Socioeconomic Mortality Differentials at Ages 95 and Higher in the United States. An Application of the Extinct-Cohort Method

Extended Abstract

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Abstract

Our paper deals with the question whether socioeconomic differentials in mortality exist also at ages 95 and higher in the United States. To answer this question, we extracted death counts by age, sex, year of death and level of education from NCHS's multiple cause of death data. The corresponding population data to compute age-specific mortality and life-tables have been estimated with the same data using the extinct-cohort method. As expected, women could expect to live slightly longer than men at age 95 ($\sim$ 0.5 years). The differences between socioeconomic groups as measured by the variable "education" were about 2.5 months in remaining life expectancy at age 95. Surprisingly, we could not detect a social gradient. Also plotting age-specific mortality resulted in the same outcome: higher socioeconomic status does not translate to lower mortality at ages 95 and higher in the United States. Our results support the hypothesis of converging mortality differentials with increasing age.

Keywords: Mortality Differentials, Socioeconomic Status, Education, Oldest-Old, Extinct-Cohort

1 Introduction

People of lower socioeconomic status (SES) die younger. This inverse relationship has been well established in numerous publications,[1] regardless whether SES has been measured via income, education, occupation, or other variables. (to name only a few: Goldman, 2001; Hummer et al., 1998; Kitagawa and Hauser, 1973; Kunst, 1997; Mackenbach et al., 1999; Rogers et al., 1995).

Nevertheless, some aspects of socioeconomic mortality differentials have not received much attention. The present analysis deals with one of them: *Do socioeconomic mortality differentials still exist at the highest ages?*

From a theoretical perspective, two antagonistic explanations are offered. The "Cumulative Advantage Perspective" argues that *socioeconomic differences diverge with age*. Ross and Wu (1996, p. 105) summarize this theory: "We propose that educational attainment increases resources that cumulate through life, producing a larger SES gap in health among older persons than younger." But it is not only the accumulation of financial resources. As pointed out by Hoffmann (2006), also unhealthy working conditions or smoking — two characteristics which typically apply rather to people of lower SES — might have a delayed effect on health and, ultimately, mortality. Empirical support for this hypothesis is rare, though. Hoffmann (2006) and Zhu and Xie (2007) found only one study each with clearly diverging mortality with age by SES.

Alternatively, it can be argued that *differentials in mortality by SES converge with age*. Typical explanations for this theory are "social policies aimed at increasing equality among the elderly, especially Social Security and Medicare" (Ross and Wu, 1996, p. 107). Others argue that some health and mortality hazards become less important at more advanced ages. For example, Marmot and Shipley (1996, p. 1177) write: "Social differentials in mortality based on an occupational status measure seem to decrease to a greater degree after retirement than those based on a non-work measure".[2] An interesting strain of explanation refers also to the changing importance for mortality of social and biological factors: at advanced ages, it is argued, biological factors gain relevance and social factors play only a minor role. Finally, there is also a compositional explanation for converging differences in mortality by SES: people from lower social strata had higher mortality throughout their life-course. Due to this selection effect, only the most robust members — the ones with a rather low mortality hazard — of this subgroup survive to the highest ages, resulting in converging mortality differentials by SES. Although there

[1] Searching *Google Scholar* on 28 December 2009 for `"Socioeconomic Mortality Differences"` and `"Socioeconomic Mortality Differentials"` yielded 289 results and 358 results, respectively.

[2] It should be noted, though, that Marmot and Shipley (1996) find "important socioeconomic differences in mortality [...] at least up to age 89."

are a few studies which find a persistent gap in mortality with age by SES, most studies actually support the hypothesis of convergence with increasing age.

The novel aspect of our study is that we analyze an age-range which has been analyzed — to our knowledge — only twice: Ages 95 and higher. In a recent study, Zhu and Xie (2007) found that socioeconomic differences still existed among centenarians in China. Ten years earlier, Manton et al. (1997) estimated remaining life expectancy at age 95 for women and men in the United States. Depending on the time period of the underlying data,[3] the difference in remaining life expectancy at age 95 between "high" and "low" education was 0.7–0.9 years for females and 0.9 years for males.

Data & Methods

We measured socioeconomic status by education for practical and theoretical reasons. From a practical point of view, education is the only variable for socioeconomic status available in our data. Despite this data limitation, education is not a poor choice for our analysis – not only because it will allow approximate comparisons to the study by Manton et al. (1997): From a causal perspective, education can be expected to predate other measures of socioeconomic status (such as occupation and income), which might be hard to measure anyway at ages 90+. And, more importantly for our study, education can be expected to be relatively stable throughout the life course (especially in our age-range), which is a necessary condition to successfully apply our methods described below.

Socioeconomic mortality differentials were analyzed in our study with two outcome measures: the probability of dying, q_x, and remaining life expectancy at age 95 (e_{95}).

We obtained the numerator to estimate q_x, i.e. the numbers of deaths at age x by sex and level of education, from the multiple cause of death data of the National Center for Health Statistics (National Bureau of Economic Research, 2009). These data are available online and list each death from 1959 until 2006 by various characteristics such as sex, age, cause of death, state of residence, year of death .... Since 1989, these data also contain information on education.

The denominator to estimate q_x, i.e. the number of people alive at age x by sex and level of education, is not directly available. Instead, we applied the "extinct-cohort" method, pioneered

[3]There were three time periods: 1982–82, 1984–85, 1989–90.

by Vincent (1951) and Depoid (1973). For this purpose, we selected the 1895 birth cohort.[4] Unfortunately, birth cohort is not one of the variables in the raw data. Since month of death of the deceased is also available, we distributed $\frac{Month-0.5}{12}$ of all deaths in a given month to the younger cohort from a Lexis square and $1-\frac{Month-0.5}{12}$ of all deaths in a given month to the older cohort (see Figure 1 on page 12). For instance, 11.5/12 of all deaths in December (month=12) were attributed to the younger birth cohort and 0.5/12 of all deaths in December to the older birth cohort.

By the end of year 2006, all initial members of birth cohort 1895 would have reached age 111 (see Figure 2 on page 13). We assumed that nobody of this birth cohort survived beyond this age. We considered this simplification to be negligible: according to current life tables from the Human Mortality Database (2009), even if a person reaches age 95, the probability is only 1.4 percent to survive another 15 years.

The logic of the extinct-cohort method starts at this highest age ("ω"). Let's assume there is one death at age ω in a cohort and there are no further survivors in that cohort. This results in a probability of dying of one because the numbers of death are equal to the number of people who reached that age. To obtain estimates for q_x for younger ages than ω, one needs to divide the numbers of deaths at this age x by the cumulative numbers of deaths between ages x and ω, i.e. $q_x = \frac{D_x}{\sum_{i=x}^{\omega} D_i}$. For instance, if three deaths have occurred at age $\omega-1$, $q_{\omega-1} = \frac{3}{1+3} = \frac{3}{4} = 0.75$.

This method allows us to estimate q_x for a combined age-range from 94 to 111 years for cohort 1895. Based on our estimates of q_x from the extinct-cohort method, we also calculated life tables using standard methods (see, for instance, Preston et al., 2001).

To obtain valid estimates in our application from the extinct-cohort method, two requirements have to be met: 1) no migration; 2) level of education remains constant. Due to the high ages we are analyzing, we assume that both of these requirements are fulfilled in our analysis.

Initial data extraction and aggregation from the NCHS data have been conducted using a recent implementation of the `awk` language (Aho et al., 1988; Dougherty and Robbins, 1997). All further analyses, incl. plotting, have been done in the `R`-language (R Development Core Team, 2009).

[4]We conducted the analysis also for birth cohort 1896. We obtained similar results to cohort 1895 and decided not to include them in this extended abstract.

Results

Table 1 (page 10) gives an overview of the number of individuals from birth cohort 1895 in each level of education at age 95. Due to our assignment procedure (e.g. 11.5/12 of all deaths in December were attributed to the older cohort), we obtained non-integer values. Our data-set contains 64,205 females. surprisingly (see, for example, Kannisto, 1994), the number of male survivors at these high ages is considerably smaller with 17,775. Among both sexes, the most common categories of education are the ones where people attended either 8 or 12 years of school, i.e. they finished elementary school or high school, respectively.

Because of the problematic accuracy of data for black people at very old ages (see, for instance, Preston and Elo, 2006), we repeated all our analyses for white women and men. As shown in Table 1, the proportion of white women and men is about 92%.

In Table 2 (page 11), we depict remaining life expectancy by level of education. The upper panel contains the results for women and men, whereas the lower panel refers only to white women and men. The two levels of education listed on top of each panel ("Education not stated" and "No Formal Education") represent outliers with values which are much higher or lower than for the other categories. At the moment, we can not say why. Since both categories can be considered as 'residual categories', data problems can not be excluded. Alternatively, the ones without formal education could have been children and adolescents from rather affluent families who received home schooling. This could explain the considerably higher values in remaining life expectancy. Besides the few number of cases in that category, it is impossible, to test this explanation with the available data.

As expected, a woman can expect to live longer than a man of the same age. According to our analysis, the difference at age 95 is on average slightly more than half a year in the other six levels of education. If we exclude the first two categories from Table 2, differences in remaining life expectancy at age 95 between the various levels of education are minor: They vary by 0.21 years (or about 2.5 months) for women as well as for men. If we narrow our analysis down to white people (lower panel), the gap becomes even smaller.

Typically, largest differences are found in our data between people who attended a few years of elementary school and people who finished elementary school after eight years. Life expectancy at age 95 of people who attended high school or college was usually somewhere in between.

Since remaining life expectancy at age 95 is only a summary measure of the mortality experience of the respective cohort at this age and all higher ages, we plotted in Figures 3–6 (pages

14–17) the probability of dying (q_x) over age for women and men (Figures 3 & 4) and for white women and white men (Figures 5 & 6).

Due to the smaller population size, the q_x-trajectories are more jagged for males than for females. But apart from the lack of smoothness and the higher level of mortality in general for males, the estimated probabilities of dying differ very little between the various levels of education in all four figures. Excluding again the categories "No Formal Education" and "Not Stated", it is virtually impossible to disentangle one trajectory from another. Even at ages 100 and higher, the mortality experience is rather similar between the various levels of education for males and females, regardless whether we analyzed the whole population or only the white sub-population.

Conclusion

To summarize: In contrast to the previous study for the United States by Manton et al. (1997) and the study about the oldest-old in China (Zhu and Xie, 2007), we found only negligible mortality differences by socioeconomic status at ages 95 and higher for the birth cohort 1895 in the US. This clearly supports the hypothesis of *convergence*. At the moment we can not yet determine whether this result is due to a selection effect, increasing importance of biological factors or effective public health measures such as Social Security and Medicare.

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Tables and Figures

Table 1: Number of Individuals of Birth Cohort 1895 Alive At Age 95 By Sex, Ethnicity/Race and Level of Education

Women				
Level of Education	Total	White	Black	Other
Education Not Stated	10,195.96	8,977.04	1,112.42	106.50
No Formal Education	856.83	695.42	92.21	69.21
Elementary School (1-7 Years)	8,078.50	6,560.38	1,351.92	166.21
Elementary School (8 Years)	14,605.25	13,906.38	643.38	55.50
High School (1-3 Years)	4,428.92	4,049.96	349.33	29.62
High School (4 Years)	15,345.17	14,600.79	648.79	95.58
College (1-3 Years)	5,912.42	5,726.17	167.38	18.88
College (4 years or more)	4,781.71	4,555.75	210.00	15.96
$\sum$	64,204.75	59,071.88	4,575.42	557.46
Men				
Level of Education	Total	White	Black	Other
Education Not Stated	2,955.33	2,520.29	391.75	43.29
No Formal Education	284.17	220.58	47.54	16.04
Elementary School (1-7 Years)	3,129.46	2,525.17	553.25	51.04
Elementary School (8 Years)	3,987.88	3,763.04	200.46	24.38
High School (1-3 Years)	1,209.58	1,116.58	85.21	7.79
High School (4 Years)	3,375.12	3,176.21	167.04	31.88
College (1-3 Years)	1,157.12	1,100.83	48.96	7.33
College (4 years or more)	1,676.54	1,606.04	55.54	14.96
$\sum$	17,775.21	16,028.75	1,549.75	196.71
Total				
Level of Education	Total	White	Black	Other
Education Not Stated	13,151.29	11,497.33	1,504.17	149.79
No Formal Education	1,141.00	916.00	139.75	85.25
Elementary School (1-7 Years)	11,207.96	9,085.54	1,905.17	217.25
Elementary School (8 Years)	18,593.13	17,669.42	843.83	79.88
High School (1-3 Years)	5,638.50	5,166.54	434.54	37.42
High School (4 Years)	18,720.29	17,777.00	815.83	127.46
College (1-3 Years)	7,069.54	6,827.00	216.33	26.21
College (4 years or more)	6,458.25	6,161.79	265.54	30.92
$\sum$	81,979.96	75,100.63	6,125.17	754.17

Note: Non-integer values for the number of individuals is due to the procedure to assign the (integer) number of deaths in a given month to different Lexis triangles (see detailed description in the *Data & Methods* section).

Table 2: Remaining Life Expectancy at Age 95 in Years for Birth Cohort 1895 by Sex and Level of Education (All Races/Ethnicities and Whites)

All Races and Ethnicities		
Level of Education	Women	Men
Education Not Stated	2.66	2.27
No Formal Education	4.54	3.35
Elementary School (1-7 Years)	3.23	2.74
Elementary School (8 Years)	3.02	2.53
High School (1-3 Years)	3.14	2.53
High School (4 Years)	3.10	2.64
College (1-3 Years)	3.17	2.62
College (4 years or more)	3.18	2.73

Whites		
Level of Education	Women	Men
Education Not Stated	2.58	2.17
No Formal Education	4.27	3.15
Elementary School (1-7 Years)	3.06	2.62
Elementary School (8 Years)	2.99	2.51
High School (1-3 Years)	3.07	2.52
High School (4 Years)	3.06	2.59
College (1-3 Years)	3.15	2.62
College (4 years or more)	3.15	2.71

Figure 1: Assigning Deaths in a Given Month to a Birth Cohort

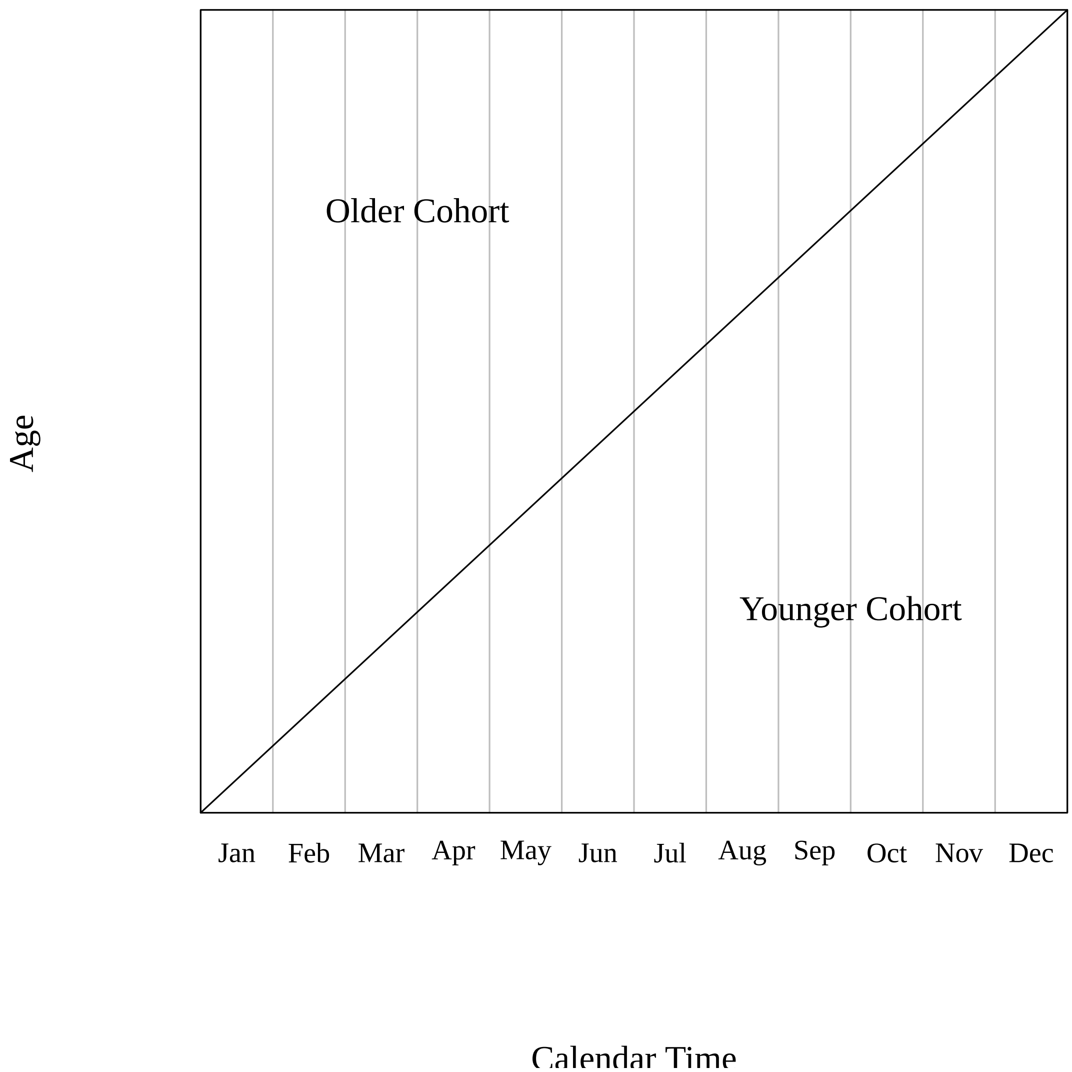
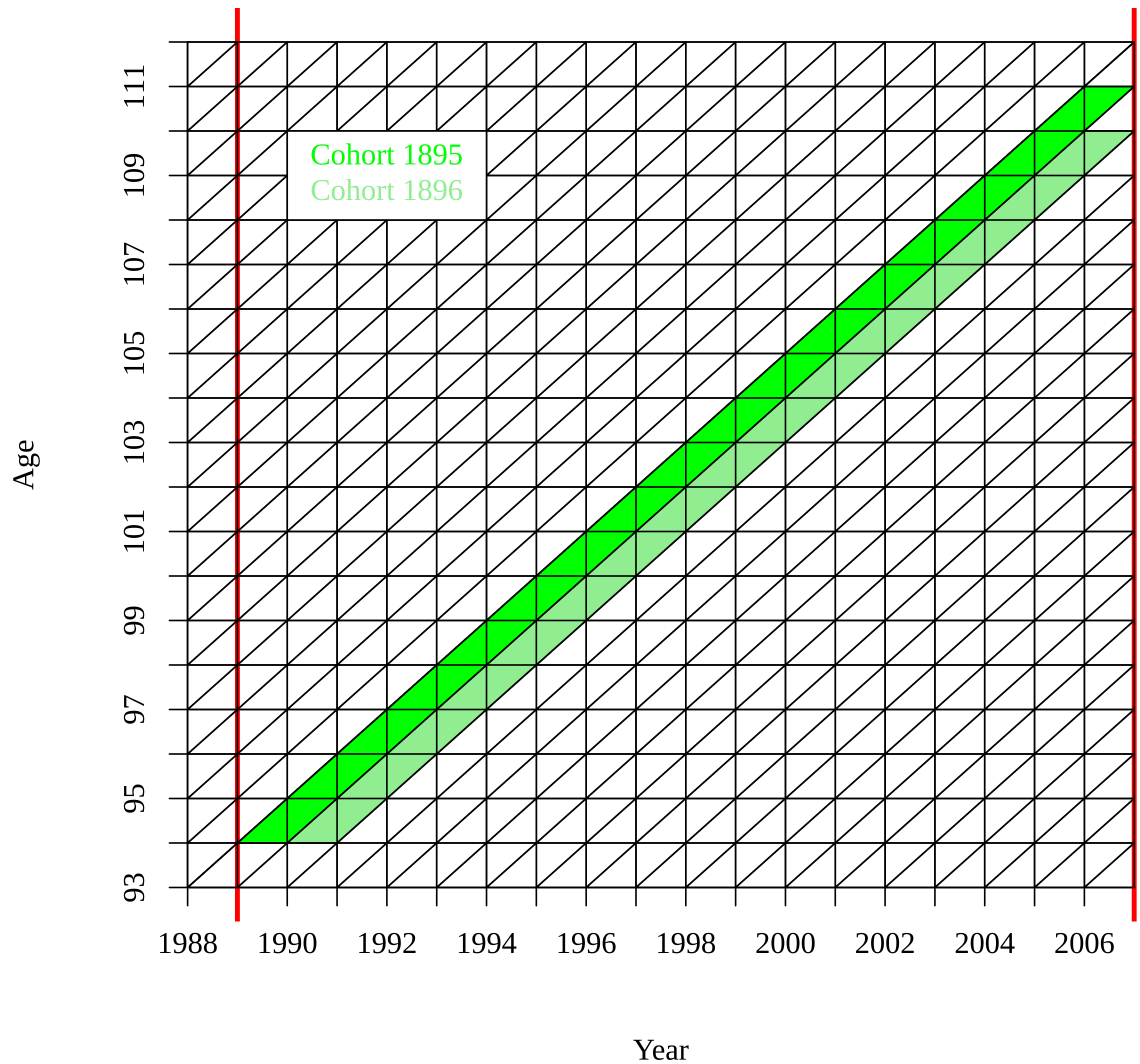


Figure 2: Basis for Data Analysis on Lexis Map



The red vertical reference lines indicate the availability of data. The green trapezoid denotes birth cohort 1895 — the cohort which has been analyzed in this extended abstract.The light green trapezoid denotes birth 1896 for which additional analyses have been conducted. The results were similar for both cohorts.

Figure 3: Probability of Dying for Birth Cohort 1895, Women

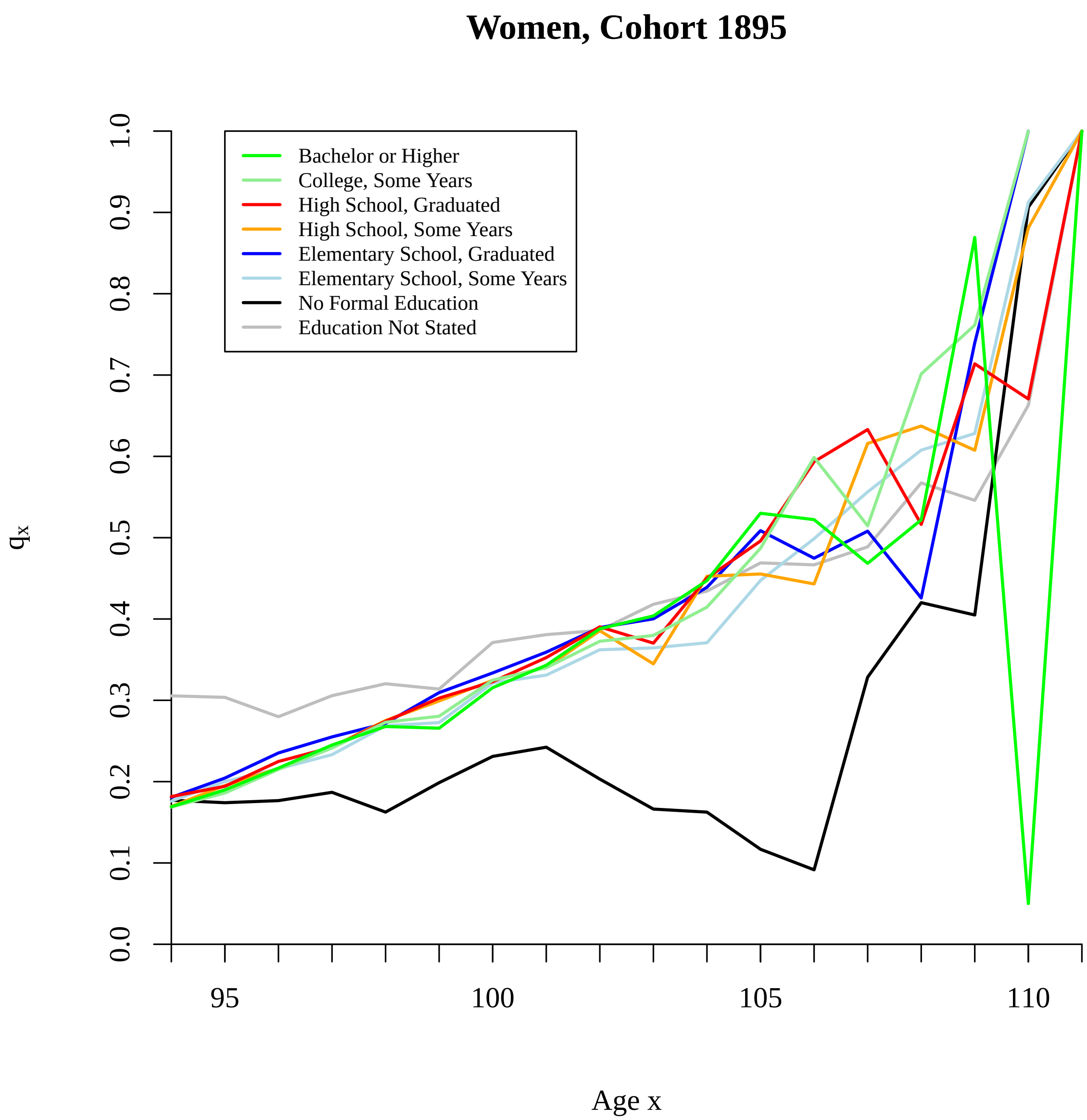


Figure 4: Probability of Dying for Birth Cohort 1895, Men

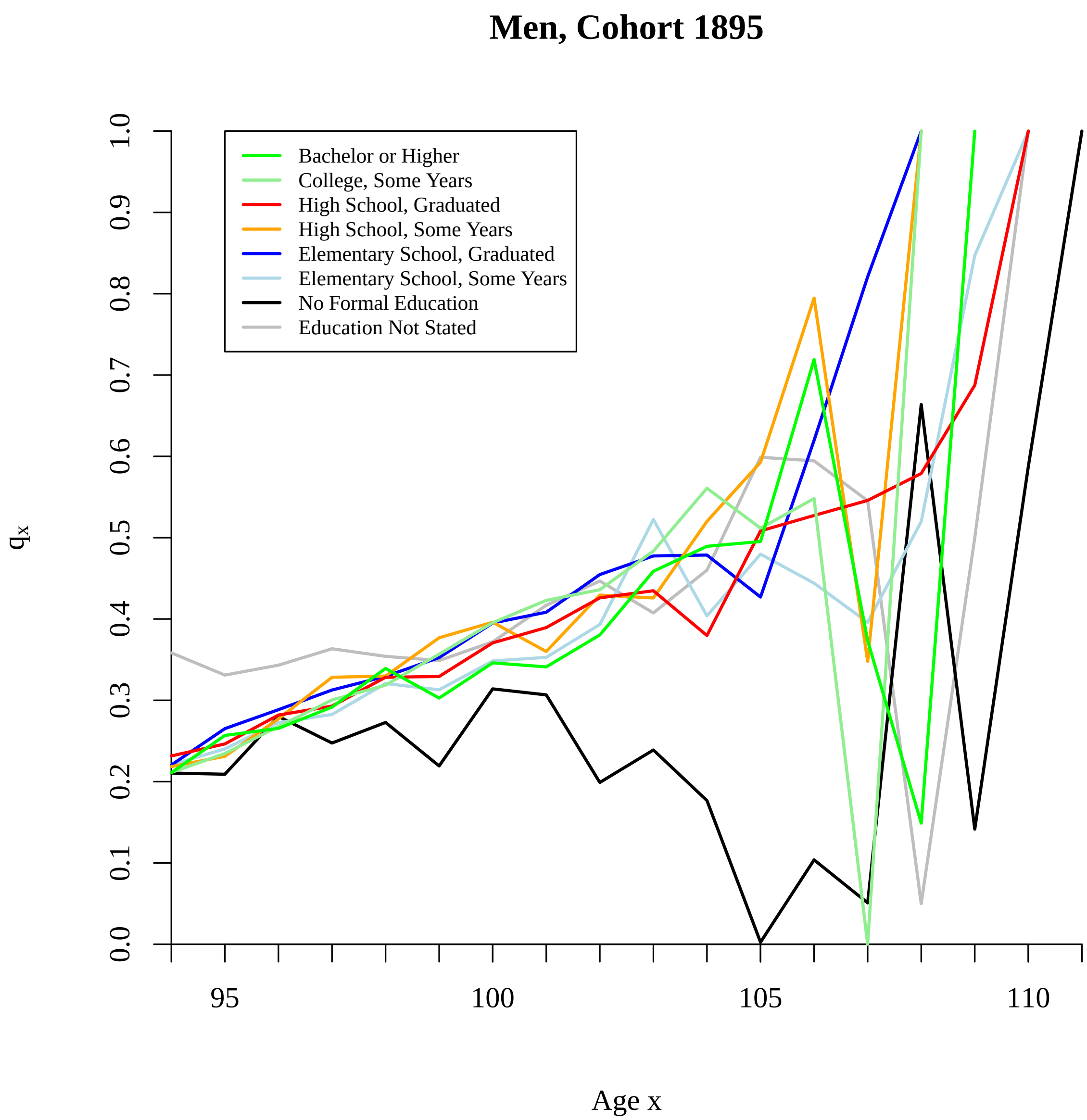


Figure 5: Probability of Dying for Birth Cohort 1895, Women, White

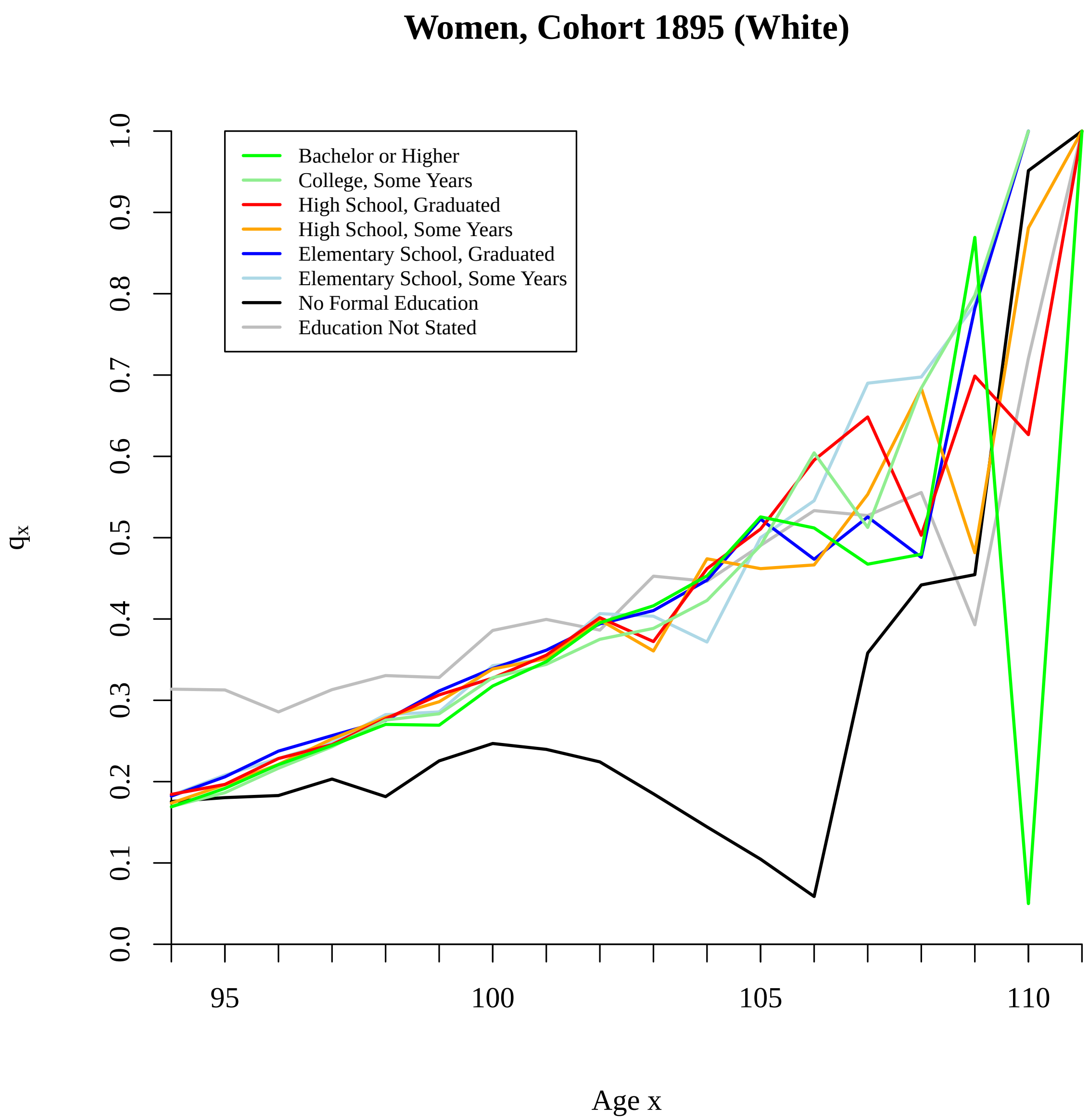


Figure 6: Probability of Dying for Birth Cohort 1895, Men, White