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Educational Attainment and Mortality in the United States: Effects of Degrees, Years of Schooling, and Certification

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Abstract

Researchers have extensively documented a strong and consistent education gradient for mortality, with more highly educated individuals living longer than those with less education. This study contributes to our understanding of the education-mortality relationship by determining the effects of years of education and degree attainment on mortality, and by including nondegree certification, an important but understudied dimension of educational attainment. We use data from the mortality-linked restricted-use files of the Panel Study of Income Dynamics (PSID) sample (N=9,821) and Cox proportional hazards models to estimate mortality risk among U.S. adults. Results indicate that more advanced degrees and additional years of education are associated with reduced mortality risk in separate models, but when included simultaneously, only degrees remain influential. Among individuals who have earned a high school diploma only, additional years of schooling (beyond 12) and vocational school certification (or similar accreditation) are both independently associated with reduced risks of death. Degrees appear to be most important for increasing longevity; the findings also suggest that any educational experience can be beneficial. Future research in health and mortality should consider including educational measures beyond a single variable for educational attainment.

Keywords

mortality; education; degrees; certification; PSID; United States

Introduction

Education is a central social factor because it affects virtually all of life's choices and chances, including whether people live or die. Social science and public health research has solidly documented a gradient between socioeconomic status (SES) and health and mortality, with those in higher positions enjoying better health and longer lives than those in lower positions. Among different SES dimensions, education typically shows the most consistent relationship to life expectancy, a relationship that endures across time and place

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(Elo 2009; Hummer and Hernandez 2013; Hummer and Lariscy 2011). Yet we still do not fully understand the education-mortality relationship, in part because education is a complex process with varied schooling trajectories, experiences, quality, and outcomes. However, population-health studies usually reduce this complex educational process to just the final attainment level, and further conceptualize the attainment as a one-dimensional construct, operationalizing educational attainment as a *single* measure, either years of education or degrees. Using additional operationalizations may more accurately capture the complex construct of educational attainment and help us to better illuminate how education influences mortality.

Using data from the mortality-linked restricted-use files of the Panel Study of Income Dynamics (PSID), this study examines the relationship between risk of death and three dimensions of educational attainment: years of education, credentials, and nondegree certificates. We use credentials to refer to degrees from 2- or 4-year colleges. Almost all previous studies used data where attainment information was collected either as years or as credentials, but not both. Researchers then constructed degrees using information about completed years or vice versa, possibly obscuring important interplay between actual completed years and earned credentials. In contrast, the data used in the present study address two related but distinct dimensions of schooling: completed years and degrees.

Considering both years of education and degrees at the same time helps us to interpret the functional form of the education-mortality relationship established by others and to contribute to the debate on human capital versus sheepskin theories of education's effects. To further inform our conclusions, we also include nondegree certificates or licenses that indicate qualifications for a specific job, such as a license to operate machinery or a nursing certificate. This is the first study of mortality, to our knowledge, that uses information on both completed years of schooling, all major secondary and postsecondary credentials, and non-degree certificates as different dimensions of educational attainment.

Education and mortality

This study builds on foundations from diverse social science disciplines that analyze the associations of years or degrees with labor-market and health outcomes. Whether using attained degrees or years of completed schooling, numerous studies have found a monotonic relationship between education and mortality, with more educated individuals living longer. Elo and associates (2006) found that each year of education was associated with a 3% reduced risk of death among non-Hispanic whites after adjusting for household size, income, marital status, and labor force participation. This approach, while demonstrating the influence of further education, assumes each year of schooling has the same effect. Other researchers categorize education, implicitly assuming no added value until a degree or some threshold level is reached. For example, Hummer and Hernandez (2013) converted completed years to the most typical educational attainment categories as less than high school diploma (0-11), high school diploma or equivalent (12), some college (13-15), and a college degree or higher (16 or more). Other studies may include more categories, such as 0–8, 9–11, 12, 13–15, 16, and 17 or more years (Hummer and Lariscy 2011), or fewer. Across these different specifications, both studies found a gradient in mortality with lower risks of

dying associated with higher educational categories. These recent findings corroborate the classic study by Backlund and colleagues (1999), which reported that education's effect on mortality was well described by using three categories: less than high school, high school diploma, and college degree or more.

Recent research has built on these two approaches (continuous years of schooling and categorized years) to model the functional form of the education-mortality relationship, using one survey question to operationalize both years of education and degrees. These models consider the effects of years of schooling, degree, and their interactions: effects of years that differ at various parts of the education distribution. Montez and associates (2012) employed the National Longitudinal Mortality Study and coded education into 0, 2.5, 5.5, 7.5, 9, 10, 11, 12, 14, 16, and 19 years to roughly correspond to multiple-year increments of education (1-4, 5-6, or 7-8 years) or degrees (e.g., associate or bachelor's degrees). They reported that the preferred functional form for the relationship is a linear decline from 0 to 11 years in education, with a step-change reduction at high school diploma and then a steeper linear decline for individuals with more than a high school diploma. Everett and her research team (2013) used the 1986-2006 National Health Interview Survey-Linked Mortality Files to describe a step-change in the education-mortality relationship that occurs at 9 years, the transition from middle to high school. Additional years of education lower mortality risk, but certain achievements, such as high school graduation, may be more important. Montez and colleagues call for additional research to identify mechanisms that explain the education-mortality relationship. We posit that credentials are central explanatory factors.

Alternatively, rather than convert measures into years of education, other studies keep measures of credentials as categories. In this group of papers, researchers only had information about degrees, with no additional data on years of schooling. Compared to those who have professional degrees, those with a GED or 12 or fewer years of schooling have the highest mortality risk, followed in order by those with high school diplomas, some college experience, associate's degrees, bachelor's degrees, and master's degrees (Rogers et al. 2010). Similarly, Zajacova, Hummer, and Rogers (2012) find that degrees have a monotonic relationship with self-rated health status.

We are aware of only three health studies (none focusing on mortality) that used both years of education and degrees in the analyses. Using data from the 1995 Aging, Status, and the Sense of Control Survey, Ross and Mirowsky (1999) found that years of education had larger effects on physical functioning and perceived health than college degrees or college selectivity; however, they looked only at college degrees, rather than at all credentials. In contrast, Liu and colleagues (2011, 2013), using data from the New England Family Study, found that degree attainment significantly reduced coronary heart disease risk and blood pressure, even with a control for years of schooling. These studies use small, non-representative samples and do not offer information on mortality, but are the only examples of health research using two different sources of educational information.

Previous studies have not used both years of education and degrees because few surveys ask multiple, separate questions on educational attainment. An additional challenge is in

conceptually separating degrees and years, as their measures are highly correlated. Typically, a respondent who reports a high school diploma would complete 12 years of schooling and a respondent with a bachelor's degree would attend school for 16 years (which is no longer the standard, because far fewer than half of college degrees are earned after four years [Complete College America 2014]). However, there is variation in the number of years for any given credential. For instance, an individual with only a high school diploma may have spent additional years as a student attending college classes but did not attain a degree. This variation could have positive or negative consequences for longevity, depending on what the longer time in school signifies. The extra schooling may bring additional benefits from postsecondary education. Alternatively, it could be associated with disadvantaged educational experiences such as intermittent or part-time educational trajectories, or the stigma of the "college dropout" label could be detrimental to health. Similarly, individuals could spend the same amount of time in school, but achieve different degrees. For example, three years in college could produce an associate's or a bachelor's degree, depending on the rate of accumulating credits toward the degrees. From this perspective, mortality risk could be similar across these individuals because they have had the same duration of exposure, or it could be different because they have attained different degrees. Thus, considering both years of education and degrees can reveal the source of education's benefits for life expectancy.

Conceptual foundations of the education-mortality association

The debate about the two ways of measuring educational attainment – years versus degrees – is important because it reflects the underlying theoretical foundations of the education-health association. The effects of educational attainment on mortality have been theorized to operate by increasing human capital or by conferring credentials that provide access to employment and concomitant economic and social resources. The theory of human capital describes the rational choice individuals make to invest in their education to secure future returns (Becker 1964). Applied to population health, the theory suggests that that social-psychological and cognitive resources increase as a function of time spent in school (Mirowsky and Ross 2003). These resources influence health outcomes primarily through learned effectiveness, or the ability to acquire, evaluate, and use information, resulting in increased personal control and a greater ability to achieve goals. Learned effectiveness improves and enriches health behaviors, social support, and productive activities like meaningful employment. Because the human capital approach to health maintains that learned effectiveness increases in proportion to the quantity of education, this theory predicts that years of education will show a stronger relationship to mortality than degrees (Mirowsky and Ross 2003).

An alternative approach emphasizes the signaling function of degrees or credentials (Collins 1979). The signaling (also referred to as sheepskin or diploma) perspective on the returns to education proposes that educational attainment effects operate via diplomas that serve as signals of workers' ability (Spence 1973). The name, proposed by Spence (1973), refers to the uncertainty that an employer faces when trying to hire workers: their capabilities are largely unobserved. Under such uncertainty, educational credentials serve as signals of the workers' productivity and thus help sort individuals into different employment and social

statuses. The signaling approach assumes no benefit accrues from schooling unless a credential is earned. Credentials allow individuals to gain more prestigious and higher-paying employment, which increases longevity (Krueger and Burgard 2011). Beyond socioeconomic attainment, degrees can influence the daily lives of individuals, such as where they live, their social networks, values, attitudes, and beliefs. For example, individuals earning college degrees not only earn more money and have better jobs but they also are happier, with more stable family lives and greater civic engagement, as well as better health behaviors and health outcomes and longer lives, compared to those less educated (Hout 2012). The evidence for this perspective would comprise of modest or perhaps no returns to additional years of schooling and high returns to diplomas. Put differently, if we examined years and credentials jointly, the latter should be more important.

Additional certifications

Although most studies examine traditional degrees from high school to professional/doctoral diplomas, other certifications may also be valuable. Certifications are important because they serve as signals to employers (Bills 1988), and usually increase employment prospects and economic returns (Kerckhoff and Bell 1998). Certifications themselves can also influence educational degree attainment (Ainsworth and Roscigno 2005) and individuals' careers (Kerckhoff and Bell 1998; Lewis, Hearn, and Zilbert 1993). However, we know little about the effect of non-degree certificates on important life outcomes, in part because national surveys have not systematically collected data on these types of highly prevalent certifications (Ewert and Kominiski 2014).

Individuals often obtain certificates or licenses (other than the standard 2- or 4-year institutional degrees) to indicate their qualifications for a particular job or occupational specialization. Professionals may also acquire certification to access new areas of specialization or gain additional expertise, such as medical doctors who obtain board certification in a specialty area. However, because of the wording of the certification questions used in this study, we focus on credentials obtained through vocational, training, or apprenticeship programs, which likely omits certifications obtained by professionals such as medical doctors. Vocational or similar certifications include a variety of fields such as mechanics, machine operation, computer programming, sales, cosmetology, health care, and protective services. Grantors of these certifications consist of institutions such as trade schools, community colleges, cosmetology schools, or police academies. Individuals may participate in education or training that lasts from several weeks up to a year or more, learning skills and knowledge specific to an occupation and highly valuable in the workforce (Sykes 2012).

The accreditations reported and used in this study generally fall under the category of subbaccalaureate certificates, an area of education becoming increasingly common. The number of certificates below the associate's level conferred each year has doubled from about 500,000 in the 1990s to one million in 2010 (Snyder and Dillow 2013). In recent years, more subassociate-level certificates were awarded than Master's degrees. However, these accreditations are rarely studied and, to our knowledge, have never been examined with respect to their influence on health or mortality.

Benefits of certifications may reflect processes of socioeconomic attainment similar to sheepskin effects. Certification increases prospects for employment, promotion, and pay. Certification may improve specific skills or knowledge, as employers typically support their current employees in pursuing vocational education, especially when the education program focuses on skills directly applicable to the job (Bills and Wacker 2003). These nondegree certifications are likely important for livelihood and may have broader significance to other outcomes, including health. Unfortunately, little is known about the effect of non-degree certificates in health research; this study is the first to test for their effects on longevity.

Early-life confounders

An important consideration when examining the association between educational attainment and mortality pertains to potential confounders, because individuals may have characteristics that shape both educational attainment and mortality. Specifically, early-life social and health circumstances influence both educational attainment and later-life health and mortality.

Germinal research on status attainment from four decades ago established early-life circumstances as a critical predictor of individuals' educational attainment (Duncan, Featherman and Duncan 1972; Sewell, Haller and Ohlendorf 1970; Sewell, Haller and Portes 1969). Current research continues to corroborate the importance of parental background for attainment (Carvalho 2012; Ermisch and Francesconi 2001). The effect of family SES on attainment may operate via diverse mechanisms, including high-quality schools and experiences that support the acquisition of cognitive and noncognitive skills and educational aspirations (Coleman 1988, Duncan, Ziol Guest and Kalil 2010; Sameroff et al. 1998).

Early-life social circumstances also have long-term effects on health status in adulthood. Childhood SES, as measured by parental education, influence self-assessed health, health conditions, and disabilities in adulthood and later-life (Bowen and González 2010, Case, Fertig and Paxson 2005; Case and Paxson 2011; Haas 2008). Social conditions in early-life have been linked to mortality among adults in the United States (Hayward and Gorman 2004) and other countries (Yi, Gu and Land 2007). Because early-life circumstances influence both attainment and later-life health, it is important to consider these factors when trying to better understand how schooling and longevity are related.

Research aims

This study aims to advance our understanding of the education-mortality relationship. Through investigating the association of both years of education and degrees with mortality, we seek to determine whether human capital or sheepskin theories better capture the education-mortality relationship. Moreover, we include an understudied but important dimension of education – nondegree certificates – and test their relationship with mortality. To further test these theories, we examine the relationship between nondegree certificates and mortality. We also isolate the relationships between education and mortality by controlling for early-life confounders.

Data and methods

Data

The Panel Study of Income Dynamics (PSID) is ideal for our study because it is a nationally representative longitudinal household survey that provides detailed information on completed years of education, as well as degrees and certificates; furthermore, it can be linked to restricted-use mortality data provided by the National Death Index (NDI; PSID 2013). The PSID started in 1968 and has followed respondents annually or biannually since. We use the 1985 interview wave of the PSID, which was the only interview wave where all respondents were asked about their educational attainment and where both years and degrees were collected simultaneously. We merge the 1985 PSID data with restricted-use NDI information on mortality status and age at death.[1] The mortality linkage is through 2009, providing up to a 24-year follow-up. We focus on individuals 25 and older, because a high proportion of those younger than 25 have not completed schooling. Our sample thus consists of individuals aged 25 and over participating in the 1985 survey, comprising 9,842 adults who were asked detailed questions about their education. We exclude 20 respondents (0.2%) due to missing data and one individual with out-of-range information on age, producing a sample size of 9,821.

Measures

Education—We use three related measures of educational attainment: completed years, degrees, and certificates. The number of completed years of schooling ranges from 0 to 17. We create the number of years of education by adding together the number of school grades (up to 12) and the number of years of college completed (up to 5). Respondents were either asked about the number of years in school grades (for those with less than high school diploma), or about the number of years in college (for those with a high school diploma or more). We assume the number of school grades among high school diploma holders to be 12. The years of education measure is top-coded as 17. In the main analyses, years of education are included as a continuous predictor.

For highest degree attained, individuals are classified into the following mutually exclusive categories: no degree, GED, high school diploma, associate's degree (AA), bachelor's degree (BA/BS), master's degree (MA/MS), and medical degree, law degree, or doctorate (MD, JD, or PhD). High school diploma is the modal category and the referent.[2]

Training and certification is measured dichotomously by the following question: "Did you receive any other degree or a certificate through a vocational school, a training school, or an apprenticeship program?" (PSID 1988). Further questions probe the type, field, and grantor of these certificates, and we briefly describe these characteristics in the Conclusion. However, as described in above, these questions focus on vocational skills rather than other types, such as professional certifications.

[1]Restricted-use data is separate from public-use PSID data, and can be obtained from PSID after meeting application and security requirements.

[2]Accordingly, we use "high school completers" to mean only those who have a diploma and no further formal degree, not all those who have a high school diploma plus higher degrees.

Covariates—We control for sociodemographic factors. We include age at the 1985 interview (25 to 96) as entry into the Cox proportional hazards models (described in detail under *Methods*). Models control for sex, race, region, and marital status. Sex is coded 1 for males and 0 for females. Race/ethnicity compares non-Hispanic whites (referent) to non-Hispanic blacks, Hispanics, and all other non-Hispanic individuals. Because of the small numbers of Asian/Pacific Islanders, American Indian/Alaska Natives, and multiracial individuals, we group these cases with those reporting "other" race. Region categorizes individuals into the Northeast (referent), North Central, South, and West (including Alaska and Hawaii) regions, with individuals residing outside the United States coded in a separate category. Marital status categorizes individuals as married (referent), never-married, widowed, or divorced.

Five variables capture early-life confounders: whether the individual's parents were poor when he or she grew up, the educational attainment of the individual's father, the educational attainment of the individual's mother, the father's occupation, and whether the individual lived with both parents until age 16. Respondents were asked the following question: "Were your parents poor when you were growing up, pretty well off, or what?" (PSID 1988). Those reporting "poor" were coded 1, and those reporting "average/it varied," "pretty well off," "don't know," or "did not live with parents" were coded 0. The reported educational attainment for both fathers and mothers is categorized into less than a high school diploma (reference), a high school diploma or more, and unknown. Parents who respondents reported could not read or write were included in the less than a high school diploma category. Father's occupation as reported by the individual is represented in four categories: professional/ managerial (reference), craftsman/laborers, farm managers, and other/don't know. Living with both parents is dichotomized into 1=yes and 0=no/don't know for responses to the following question: "Were you living with both your natural parents most of the time until you were age 16?" (PSID 1988).

Mortality—The restricted-use mortality file includes 2,425 deaths in the sample of 1985 respondents. NDI provided death status and year of death for 2,342 individuals and PSID used archival sources or death certificates for the other 83 individuals. Individuals not included in the mortality file were assumed to be alive. PSID offers a summary measure of the matching quality (which refers to the year of death), ranging from "poor" to "best" match. Results from models using only the best NDI matches (from the summary measure provided by PSID) did not differ substantively from the results presented (using all matches), suggesting findings are robust to matching procedures.

Methods

Frequencies provide information on the distributions of years of education, degrees, and certifications. We use Cox proportional hazard models to estimate the effect of education on mortality. Age at the 1985 interview is included in the models as age at entry and duration is the age at death or age in the year 2009 for those who survived the follow-up period. This approach using age as the time scale produces less bias than models that use age as the covariate and define duration as the time between interview and death or censoring (Thiébault and Bénichou 2004). Failure is defined as having died during the study period.

We first estimate models including years of education, highest degree attained, and certification separately and jointly. Variance inflation factor tests did not indicate multicollinearity issues for any of the models reported in this study, as all tolerance values were above .20. However, including interaction terms between years and degrees in all-sample models did produce collinearity. We instead stratify hazard models by educational degree and estimate within-group effects of years of schooling.

All of the variables of interest (all education variables) met the assumption of proportional hazards, which is most important for our analyses, although the full models failed a global test of proportionality. The categories black, other race, single, father with high school diploma, retired, and disabled violated proportionality, but controlling for these indicators is preferable to excluding them. Logistic regression predicting death across person-year observations produced a nonsignificant interaction term between years of education and observation years, further corroborating proportionality over time. Because many respondents are married couples, we adjust the standard errors to account for clustering at the couple level. Supplemental analyses accounting for complex survey design resulted in no differences in coefficients or standard errors. Thus, we prioritize adjustments for clustering at the couple level and calculations for model fit statistics and do not adjust the estimation for probability weights, strata, or sampling units.

Sensitivity Analyses

We conducted extensive auxiliary or sensitivity analyses to assess whether the model assumptions hold and how robust our findings are to different model specifications. First, we examined whether results were sensitive to respondent age. We choose to present results from the sample aged 25 and up, but results from an additional set of models on the full sample ages 18 to 96 were similar. We also compared results from a sample restricted to those aged 30 and higher at the time of interview which were also similar to those presented here. Models restricting the sample to individuals 65 and under (excluding about 10% of the sample) produced similar patterns, but, as other studies have reported (Beckett 2000; Lauderdale 2001), the effects of schooling were generally stronger for the younger sample.

Second, we tested for sensitivity to the follow-up period. Supplemental models with a 15- rather than 24-year follow-up produced similar but more variable hazard ratios, most likely because of a smaller number of deaths.

Third, we established the robustness of the specification for years of education. In auxiliary analyses we included years of education as a categorical variable (dummies for each year of completed schooling, with 12 as the referent) to ensure that findings are not biased by the assumed linearity in the continuous-education specification. Models using the categorical specification (not shown but available on request) yielded equivalent findings to the continuous specification presented below. Additional models specified different ranges of years of schooling (with top- and bottom-codes) to test whether the findings are influenced by the tails of the distribution of years of education, and the results confirmed those reported in this study.

Fourth, we tested for differences between men and women. Interactions between educational measures and gender demonstrated that the effects of education are similar for men and women.[3] Fifth, we considered the effect of marital status. Marital status is typically included in models of mortality as an important demographic covariate, but it may also be conceptualized as a mediator or even confounder of schooling's effect on mortality. We therefore estimated models with and without this information, and there were no substantive differences in the magnitude or significance of education variables across these models. Thus, we include marital status in the results presented here.

Sixth, models with the full set of covariates using self-rated health rather than mortality as the outcome variable produced hazard ratios of education that were somewhat attenuated but very similar to those reported here. The findings suggest that education effects on health and mortality are consistent.

Supplemental models include hypothesized mediators focused on socioeconomic components other than education. Because education has been shown to increase income, wealth, and job prospects that in turn shape health and mortality risk (Mirowsky and Ross 2003; Rogers et al. 2013), we include measures of adult employment and economic circumstances: income-to-needs ratio, home ownership, and employment status. Income-to-needs ratio is a continuous measure taken from a PSID-created variable representing the ratio of total family income to the poverty threshold for that year, adjusted for household size. Home ownership is represented with a dichotomous measure, with those owning a home coded 1 and those renting or neither owning nor renting coded 0. Employment status compares those working (referent) to those temporarily not working, looking for work, retired, disabled, keeping house, attending school, and other. We examined whether findings were sensitive to disability, which might influence both education and mortality. The results were similar, suggesting that disability is not driving any of the substantive conclusions.

Results

Table 1 displays descriptive statistics for education and independent variables by highest degree attained. As the bottom row indicates, those with a high school diploma are the largest group, followed by adults with no degree, BA, GED, MA, AA, JD/MD, and PhD. The overall average years of education completed is 12.1. Predictably, individuals with more advanced degrees have been in school longer; each degree is associated with a range of completed years of schooling. However, as respondents could not report more than five years of college, it appears that most individuals attaining degrees beyond a bachelor's reported the maximum amount, as the averages for these categories are nearly 17 years. Because of the restricted range of completed years and small number of respondents with the highest degrees, we group the advanced degrees into one category in the survival models. Still, the variation across other groups is sufficient to examine years of education for these

[3]There were no significant interaction terms between gender and certification in the full models or the models disaggregated by degree. For analyses of education degrees, BIC values indicated better fit for models excluding the interactions, so we do not conclude any differences. The interaction between years of education and gender was not significant in the full model, and in the disaggregated models, only one degree group demonstrated a significant interaction. Among those with a GED, more years of education reduced the higher risk for men. In the discussion section, we discuss the complex and changing significance of the GED, which might contribute to this interaction. However, we interpret the results as evidence of generally similar effects of education across gender.

individuals. Notably, individuals with associate's and bachelor's degrees report educational years ranging from 12 to 17. A sizable percentage, about a quarter of the overall sample, obtained additional certification, with 39.3% of GED earners and nearly a third of high school completers and associate's degree holders earning a certificate.

Other descriptive results confirm racial and socioeconomic stratification patterns in the United States. Non-Hispanic whites show a greater percentage of professional degrees and a smaller percentage of lower educational categories, whereas non-Hispanic blacks display the reverse pattern, with greater percentages of no degree and GED and smaller percentages of college or professional degrees. The five social origin variables indicate intergenerational transmission of SES, evident from the strong gradient between each measure of disadvantaged social origins and lower educational attainment. For adult employment and economic circumstances, higher income, home ownership, and currently working are increasingly common among individuals with more advanced degrees. Among those with a Ph.D., J.D., or M.D., none have a household income-to-needs ratio of less than 300%. Those with no degree or a GED are more likely to be unmarried, whereas those with degrees beyond college are more likely to be married. The Northeast has higher percentages of adults with higher degrees, whereas the South is overrepresented in the lower categories.

Table 2 presents the effects of different educational measures on mortality, estimated with multivariate Cox hazards models. The first set of models (Panel A) uses years of education as a continuous measure; each year of education reduces mortality risk over the follow-up period by 4% (HR=0.96), net of sex, race/ethnicity, marital status, and region (Model 1). With the addition of social origin variables, the effects of education attenuate but remain statistically significant. Adding in the dichotomous indicator for additional certification (Model 3), the effect of years of education only changes slightly (HR=.974 in Model 2 and HR=.975 in Model 3) and the certification measure itself is not significant.

The next set of models (Panel B) uses educational degrees instead of years of education. These categories demonstrate a monotonic relationship with mortality risk. Compared to those with a high school diploma, those without the diploma have a 22% higher mortality risk over the follow-up period (Model 4). There is no significant difference in mortality between those with GEDs and high school diplomas. Those with associate's, bachelor's, or further advanced degrees show lower mortality risk than those with only a high school diploma. Taking into account social origins in Model 5 does not attenuate the effect of degrees substantially, as the degree effects change between 0 and 5% and the significance levels do not change. Similar to Panel A, certification is not influential, as the measure is not significant and does not change the coefficients associated with other variables.

The last set of models (Panel C) in Table 2 includes both years of education and degrees attained. Interestingly, degrees have a stronger effect than in Panel B where years are not included. In contrast, years of education become not significant. Last, the certification measure shows a similar effect to that of the previous models and remains nonsignificant. Likelihood ratio tests (not shown) and Bayesian Information Criteria (BIC) assess model fit. BICs are lowest, or best fitting, for models with fewer variables. BICs were lowest for Models 1, 4, and 7. The BIC statistics do not differ much across Models 1, 4, and 7,

however, but a likelihood ratio test of the full model indicates significant improvement ($p<.001$) from the inclusion of degrees compared to the same model with only years of schooling.

Supplemental results displayed in Appendix Table A1 display hazard ratios from models also including hypothesized mechanisms of adult employment and economic circumstances (income, home ownership, and employment status). These components explain education's effects. Years of education is no longer significantly associated with risk of death (Model 1) and only the highest educational degrees are significantly different from high school diploma (Model 2). Overall, these results are consistent with previous research indicating that income, wealth, and employment are important pathways for education's effect on health. However, these socioeconomic characteristics are a limited set of potential mechanisms, and there are other important mediators that we were unable to include, such as health behaviors or psychosocial variables like social support, cognitive ability, or sense of control.

To further examine the complex relationship between years of education and mortality, we stratify the models by degree. Table 3 displays results from these stratified models, controlling for the same set of covariates in Table 2 (sex, race, marital status, region, social origin variables). We include years of education and certification separately in Models 1 and 2, and together in Model 3. Surprisingly, years of education are significant only among those with a high school diploma (Model 1). For this group, each year reduces their risk of death over the follow-up period by 8%. Among those without a high school diploma, more education appears to be unimportant, as the years of education hazard ratios are very close to one. While the coefficient is not significant, duration of education has a positive relationship to mortality for those with a GED or an AA degree.

Certification is salient for high school diploma earners, as this group shows a significant 17% reduction in mortality risk over the follow-up period for those who have vocational or similar training certification (Model 2, High School Diploma findings). The effects of years of education and certification appear independent for this group of high school completers, as the effects are the same in Model 3.

Discussion

The aims of this study were to examine the unique effects of years of education, degree attainment, and nondegree certification on U.S. adult mortality. We highlight the contributions of these results to the debate between human capital and sheepskin theories of education's effects. Whereas years of education and degrees were each significantly related to mortality in separate models, only degrees remained significant in models including both measures. Both nondegree certification and years of education reduced mortality risk among high school diploma holders. These results underscore that education is complex and multidimensional, and point to degrees as the dominant dimension of attainment on longevity among U.S. adults.

The results also shed light on the findings of other studies that examined the functional form of the education-mortality relationship. The inflection point that indicates a discontinuity in mortality risk at 12 years of education (Everett et al. 2013; Montez et al. 2012) likely captures the effect of a high school diploma, but may overlook the effects of postsecondary schooling or a vocational certificate for high school diploma holders, which our results demonstrate are important for mortality. Thus, our results provide a more complete picture of the education-mortality relationship and suggest that the functional form of years of education is in part due to a combination of years, degrees, and certification.

The findings also corroborate results by Liu and associates (2011, 2013) for coronary heart disease risk and blood pressure—degree attainment is significantly associated with health outcomes beyond years of education. The data suggest that mechanisms postulated by sheepskin theories may be more salient than those posited by human capital theory.

Importantly, the effect of additional certification for high school diploma holders was significant whether or not we adjusted for years of schooling. There may be several reasons why certificates matter for this group. First, high school graduates were most likely to earn certificates, perhaps because they are aware of their benefits. Nearly a third of high school completers earned a nondegree certification, demonstrating the prevalence of these certifications. Second, vocational or similar certifications may improve employment options for those with a high school diploma more than in other educational groups. Alternatively, a selection effect may be at play here: high school graduates with greater skills, drive, or motivation may be more likely to both earn certificates and live longer.

To characterize the kinds of certificates that were reported in the survey, additional descriptive analysis examined the types, grantors, and fields of these certifications (results not shown). Individuals report earning a variety of accreditation types, including certificates, degrees, licenses, and diplomas. The most common grantor of certifications was a vocational or trade school, followed by a “business school or financial institute; secretarial school.” Other responses included community or junior college, armed forces, high school, health care facility, cosmetology school, police academy, job training through government agencies, private employer training, and religious institutions. The fields of these certifications were diverse, with the largest proportion of high school graduates certifying in a health-related field (19%). Skilled crafts (mechanics, repairperson, auto/appliance/computer) was also a common response, comprising 12% of the certifications. While there was too much variation in these characteristics to include in this study’s mortality models, future health studies should collect and analyze this additional detail on certifications, which are an education dimension distinct from other education indicators and important for longevity.

These results do not imply that human capital approaches emphasizing social psychological and cognitive benefits are inaccurate, as education likely embeds important resources in individuals that influence health and mortality. The group for which we arguably have the best data to test years of education and degrees simultaneously, high school diploma holders, shows substantial benefits for additional years of education. For these individuals, more than 12 years of education indicates postsecondary education, which may improve cognitive and

noncognitive resources that then increase longevity. There are three possible explanations of the nonsignificant relationships between years of education and mortality within other groups. First, there may be no health or longevity advantages to further education without degrees for these groups. Second, there may a selection effect whereby students are in school longer because of difficulty in finishing their degrees. Third, as we discuss below, data limitations may prevent us from properly quantifying educational years for some groups.

Our findings diverge from those of Ross and Mirowsky (1999), who found that years of education had a stronger effect on health status and physical functioning than the effect of a bachelor's degree. There may be a few reasons for the divergent findings. First, the mechanisms for mortality may differ from those for health status and physical functioning. Second, the different data resulted in different coding schemes. We use more detailed indicators of degrees, while they included a dichotomous measure of college degree. Finally, as Ross and Mirowsky's college degree variable interacted with college selectivity, its coefficient captures the effect of a degree from a college lacking selectivity, rather than the average effect of all college degrees.

While degrees overall were significant, the effect of GEDs did not differ from high school diplomas, in contrast to other studies that have found that individuals with GEDs have worse health and survival prospects than those with high school diplomas (Rogers et al. 2010; Zajacova 2012; Zajacova and Everett 2013). This could be due to the small number of GED recipients in the PSID data, or their older age (many respondents reached adulthood before the GED was available).[4] Further research should examine the effects of GEDs in larger and younger cohorts. Notwithstanding cohort trends, the central education-mortality results persisted.

To our knowledge, the restricted-use PSID is the only nationally representative dataset with mortality follow-up that asks separate questions about years of schooling and degrees. Still, three limitations to our study remain. First, respondents could report a maximum of five or more years of college, so the survey likely misses important variation in the years of education among those achieving degrees beyond a bachelor's. To test for sensitivity to this top-coding, we estimated the Table 2 models excluding individuals with master's degrees, medical degrees, law degrees, or doctorates. The results were nearly identical, suggesting top-coding is not changing the substantive conclusions. We caution that we cannot draw strong conclusions about individuals with advanced degrees, since the data are limited for this group. Further, the top-coding may restrict conclusions for college graduates because these individuals may have not been able to report the full range of years spent in college. As we describe in the Introduction, earning a college degree in four years is becoming less common. However, individuals may take time off which would count towards time since

[4]There was a small number of GED earners in this data sample. PSID respondents averaged 40.9 years of age in 1985 and the GED was unavailable or uncommon for much of this study's sample. The nonsignificant findings for GED may also be due to cohort differences, as both the meaning of the GED and the types of persons obtaining GEDs have changed. The GED was introduced in 1942 to target World War II veterans who joined the military before completing high school, and GED earners did not exceed even 8% of high school credentials until the 1970s (Heckman, Humphries, and Mader 2010). Supplemental models (not shown) run within cohorts show differences: GEDs are associated with reduced mortality risk over the study period for the oldest cohort (1887–1928), but increased risk for those born 1929-1945 and 1946-1967, compared to high school diplomas.

matriculation but not time in school. Future research should determine how individuals quantify their time spent in school given different enrollment patterns. Yet, for adults with secondary or subbaccalaureate degrees, the top-coding should have less of an effect because fewer of these respondents attended school for more than 17 years.

Second, those with a high school diploma or higher were not asked the number of years they spent in grade school, which may differ from 12 if they skipped or repeated grades. Auxiliary analyses further restricting the range of years of education to just 8 to 16 years show results similar to those presented here, with years of education nonsignificant and degrees remaining influential. We reason that our estimates may be conservative because duration of education has a broader range than dichotomous degree indicators. Finally, as we note in the section on measures, the questions on certification do not capture additional accreditation for those in occupations that require higher education. Future research should examine effects of certifications for doctors, lawyers, or other professionals. Despite these limitations, the results suggest that the years of education, degree, and certification capture different educational dimensions.

Third, there may be confounding influences that could bias the observed relationship between education and mortality. We had some information about the respondents' early social circumstances, but there may be other factors that influence both attainment and health, such as cognitive or noncognitive skills, influence of peers or significant others, or school quality. The results appear robust and comport with previous findings that education affects mortality (Lleras-Muney 2005).

The results of this study have several implications for future research and data collection. Given the strong associations between education and mortality, it is of paramount importance for U.S. health surveys to include several detailed questions on education. For example, the National Health Interview Survey changed its education question in 1997 from one measure, the number of years of education, to another that captures mostly degrees, asking about years of education only for those not attaining any degree. Asking about both may provide valuable insight into the mechanisms of education that shape health and mortality. Notably, the significance of vocational school and similar certifications for high school diploma earners reveal that other educational experiences are also related to health and longevity.

More information on quality of education would also likely prove useful. The results of this study suggest that there are other ways to capture different dimensions of education. For example, analyzing the grantors and fields of degrees and certifications, including but not limited to college degrees, may provide insight into how educational quality influences mortality. Moreover, school characteristics associated with educational quality, such as student-teacher ratio and teacher wages has been shown to have important health effects (Walsemann, Gee, and Ro 2013). Further understanding may also be gained by investigating education over the life course and when degrees are obtained, particularly the effects of normative and non-normative timing of educational attainment. Initial research in this area suggests that contextualizing education's effects is fruitful; Miech et al. (2015) report that those who marry before rather than after college completion are more likely to become

obese. Future research aiming to understand the social determinants of health should include multiple measures of educational experience, not just attainment levels.

Conclusion

The results of this study indicate that both degrees and years of education are simplified operationalizations of educational experiences; separating them can distinguish some of the mechanisms of influence and clarify the functional form of the education-mortality relationship. High school graduates benefit from earning their diploma, but also benefit from gaining additional years of education and nondegree training and certification. Thus, different educational opportunities provide multiple pathways to better health and longer lives. We hope that these provocative conclusions will spur future efforts to collect and analyze more detailed questions in these key areas. As the mortality gap by education grows and patterns change (Masters et al. 2012; Montez et al. 2011), research should continue to document the importance of educational indicators for mortality.

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Appendix

Table A1

Mediating factors between education and the risk of death, U. S. adult respondents ages 25+, 1985-2009 (hazard ratios)

	Model 1	Model 2	Model 3
Years of education	1.00		1.03*
Degrees (High School Diploma)			
No degree or diploma		1.07	1.19*
GED		1.08	1.16
AA		0.67*	0.64*
BA		0.85+	0.79*
MA/JD/MD/PhD		0.74*	0.67**
Certification	0.96	0.96	0.95
Controls			
Male	1.70***	1.71***	1.73***
Race/ethnicity (non-Hispanic White)			
Non-Hispanic Black	1.08	1.07	1.08
Non-Hispanic Other	0.82	0.82	0.84

	Model 1	Model 2	Model 3
Hispanic	0.62**	0.62**	0.64**
Marital status (Married)			
Single	1.51***	1.54***	1.53***
Widowed	1.50***	1.50***	1.50***
Divorced	1.41***	1.41***	1.39***
Region (Northeast)			
North Central	1.04	1.04	1.03
South	0.97	0.97	0.98
West	0.90	0.90	0.89
Foreign country residence	0.51	0.52	0.51
Social Origins			
Poor growing up	1.04	1.04	1.05
Father Education (less than HS)			
High school degree	0.94	0.96	0.96
Don't know	0.88	0.88	0.89
Mother Education (less than HS)			
High school degree	0.82**	0.85*	0.85**
Don't know	0.98	0.97	0.98
Father occupation (professional)			
Craftsman/laborers	1.10	1.07	1.07
Farm managers	0.99	0.96	0.96
Other/don't know	0.95	0.92	0.92
Lived with two parents	0.98	0.98	0.98
Employment and Economic			
Income-to-needs ratio	0.99+	1.00	1.00
Owns home	0.97	0.98	0.97
Employment status (working)			
Temporarily not working	1.29	1.26	1.26
Looking for work	1.53***	1.51***	1.49**
Retired	1.89***	1.86***	1.88***
Disabled	2.78***	2.72***	2.77***
Keeping house	1.68***	1.64***	1.66***
Student	1.00	1.01	0.99
Other; prison; jail	0.79	0.77	0.74

Source: Panel Study of Income Dynamics, 1985

Notes: Accounts for clustering between couples. Referent is listed in parentheses. N=9,821.

*** $p \leq .001$;

** $p \leq .01$;

* $p \leq .05$;

+ $p \leq .10$

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Table 1

Descriptive statistics of education and control variables of U.S. adult respondents ages 25+, 1985

	All	No degree	GED	HS Dipl	AA	BA	MA	PhD	JD/MD
Education									
Average years of education	12.1	8.5	10.6	12.6	14.4	16.1	16.97	16.96	16.92
Range of years of education	0-17	0-16	0-17	12-17	12-17	12-17	14-17	16-17	15-17
Has certification	25.3%	12.5%	39.3%	32.2%	32.0%	22.3%	17.1%	15.2%	5.1%
Sociodemographic controls									
Average age	43.2	51.9	38.9	40.4	36.0	38.7	41.9	45.7	40.5
Male	45.2%	43.0%	53.2%	42.0%	50.1%	52.2%	51.4%	80.4%	83.5%
Race/ethnicity									
White	63.5	46.1	54.2	66.5	68.6	83.0	85.8	80.4	87.3
Black	32.0	47.7	37.9	29.8	27.0	14.5	10.5	15.2	3.8
Other	1.3	1.6	2.1	0.9	1.2	1.2	2.1	4.3	2.5
Hispanic	3.2	4.6	5.8	2.8	3.2	1.3	1.6	0.0	6.3
Marital status									
Married	73.2	62.7	69.4	76.6	77.7	79.2	80.1	93.5	86.1
Single	8.1	7.1	8.5	7.7	8.8	10.2	13.1	4.3	10.1
Widowed	6.7	15.2	2.9	4.4	1.8	2.3	1.3	0.0	1.3
Divorced	12.0	15.0	19.1	11.3	11.7	8.3	5.5	2.2	2.5
Geographic controls									
Region									
Northeast	15.9	10.6	10.8	16.6	21.4	21.3	26.0	28.3	19.0
North Central	23.5	20.5	23.4	24.8	18.5	26.6	21.0	17.4	38.0
South	43.9	58.1	51.3	40.2	37.0	32.2	31.0	34.8	29.1
West	16.3	10.7	14.3	18.0	23.2	19.4	20.5	19.6	12.7
Foreign country	0.4	0.1	0.2	0.4	0.0	0.4	1.3	0.0	1.3
Social Origins									
Father's education									
Less than high school	59.2	79.6	69.6	57.7	45.5	32.7	32.8	23.9	16.5
High school degree	33.8	9.2	22.1	36.0	49.9	64.8	65.6	73.9	81.0

	All	No degree	GED	HS Dipl	AA	BA	MA	PhD	JD/MD
Don't know	7.0	11.2	8.3	6.4	4.7	2.5	1.6	2.2	2.5
Mother's education									
Less than high school	50.9	73.8	59.6	48.1	35.8	23.8	25.7	19.6	13.9
High school degree	42.3	11.6	31.5	47.3	62.8	74.9	73.2	71.7	83.5
Don't know	6.9	14.6	8.9	4.7	1.5	1.3	1.0	8.7	2.5
Poor growing up	41.2	62.3	54.5	35.6	32.0	22.0	28.6	19.6	10.1
Father's occupation									
Professional	14.9	4.2	7.5	13.4	19.9	34.9	37.3	52.2	60.8
Craftsman/laborers	47.0	45.7	58.6	51.8	53.7	32.8	29.7	15.2	12.7
Farm managers	19.1	34.2	11.8	15.1	9.7	11.7	12.1	6.5	3.8
Other/don't know	18.9	15.9	22.1	19.7	16.7	20.6	21.0	26.1	22.8
Lived with both parents	24.3	31.4	35.2	22.3	20.5	17.1	16.8	8.7	6.3
Employment and Economic									
Income-to-needs ratio									
<100%	2.4	4.1	4.3	2.0	0.6	0.4	0.8	0.0	0.0
100-200%	4.9	11.3	5.4	3.3	2.3	0.2	0.0	0.0	0.0
200-300%	7.2	17.4	7.4	4.0	2.3	1.7	1.0	0.0	0.0
300%+	84.2	67.2	83.0	90.7	94.7	97.7	98.2	1.00	1.00
Owns home	62.7	55.8	51.1	64.6	65.4	68.8	76.4	82.6	75.9
Employment status									
Working	64.0	42.2	69.6	67.8	81.5	80.4	83.7	84.8	88.6
Temporarily not working	1.3	1.3	1.5	1.3	1.5	1.0	1.6	0.0	0.0
Looking for work	5.0	6.6	9.9	4.6	3.5	2.8	1.6	2.2	0.0
Retired	10.5	19.4	5.2	8.5	2.6	5.2	6.0	10.9	6.3
Disabled	3.0	8.1	2.3	1.5	0.6	0.2	0.0	0.0	1.3
Keeping house	15.0	21.7	7.7	15.2	7.9	8.9	6.6	0.0	1.3
Student	1.0	0.3	2.7	0.9	2.3	1.5	0.5	2.2	2.5
Other; prison; jail	0.2	0.3	1.0	0.2	0.0	0.1	0.0	0.0	0.0
N	9821	2586	517	4709	341	1162	381	46	79

Source: Panel Study of Income Dynamics, 1985

Table 2

Education and the risk of death (hazard ratios), U. S. adult respondents ages 25+, 1985-2009

	Panel A: Years of education			Panel B: Degrees attained			Panel C: Years of educ. and degrees		
	Model 1	**Model 2**	**Model 3**	**Model 4**	**Model 5**	**Model 6**	**Model 7**	**Model 8**	**Model 9**
Years of education	0.96***	0.97***	0.98***				1.01	1.01	1.01
Degrees (High School Diploma)									
No degree or diploma				1.22***	1.18**	1.16**	1.26**	1.22**	1.21**
GED				1.09	1.06	1.07	1.11	1.09	1.10
AA				0.61*	0.61*	0.61*	0.60*	0.60*	0.60*
BA				0.72***	0.77**	0.76**	0.70***	0.74**	0.74**
MA/JD/MD/PhD				0.62***	0.67***	0.66***	0.61***	0.64***	0.63***
Certification			0.94			0.94			0.93
Controls									
Male	1.62***	1.61***	1.62***	1.66***	1.65***	1.65***	1.66***	1.65***	1.66***
Race/ethnicity (NH white)									
Non-Hispanic black	1.12*	1.10+	1.10+	1.11+	1.10+	1.10+	1.11+	1.11+	1.11+
Non-Hispanic other	0.84	0.82	0.82	0.87	0.85	0.85	0.87	0.85	0.85
Hispanic	0.67*	0.65*	0.65**	0.68*	0.65*	0.65*	0.68*	0.66*	0.66*
Marital status (married)									
Single	1.59***	1.59***	1.59***	1.61***	1.61***	1.60***	1.60***	1.60***	1.60***
Widowed	1.63***	1.63***	1.63***	1.62***	1.62***	1.62***	1.63***	1.63***	1.62***
Divorced	1.44***	1.43***	1.43***	1.41***	1.41***	1.41***	1.41***	1.40***	1.40***
Region (Northeast)									
North Central	1.05	1.05	1.05	1.04	1.04	1.04	1.04	1.04	1.04
South	0.98	0.98	0.97	0.97	0.97	0.97	0.97	0.98	0.97
West	0.89	0.90	0.91	0.89	0.90	0.90	0.89	0.90	0.90
Foreign country residence	0.49	0.51	0.52	0.49	0.51	0.52	0.49	0.51	0.52
Social Origins									
Poor growing up		1.05	1.04		1.05	1.05		1.06	1.06

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	Panel A: Years of education			Panel B: Degrees attained			Panel C: Years of educ. and degrees		
	Model 1	**Model 2**	**Model 3**	**Model 4**	**Model 5**	**Model 6**	**Model 7**	**Model 8**	**Model 9**
Father Education (less than HS)									
High school degree		0.92	0.92		0.94	0.94		0.94	0.94
Don't know		0.85+	0.85+		0.86+	0.85+		0.86	0.86
Mother's education (less than HS)									
High school degree		0.82**	0.81**		0.84**	0.84**		0.84**	0.84**
Don't know		1.01	1.01		1.00	1.00		1.01	1.00
Father occupation (professional)									
Craftsman/laborers		1.09	1.10		1.05	1.05		1.05	1.06
Farm managers		0.98	0.98		0.95	0.95		0.95	0.95
Other/don't know		0.95	0.95		0.91	0.91		0.91	0.91
Lived with two parents		1.00	1.00		1.00	1.00		1.00	1.00
BIC	34133	34179	34187	34134	34189	34197	34142	34198	34205

Source: Panel Study of Income Dynamics, 1985-2009

Notes: Accounts for clustering between couples. Referent is listed in parentheses. N=9,821.

*** p ≤ .001;

** p ≤ .01;

* p ≤ .05;

+ p ≤ .10

Table 3

Educational degree, years of education, certification, and the risk of death (hazard ratios), U.S. adult respondents ages 25[+], 1985-2009

	Model 1	Model 2	Model 3
	No Degree (N=2,276)		
Years of education	0.99		0.99
Certification		0.99	1.00
	GED (N=403)		
Years of education	1.08		1.07
Certification		1.13	1.09
	High School Diploma (N=3,582)		
Years of education	0.92[*]		0.92[*]
Certification		0.83[*]	0.83[*]
	AA Degree (N=261)		
Years of education	1.21		1.20
Certification		1.34	1.31
	BA Degree (N=890)		
Years of education	0.86		0.86
Certification		1.08	1.09

Source: Panel Study of Income Dynamics, 1985-2009

Notes: Accounts for clustering between couples. Models control for sex, race/ethnicity, marital status, region, being poor while growing up, father's education, mother's education, father's occupation, and living with two parents until age 16.

[***] $p \leq .001$;

[**] $p \leq .01$;

[*] $p \leq .05$;

[+] $p \leq .10$