How Much Life Does a Good Education Buy?[1]

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DETAILED ABSTRACT

Education has a profound impact on mortality. The rise of mass education is an important pathway in reducing developing countries' mortality levels (Caldwell 1986, 1990). Within both developing and developed countries, higher educational achievement signals lower mortality (Braveman and Tarimo 2002; Mackenbach et al. 1999; Sastry 2004). The tie between education and mortality has strengthened in recent decades in a number of developed countries including the United States (Feldman et al. 1989; Lynch 2003; Pappas et al. 1993), with some scholars suggesting that education has become increasingly important in determining life chances due to its interaction with modern medicine (Preston and Elo 1995). A recent and very important study documents that education's association with mortality is causal in nature and suggests that prior research may have underestimated its effect (Lleras-Muney 2005) on individuals' life chances.

Despite an enormous literature documenting the association between education and mortality, there is a dearth of information documenting education's consequences for a *population*'s mortality experiences over a life time. No developed countries produce official life tables for major educational groups despite the prominence in national health policies of reducing health disparities. Despite a heady scientific tradition since Kitagawa and Hauser's (1973) seminal work on this topic, only a handful of scientific studies directly address the question of how many years of life are gained by additional years of education, and it is this work on which our study builds.

The major goal of this study, then, is to use a demographic approach in evaluating the association between education and mortality by developing life tables that characterize the mortality experiences of American men and women with different levels

of educational achievement. We focus on persons 50 years of age and older and thus capture the bulk of mortality caused by chronic conditions. We use a multivariate life-table approach, because it allows us to evaluate a number of fundamental issues regarding education's consequences for mortality. Does more education reduce the risk of death throughout the continuum of education, or does education's influence plateau after a certain level of achievement? Do males and females share the same benefits of education, or are the benefits less evident for women as some researchers have suggested? Does the effect of education diminish with age, or do individuals continue to reap the benefits of education even into advanced old age? What are the implications of the effect of education on the risk of death for the number of years separating persons with different levels of achievement? Are the mortality experiences of highly educated persons approaching an upper limit in human longevity?

This study, then, represents one of the most in-depth demographic studies of educational differentials in U.S. mortality here to date. Our analysis is part of a larger NICHD-funded study on education's association with mortality, and sets the stage for future work on trends in the educational gap in mortality, the intersection of gender, race/ethnicity and education for mortality, and the ways in which education combines with race/ethnicity and gender to influence mortality from major causes. Ultimately, this body of work will result in the most comprehensive study of education's association with mortality since Kitagawa and Hauser (1973).

A Demographic Approach in Evaluating Educational Differences in Mortality

Two recent studies have produced life tables for major educational groups in the United States (Crimmins and Saito 2001; Molla, Madans and Wagener 2004). Although these studies differ somewhat in their approach, both produce life tables based on traditional occurrence/exposure rates in which the death counts are obtained from Mortality Detail Files and the mid-year population is estimated based on the decennial U.S. Census. Crimmins and Saito produced life tables for major education groups by adjusting national life tables using mortality ratios for age-sex-race-education groups derived from Kitagawa and Hauser's Matched Record study and the National Longitudinal Mortality Study. Molla and his colleagues combined death certificate reports of education with census information about the "at risk" population for an education group. Although neither study was specifically focused on the association between education and mortality (they both examined healthy life expectancy), their calculations of education-specific life expectancy are useful to benchmark the results of the present study.

The methodological limitations of using occurrence/exposure rate-based life tables to examine sub-group differentials in mortality are well known, and neither study was able to directly assess or observe how education affected individuals' risks of death.[2] For these reasons, the prior studies were unable to address the types of issues we take up in this study. These issues are:

1. What is the functional form of the relationship between education and the risk of death? Prior demographic studies have largely side-stepped this question as has the vast bulk of individual level studies of the education-mortality association. However, establishing the functional form is fundamentally important in

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[2] Crimmins et al used an mathematical adjustment approach based on extant data to derive education-specific mortality rates, while education-specific mortality rates in the study by Molla et al drew on different data sources for the reports of decedents' education and the number of persons of a given age-sex-education level at risk. In both studies, education-specific mortality is not directly observed.

understanding the possible ways in which education influences mortality and in defining appropriate education groups that accurately differentiate the risk of death.

2. Does the functional form of the association differ for males and females? In substantive terms, this question speaks to the issue of whether men and women share the same benefits of education, or whether the benefits are less evident for women. Some researchers have argued that the education gradient in mortality is less for women compared to men in the United States although the evidence is inconsistent across countries (Mackenbach et al. 1999). Our study provides new evidence on this issue and demonstrates the implications of sex differences in the association between education and the risk of mortality for sex differences in educational inequality in life expectancy in the U.S. population.
3. Does the effect of education diminish with age, or do individuals continue to reap the benefits of education even into advanced old age? A vigorous debate has grown up around this issue with some researchers arguing that the effects of education decline with aging (Beckett 2000; House et al. 1994) while other researchers arguing that education's effect persists into advanced ages (Lynch 2003). Here, we assess not only whether education's effect declines with age, but we also document the implications of these association for survivorship and life expectancy. The importance of this demographic perspective can be seen in the fact that while the risks of death for educational groups might converge or even cross-over at advanced ages, as one might expect in a population with differential frailty (Manton and Stallard 1984), the probability of *surviving* to advanced ages

is likely to differ substantially for educational groups. Differential survivorship is essential for understanding the long-term consequences of education – a fact that is typically ignored in individual-level studies.

4. Are the mortality experiences of highly educated persons approaching an upper limit in human longevity? Fries (Fries 1980, 1983) put forth the idea that in the context of a fixed life span, the postponement of chronic disease will lead to the rectangularization of the survival curve as life expectancy abuts fixed genetic limits. Substantial controversy surrounds this idea and the evidence is mixed. Evidence of rectangularization was recently observed for Hong Kong, for example, yet there is no evidence that mortality is approaching an upper limit in Japan – the country which has the longest life expectancy (Cheung and Robine 2007; Cheung et al. 2005). Comparisons across countries are difficult, of course, due to a host of societal and historical differences in factors influencing chronic disease processes over a population's lifetime. Here, we investigate this issue by comparing educational differences *within* the United States in the rectangularization of the survival curve. Because education leads to multiple and reinforcing socio-biological pathways that influence the nature and timing of chronic disease processes, examining educational differences in the rectangularization of the survival curves potentially offers new insights into whether fixed genetic limits in life span are evident for persons who have the greatest advantage in postponing chronic disease.

The underlying analytic approach we take in addressing these issues is a multivariate life-table model (Guilkey and Rindfuss 1987; Teachman and Hayward

1993). Within this framework, we are able to statistically assess the functional form of education's association with the risk of death, sex differences in the functional form, and whether the effects of education diminish with age. Parameter estimates from the models are used to calculate predicted death rates by age, sex, and education, and education-specific life tables are produced. The life tables provide the information necessary to address those issues raised above. Specific methods will be elaborated in the full paper.

Data

At the present our analysis is based on the Health and Retirement Survey for the years 1992-2004. We have estimated all of the multivariate life table models (MLTMs), and we have constructed the life tables necessary to address the questions raised above. At this point, we have not completed the analysis of the rectangularization of survival curves but anticipate completing the analysis within a month.

In approaching the estimation of the MLTMs, we paid particular attention to data quality issues. A major concern was how closely the HRS-generated mortality rates approximated vital statistics rates. The HRS, of course, is a sample of the older non-institutionalized population, although mortality follow-up occurs even when respondents attrite or enter institutions. The HRS submits information on decedents uncovered in the survey to the National Death Index to obtain information about the date of death and cause. In our analysis, we examine total mortality, so we include all decedents uncovered by the HRS – not simply those with probable matches in the NDI. When the HRS mortality rates are exponentially smoothed, they closely approximate the vital statistics rates throughout the entire age range from 50 onward with minor discrepancies only at advanced ages.[3]

Preliminary Results

The risk of mortality among persons aged 51 years and older in the HRS is statistically stable for educational attainment less than 12 years (results not shown). This is the case for both males and females. Both sexes experience a significant drop in mortality at 12 years of education. Mortality drops significantly again for men with more than a high school education. We also observed a decline in the risk of death for women with more than a high school education, but the drop was not statistically significant and substantively very close to the mortality rates for women with 12 years of education. Overall, then, the education gradient in the risk of mortality was greater for males than females – a finding consistent with prior research showing a smaller SES gradient in women's health compared to men's.

We also found statistical evidence that the effect of education on the risk of death diminished with age for both males and females. Although we have not and cannot control for cohort changes in the effect of education, we note that the span of birth cohorts in our analysis is narrower than prior studies who found evidence that the education's effect on health strengthened with age among more recent cohorts (Lynch 2003). In addition, the pattern of our results is consistent with the narrowing of educational effects on vital statistics mortality rates reported by Molla and his colleagues

[3] Our original plan was to use the HRS to pilot test basic functional forms, examine data quality issues, and so on before ultimately turning the National Health Interview Survey (NHIS) linked to the National Death Index. The reason for using the NHIS, of course, is the enormous number of deaths compared to those in the HRS. Thus far, however, we have held off using the NHIS because we have determined that relying on NDI probable deaths leads to downwardly biased mortality rates at ages 80-85 and above, with the bias much worse for females than for males.

(Molla et al. 2004) for the entire population. The narrowing of education's effect on mortality at older ages is not surprising – and indeed might be expected – based on the demographic perspective of differential frailty (Manton and Stallard 1984).

The consequences of these statistical patterns is evident in Figures 1 and 2 showing the mortality rates for the 0-11, 12, and 13+ education groups. For males, the absolute gap in death rates grows until about age 85, at which point the rates begin to narrow. Note that the rates converge at advanced ages but do not cross. Convergence starts about the same age for women, but unlike males, we observe a mortality cross-over about age 95. Given the sparse numbers of deaths at these ages within education groups, we hesitate to draw analogies with studies of the race cross-over in mortality. However, the general patterns of education and race differences are similar.

The implications of the education-specific mortality rates for life expectancy and survival are shown in Table 1. We have paired survival probabilities with the expectancies to provide a sense about what portion of the life table population the expectancies pertain to. Males at age 50, the radix age in our life tables, have approximately a 4.6 differences in life expectancy between persons with 0-11 and 13+ years of education. By age 80, only 42% of men with 0-11 years of education (and alive at age 50) have survived compared to 59% of men with 13+ years of education; the difference in life expectancy is 1.4 years. By age 90, only 13% of men with 0-11 years survived compared to 24% of men with 13+ years. While the men's gap in life expectancy at age 90 is small due to the convergence in mortality rates, it is clear that survivorship to this age is dramatically linked to educational attainment. The same pattern is evident for females although the overall levels of survivorship and life expectancy are greater due to lower levels of mortality.

Next Steps

1. As noted earlier, our assessment of the rectangularization of survival curves is still underway, but we anticipate the analysis will completed within a month.

Conclusions

A good education buys about 4.5 years of life for men and women aged 50. This is the gap separating persons with 0-11 and 13+ years of education. The biggest benefit in men's life expectancy stems from attending college. For women ages 50 and older, however, the benefit comes from attaining a high school education. College education provides less of a mortality benefit to women compared to men, and this gender difference is an important issue to unpack in our future work.

While we observed diminishing effects of education on the risk of death at advanced ages, it is a mistake in our opinion to focus on the convergence of death rates. Differential survival by education clearly denotes the lifetime benefits of education. Differential survivorship to advanced ages is stark for men and women. The long-run consequences of education for survivorship are enormous. Thus, while a good education might not buy a lot of extra life at age 90, a good education drastically increases the chances of surviving to that age.

Figure 1. Education Differences in M(x), Males

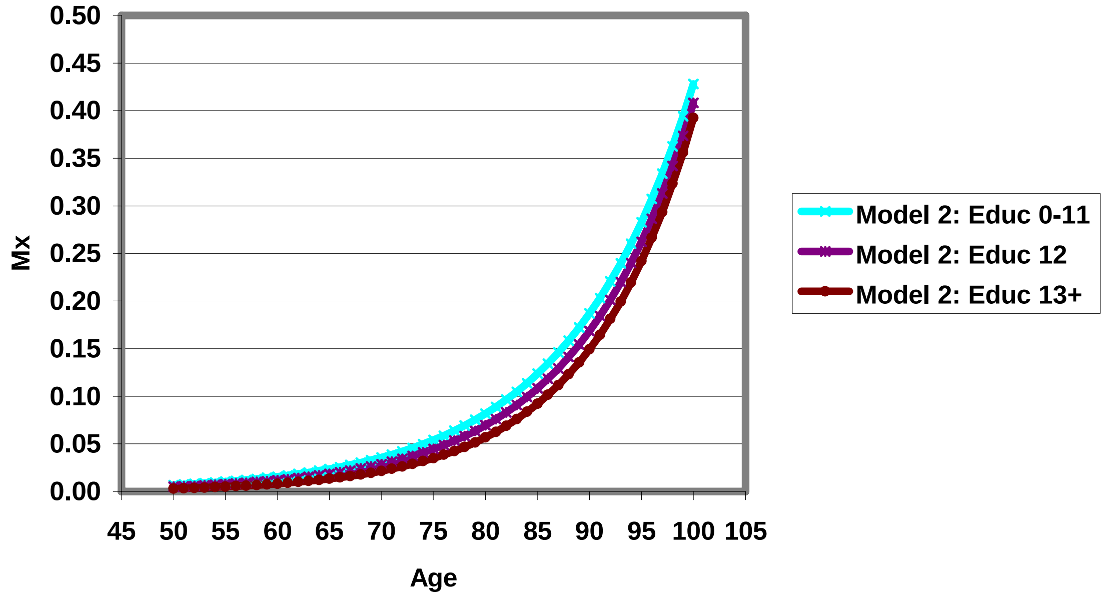

Figure 2. Education Differences in M(x), Females

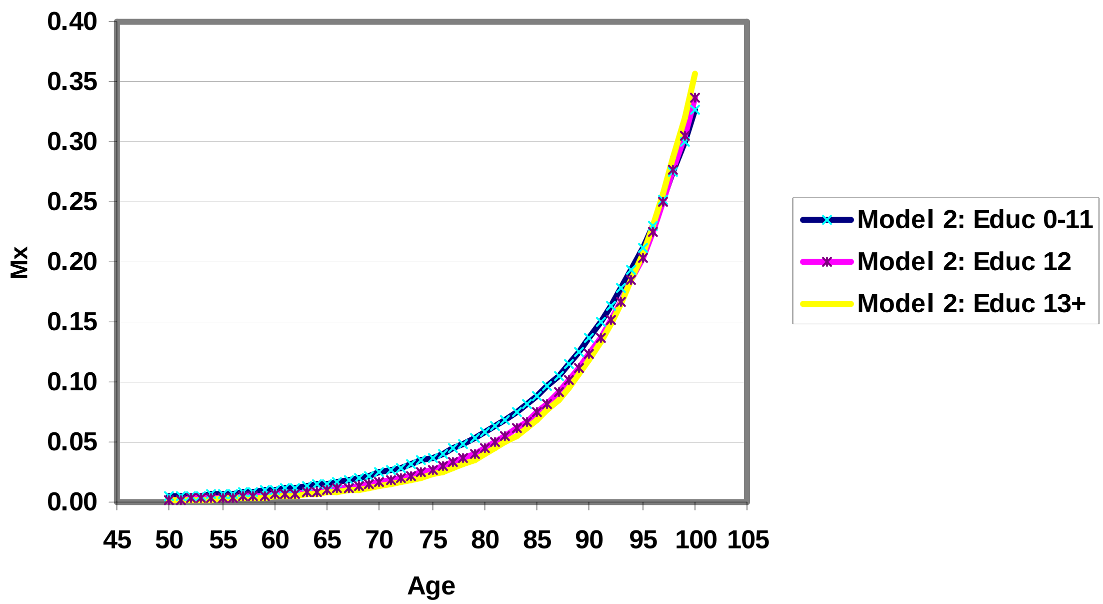

Table 1. Education Differences in E(x) and l(x)

e(x)	0-11	12	13+
Male			
50	26.7 (1.00)	28.8 (1.00)	31.3 (1.0)
60	18.9 (.90)	20.6 (.92)	22.6 (.95)
70	12.4 (.71)	13.6 (.76)	15.0 (.83)
80	7.5 (.42)	8.1 (.47)	8.9 (.59)
90	4.1 (.13)	4.4 (.15)	4.7 (.24)
Female			
50	30.5 (1.00)	33.7 (1.00)	35.1 (1.00)
60	22.2 (.93)	24.7 (.96)	25.9 (.97)
70	15.0 (.79)	16.7 (.86)	17.4 (.90)
80	9.2 (.54)	10.1 (.64)	10.4 (.72)
90	5.2 (.22)	5.4 (.29)	5.4 (.36)

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