? Implications for health disparities research and public health policy. *SSM Popul Health*. 2019;8:100438. https://doi.org/10.1016/j.ssmph.2019.100438 PMID:31321279
22. VanderWeele TJ, Knol MJ. A tutorial on interaction. *Epidemiol Methods*. 2014;3(1):33-72. https://doi.org/10.1515/em-2013-0005
23. Ward JB, Gartner DR, Keyes KM, Fliss MD, McClure ES, Robinson WR. How do we assess a racial disparity in health? Distribution, interaction, and interpretation in epidemiological studies. *Annals of Epidemiology*. 2019;29:1-7. https://doi.org/10.1016/j.annepidem.2018.09.007
24. Cuschieri S. The STROBE guidelines. *Saudi J Anaesth*. 2019;13(5)(suppl 1):S31-S34. https://doi.org/10.4103/sja.SJA_543_18 PMID:30930717
25. Rogot E, Sorlie PD, Johnson NJ, Schmitt C. A mortality study of 1.3 million persons by demographic social and economic factors: 1979-1985 follow-up. US National Longitudinal Mortality Study. 1992. Washington, DC: National Institutes of Health: National Heart, Lung, and Blood Institute. NIH Publication No. 92-3297
26. Thompson DM, Zhao YD. Choosing statistical models to assess biological biological interaction (as departures from additivity: 2016. Last accessed Oct 5, 2021 from https://bit.ly/3iDxPpX
27. Spiegelman D, Hertzmark E. Easy SAS calculations for risk or prevalence ratios and differences. *Am J Epidemiol*. 2005;162(3):199-200. https://doi.org/10.1093/aje/kwi188 PMID:15987728
28. Jemal A, Thun MJ, Ward EE, Henley SJ, Cokkinides VE, Murray TE. Mortality from leading causes by education and race in the United States, 2001. *Am J Prev Med.* 2008;34(1):1-8. https://doi.org/10.1016/j.amepre.2007.09.017.
29. Meara ER, Richards S, Cutler DM. The gap gets bigger: changes in mortality and life expectancy, by education, 1981-2000. *Health Aff (Millwood)*. 2008;27(2):350-360. https://doi.org/10.1377/hlthaff.27.2.350 PMID:18332489
30. Montez JK, Berkman LF. Trends in the educational gradient of mortality among US adults aged 45 to 84 years: bringing regional context into the explanation. *Am J Public Health*. 2014;104(1):e82-e90. https://doi.org/10.2105/AJPH.2013.301526 PMID:24228659
31. Zajacova A. Education, gender, and mortality: does schooling have the same effect on mortality for men and women in the US? *Soc Sci Med*. 2006;63(8):2176-2190. https://doi.org/10.1016/j.socscimed.2006.04.031 PMID:16781036
32. Farmer MM, Ferraro KF. Are racial disparities in health conditional on socioeconomic status? *Soc Sci Med*. 2005;60(1):191-204. https://doi.org/10.1016/j.socscimed.2004.04.026
33. Assari S. Health disparities due to diminished return among Black Americans: public policy solutions. *Social Issues and Policy Review*. 2018;12(1):112-145. https://doi.org/10.1111/sipr.12042
34. Mehta N, Preston S. Are major behavioral and sociodemographic risk factors for mortality additive or multiplicative in their effects? *Soc Sci Med*. 2016;154(154):93-99. https://doi.org/10.1016/j.socscimed.2016.02.009 PMID:26950393
35. Case A, Deaton A. *Deaths of Despair and the Future of Capitalism*. Princeton, NJ: Princeton University Press; 2021. https://doi.org/10.2307/j.ctv161f3f8
36. Hendi AS. Trends in U.S. life expectancy gradients: the role of changing educational composition. *Int J Epidemiol*. 2015;44(3):946-955. https://doi.org/10.1093/ije/dyv062 PMID:25939662