What Can Lifespan Variation Tell Us about Inequality and the Future of Mortality? The Curious Case of High School Educated Americans

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OBJECTIVES

Low educated Americans lead shorter lifespans, on average, and exhibit greater variability in age at death than their college-educated counterparts. Absolute declines in life expectancy have recently been documented among non-Hispanic whites with fewer than 12 years of schooling, but less is known about trends in lifespan variation. Using U.S. vital statistics data from 1990 to 2010, this study reconstructs complete age-at-death distributions by educational attainment in order to:

- Document trends in life expectancy *and* lifespan variation by educational attainment for both non-Hispanic black and white Americans.
- Evaluate how much educational differences in lifespan variation contribute to total lifespan inequality.

CONCEPTUAL FRAMEWORK

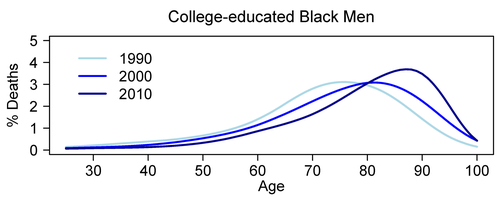
Documenting patterns in lifespan variation is important for two reasons. First, they enrich our understanding and characterization of lifespan inequality between socioeconomic strata. From a population perspective, higher and increasing lifespan variation among low and high-school educated Americans can point to a higher prevalence of frailty, lower capacity to optimize health over the life course, or the rising importance of other social determinants of health interacting with educational attainment (e.g., marital stability, parenthood, and psychological wellbeing are known to have an especially protective effect on health among low educated women—over and above their effect for women with higher education).

Second, trends in lifespan variation can shed light on future mortality scenarios for different social groups. Researchers have long debated which scenario best describes the future of mortality for low mortality countries—adult mortality compression, whereby gains in life expectancy are accompanied by decreasing lifespan variation, or shifting mortality, whereby the age-at-death distribution is merely translated upwards while the shape of the distribution remains the same (i.e., constant variation). Yet these scenarios have not been evaluated for different socioeconomic strata in the U.S. and particularly over time.

METHODOLOGY

Adult age-at-death distributions, starting at age 25, were estimated for each educational attainment category (0-11, 12, 13-15, and 16+ completed years of schooling) using the following strategy:

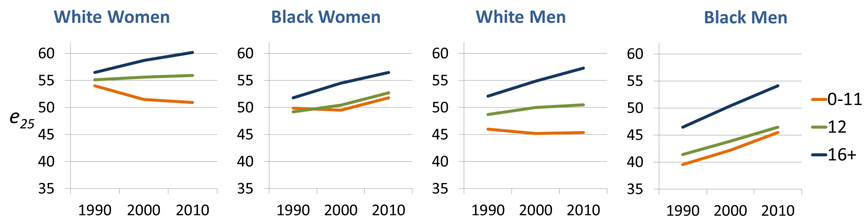
1. Estimate age-race-gender-education specific mortality rates using the U.S. Multiple Cause of Death files, the National Center for Health Statistics bridged-race population estimates, and census microdata from 1990, 2000, and 2010 (see *Spotlight on Data Quality*).
2. Smooth 5-year log mortality rates to single years using natural cubic splines.
3. Obtain discrete age-at-death distributions from standard period life tables (the ${}_nd_x$ column) by race, gender, and educational attainment for each year:



4. Calculate the mean (e_{25}) and standard deviation (S_{25}) of each distribution.

RESULTS

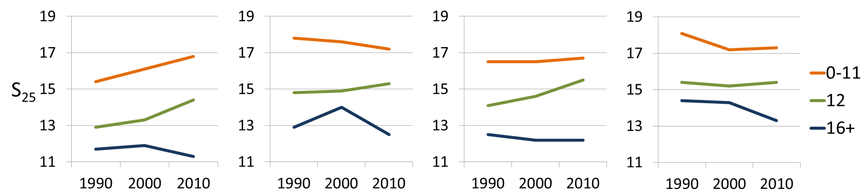
Life Expectancy at Age 25 (e_{25}) by Educational Attainment, U.S. 1990-2010



Key Findings:

- Educational disparities in life expectancy at age 25 (e_{25}) widened dramatically in all race-gender groups since 1990, with the highly educated faring better than the low educated.
- For whites, e_{25} increased among the college educated, stagnated among the high-school educated, and declined among low educated women (-3.1 years) and men (–0.6 years).
- Blacks have experienced gains in e_{25} across all educational attainment groups, but are a still generally disadvantaged compared to whites of the same gender and level of education.

Lifespan Variation (S_{25}) by Educational Attainment, U.S. 1990-2010



Key Findings:

- Patterns in lifespan variation (S_{25}) mimic those in life expectancy in reverse. Across all race-gender groups, the highly educated exhibit lower variability in age at death compared to their low educated counterparts.
- Between 1990 and 2010, S_{25} increased by about 1.5 years among high-school educated whites of both genders, and to a lesser degree among black women, reflecting increasing heterogeneity in mortality outcomes.
- Among college educated whites, S_{25} stagnated at a record low (around 11.5 for women and 12.2 for men), consistent with a "shifting mortality" scenario.

SPOTLIGHT ON DATA QUALITY

U.S. death certificates are notorious for missing (and misreported) information on educational attainment, which was first collected in 1989. This study makes the conservative assumption that the relationship between education and mortality is equivalent among observed and unobserved cases, *weighted by the educational composition and overall level of mortality in each U.S. state*—an imputation method that is particularly useful in states with high proportions missing. This relationship is made clear by Bayes' theorem

$$p(\text{Education}|\text{Death}) = p(\text{Death}|\text{Education}) \times p(\text{Education}) \times \frac{1}{p(\text{Death})}$$

where, rather than being treated as a mathematical identity, each term on the right hand of the equation is estimated separately from complete cases using both the vital registry and census data.

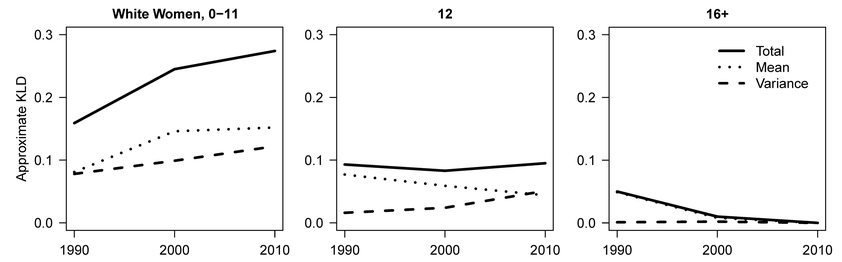
TOTAL LIFESPAN INEQUALITY

The Kullback-Leibler distance (KLD), a measure of distributional divergence, can be used to evaluate educational differences across the entire age-at-death distribution. In other words, it measures total lifespan inequality between college educated Americans (p_0, the reference distribution) and lower education groups (p_1, the comparison distribution). Two identical distributions have a KLD value of zero, whereas larger KLD values indicate higher divergence. Furthermore, assuming that the distributions are approximately normal, the KLD can be decomposed into two additive terms—divergence due to difference in means (term A) and divergence due to difference in variances (term B):

$$KLD(p_0, p_1) = \underbrace{\left[\frac{(\mu_0-\mu_1)^2}{2\sigma_1^2}\right]}_{\text{A}} + \underbrace{\left[log\left(\frac{\sigma_1}{\sigma_0}\right) + \frac{\sigma_0^2}{2\sigma_1^2} - \frac{1}{2}\right]}_{\text{B}}$$

The decomposition reveals the relative importance of each component to total lifespan inequality between two groups. This is illustrated in the next figure for low, high-school, and college-educated white women over time. The reference distribution in all comparisons is college-educated women *in 2010*, representing the most favorable lifespan conditions to date.

Decomposing Total Lifespan Inequality: Differences in Means and Variances



Key Findings:

- Lifespan conditions have worsened for low educated women in absolute terms since 1990. This is reflected in overall divergence from the reference distribution over time, owing almost equally to declining life expectancy and to increasing lifespan variation.
- High-school educated women have seen gains in life expectancy coupled with rising lifespan variation, resulting in overall divergence from the age-at-death distribution of their college educated counterparts.
- College educated women experienced gains in life expectancy but no further reductions in variation, consistent with a shifting mortality scenario (and, by design, converged to a KLD of zero in 2010).

DISCUSSION

Educational disparities in lifespan variation constitute a unique dimension of inequality, with higher variation translating into greater uncertainty in the time of death, from an individual standpoint, and higher group heterogeneity from a population perspective. Furthermore, trends in lifespan variation complement those in life expectancy and, taken together, can shed light on future mortality scenarios for various subpopulations. College educated Americans appear to be following a shifting mortality scenario, whereby the age-at-death distribution is translated to older ages while variation remains constant. By contrast, trends among low educated white Americans (but not blacks) have been dominated by absolute declines in life expectancy over the past two decades. Trends among the high-school educated are even more peculiar—despite modest gains in life expectancy, S_{25} had increased by roughly 1.5 years from 1990 to 2010 among whites of both genders and to a lesser degree among black women. Educational disparities in lifespan variation have become so important among some subpopulations (e.g., white women), that they now overshadow those in life expectancy in explaining total lifespan inequality.

Higher variation in age at death among low and high-school educated Americans may reflect limited access to material and nonmaterial resources needed to optimize health over the life course. However, it is also consistent with a higher prevalence of frailty. Future studies should therefore focus on determinants and consequences of heterogeneity within, in addition to between, educational attainment groups.

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