Birth Cohorts, Synthetic Cohorts, and SES Differentials in Longevity: The Implications of Changing Educational Distributions for Life Expectancy Gradients

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Abstract

One of the primary goals of social demographers is to measure and understand socioeconomic differentials in life expectancy. However, recent research has questioned whether shifting education distributions across cohorts are contaminating our estimates of socioeconomic status gradients in mortality. Since synthetic cohorts are constructed from the mortality rates of multiple real birth cohorts, and since the relationship between education and status is cohort-specific, using a synthetic cohort (cross-sectional) approach to measure SES differentials in life expectancy may produce misleading estimates. In this study, we use high-quality Finnish register data for 1971-2005 to identify an empirical regularity in the relationship between percentile rank in the education distribution and mortality. We find that these two variables are related by a negative logarithmic curve. We specify and estimate a two-parameter model that captures the great majority of the variation in this relationship, and show that relative mortality differentials have increased over the follow-up period. We then use the model parameters to generate educational quintile-specific life expectancies for seven 5-year periods, thus adjusting for the changing education distribution. These distribution-adjusted education differentials in life expectancy appear to have increased for men, but not for women between 1971 and 2005. Although relative education inequality in mortality has increased for both sexes, this effect has been cancelled out for absolute life expectancy differentials for women due to more rapid declines in overall mortality. Roughly 59% and 100% of the increase in educational differentials in life expectancy for men and women, respectively, can be attributed to shifting education distributions. Had the relative inequality parameters of mortality differentials governing the Finnish population remained constant at the 1971-75 values, the difference in life expectancy between the top and bottom education quintiles would have narrowed by 0.9 years for men and 0.4 years for women. In the next few weeks, we will analyze U.S. data from the National Longitudinal Mortality Study and the National Health Interview Survey to investigate whether shifting education distributions have a similar effect in the U.S. as in Finland on synthetic cohorts and birth cohorts.

Introduction

The measurement of inequality is one of the primary enterprises of social demography, and accordingly much attention has been focused on the idea that growing social inequality is driving inequality in life expectancy and health. Life expectancy is an absolute measure of wellbeing, and differentials in life expectancy also have implications for outcomes like wealth accumulation and inheritance and the receipt and provision of social security income. Given the importance of socioeconomic inequalities in mortality, it is crucial that we conceptualize and operationalize them carefully, so that we can properly understand both the mechanisms underlying the mortality inequality and the effects of the inequality.

Many prior studies have identified socioeconomic gradients in mortality and attempted to either explain their existence or document their variation and change over time (Elo, Martikainen, and Smith 2006; Elo and Preston 1996; Hendi 2015; Ho and Fenelon 2015; Mackenbach et al. 1999; Meara, Richards, and Cutler 2008; Montez and Zajacova 2013). Many of these studies have focused on education as the stratifying variable.

However, recent research has pointed out that the interpretations and conclusions in these studies are predicated on the assumption that education is a static measure of socioeconomic status (Begier, Li, and Maduro 2013; Dowd and Hamoudi 2014; Hendi 2015). The conclusions can be misleading if the education distribution has been changing over time, as it has been in nearly every country in the world. There are two main types of problems that arise when education distributions are shifting. First, over-time comparisons of educational differentials in mortality may become biased measures of changes in the socioeconomic gradient in mortality. Second, cross-sectional (within-time-period) estimates of education-specific period life tables consist of the mortality experience of multiple birth cohorts, each of which has a different

education distribution, such that these estimates may not correspond to the real experience of any one level of socioeconomic status (SES). Consider the real-to-life example that in contemporary life tables for people with only a basic education, people aged 85-89 years might be at the 50th percentile of the education distribution and may thus be considered to have a median level of social standing, whereas people aged 25-29 years might be in the 5th percentile and thus have a very low level of social standing. The period life table for people with basic education would thus combine younger, low-SES people with older, median-SES people. Such a life table would tell us little about how long low-SES people can be expected to live.

These two issues are problematic because they assume that the relationship between education and SES are static over time and that the SES-education relationship is static across cohorts within the same time period. Education category differentials in life expectancy and mortality are therefore not consistent measures of SES gradients in mortality when educational distributions are changing rapidly. In most theoretical frameworks, status is a relative construct, so education levels must be interpreted in relation to the education distribution if we are to use education as a marker of SES.

In this paper, we critically discuss how educational expansion affects measurement of inequality in mortality, and introduce a methodological innovation, which allows us to measure SES gradients in mortality while adjusting for changes in the education distribution. The methodological innovation is based on the negative logarithmic relationship between education-specific mortality ratios and position in the education distribution. We use high-quality Finnish registry data to show that this logarithmic relationship holds across age and sex groups and over time. We then construct a series of curves tracing out the relationship between exact education percentile and mortality over time. We show that while SES gradients in mortality have indeed

steepened over time, much of the change over time in the life expectancy difference between the highest and lowest education levels is due to the shifting education distribution. These results, coupled with our finding of a universal logarithmic relationship between mortality ratios and educational percentile, suggest that using education categories as the stratifying measure will tend to overstate the over-time increase in the social gradient in mortality. Our findings explicitly demonstrate why the existing literature has been finding rapidly growing inequality in relative mortality, and show that much of the rise in this measured inequality is at the low end of the education distribution, where fewer and fewer people are concentrated over time.

The Historical Context of the Finnish Educational Transition

While today Finland is considered one of the most forward-thinking countries in terms of education, for much of the twentieth century, it was a largely agrarian society with very little formal education. Most people born before the 1920s had at most four years of formal education. The first major change in the Finnish education system occurred in 1921 with the Compulsory Education Act of 1921. This law guaranteed six years of formal education to all Finnish citizens and it was very rapidly adopted and implemented. As a result, there was quite a stark educational divide between cohorts born prior to this period and those born afterwards.

Between the 1920s and World War II, the Finnish education distribution remained fairly stable—most people had six years of education. The years following the Second World War proved difficult for Finnish society and the Finnish economy. As part of the terms of the peace accord between Finland and the USSR, Finland was required to give roughly one-tenth of its land to the Soviet Union. This forced hundreds of thousands of Finns to leave the newly annexed land for the rest of Finland. At the time, Finland's major industries were agriculture, timber, and wood processing. War reparations to the USSR in ships and machinery also required Finland to

develop new industries in the late 1940s-early 1950s to meet these demands. By the late 1950s, however, the Finnish government became concerned about generating new jobs and competing in new industries. This became clearest when Finland joined the European Free Trade Association in 1961. Government officials in Finland realized that they would need to innovate and compete in the global economy in order to grow their own economy and keep their population employed.

To achieve the dual goals of promoting social equity and economic growth the government implemented a new schooling reform: the 1968 Basic Education Reform Act. The 1968 Act made 9 years of schooling compulsory for all Finnish children. It was thought that this measure would level class differences and also prepare Finland to enter into the global economy in the expanded manufacturing and service industries. This education reform coincided with rapid industrialization in the 1950s and 1960s and mass rural-to-urban migration in the 1960s and 1970s. It was fully implemented by 1977. Once again, there was a sharp divide in educational attainment between cohorts who were born prior to the implementation of this reform versus after. The educational expansion prepared a greater number of Finns to participate in the manufacturing industry and later the service industry.

Following the 1970s, education reform took on its own momentum, leading to ever-higher levels of educational attainment for the younger segment of the Finnish population. Education grew in importance not only as a means to produce economic growth but also as an end in its own right—a social right. Smaller reforms in the 1980s, 1990s, and 2000s allowed for greater flexibility in transitioning between vocational and academic educational tracks in a further attempt to level class differences (Aho, Pitkanen, and Sahlberg 2006).

Cohort Effects, Status, and Education

One of the defining features of the Finnish education transition is that the major changes were implemented very rapidly—often within a period of five years—and thus produced large differences in educational attainment between earlier and later cohorts. This transformation can be seen mostly clearly in Figures 1 and 2, where we can see the very sudden decline in the proportion of people with only a basic education corresponding to cohorts who completed their schooling after the 1920s. Similarly, cohorts that completed schooling prior to the 1970s have a very different education profile than cohorts that benefited from the education reforms of 1968. Because most formal schooling is completed by age 30, we can say that education transitions imprint distinctly on cohorts. Birth cohorts separated by only a few years may have very different education profiles.

When we observe populations in cross-sections of time—for example, the Finnish population in 2005—we mix together these very distinct cohorts. If we wish to use education as a direct proxy for socioeconomic status, this leads to the question of whether the relationship between education and status in a given period differs across birth cohorts. The answer, of course, is that it certainly does.

It is problematic that the status attached to the same education level differs across birth cohorts because when period measures of educational inequality are used to proxy for socioeconomic inequality, education-specific estimates are essentially weighted sums of values corresponding to different levels of status. In other words, within a given education category,

you end up with a mixture of individuals with differing levels of socioeconomic status depending to which birth cohort they belong.

Why does the status attached to a given educational level differ across birth cohorts?

The educational reforms that were undertaken led to a credentialing process for entry into different segments of the labor market. The same type of job that one could have had before now required a higher level of schooling. This patterning is reflected in Figure 3, which plots the education distribution within occupational categories for men (lower occupation category numbers indicate higher social class). It's immediately apparent that within the same occupation types, the education distribution shifted across cohorts. Ivar Berg and Randall Collins theorized about this process in the sociology of education and the labor market literature and Michael Spence in the economics literature. All three authors predicted that because of increased labor market competition, individuals will compete on the basis of status to signal their value to potential employers. Employers in turn hire those with the best signal, which is equivalent in this context to higher level of education (Berg 1970; Collins 1971, 1979; Spence 1973).

Within the Finnish context, competition for jobs was not based on education in the early 20th century. It was based largely on families' social class, which was determined by a variety of other factors including place of residence, families' occupational history, and wealth. This pattern began to change in the 1920s and accelerated during the postwar era. In the postwar era, the incentives to compete on education increased both domestically and internationally. At the international level, Finland increased her participation in the global economy and accepted global norms, including the belief that people should complete secondary or even tertiary education. There is evidence that the leaders of Finland kept a close eye on foreign academic literatures, which posited that human capital formation was one of the best ways to promote

economic growth (Aho et al. 2006). At the domestic level, the loss of land to the USSR along with the decline in farming led to competition for jobs in the industrial and service sectors. People needed to compete for jobs, and they began to do so on the basis of education.

In summary, earlier in the twentieth century, education was only loosely tied to status, and did not figure strongly in competition for jobs. Policies implemented in the 1970s led the entire Finnish population to rapidly increase its mean level of education. By the 1980s, education had become much more important for jobs and thus became a strong marker of socioeconomic status. This intensification of status competition was reinforced by the acceptance of world society norms including the desirability of higher education, and globalization, which forced the Finnish population to compete more directly with people in other countries.

The increased status competition in the labor market led to greater status differentiation by education level for later birth cohorts than for earlier birth cohorts. Essentially, education was a better determinant of socioeconomic status for people born later.

Over the same time period—the 1960s through the present era—Finland experienced growing educational differentials in life expectancy. While prior to the 1960s, mortality differentiation might have been determined mostly on the basis of social class or urban-rural status, education became a better predictor of mortality relative to the past. This suggests that part of the growth in the educational gradient in mortality may be due to the fact that education became more closely tied to status, which has always been a prime determinant of mortality. Thus, when attempting to measure socioeconomic gradients in mortality, one must take care to ensure that the measurement uses an indicator of socioeconomic status that is consistent across cohorts. For all its virtues, education is not a consistent measure of status across cohorts. In this article, we present a parameterization of the relationship between the education distribution and

mortality that allows us to generate estimates of status gradients in mortality based on educational attainment that are more consistent across cohorts.

Data and Methods

We use data on deaths and exact person-days lived cross-tabulated by sex, age, and education for Finland in the following five-year periods: 1971-1975, 1976-1980, 1981-1985, 1986-1990, 1991-1995, 1996-2000, 2001-2005. The data come from five-year censuses and death register data and are provided by Statistics Finland. Age is collapsed into five-year age groups and education is categorized into a 7-category measure: elementary school or no formal schooling (henceforth basic), middle school, high school, vocational degree, polytechnic college degree, university degree, and graduate degree. For the 2001-2005 period, the education categorization changes slightly and collapses the second group with a portion of the third group (the categorization for the lowest and the highest education groups remains the same). The person-years measure is the total number of days lived by people within a sex-age-education group in a given five-year period. Individuals are allowed to age out of and into adjacent age groups. Mortality follow-up (the counting of person-days) begins as of January 1 of the first year within the five-year period, and education is measured at the time of the census.

Methods

Death Rates and Life Tables

We compute age-sex-education-specific mortality rates (occurrence-exposure ratios) by five-year age groups for each of the seven time periods listed above, for age groups 25-29, 30-34, …, 90-94, 95+ years. We do not compute death rates for people aged younger than 25 since

many of them are unlikely to have completed their education by that age. Ages 95 years and older are combined into an open-ended age group and the death rate is presumed to be constant. Each rate is multiplied by 365.25 so that the rates are measured in terms of deaths per person-year. Abridged life tables starting at age 25 years are computed using standard methods with ${}_{n}a_{x}$ calculated by using Keyfitz's iteration approach (Preston, Heuveline, and Guillot 2001) (iterations continued until all age-specific ${}_{n}a_{x}$ values in the life table changed by less than 0.0001 from one iteration to the next).

Modeling the Relationship between SES and Mortality

Since our objective is to examine the relationship between education percentile (that is, position in the education distribution) and mortality, we computed age-sex-period-specific education distributions and mortality ratios. Within an age-sex group in a given five-year period, we divided each of the seven education-specific death rates by the general mortality rate (the age-sex-specific mortality rate for that period). This produced seven mortality ratios for each age-sex group in each period (with the exception of the 2001-2005 period, which had only six education categories):

$$R_i = {}^{n}m_x^i / {}_{n}m_x \quad i = 1, \ldots, 7$$

where ${}_{n}m_x^i$ is the death rate for education group i, and ${}_{n}m_x$ is the death rate for the general population. We then computed the education distribution for each age-sex group in each period by tabulating the number of person-years lived by each education group and dividing by the total person-years lived across all education groups within the age-sex group in that period. The SES Index value (the education percentile) for each age-sex-education group in a given year is the percentile corresponding to the halfway point for the education group within the education

distribution in that period. For example, in 1971-1975 the middle school education group for males aged 25-29 ranged from the 52nd percentile to the 78th percentile. The midway point for this group is (0.52+0.78)/2 = 0.65, so the education percentile value for 25-29 year-old males in 1971-1975 with a middle school education is 0.65. By 1996-2000, the middle school education group for males aged 25-29 ranged from the 22nd percentile to the 46th percentile. The midway point for this group is (0.22+0.46)/2 = 0.34, so the education percentile value for 25-29 year-old males in 1996-2000 with a middle school education is 0.34. We then plotted the mortality ratios against the education percentile values to trace out the socioeconomic gradient in mortality.

Based on the observed relationship between the mortality ratios and the education percentile, we estimated regressions of the following form:

$$\log(R_i) = \alpha + \beta e_i + u_i \quad i = 1, \ldots, 7$$

where i represents an education group, R_i is the education-specific mortality ratio for a given age-sex group in a particular period, e_i is the education percentile corresponding to education group i in that year and for that age-sex group, and u_i is a mean-zero error term. Since there are 15 age groups, 2 sexes, and 7 five-year periods, we compute a total of $15 \times 2 \times 7 = 210$ regressions, each with two parameters (α and β). The α and β parameters are the skewness and inequality parameters, respectively, pertaining to the mortality-SES relationship. e^{α} can be interpreted as the mortality ratio relative to the general population for people at the bottom of the SES distribution. All else being equal, a higher α value indicates that mortality is more concentrated (skewed) toward the lower end of the SES spectrum. If α increases over time, then there is evidence that the mortality of the most poorly educated is diverging from the general level of mortality in the total population. If α decreases over time, then the mortality of the most

poorly educated is converging to the general level of mortality in the total population—the mortality distribution is less skewed towards lower levels of education. The β parameter indicates the overall level of relative inequality by SES in mortality. $(e^{\beta} - 1)$ can be interpreted as the average percent difference in mortality between the lowest-SES and highest-SES individuals. For example, a β value of -1.8 means that the highest-SES people have mortality rates that are around 83% lower than those of the lowest-SES people ($e^{-1.8} - 1 \approx -0.83$). If β decreases over time, then there is evidence that the relative difference in mortality between the highest-SES and lowest-SES people is growing. A mean-preserving change in α requires that β changes in the opposite direction. In other words, if the situation of the worst-off is improving relative to the total population (α is decreasing) but the total mortality rate in the population remains constant, then by necessity the best-off must shoulder a greater portion of the mortality burden (β must increase). Together, these two parameters summarize the main features of SES gradients in mortality: the relative difference between the lowest-SES and the highest-SES, and the portion of the SES spectrum at which inequality is concentrated.

Computing Life Tables by SES Quintile

The major objective of this analysis is to compute life tables that take into account the changing education distribution across cohorts in a given time period and across time. To do so, we must be able to compare a fixed set of SES categories—for example, quintiles of SES—and compute life tables based on the mortality rates corresponding to those fixed quintiles. Now that we have regression estimates (α and β) that model the relationship between SES and mortality ratios, we can use the regression estimates to compute mortality rates that correspond to the SES quintiles. If an SES quintile ranges between SES Index values a and b, then the average mortality ratio corresponding to that quintile is:

$$\bar{R}_{(a,b)} = \frac{1}{b-a}\int_{a}^{b} e^{\alpha+\beta x}\,dx = \frac{e^{\alpha}}{\beta(b-a)}\left(e^{\beta b} - e^{\beta a}\right)$$

which means that the average mortality rate corresponding to that quintile is just the age-sex-specific general mortality rate multiplied by $\bar{R}_{(a,b)}$. For example, the second SES quintile ranges from SES Index value 0.20 to 0.40. Then $b = 0.40$ and $a = 0.20$. If, for a given age-sex group in a particular period, $\alpha = 0.8$ and $\beta = -1.8$ then $\bar{R}_{(a,b)} = 1.3$. If the age-sex group in question is males aged 25-29 in 1986-1990, then the death rate is 0.0015, so the quintile-specific death rate is $1.3 \times 0.0015 = 0.00195$.

Using the two model estimates we compute quintile-specific death rates for each age-sex group in each of the seven periods to produce a full set of age-specific death rates for 70 distinct life tables (5 quintiles over 7 periods for 2 sexes).[1] We then compute the life tables, again using Keyfitz's iteration technique to calculate the ${}_{n}a_{x}$ values.

Counterfactuals

Finally, we also compute counterfactual estimates. These counterfactual estimates allow us to make statements like: "If relative educational inequalities in mortality hadn't changed over time (but if general mortality rates evolved as observed), what would be the difference in life expectancy between the first and fifth quintile of the education distribution?" To do so, we can simply borrow the α and β estimates from 1971-1975 and apply them to the 1976-1980, 1981-

[1] Note that these quintiles do not correspond directly to the education categories. We use the education categories to estimate the SES-mortality relationship and in turn use the estimated relationship to produce quintile-specific mortality rates.

1985, 1986-1990, 1991-1995, 1996-2000, and 2001-2005 general mortality rates to compute the counterfactual life table.

Results

Figures 1 and 2 plot the changing education distribution of Finnish men and women, respectively, by 20-year age groups. Each bar represents the education distribution in a given year, with the darker colors at the bottom of the bar representing lower levels of educational attainment and the lighter colors at the top of the bar representing higher levels of educational attainment. From darkest to lightest, the bar segments represent: no formal education or basic education, middle school, high school, vocational education, polytechnic college degree, university degree, and graduate level degree. Clearly, the education distribution is shifting towards higher levels of educational attainment as time progresses. This is particularly the case for people aged 25-44 years and 45-64 years. The majority of movement in the education distribution occurs at the lower end—fewer and fewer people have only a basic level of education, as more people complete secondary and tertiary levels of education. In 1971-1975, over 60% of men and women aged 25-44 had at most a basic level of education. By 2001-2005, that number was reduced to less than 20% for men and around 14% for women.

Another fact that is made clear by these figures is that educational expansion in Finland was a cohort phenomenon. Even though the education distribution changed dramatically for people younger than 65, the distribution changed far less for those aged 65-84 and almost not at all for people aged 85+.

Table 1 shows life expectancy at age 25 by education for each of the seven time periods for men and women separately. Life expectancy increased for all education categories, though

not at an equal pace. People with higher levels of education tended to experience faster increases in life expectancy than people with lower levels. This led to an increase in the difference in life expectancy between graduate degree holders and people with basic education. Between 1971-1975 and 2001-2005, this differential increased from 5.9 years to 9.8 years for men (a 3.9 year increase) and from 2.0 years to 3.7 years for women (a 1.7 year increase). This increase in the life expectancy differential is entirely due to faster increases among the most educated.

Figure 3 shows the distribution of education within occupation categories over time. Within a given occupation category, the education distribution shifted rightward across periods. In other words, the educational qualifications required for the same types of jobs became higher for later birth cohorts. Thus, individuals who obtained higher status occupations in earlier periods needed less schooling than individuals in later birth cohorts.

Figures 4 and 5 plot the relationship between the SES index (position in the education distribution) and mortality ratios (the ratio of education-specific mortality to general mortality). The point markers are two-digit numbers representing the year to which the estimate corresponds. The colors correspond to 5-year age groups, with red being the youngest age group and green the oldest (within the broader 20-year age groups). We find a strikingly regular negative logarithmic relationship. Mortality ratios are highest for people with the lowest SES, and the rates of decline in the mortality ratio are highest at these low SES values. The points cross the 1.0 (equality) line at around SES=0.5 for men and SES=0.4 for women, indicating a slightly greater concentration of inequality at the lower SES levels for men than for women. The negative logarithmic relationship appears to hold for both men and women and for all age groups and time periods, though the relationship is clearer for people aged 25-84. This is consistent with the lack of a large SES gradient in mortality among people aged 85+.

Figures 6 and 7 plot the percent difference in mortality between the least and most educated people for males and females, respectively. Each line represents a different 5-year age group. These estimates are computed as $e^{\beta} - 1$, where β comes from the logarithmic regression estimates (described in the Methods section) that model the relationship between SES index and mortality ratios. As expected, the percent differences are greatest for people at younger ages, where mortality gradients are more pronounced and where overall mortality rates are lower, and smallest at older ages, where mortality gradients tend to be muted and where overall mortality rates are higher. We see that for both men and women, the percent difference increased over time in magnitude (that is, they became more negative). The changes were most pronounced for younger age groups.

Figures 8 and 9 plot the concentration of mortality inequality among the least educated for males and females, respectively. Each line corresponds to a single five-year age group. The values are computed as e^{α} (the mortality ratio for people at the 0^{th} percentile of the education distribution), where α comes from the regression equations described above. While α is a level parameter in the regression, because the outcome is a relative measure, α actually describes the concentration of mortality at the low end of the SES spectrum. The lines tend to be higher for males than for females. The clearest pattern from these graphs is that younger age groups have a greater portion of inequality concentrated at the low end of the SES spectrum. For males aged 25-29, the values range from 1.7 to well above 2.5. For males aged 85-89, however, the values are much closer to 1.0. This is consistent with, but not entirely explained by, the leveling of socioeconomic gradients in mortality at the older ages. The second noticeable pattern is that the concentration of inequality at lower SES values has trended upward over time. In other words, as

time progresses, the reason for rising SES inequality in mortality is increasingly the concentration of inequality at the lower end of the SES spectrum.

Table 2 shows life expectancy at age 25 by SES quintile. These values are computed using the general (not by education) age-specific mortality rates and the regression estimates described earlier. Life expectancy increased for all SES quintiles for both men and women. For men, life expectancy increased more quickly for those in the higher SES quintiles than for those in the lower SES quintiles. This is not the case for women. Women in all five SES quintiles experienced increases in life expectancy between 5.6 and 5.8 years. The difference in life expectancy between the fifth and first SES quintiles increased from 6.6 years to 8.2 years (1.6-year increase) between 1971-1975 and 2001-2005 for men. The difference in life expectancy between the fifth and first SES quintiles did not change for women between 1971-1975 and 2001-2005. However, women did experience a slight decrease in the difference between 1971-1975 and 1986-1990, and then a slight increase from 1996-2000 to 2001-2005.

Table 3 shows counterfactual life expectancies at age 25 by SES quintile. This table answers the question: "If the inequality and skewness parameters (β and α) had not changed over time, but general mortality rates were allowed to vary as observed, then what would happen to SES differences in life expectancy?" We find that if such a scenario held, then the lowest-SES individuals would experience greater increases in life expectancy than the highest-SES individuals. For men, life expectancy among the first quintile would increase from 40.6 to 48.1 years (6.0-year increase), where life expectancy among the fifth quintile would increase from 47.2 to 53.7 years (5.1-year increase). This would shrink the difference in life expectancy between the first and fifth quintiles by 0.9 and 0.4 years for men and women, respectively. Since total (non-education-specific) mortality rates were allowed to vary as observed in the actual

population, total life expectancy in the counterfactual scenario is equal to total life expectancy in the factual scenario.

Discussion and Conclusion

The great majority of contemporary research on socioeconomic gradients in mortality has assumed that the relationship between education categories and socioeconomic status is fixed (Ho and Fenelon 2015; Miech et al. 2011; Montez and Zajacova 2013). That is, individuals with a given level of education and who were born in 1910 would have the same SES as individuals with the same level of education but born in 1980. Given that status is a relational concept – that is, the status of an individual exists only in relative terms (i.e., relative to other individuals in the population) – the empirical fact that education distributions worldwide have been shifting poses a problem precisely because it suggests that the relationship between socioeconomic status and education is changing.

There are two main problems with using observed educational categories as measures of status. The first of these problems is that the education distribution has been shifting over time towards higher levels of education, leaving the lowest education categories smaller in size. This suggests that the relationship between specific education categories and position within the status hierarchy has changed. By implicitly assuming that the relationship hasn't changed, prior studies which measure SES gradients in mortality by using education categories may thus overstate the increase in inequality over time. The second problem is that even within a given time period, different birth cohorts have different education distributions. This is because educational expansion is a cohort phenomenon. People who are 85 or older tend to have relatively little formal education. The great majority of them in Finland have only a basic education or less. People who are in their late twenties or early thirties, on the other hand, have almost all

completed some form of secondary schooling, and many have attended college or university. Thus, within a given time period, a basic education for an 85-year-old may correspond to a medium level of SES, while a basic education for a 25-year-old would correspond to low SES. If we compute a period life table for people with a basic education, as has been done in most previous studies, we are mixing people of different SES levels across age groups.

The first empirical contribution of this study is to identify what appears to be an empirical regularity in the relationship between socioeconomic status and mortality. We find that there is a negative logarithmic relationship between the percentile rank of an individual's education and the ratio of that percentile's mortality to the total mortality rate. We say this relationship is regular because it appears to hold across both sexes, all relevant age groups, and across time. The discovery of this empirical regularity allows us to make our second major empirical contribution.

The second contribution is to develop a new method, which adjusts for cohort differences in the education distribution when computing SES differentials in life expectancy using period life tables. This method uses the fact that there is a negative logarithmic relationship between SES and relative mortality to estimate a two-parameter model, which traces out a relationship between the SES index and mortality. This allows us to construct period life tables corresponding to any arbitrary segment of the SES spectrum. For example, if we wanted to compute a life table for people who fell between the 37^{th} and 63^{rd} percentile of the SES distribution, we can now do so thanks to this method. This is important because it solves the two problems listed above. This method allows us to compute SES gradients adjusting for the fact that the education distribution has been changing over time and across cohorts. This method has further applications in terms of making comparisons across populations (e.g., international

comparisons or comparisons across states), since different populations have differing education distributions.

We apply this new methodology to data from Finland to compute SES quintile-specific life tables in multiple time periods. We find that much of the increase in inequality in life expectancy over time observed when using education categories to compute SES differentials can be explained by the simple fact that the education distribution has shifted over time. Roughly 59% of the increase in inequality for men and 100% of the increase in inequality for women can be attributed to shifting education distributions (even though the inequality parameters increased, women's mortality declined quickly enough to cancel out this increase). This is a surprising finding and suggests that future studies should use this or other methods to adjust for changing education distributions when measuring socioeconomic gradients in mortality. In fact, this issue of changing education distributions is not specific to just mortality —when using education to measure the SES gradient in any outcome (health, fertility, marriage, etc.), one must account for the changing relationship between education and SES.

All of this is not to say that inequality has not increased —it has. The two parameters of the regression model estimated in this paper measure the skewness and level of inequality in mortality. Both of these measures have grown more extreme over time in Finland, suggesting that had inequality not become a stronger force, then SES differences in life expectancy might not have grown and may even have shrunk over time. We show through a counterfactual exercise that had the inequality parameters of the population stayed fixed at their 1971-1975 levels, then the difference in life expectancy between the top and bottom educational quintiles for both men and women would have shrunk over time. Differences in life expectancy would have decreased because overall declines in mortality would have been more equitably shared by people across

the education spectrum.

In the next few weeks, we will analyze U.S. data from the National Longitudinal Mortality Study and the National Health Interview Survey to investigate whether shifting education distributions have a similar effect in the U.S. as in Finland on synthetic cohorts and birth cohorts.

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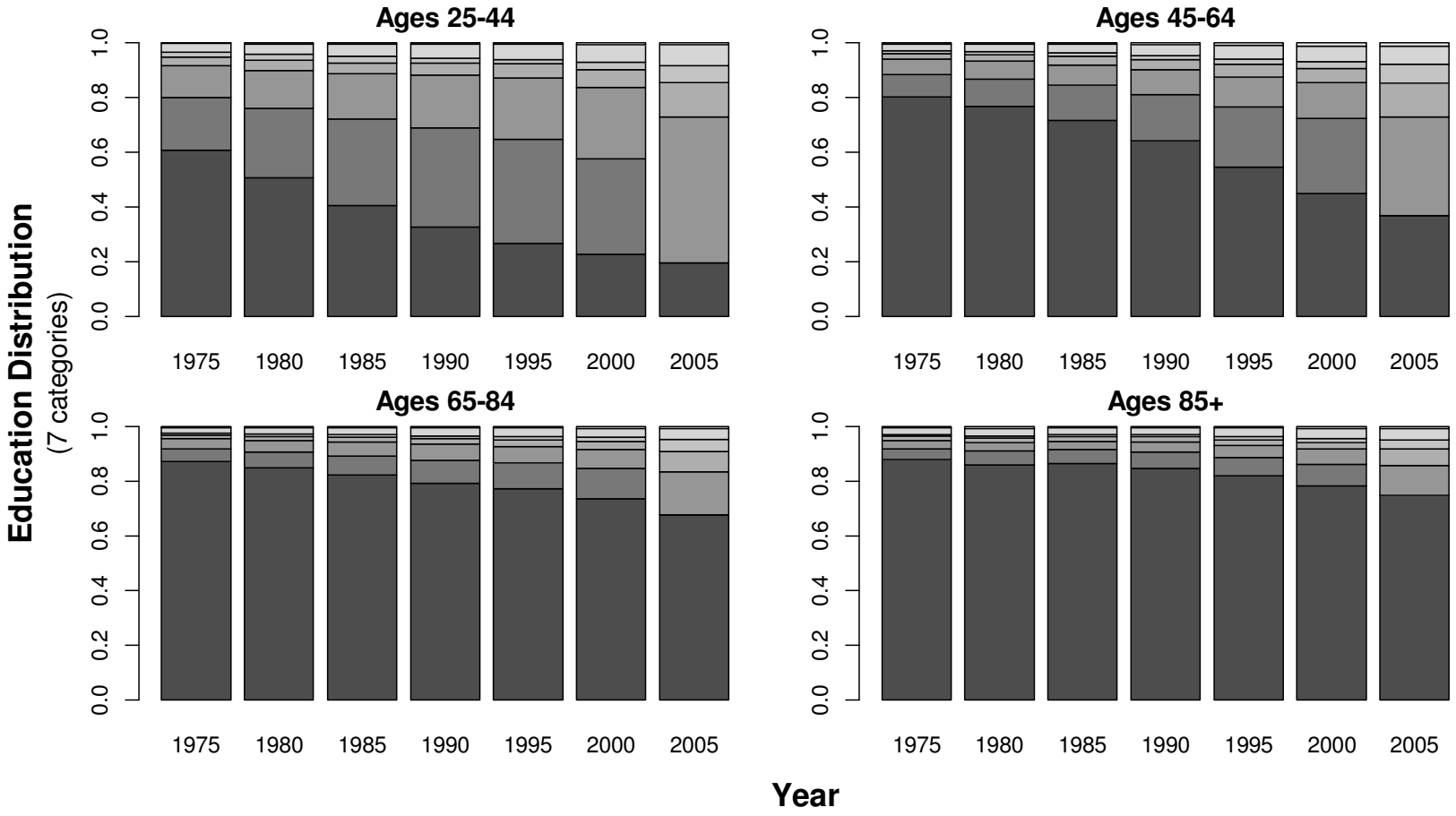
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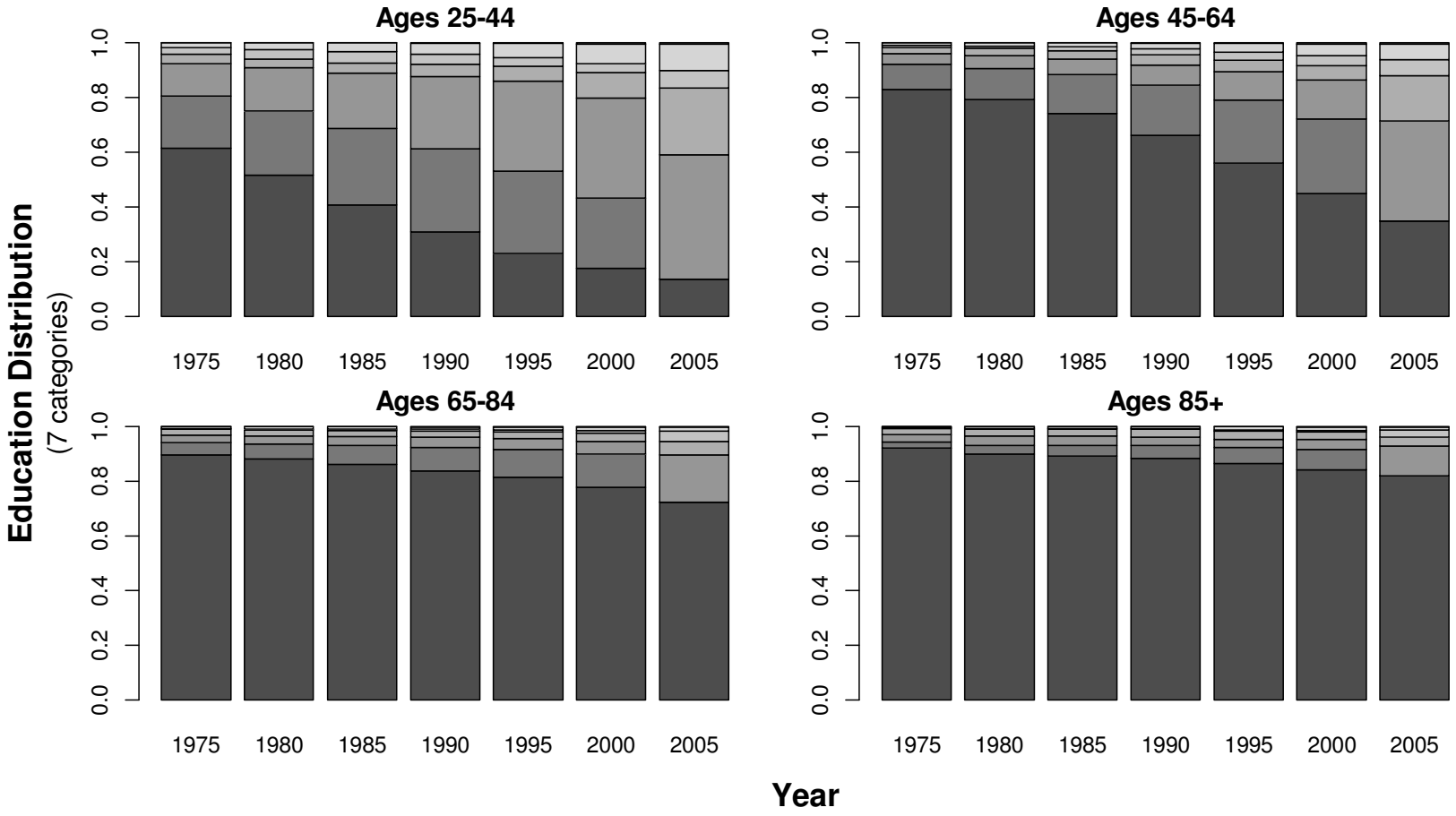
Figure 1. Changing Education Distribution by Age and Year, Males, 1971-2005



Source: Authors' calculations based on Finnish registry data and censuses.

Note: The darker and lighter colors represent lower and higher education categories, respectively. Years on x-axis indicate the end of a period. The education categorization changed for the 2001-2005 period.

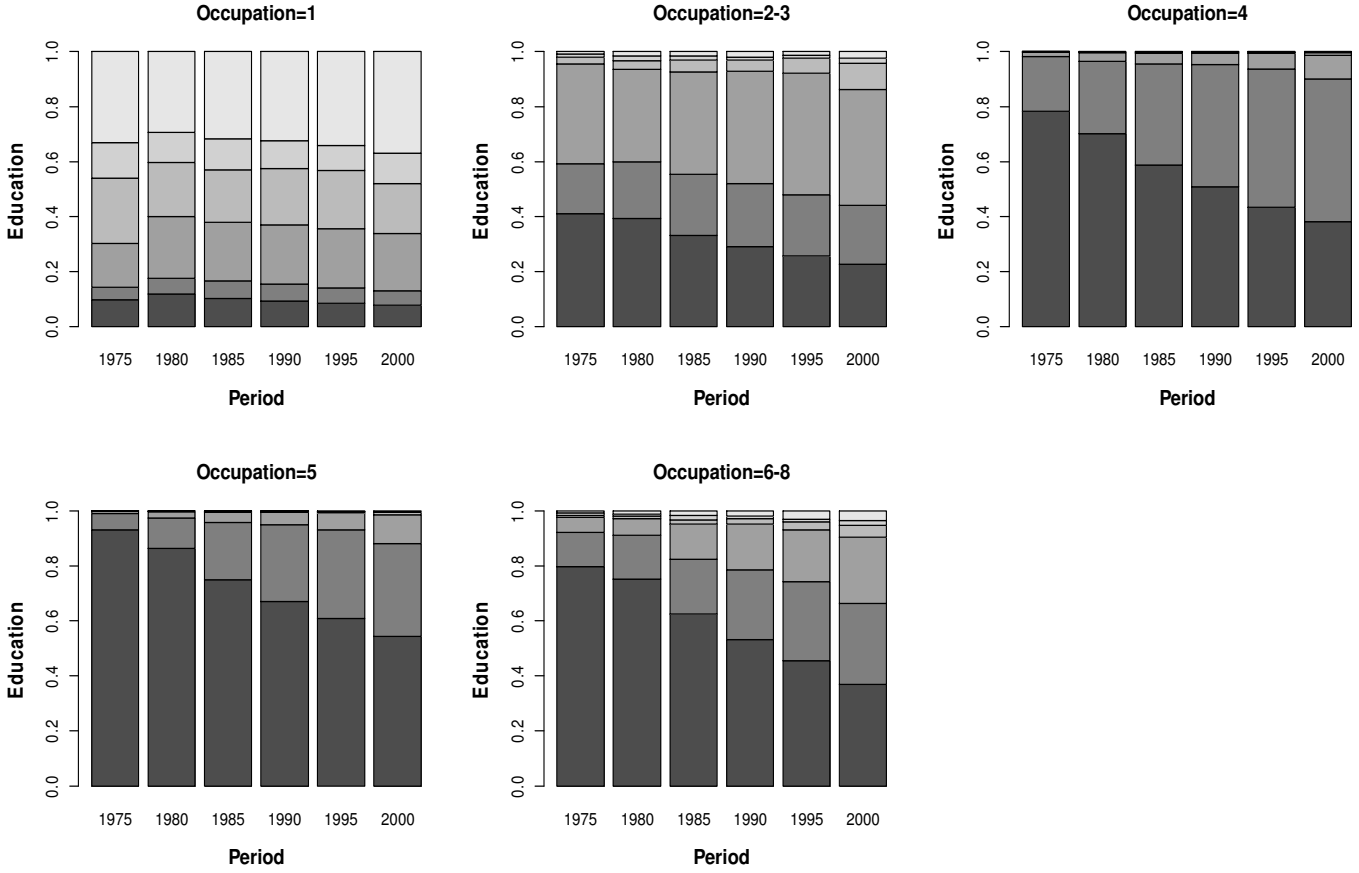
Figure 2. Changing Education Distribution by Age and Year, Females, 1971-2005



Source: Authors' calculations based on Finnish registry data and censuses.

Note: The darker and lighter colors represent lower and higher education categories, respectively. Years on x-axis indicate the end of a period. The education categorization changed for the 2001-2005 period.

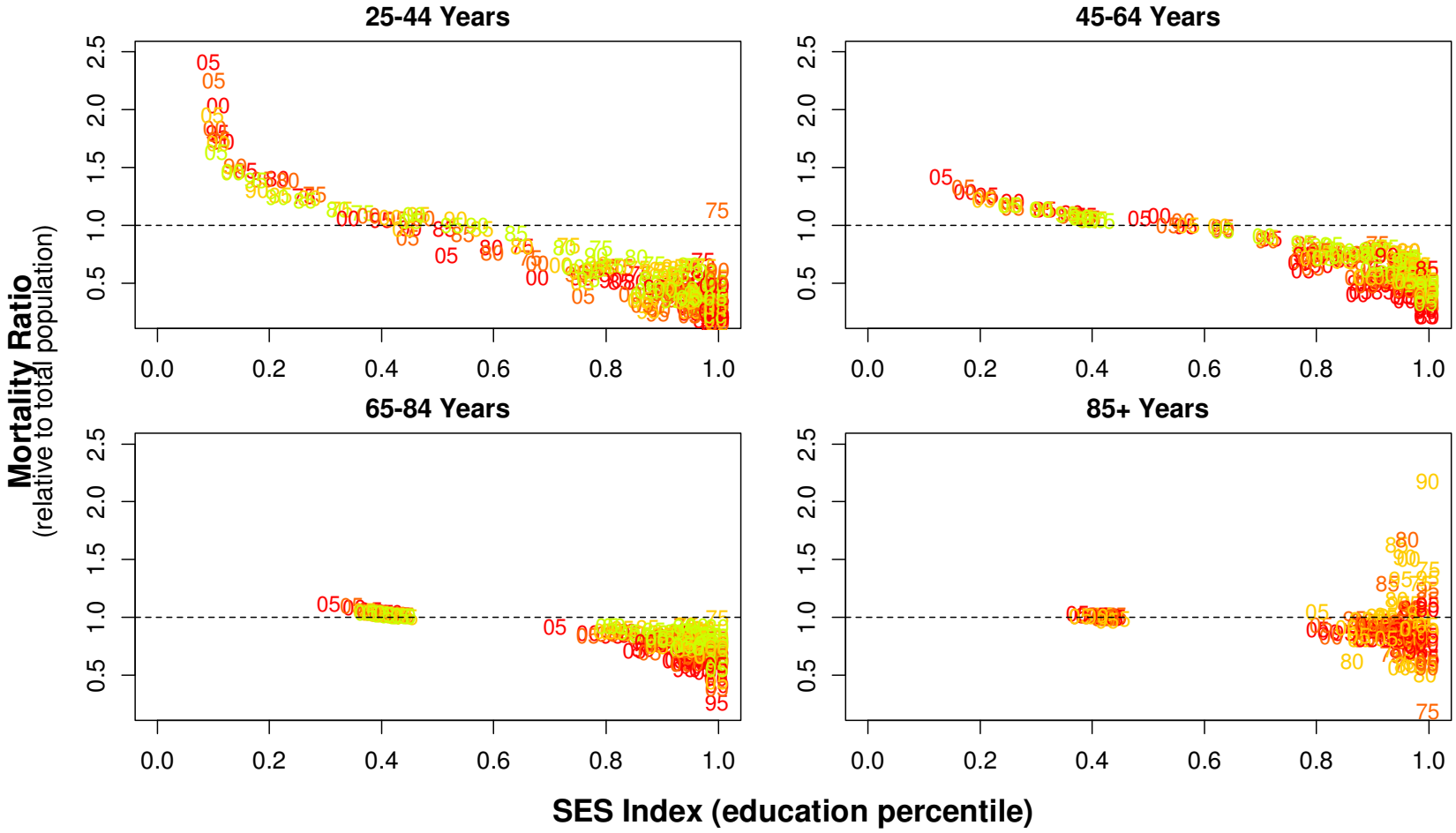
Figure 3. Education Distribution by Occupation Category, Males, 1971-2000



Source: Author's calculations based on Finnish censuses

Note: Lower occupation category numbers correspond to higher social class. The darker and lighter colors represent lower and higher education categories, respectively. Years on x-axis indicate the end of a period.

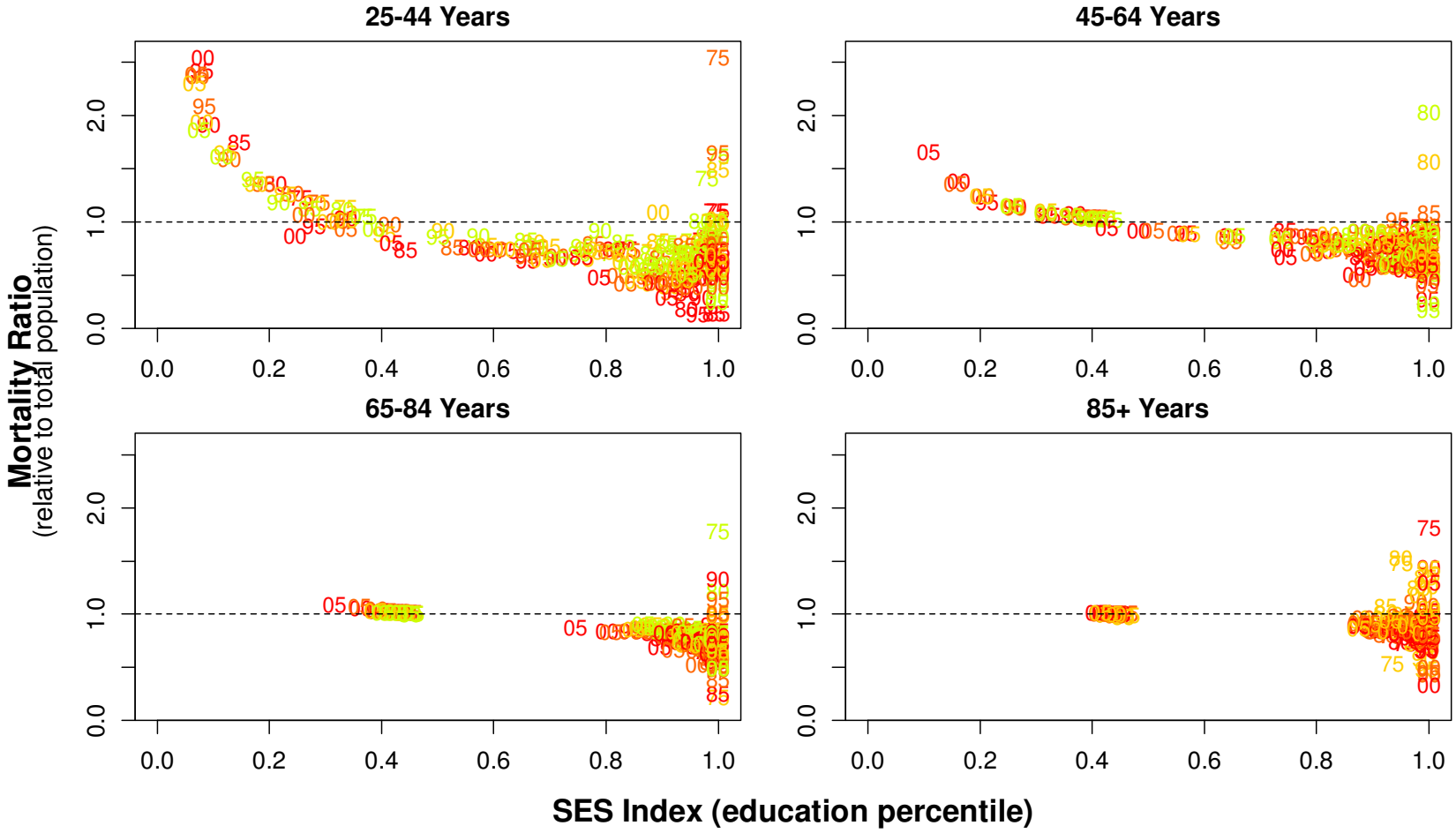
Figure 4. Mortality Ratios by Age and Education Percentile, Males, 1971-2005



Source: Authors' calculations based on Finnish registry data and censuses.

Note: Mortality ratio is the ratio of education-age-specific mortality to general age-specific mortality. The point markers correspond to the end year for each time period, and the color represents each five-year age group, ranging from red (youngest) to green (oldest).

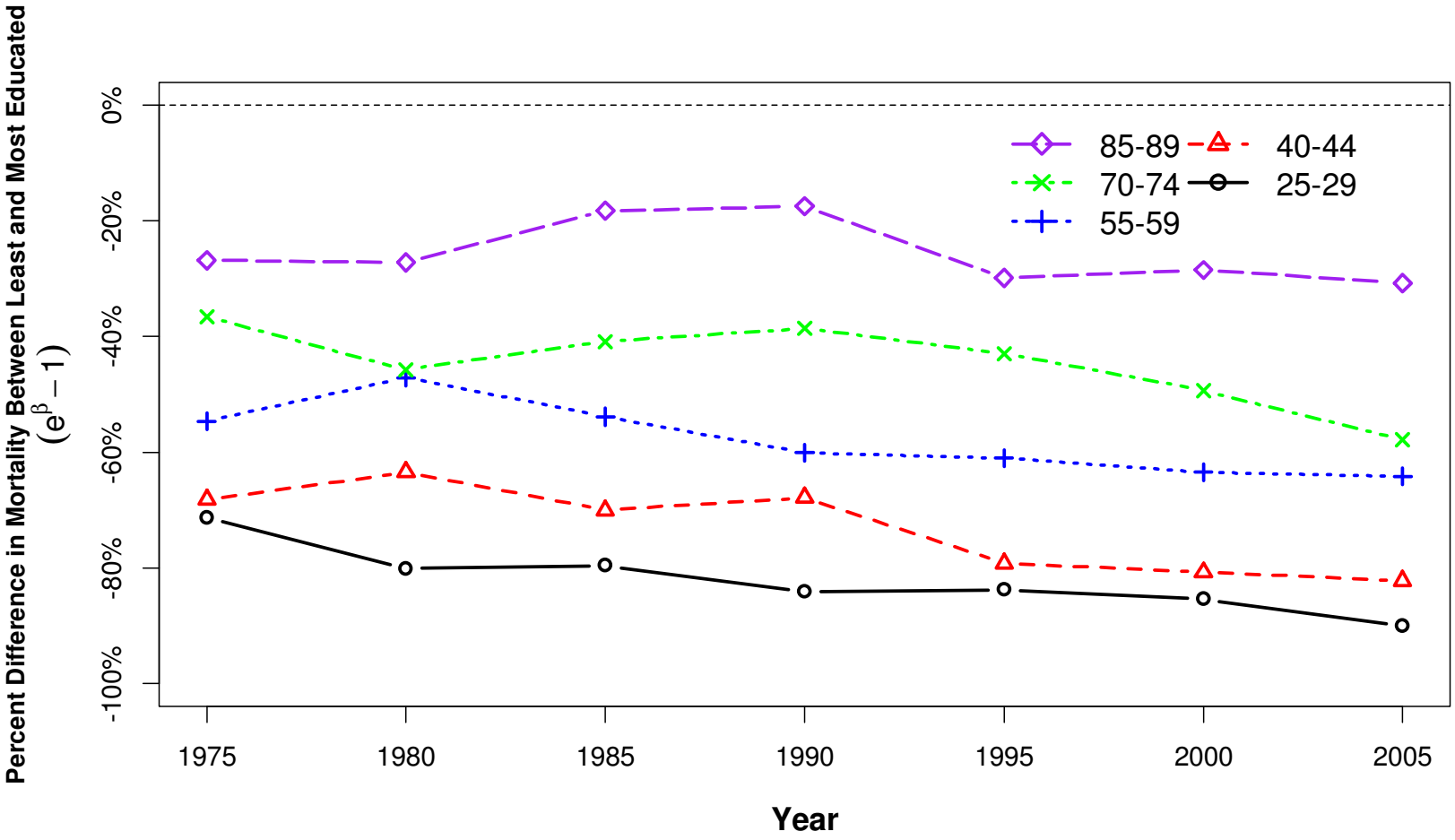
Figure 5. Mortality Ratios by Age and Education Percentile, Females, 1971-2005



Source: Authors' calculations based on Finnish registry data and censuses.

Note: Mortality ratio is the ratio of education-age-specific mortality to general age-specific mortality. The point markers correspond to the end year for each time period, and the color represents each five-year age group, ranging from red (youngest) to green (oldest).

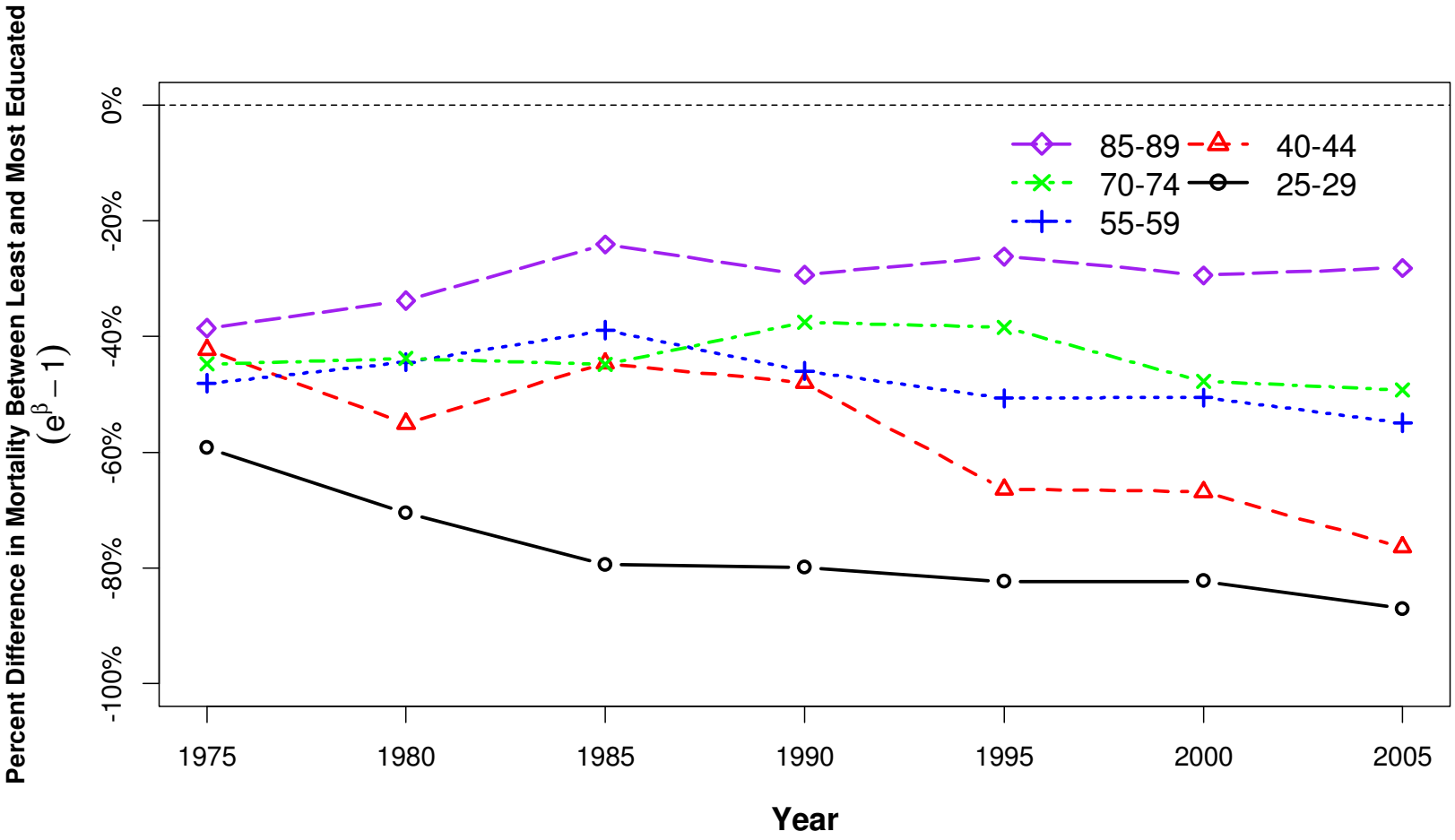
Figure 6. Percent Difference in Mortality Between the Least and Most Educated by Age and Year, Males, 1971-2005



Source: Authors' calculations based on Finnish registry data and censuses.

Note: Values are estimated on the basis of regressions described in the text.

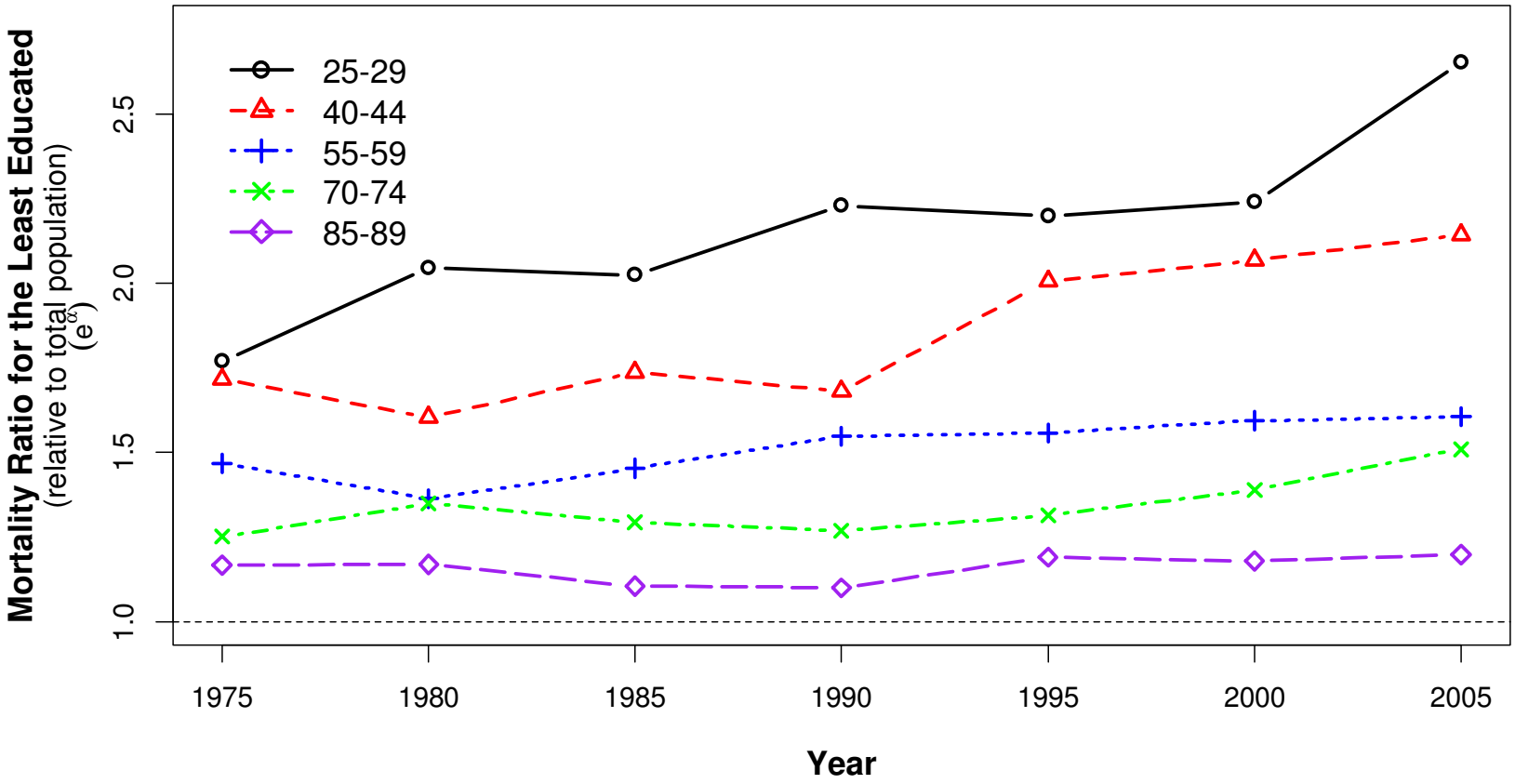
Figure 7. Percent Difference in Mortality Between the Least and Most Educated by Age and Year, Females, 1971-2005



Source: Authors' calculations based on Finnish registry data and censuses.

Note: Values are estimated on the basis of regressions described in the text.

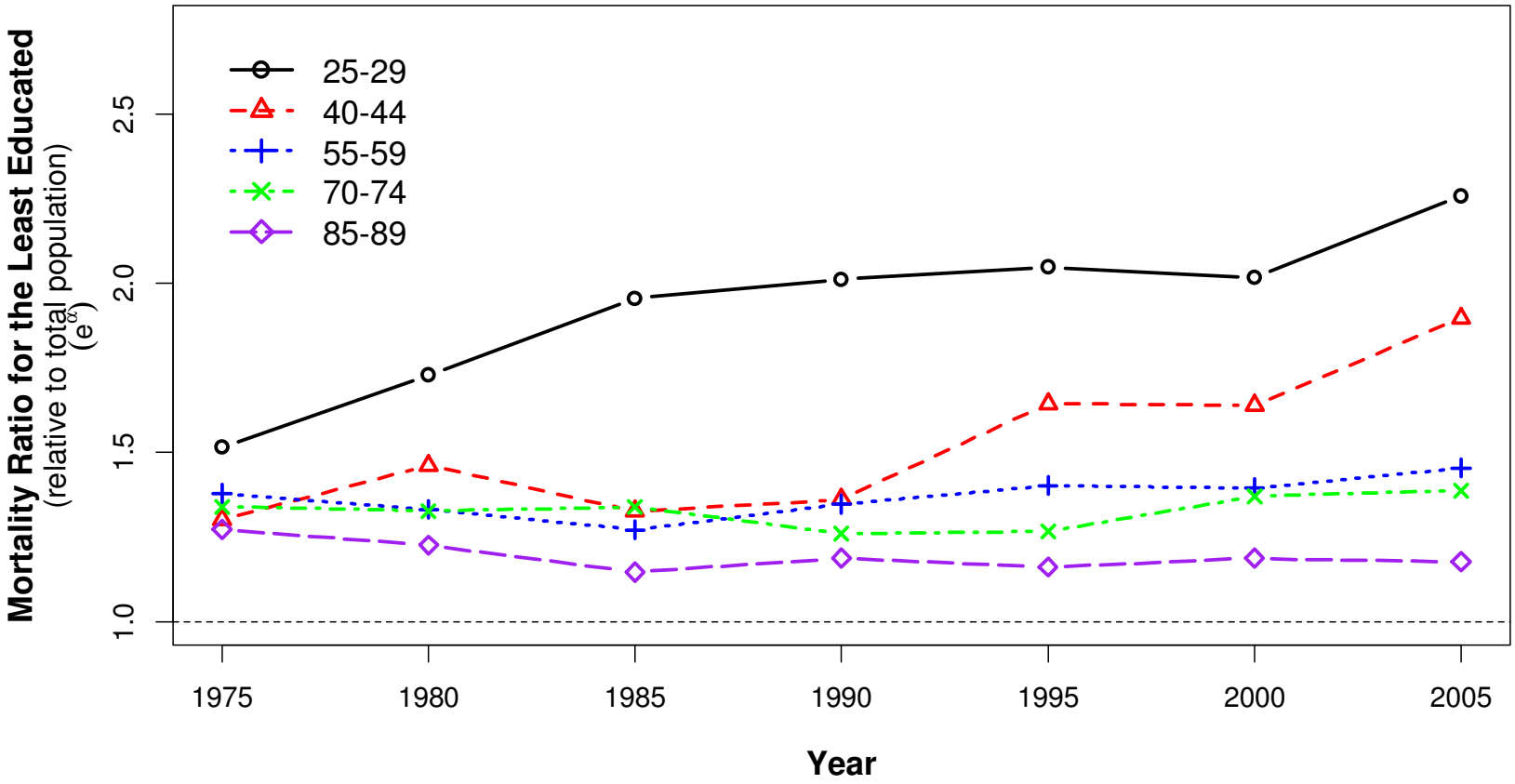
Figure 8. Concentration of Mortality Inequality Among the Least Educated by Age and Year, Males, 1971-2005



Source: Authors' calculations based on Finnish registry data and censuses.

Note: Values are estimated on the basis of regressions described in the text.

Figure 9. Concentration of Mortality Inequality Among the Least Educated by Age and Year, Females, 1971-2005



Source: Authors' calculations based on Finnish registry data and censuses.

Note: Values are estimated on the basis of regressions described in the text.

Table 1. Life Expectancy at Age 25 by Education and Year, Males and Females, 1971-2005

Education Level	Time Period							Change Over Time
Males	***71-75***	***76-80***	***81-85***	***86-90***	***91-95***	***96-00***	***01-05***	***71-75 to 96-00***
1. Basic or None	43.2	44.0	45.3	45.6	46.5	47.4	48.3	4.2
2. Middle School	46.8	47.6	47.8	48.1	49.1	50.1	NA	3.3
3. High School	46.3	47.6	48.9	49.6	50.9	52.3	51.6	6.0
4. Vocational	48.2	49.5	50.7	51.7	52.9	54.4	54.4	6.3
5. Polytechnic	48.0	48.1	49.8	50.7	52.3	54.0	55.6	6.0
6. University Degree	48.5	49.7	50.9	52.4	53.7	55.0	56.1	6.5
7. Graduate Degree	49.1	51.4	51.8	53.2	54.6	56.0	58.1	6.9
Total	44.0	45.0	46.4	47.0	48.3	49.6	51.0	5.6
Difference (7-1)	5.9	7.4	6.5	7.6	8.1	8.5	9.8	2.7
Females	***71-75***	***76-80***	***81-85***	***86-90***	***91-95***	***96-00***	***01-05***	***71-75 to 96-00***
1. Basic or None	51.4	52.8	53.8	53.9	54.4	55.1	55.7	3.7
2. Middle School	54.1	55.0	55.7	55.8	56.6	57.4	NA	3.3
3. High School	54.1	54.9	56.1	56.1	57.1	58.0	58.4	3.9
4. Vocational	54.2	55.9	56.7	57.2	58.1	59.3	59.6	5.1
5. Polytechnic	54.0	56.3	56.5	57.4	57.9	58.7	60.1	4.7
6. University Degree	55.0	56.0	56.8	57.4	58.7	58.6	60.0	3.6
7. Graduate Degree	53.4	53.1	56.1	56.2	57.4	61.1	59.4	7.7
Total	51.8	53.3	54.3	54.6	55.4	56.4	57.4	4.6
Difference (7-1)	2.0	0.3	2.3	2.3	3.0	6.0	3.7	4.0

Table 2. Life Expectancy at Age 25 by SES Quintile and Year, Males and Females, 1971-2005

Education Level	Time Period							Change Over Time
Males	***71-75***	***76-80***	***81-85***	***86-90***	***91-95***	***96-00***	***01-05***	***71-75 to 01-05***
1. First Quintile	40.6	41.6	43.2	43.4	44.4	45.5	46.7	6.1
2. Second Quintile	42.4	43.5	44.9	45.5	46.6	47.9	49.3	6.8
3. Third Quintile	44.1	45.2	46.6	47.3	48.6	49.9	51.4	7.3
4. Fourth Quintile	45.7	46.9	48.1	48.9	50.3	51.8	53.3	7.6
5. Fifth Quintile	47.2	48.4	49.5	50.4	51.9	53.4	54.9	7.7
Total	44.0	45.0	46.4	47.0	48.3	49.6	51.0	7.0
Difference (5-1)	6.6	6.8	6.3	7.0	7.5	7.8	8.2	1.6
Females	***71-75***	***76-80***	***81-85***	***86-90***	***91-95***	***96-00***	***01-05***	***71-75 to 01-05***
1. First Quintile	49.6	51.3	52.5	52.8	53.4	54.4	55.2	5.6
2. Second Quintile	50.7	52.3	53.4	53.7	54.5	55.5	56.4	5.7
3. Third Quintile	51.8	53.3	54.3	54.7	55.5	56.5	57.6	5.8
4. Fourth Quintile	52.9	54.3	55.2	55.6	56.5	57.5	58.6	5.7
5. Fifth Quintile	54.0	55.2	56.1	56.4	57.4	58.4	59.6	5.6
Total	51.8	53.3	54.3	54.6	55.4	56.4	57.4	5.7
Difference (5-1)	4.4	4.0	3.6	3.6	4.0	4.0	4.4	0.0

Table 3. Counterfactual Life Expectancy at Age 25 by SES Quintile and Year Assuming No Change in Inequality, Males and Females, 1971-2005

Education Level	Time Period							Change Over Time
Males	***71-75***	***76-80***	***81-85***	***86-90***	***91-95***	***96-00***	***01-05***	***71-75 to 01-05***
1. First Quintile	40.6	41.8	43.2	43.9	45.2	46.6	48.1	6.0
2. Second Quintile	42.4	43.5	44.9	45.6	46.8	48.2	49.7	5.8
3. Third Quintile	44.1	45.2	46.5	47.2	48.4	49.7	51.1	5.5
4. Fourth Quintile	45.7	46.7	48.0	48.7	49.8	51.0	52.4	5.3
5. Fifth Quintile	47.2	48.2	49.4	50.0	51.1	52.3	53.7	5.1
Total	44.0	45.0	46.4	47.0	48.3	49.6	51.0	5.6
Difference (5-1)	6.6	6.4	6.1	6.2	6.0	5.7	5.5	-0.9
Females	***71-75***	***76-80***	***81-85***	***86-90***	***91-95***	***96-00***	***01-05***	***71-75 to 01-05***
1. First Quintile	49.6	51.1	52.1	52.4	53.3	54.4	55.4	4.8
2. Second Quintile	50.7	52.2	53.2	53.6	54.4	55.4	56.5	4.7
3. Third Quintile	51.8	53.3	54.3	54.6	55.4	56.5	57.5	4.6
4. Fourth Quintile	52.9	54.4	55.4	55.7	56.5	57.5	58.5	4.5
5. Fifth Quintile	54.0	55.5	56.4	56.7	57.5	58.4	59.4	4.4
Total	51.8	53.3	54.3	54.6	55.4	56.4	57.4	4.6
Difference (5-1)	4.4	4.4	4.3	4.3	4.2	4.1	4.0	-0.4