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Franz Schwarz

Widening Educational Differentials in Mortality: Analysis for Austria with International Comparisons

Vienna Institute of Demography
Austrian Academy of Sciences

Prinz Eugen-Straße 8-10 · A-1040 Vienna · Austria

E-Mail: vid@oeaw.ac.at
Website: www.oeaw.ac.at/vid

Abstract

Recent studies have reported a widening in the relative mortality gap between the socioeconomic classes in several industrialized western countries. The present paper aims to determine whether or not education-related differentials in mortality have increased between 1981/82 and 1991/92 in Austria, and compares the findings with those from other European countries, the USA and New Zealand. For the Austrian analysis the source of the data is based on a one year mortality follow up of the entire Austrian census population, and contains for the examined population aged 30-74 in total 3,805,208 individual records for 1981/82 and 4,064,184 records for 1991/92 of which 34,218 and 29,443 were deceased. The study applies a sophisticated measure of inequality that takes into account the relative position of the educational groups, since changing educational compositions over time may reduce comparability. The findings suggest that educational inequalities in mortality have widened in Austria, but more among men than among women. The Austrian results are similar to patterns observed in the other countries. However, the international trends vary with regard to age groups and sex.

Keywords

Mortality, Socioeconomic, Differentials, Inequalities, Education, Relative Index of Inequality, Austria

Author

Franz Schwarz is a research scientist at the Vienna Institute of Demography, Austrian Academy of Sciences. Mailing Address: Vienna Institute of Demography, Prinz Eugen Strasse 8, 2nd floor, 1040 Vienna, Austria. E-mail: Franz.Schwarz@oeaw.ac.at. Phone: +43 1-515-81-7720. Fax: +43 1-515-81-7730.

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1. Introduction

The inverse relationship between social class and mortality is a well-documented fact (i.e. Kitagawa and Hauser 1973, Kunst 1997, Whitehead and Diderichsen 1997, Spijker 2004). Recent studies from several countries, however, reported a widening in the relative mortality gap between socioeconomic groups: In the United States, there were few differentials among whites in 1960 (Kitagawa and Hauser 1973), but findings for the 1980s suggest substantial educational differentials in mortality (Feldman et al. 1989, Pappas et al. 1993, Preston and Elo 1995). In Europe, an EU-sponsored project on monitoring of socioeconomic inequalities in mortality and morbidity also produced evidence from all monitored countries towards a widening of relative inequalities in mortality between the early 1980s and early 1990s, while the absolute gap remained about the same (Kunst et al. 2004). Other European studies as well as a study from New Zealand additionally suggest a widening of the social class gradients, depending on sex and age (Pamuk 1985, Dahl and Kjaersgaard 1993, Regidor et al. 1995, Drever and Buntig, Whitehead and Diderichsen 1997, Harding et al. 1997, Valkonen 2001, Blakely et al. 2005).

In Austria, socioeconomic mortality inequalities were reported for the years 1981/82 (Doblhammer 1997) as well as for 1991/92 (Schwarz 2006). Doblhammer et al. (2005) recently reported a widening gap between 1981/82 and 1991/92 in educational and occupational differentials in all-cause mortality. The present article reconsiders the changes in the educational differentials in mortality for Austria during the 1980s, using a regression-based measure of inequality, the *Relative Index of Inequality*. This measure takes into account differences in the educational distributions between different populations or time periods. First, the measure is applied to examine how much education-related differentials in all-cause mortality have increased between 1981/82 and 1991/92 in Austrian adults aged 30–59 and 60–74, taking into account changes in the relative position among the educational groups. Such change in distribution may be partly responsible for the increased gap, because a decreasing number of people with a low level of education and an increasing number of people with a high level of education means that the relative position of those with less education will worsen. Complementary, age-standardized death rates, rate ratios and rate differences are also used. Second, the *Relative Index of Inequality* is applied to examine whether specific patterns exist in international trends in educational mortality inequalities with regard to sex and age, and whether the Austrian trends differ from any international findings. The first part of the study, however, provides a thorough overview on the international literature and research findings on trends in socioeconomic mortality differentials.

2. Research on Trends in Socioeconomic Mortality Differentials

2.1. United Kingdom

The country with the longest tradition of reporting social health and mortality inequalities is England. Occupational mortality reports for England and Wales have been published by the Registrar General since 1851. Analyses of mortality by occupationally defined social class started with the report for 1921–23 for both working and retired adult males, for females analyzed by the social class of their husband, and for infants classified by the occupation of the father. Pamuk (1985) tried to determine whether or not sufficient confidence can be placed in the trend in social class mortality differentials indicated by these reports from 1921 to 1972, which account for potential sources of bias in the database that could affect measurements. The findings suggest that class inequalities in mortality among working and retired adult males declined in the 1920s and increased again during the 1950s and 1960s. In the early 1970, differentials were greater than they had been in 1920, in both absolute and relative terms.[1] For married women, a similar increase was observed in the inequalities between the reports for 1949–53 and 1970–72. On the other hand, social class differentials in infant mortality have declined considerably in absolute terms. Considering the trend of declining inequalities relative to the trend of declining overall death rates, however, social class inequalities among infants are similar to that for adults.

Drever and Buntig (1997) analyzed trends in mortality for the period between the 1971 to the 1991 censuses for men aged 20–64. Their findings suggest a relative widening of occupationally defined social class differentials over the 1970s and 1980s, from a two-fold difference in 1970–72 to almost a three-fold difference in 1991–93 between the highest and the lowest social classes. Harding et al. (1997) used data from the Office of National Statistics Longitudinal Study (LS) to investigate social class trends in mortality among men and women aged 35–64 accounted for in the 1971 Census, subsequently following up to 1992. The LS is a representative one-percent sample of the population of England and Wales that begun in the early 1970s containing linked census and vital statistics data for approximately 500,000 people. Their study found also clear evidence of widening social class inequalities among working-age males and females, due to the greater decline in death rates among groups of non-manual vs. manual (i.e. white-collar vs. blue-collar) workers.

2.2. European Continent

In Austria, Doblhammer et al. (2005) recently reported a widening gap in educational and occupational differentials in all-cause mortality, in both relative and absolute terms, between 1981/82 and 1991/92. With regard to age-specific analyses, the increase was restricted to men aged 50–74, while mortality differentials at younger and older ages alike

[1] The cited studies measured mortality inequalities in absolute and relative terms. Absolute inequalities are differences in mortality rates among socioeconomic groups. Relative inequalities are the ratio of mortality rates among the socioeconomic groups.

remained unchanged or underwent a slight decrease for both men and women. Multivariate analyses among men show increasing educational differentials for the age group 35–64—independent of corrections for occupational status—but little change in the relative mortality risks for males aged 65–89. For females, educational differentials remained unchanged for both age groups. Occupational inequalities among young females tended to lessen. Age-standardized death rates for the age groups 35–65 and 65–89 show widening disparities in absolute terms for younger females as well. The calculation of relative changes in death rates between 1981/82 and 1991/92, however, also reveals increasing relative educational differentials in mortality for the older age group (65–89) and for women from both age groups. For instance, among older females who had completed their compulsory education (elementary and lower secondary levels), death rates decreased by 13.5% over the ten-year period under study; at the same time, these rates were as high as 17% for those who had completed upper secondary and/or university education. For older men, the relative decline was 12.3% for those who had completed compulsory education and 17.4% for those who had completed tertiary education.

Valkonen et al. analyzed socioeconomic mortality inequalities in Finland from the 1970s to 1995 (Valkonen et al. 1990, Valkonen et al. 1993, Valkonen 1999, Valkonen 2001). Their main finding suggest a widening gap in life expectancy at age 35 between male blue-collar workers and upper-class male white-collar employees from 4.5 years in 1972/74 to 6.1 years in 1993/95. Among women, the gap increased from 2.3 years to 3 years. The results are approximately the same when the level of education is used as the socioeconomic indicator. A recent study, based on an EU-sponsored project on monitoring socioeconomic inequalities vis-à-vis mortality and morbidity, presented findings indicating changes in socioeconomic inequalities related to mortality between the early 1980s and the early 1990s in nine Western European countries (Kunst et al. 2001, Kunst et al. 2004). In Finland, the magnitude of relative inequalities in mortality between blue-collar and white-collar groups of men aged 30–59 increased in this short period with statistical significance: from a rate ratio of 1.63 to 1.96; the difference in absolute mortality increased from 2.75 to 3.28 deaths per 1,000 person-years.

In Denmark, findings for the economically active male population suggest a decline in mortality rates by more than 25% among white-collar employees and skilled workers from 1971/75 to 1991/95, while among unskilled workers and farmers, this decline is just 12% (Valkonen 2001).

Dahl and Kjaersgaard (1993) described trends in mortality by occupational class in Norway for the periods from 1960–65, 1970–75 and 1980–85 for those economically active at the time of the census. Their findings suggest that, among men, differentials were much greater in 1985 than they had been in 1965. Among women, no clear trend could be identified. According to a more recent comparative European study (Kunst et al. 2004),the magnitude of relative inequalities in mortality between blue-collar and white-collar groups of men aged 30–59 showed a statistically significant increase from a rate ratio of 1.42 to 1.56 between the periods 1980–84 and 1990–94, while the absolute gap remained about the same.

For Sweden, a 1995 study by Vagero and Lundberg revealed increased mortality differentials from 1961–65 to 1981–86 between blue-collar workers and white-collar male employees, in both absolute and relative terms. There was almost no decline in all-cause mortality among manual workers, and cardiovascular mortality increased in this group—while among the white-collar employees, both overall mortality and cardiovascular mortality declined noticeably (Valkonen 2001). In the period from the early 1980s to the early 1990s, the magnitude of relative inequalities in mortality between white-collar and blue-collar groups of men aged 30–59 showed a statistically significant increase from a rate ratio of 1.51 to 1.64; the absolute gap, on the other hand, decreased only slightly (Kunst et al. 2004).

For the Southern European countries, there are no studies on trends in socioeconomic mortality differentials that cover the national population; however, there are studies for the City of Turin, Italy, by Costa et al. in 1998, as well as findings for Spanish provinces (Regidor et al. 1995). In Turin, census records from 1971, 1981 and 1991 of both men and women were linked with death records. The findings show that differences among the two highest educational categories had remained about the same, while the differences for those with no education or elementary education departed significantly over time from those highly educated. For women, educational differentials increased over time as well between the 1970s and the 1990s (Valkonen 2001).

Regidor et al. (1995) used information from death certificates in 1980–82 and 1988–90 from eight Spanish provinces on males who died between age 30 and 64. They applied the mortality registry for the numerator and the census for the denominator, rather than linking individual cases directly. The main purpose of their study was to compare mortality from the leading causes of death among professionals and managers vs. those among manual workers. With regard to all-cause mortality, mortality between these two groups increased from a rate ratio of 1.27 in 1980–82 to 1.72 in 1988–90. Kunst et al. (2004), however, considered these results somewhat surprising, since in the very short period of eight years, rate ratios would had increased to a relatively large extent in comparison to other European countries. After closer inspection of the data, Kunst et al. (2004) suggest that the results may be biased due to the numerator-denominator problem. This problem occurs when two different datasets are used for calculating death rates (Macintyre 1997).

Most Eastern European countries lack reliable data and results on mortality trends by socioeconomic status. So far, there has been only the study by Shkolnikov et al. (1998) that deals with trends in educational differentials among Russians between 1979 and 1994. Socioeconomic inequalities in mortality in the early 1980s were at least as sizeable as they were in the Western countries. During the transition period from 1988–89 to 1993–94, overall mortality increased substantially. However, among those with a lower educational level, mortality increased more rapidly than for those with a higher one, resulting in a widening gap between men and women. Shkolnikov et al. (1998) relates the widening of this inequality in mortality to the vast increase in alcohol-related deaths and the excessive consumption of alcohol among people with a lower level education.

2.3. United States

For the United States, Feldman et al. (1989), Pappas et al. (1993), and Preston and Elo (1995) concluded that educational disparities widened between 1960 and the 1980s, depending on age, race and sex. All three studies replicated or used the analyses by Kitagawa and Hauser (1973) on differential mortality in 1960 and compared them with outcomes from the 1980s using different data sources. Kitagawa and Hauser's findings of the Matched Record Study 1960 suggest that there were scant educational differentials in mortality in the United States among white people. Feldman et al. (1989) examined changes in educational differentials in mortality for middle-aged and older white men and women in the United States with the 1971–1984 data from the first National Health and Nutrition Examination Survey (NHANES I). They concluded that among men, death rates declined more rapidly for the higher educated than for the lower educated, while among women, death rates declined at about the same rate regardless of education. Pappas et al. (1993) used records from the National Mortality Followback Survey and the National Health Interview Survey, both conducted in 1986. Their findings for people aged 25–64 suggest increasing mortality disparities based on income and educational level, regardless of race, sex, and family status. Inequalities according to educational level increased for both whites and blacks by over 100% in men, and—contrary to the findings of Feldman et al. (1989)—also among women by over 20%. Preston and Elo (1995) reconsidered these two studies by introducing a better-suited, much broader data source, the National Longitudinal Mortality Survey 1979–85. Analogous to Pappas et al. (1993), they found widening educational mortality inequalities for males but narrowing figures for females aged 25–64. Further, inequalities diverged more in those aged 65–74 than in the working-age population—for both sexes.

Schalick et al. (2000) investigated the change in mortality inequalities from 1967 to 1986 for persons aged 35–64 years by income level, using the National Health Interview Surveys 1967 and the National Mortality Followback Surveys 1986. The findings suggest that the inverse relationship between mortality and income was greater in 1986 than in 1967 for both men and women as well as for both blacks and whites. Between 1967 and 1986, death rates for those in the upper-income bracket declined between two and three times more rapidly than did rates for the middle- and low-income groups did. The greatest increase in relative inequality was seen among white males.

2.4. Other Countries

A recently published study by Blakely et al. (2005) reported mortality trends by socioeconomic status in New Zealand for the periods 1981–84, 1986-89, 1991–94 and 1996–99. Their findings suggested that absolute socioeconomic inequalities in mortality among males and females aged 25–77 years were on average stable over the 1980s and 1990s, whereas relative inequalities increased. The relative inequalities in mortality among males and females aged 25–77 years increased more when using income as the measure of socioeconomic position than when using education. Increasing socioeconomic inequalities in all-cause mortality over time were most notable among 25–44-year-olds. Educational inequalities in mortality tended to be greater than income inequalities among 25–44-year-olds, while the opposite was found for 45–59 and 60–77-year-olds.

For Canada, Wilkins et al. (2002) examined trends in mortality by neighborhood income in urban Canada from 1971 to 1996, using small-area-based socioeconomic data. Their findings suggest, contrary to others, that differences in life expectancy between the richest and poorest income quantiles diminished by well over one year for each sex, from 6.3 to 5.0 years for males and from 2.8 to 1.6 years for females. Neighborhood income disparities in mortality also diminished for most causes of death. Turrell and Mathers (2001) used small-area-based socioeconomic mortality data for Australia. Their findings suggest that the highest death rates occur in the most disadvantaged areas. Depending on sex and age, increases and decreases in mortality inequality were observed between 1985–87 and 1995–97.

Altogether, the findings from all countries observed—that is England and Wales, Finland, Norway, Sweden, Denmark, Austria, Italy, Spain, Russia, the USA, New Zealand, and Australia—provided evidence for a widening of mortality inequalities over the last few decades. Nonetheless, the results vary with regard to sex and age. Diminishing differences were only observed for Canada; however, that study used small-area-based socioeconomic data and is hardly comparable with studies that used individual-level data.

3. Data and Methods

3.1. Data

To form a mortality follow-up study of the entire Austrian population, the census cohorts from 1981 and 1991 were linked with death register records of those who died within one year after the respective reference date for the census (census day). The data set contains for the examined population aged 30–74 in total 3,805,207 individual records for 1981/82 and 4,064,184 records for 1991/92 of which 37,064 and 29,443 were deceased.

The Austrian census and the death registry were merged according to address, sex and birth date, as well as by marital status and year of marriage. In the death registry 90,693 records in total were registered between the census day 12 May 1981 and 13 May 1982, and 83,324 records between census day 15 May 1991 and 14 May 1992. In the Austrian provinces about 92% of these records were linked to the census; in Vienna, it was just around 88% in 1981/82 and 85% in 1991/92. This means that around 10% of the deaths in the death register could not be linked to the census. The merging rate depended on peoples' mobility before death. Because old people often move to nursing homes or in with relatives due to their need for care, the merging rate decreases at a more advanced age. In Vienna, the number of old people living alone is higher than in the provinces, which partly may explain the lower success rate of merged cases. In addition, the higher proportion of foreigners in Vienna may also have caused a lower merging rate.

A result of the missing merged death is that the calculated death rates are around 10% lower than actual death rates would be. Since principally just ratios of the death rates were considered, the missing deaths do only matter if the merging rates vary by level of education. Thus, the present study assumes equal merging rates for each sub-population. Because of the high percentage of linked cases, however, the bias would be negligible even when more deaths of those with lower education were linked to the census than deaths among those with higher education.

3.2. Socioeconomic Status

For the assessment of social inequalities, educational level is one of the most important indicators of social stratification and has become the main social variable in epidemiological and demographic research, for two important reasons: Unlike occupation and income, education remains virtually constant throughout adulthood and is available for all adults, whether or not they are currently in the labor force. Furthermore, education is influenced less by health problems that develop in adulthood (Preston and Elo 1995, Davey Smith 1998). For these reasons, education was chosen as the indicator of social status in this study.

The educational distribution in a country strongly depends on its educational system. Austria has a free public school and university system. Nine years of education (eight years before 1962)—are compulsory. This so called compulsory education consists normally of primary and lower-secondary school. Thereafter, many educational paths are possible, and thus, many types of higher educational attainment exist. To ensure a sufficient population size in each category, the levels of education were combined as follows:

1. *Low*: Compulsory education (8–9 years of schooling)
2. *Middle*: Apprenticeship or vocational school (10–11 years of schooling)
3. *High*: Upper-secondary school that ends with the Matura (university entrance degree), a diploma from an academy or prep school, or a college or university degree (12 or more years of schooling).

Table 1 lists population and deaths according to education and sex for the working-age population (30–59 years) and for older people (60–74 years), with age at the time of the census. It shows that the educational distribution changed considerably from 1981/82 to 1991/92. While the proportion of those with less education declined, the percentage of those with more increased. Noticeable is the high percentage of less-educated females, while only a small proportion of females have a high level of education—especially among the older age group. This results in a very small number of deaths for highly educated females (3% in 1981/82), which causes great statistical variation.

People older than 74 were excluded from the analyses because of diminishing socioeconomic inequalities in mortality with increasing age among men, resulting most likely from a systematic selection of robust individuals. Since the number of deaths also increases extensively, the results for a broader age group of, for example, 60–89-year-olds would be dominated by those who are very old. Hence, only a few educational mortality differentials would be observed for the entire group aged 60–89, even if large differentials existed for those aged 60–74. Furthermore, because of co-morbidity at a more advanced age, it becomes increasingly difficult to accurately determine the main cause of death. Another reason to limit the maximum age to 74 concerns average life expectancy, which in 1991 was around 75 years for both sexes together. By referring to this period-lifetable concept, the study can be interpreted as an examination of educational disparity in premature mortality among adults.

Table 1: Percentage of population and deaths in each educational category, by sex and age group, Austria, 1981/82 and 1991/92

Education	Males				Females			
	30–59 years		60–74 years		30–59 years		60–74 years	
	1981/82	1991/92	1981/82	1991/92	1981/82	1991/92	1981/82	1991/92
Population								
Low	35.1	25.4	45.8	39.2	57.9	43.7	75.2	67.6
Middle	51.1	56.9	42.1	46.6	33.8	43.0	20.1	25.4
High	13.7	17.6	12.1	14.3	8.3	13.4	4.7	7.0
N	1,367,950	1,519,864	387,957	426,571	1,440,704	1,504,472	608,596	613,277
Deaths								
Low	46.9	38.0	49.7	45.7	68.9	57.4	78.6	72.8
Middle	45.5	53.9	41.8	44.3	25.4	35.0	18.3	22.2
High	7.6	8.2	8.5	10.0	5.8	7.6	3.0	4.9
Deaths[2]	7,520	6,461	13,904	11,059	4,005	3,257	11,635	8,666

3.3. Measures

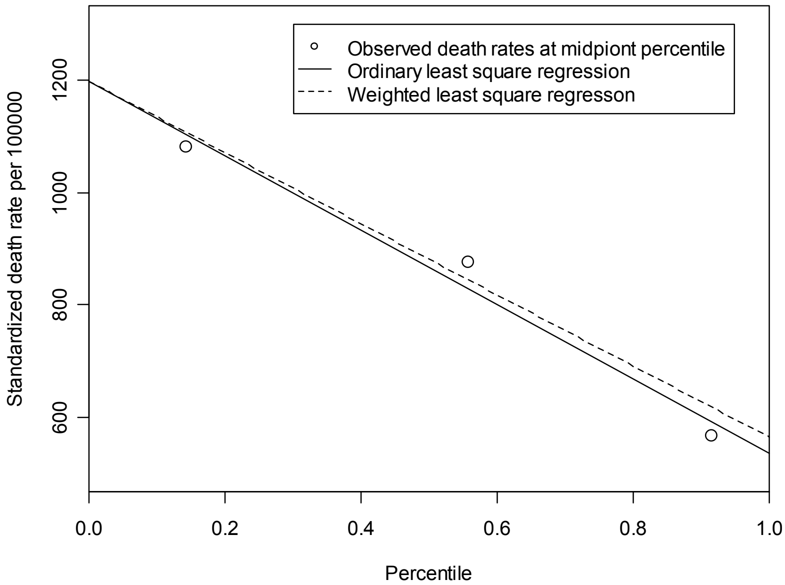
3.3.1. Index of Inequality

The age-standardized mortality rates in this study were calculated with the direct method for each sex and year of death (1981/82 and 1991/92), using the total population 1991/92 as the standard population and 5-year age groups. Rate ratios and rate differences were calculated directly by dividing, or subtracting respectively, the age-standardized rates of the two groups. A disadvantage of the rate-ratio measure is that it does not include other levels of education than those of the two opposing groups. Therefore, the rate ratio of the least vs. the most educated neglects those at the middle level. In the case of clearly hierarchical categories, the regression-based *Slope Index of Inequality* (SII) and its relative counterpart, the *Relative Index of Inequality* (RII) explain inequalities with one single value that comprises all categories at once. The basic concept of these inequality measures was introduced by Preston, Haines and Pamuk in 1981 (c.f. Pamuk 1985, Preston and Elo 1995). The SII and RII take into account the relative position and size of the educational groups, which is very useful when populations differ in their distribution with respect to the inequality variable, or when the distribution changes over time. In Austria, for example, the educational distributions of men and women differ substantially.

[2] Merged deaths only; The actual number of deaths is around 5-10% higher.

The SII is obtained by arranging the education groups from lowest to highest on a horizontal axis and computing the cumulative proportionate distribution of the population. As a result, each group covers a range on the x-axis proportional to its population size on a scale from 0 to 1. Then the age-standardized death rate of each education group is plotted against the midpoint of the percentile range of the respective education group (c.f. Figure 1). The regression line for the relation between the death rates y and the midpoints on the cumulative education distribution x has the form $y = \alpha + \beta x$. The regression slope β is then the SII (Pamuk 1985, Hayes and Berry 2002). The values $x = 0$ and 1 represent extreme hypothetical subgroups and do not correspond to the lowest and highest categories.

Figure 1: Age standardized death rates plotted against the midpoint of the percentile range of the education distribution from lowest to highest education, together with the predicted regression lines.



With the assumption of a linear relationship between education and mortality, the SII can be interpreted as the average change in standardized death rates moving from the lowest level to the highest. A positive value for the slope indicates that mortality increases with higher levels of education, and vice versa on the negative side of the slope. Mortality and education, however, are inversely related in the vast majority of causes of death. To obtain positive values for an inverse association, a minus sign is put in front of the formula:

$$SII = -\beta . \tag{1}$$

The interpretation, then, is that a greater value of the SII indicates a more extreme inverse relationship between mortality and education. In order to minimize the effect of deviant rates from categories with a small number of cases, Pamuk (1985) applied weighted least-square regression (WLS) with the weights proportional to the population size.

In most applications, it is more appropriate to consider the relative rather than the absolute effect. The *Relative Index of Inequality* (RII) was introduced by Pamuk (1985) as

$$RII = -\frac{\beta}{\bar{y}}, \tag{2}$$

where β is the regression slope and $\bar{y}$ is the overall mean death rate. The RII indicates the mean proportionate decline in mortality when levels advance from the lowest to the highest. A positive value indicates that mortality decreases with increasing education; a negative RII means that mortality rises with increasing education. When ordinary least-square regression (OLS) is applied, then $\bar{y} = 1/k\sum_{i=1}^{k} y_i$, where the y_i are the age-standardized death rate (SDR) for the k educational categories. Using weighted least square regression requires weighing the standardized death rates according to the population size n, $\bar{y} = 1/k\sum_{i=1}^{k} y_i n_i$. In that case, $\bar{y}$ is approximately equal to the overall age-standardized death rate for all educational categories combined.

Kunst and Mackenbach (1994) used not only the regression slope β for the relation between death rates and midpoints on the cumulative educational distribution, but also the constant α. Their *Relative Index of Inequality*

$$RII_{KM} = \frac{\alpha}{\alpha + \beta}, \tag{3}$$

measures the ratio of the mortality of the hypothetically most disadvantaged ($x = 0$) to the most advantaged ($x = 1$).

3.3.2. Variance of the SII and RII

The variance of the regression coefficient β can be estimated in two ways. The conventional approach is simply to use the standard deviation about the fitted regression line,

$$\text{var}(\beta) = \frac{\sigma_\varepsilon^2}{\sum_{i=1}^{k}(x_i - \bar{x})^2}, \tag{4}$$

where the residual variance σ_ε^2 is estimated by

$$s_\varepsilon^2 = \frac{1}{k-2}\sum_{i=1}^{k}(y_i - \hat{y}_i)^2 .$$

If a real linear relation is assumed, this would be the appropriate choice. However, in the present application, there is no *a priori* assumption of a necessarily linear relationship. The fitting of a straight line can rather be considered as a convenient approximation of a general trend (Hayes and Berry 2002). This leads to an alternative approach, namely to ignore non-linearity and instead use the standard deviation SE(y_i) of the age-standardized death rates for each of the k educational categories. The variance of y is simply the average of the k variances,

$$\text{var}(y) = \frac{1}{k}\sum_{i=1}^{k}\text{SE}(y_i)^2 . \tag{5}$$

Hence, the variance of the SII is

$$\text{var}(SII) = \text{var}(\beta) = \frac{\text{var}(y)}{\sum_{i=1}^{k}(x_i - \bar{x})^2}, \tag{6}$$

with $\bar{x} = 1/k\sum_{i=1}^{k} x_i$ when OLS is used, and $\bar{x} = 0.5$ when WLS is applied. The variance of the RII is

$$\text{var}(RII) = \text{var}\left(\frac{\beta}{\bar{y}}\right) = \frac{\text{var}(\beta)}{\bar{y}^2}. \tag{7}$$

Hayes and Berry (2002) considered the calculation of the standard error for the Kunst-Mackenbach *Relative Index of Inequality* $RII_{KM} = \alpha/(\alpha + \beta) = \gamma$. According to the regression equation the constant $\alpha = \bar{y} - \beta\bar{x}$, then

$$\gamma = \frac{\bar{y} - \beta\bar{x}}{\bar{y} + \beta(1 - \bar{x})}. \tag{8}$$

The variance of γ then depends on the variances of β and $\bar{y}$. Hayes and Berry (2002) suggest an approximate estimation of the variance of γ, as follows:

$$\text{var}(\gamma) = \left(\frac{\delta\gamma}{\delta\bar{y}}\right)^2 \text{var}(\bar{y}) + \left(\frac{\delta\gamma}{\delta\beta}\right)^2 \text{var}(\beta), \tag{9}$$

This gives

$$\text{var}(\gamma) = \frac{\beta^2 \,\text{var}(\bar{y}) + \bar{y}^2 \,\text{var}(\beta)}{\left[\bar{y} + \beta(1 - \bar{x})\right]^4}, \tag{10}$$

with

$$\text{var}(\bar{y}) = \frac{1}{k^2}\sum_{i=1}^{k} \text{SE}(y_i)^2, \tag{11}$$

where the SE(y_i) are the standard errors of the age-standardized death rates. Hayes and Berry (2002) recommend working with the natural logarithm of γ; subsequently,

$$\text{var}\left[\ln(\gamma)\right] = \frac{\beta^2 \,\text{var}(\bar{y}) + \bar{y}^2 \,\text{var}(\beta)}{\left[\bar{y} - \beta\bar{x}\right]^2 \left[\bar{y} + \beta(1 - \bar{x})\right]^2} \tag{12}$$

The confidence interval of γ is then calculated as $\text{CI}(\gamma) = \exp\{\ln(\gamma) \pm c \cdot \text{SE}[\ln(\gamma)]\}$, where $\text{SE}[\ln(\gamma)] = \sqrt{\text{var}[\ln(\gamma)]}$ and c represents the critical value from the appropriate test distribution. Alternatively, the variability in $\bar{y}$ may be ignored; hence,

$$\text{var}\left[\ln(\gamma)\right] = \frac{\bar{y}^2 \,\text{var}(\beta)}{\left[\bar{y} - \beta\bar{x}\right]^2 \left[\bar{y} + \beta(1 - \bar{x})\right]^2}. \tag{13}$$

4. Results

4.1. Educational Mortality Differentials in Austria

As Table 2 shows, educational inequalities in mortality are evident for both age groups and sexes, and there has been a decline in age-standardized death rates for each level of education from 1981/82 to 1991/92. However, while the relative declines in the death rates turned out to be greater with increasing level of education for both age groups and sexes (Figure 2), the results for the absolute decline in the death rates are mixed.

Among men aged 30–59 years, the absolute decline in death rates was highest among middle-educated men (0.98 deaths per 1,000 person-years) and lowest among highly educated working-age males (0.86 deaths per 1,000 person-years). In relative terms, however, mortality decreased most among the most educated (27.1%) and least for those with a low level of education (14.5%). Among females aged 30–59, the absolute changes in death rates were about the same for all levels of education, but in relative terms the decline in the death rates increased with an increasing level of education (-12% to -17.6%). The death rates among older men declined significantly more as the educational level increase with a decline of 14.1% for less educated and 26% for high educated older men. The absolute decline was 4.99 deaths per 1,000 for those with the least education, while among those with middle education it was 6.55 deaths per 1,000 person-years. Among older females, differences in the absolute and relative decline of death rates are minor; but, here again, the relative decline rises slightly with an increasing level of education from -18.2% to -22.2%.

Table 2: Age-standardized mortality rates, and absolute and relative change from 1981/82 to 1991/92 in Austria, by education, sex and age group (95% confidence intervals in parentheses)

	Age-standardized death rates per 1,000				Change from 1981/82 to 1991/92			
	1981/82		1991/92		Absolute		Relative in %	
30–59 years								
Males								
Low	5.51	(5.29-5.73)	6.44	(6.23-6.66)	-0.93	(-1.24--0.62)	-14.5	(-18.9--9.9)
Middle	4.15	(4.01-4.29)	5.13	(4.95-5.30)	-0.98	(-1.20--0.76)	-19.0	(-22.8--15.1)
High	2.32	(2.11-2.52)	3.18	(2.92-3.44)	-0.86	(-1.20--0.53)	-27.1	(-35.4--17.8)
Females								
Low	2.45	(2.33-2.56)	2.78	(2.67-2.89)	-0.33	(-0.49--0.18)	-12.0	(-17.2--6.5)
Middle	1.96	(1.84-2.07)	2.26	(2.12-2.40)	-0.31	(-0.49--0.12)	-13.6	(-20.7--5.8)
High	1.70	(1.47-1.92)	2.06	(1.78-2.33)	-0.36	(-0.72--0.01)	-17.6	(-31.7--0.4)
60–74 years								
Males								
Low	30.29	(29.46-31.11)	35.28	(34.42-36.13)	-4.99	(-6.18--3.80)	-14.1	(-17.2--11.0)
Middle	25.59	(24.88-26.29)	32.14	(31.29-32.99)	-6.55	(-7.66--5.45)	-20.4	(-23.4--17.3)
High	17.76	(16.72-18.80)	24.01	(22.65-25.38)	-6.25	(-7.97--4.53)	-26.0	(-31.8--19.7)
Females								
Low	15.14	(14.77-15.51)	18.50	(18.12-18.89)	-3.36	(-3.89--2.83)	-18.2	(-20.8--15.5)
Middle	12.82	(12.25-13.39)	16.45	(15.74-17.15)	-3.63	(-4.54--2.72)	-22.1	(-26.7--17.1)
High	10.34	(9.36-11.31)	13.28	(11.90-14.66)	-2.94	(-4.64--1.25)	-22.2	(-32.4--10.4)

Figure 2: The relative (log scale) decline in mortality rates from 1981/82 to 1991/92 in Austria, by education, sex and age group

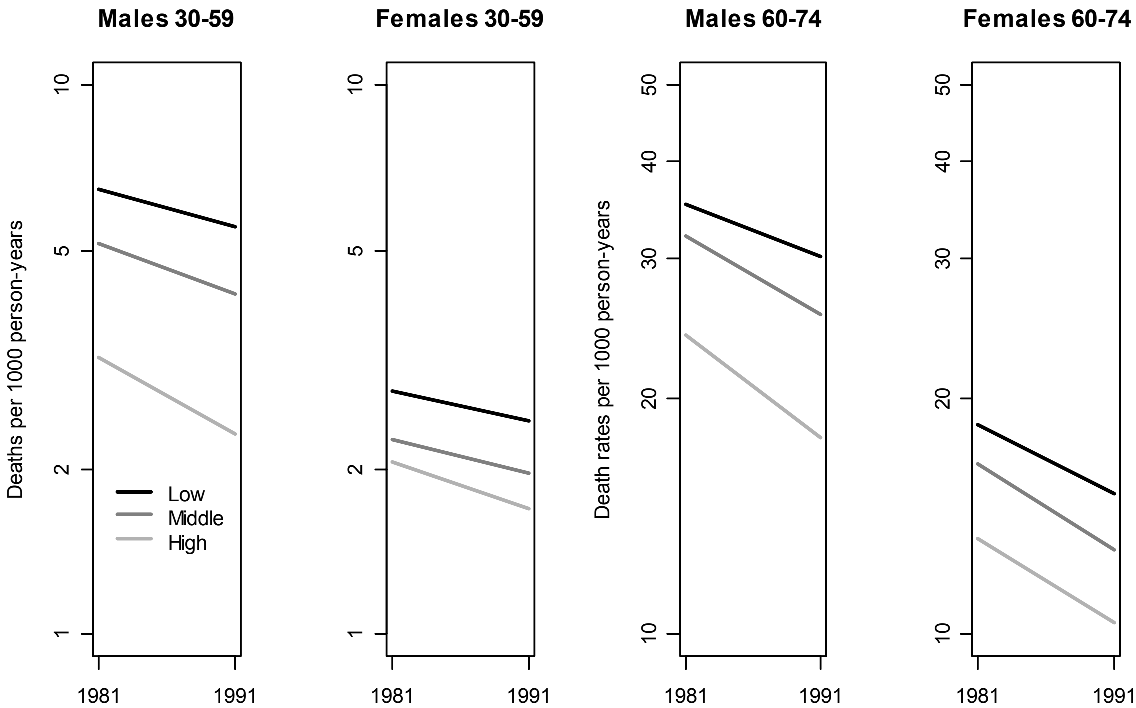


Table 3 shows rate ratios and rate differences of lowest versus highest level of education, as well as the *Slope Index of Inequality* (SII) and the *Relative Index of Inequality* (RII). A disadvantage of the rate-ratio measure is that it does not include the mortality level of the middle educational level, nor does it take into account any changes in the relative position among the educational groups between 1981/21 and 1991/92. The regression-based *Slope Index of Inequality* and the *Relative Index of Inequality*, on the other hand, do (c.f. Section 3.3). Among working-age males, the ratio in mortality rates between highest and lowest level of education has widened from a 2.03-fold differential in 1981/82 to a 2.38-fold gap in 1991/92, while in absolute terms the differences stayed at about 3.2 deaths per 1,000 person-years. The SII among men aged 30–59 is 4.25 in 1981/82 and 4.06 in 1991/92. This can be interpreted as the difference in the death rates between the hypothetically least and the hypothetically most educated persons was slightly higher in 1981/82. The RII—which can be interpreted as the ratio of death rates between the hypothetically most disadvantaged to the most advantaged—has increased from 2.37 to 2.96 for men aged 30–59. Among men aged 60–74, educational inequalities in mortality have not only increased substantially in relative terms but in absolute terms as well.

For women, the changes in educational inequalities in mortality were much smaller than for men in absolute and relative terms. Among younger females there was no change in the SII, and just a slight increase in the RII from 1.54 to 1.66. Among older females the SII decreased from 7.47 to 4.07 deaths per 1,000 between the hypothetically least and most educated; and RII rose slightly from 1.53 to 1.66. The outcomes for the rate differences and rate ratios are similar to them of the SII and the RII.

Table 3: Indices of inequality, Austria, 1981/82 and 1991/92 (95% CI in parentheses)

Sex and age	Rate difference lowest vs. highest educational level (per 1,000)		Rate ratio lowest vs. highest educational level		Slope Index of Inequality[3] (SII)		Relative Index of Inequality (RII)	
30–59 years								
Males								
1981/82	3.26	(2.92-3.61)	2.03	(1.85-2.22)	4.25	(3.84-4.66)	2.37	(2.10-2.69)
1991/92	3.19	(2.89-3.49)	2.38	(2.16-2.62)	4.06	(3.71-4.40)	2.96	(2.59-3.37)
Females								
1981/82	0.72	(0.43-1.02)	1.35	(1.18-1.55)	1.09	(0.70-1.48)	1.54	(1.25-1.90)
1991/92	0.75	(0.50-1.00)	1.44	(1.25-1.66)	1.06	(0.74-1.37)	1.66	(1.37-2.00)
60–74 years								
Males								
1981/82	11.26	(9.65-12.88)	1.47	(1.38-1.56)	15.02	(12.95-17.10)	1.61	(1.48-1.75)
1991/92	12.53	(11.20-13.85)	1.71	(1.60-1.82)	16.69	(15.03-18.36)	1.95	(1.78-2.13)
Females								
1981/82	5.22	(3.79-6.66)	1.39	(1.25-1.55)	7.47	(5.41-9.53)	1.53	(1.29-1.82)
1991/92	4.80	(3.76-5.85)	1.46	(1.33-1.62)	7.07	(5.58-8.56)	1.66	(1.41-1.96)

4.2. International Comparisons

Table 4 presents the RII for educational differentials in mortality in the early 1980s and the 1990s in five European countries and New Zealand, and in the USA for the years 1960 and 1979–84. To reveal possible variations in the age-specific trends between the countries, a distinction was made between age groups of younger, middle-aged, and older adults. Kunst et al. (2001 and 2004) expressed relative inequalities in mortality by means of the RII, which has the advantage of taking into account differences in educational distribution between age groups, in particular the fact that younger people have higher levels of education. For the USA, relative inequalities were measured by the SII divided by the overall death rates, for males and females aged 25–64 and 65–74 for 1960 and the period 1979–85.

[3] In the present paper, a positive SII indicates an inverse relation between mortality and education, while the slope would actually be negative (c.f. measures in Section 3).

Table 4: Relative index of inequality (RII) for educational differentials in mortality among younger, middle-aged, and older adults in several countries, early 1980s and 1990s, by sex

Country	Age	Males				Females			
		Early 1980		1990s[d]		Early 1980		1990s[d]	
Austria	30-44	3.48	(2.54-4.77)	3.10	(2.50-3.83)	1.42	(1.01-2.00)	1.80	(1.38-2.35)
	45-59	1.80	(1.61-2.02)	2.55	(2.23-2.92)	1.56	(1.24-1.96)	1.61	(1.28-2.02)
	60-74	1.61	(1.48-1.75)	1.95	(1.78-2.13)	1.53	(1.29-1.82)	1.66	(1.41-1.96)
Finland[a]	30-44	2.87	(2.63-3.14)	3.36	(3.11-3.64)	2.13	(1.84-2.48)	3.29	(2.89-3.75)
	45-59	2.16	(2.02-2.30)	2.22	(2.09-2.36)	1.63	(1.47-1.80)	1.92	(1.75-2.10)
	60-74	1.72	(1.63-1.80)	1.80	(1.72-1.88)	1.67	(1.57-1.78)	1.61	(1.52-1.70)
Norway[a]	30-44	3.16	(2.79-3.59)	3.85	(3.42-4.35)	1.46	(1.23-1.73)	2.45	(2.08-2.90)
	45-59	1.87	(1.76-1.99)	2.48	(2.31-2.67)	1.63	(1.49-1.79)	2.01	(1.81-2.22)
	60-74	1.43	(1.38-1.49)	1.70	(1.63-1.77)	1.49	(1.42-1.57)	1.78	(1.69-1.88)
Denmark[a]	30-44	1.98	(1.77-2.20)	2.86	(2.58-3.16)	1.50	(1.31-1.71)	2.04	(1.79-2.34)
	45-59	1.47	(1.37-1.57)	1.75	(1.65-1.86)	1.49	(1.37-1.63)	1.61	(1.50-1.73)
City of Turin[a]	30-44	1.92	(1.50-2.46)	3.02	(2.28-4.02)	1.05	(0.78-1.42)	1.62	(1.11-2.37)
	45-59	1.44	(1.28-1.61)	2.03	(1.77-2.34)	1.12	(0.95-1.32)	1.24	(1.03-1.50)
	60-74	1.35	(1.24-1.46)	1.43	(1.32-1.56)	1.45	(1.29-1.61)	1.36	(1.22-1.53)
New Zealand[b]	25-44	2.5	(1.8-3.5)	3.0	(2.3-4.0)	1.8	(1.3-2.4)	2.4	(1.7-3.3)
	45-59	1.7	(1.4-2.0)	2.3	(2.0-2.6)	1.7	(1.3-2.2)	1.9	(1.6-2.2)
	60-77	1.5	(1.3-1.6)	1.4	(1.3-1.5)	1.6	(1.4-1.8)	1.6	(1.5-1.7)
		1960		1979-85		1960		1979-85	
USA[c]	25-64	-0.49		-0.80		-0.56		-0.41	
	65-74	-0.13		-0.54		-0.44		-0.55	

[a] Source: Kunst et al. (2001 and 2004)

[b] Source: Blakely et al. (2005)

[c] Source: Preston and Elo (1995); presented measure is the *Slope Index of Inequality* divided by the overall mean death rate, which is called also called *Relative Index of Inequality* (cf. Section 3.3); no confidence intervals available; white males and females only.

[d] Austria: 1991/92; Finland, Norway, Denmark, Turin: 1990-94; New Zealand: 1996-99

Educational inequalities in mortality were evident in all countries, and differentials decline with increasing age more for men than for women. Young and middle-aged men were most affected by the widening educational disparities in mortality between the early

1980s and the 1990s. Austrian men aged 30–44 departed from this pattern, with a slight decrease in the RII over the 1980s. Finnish men aged 45–59 also departed from the general pattern, with almost no change in the gap during the 1980s. Among older men, a notable widening of the gap occurred in Austria, Norway, Denmark, and the USA. For females, the widening of the gap tended to be greater among younger women than among middle-aged women. Apart from the USA, among females the age group of 30–44 years was most affected by the widening educational inequalities. Among older females, a notable widening of the gap only occurred in Norway, Denmark and the USA. The RII presented in Table 4, however, partly have a large statistical variability, especially in the estimates for people aged 30–44.

5. Discussion

The study confirms the inverse relationship between education and mortality and shows that, in Austria, the gap in all-cause mortality has widened from 1981/82 to 1991/91. Educational inequalities in mortality, however, have increased more among males than among females. The slight decrease in the mortality gap among Austrian men aged 30-44, though, is rather surprising and may be a result of statistical variation. In general, the patterns of educational inequalities in mortality in Austria are similar to those of other European countries, the USA or New Zealand. In the Nordic European countries, however, working-age females are more affected by the widening gap; and in Finland, Turin and New Zealand, older males seem to be hardly affected by the increase in the gap, in comparison to the other countries observed.

Trends in social differentials for heart-disease mortality were responsible for much of the trend for all-cause mortality in several European countries (Valkonen 2001) and in the USA (Feldman et al. 1989). Here, the upper socioeconomic groups have benefited more from the decline in cardiovascular mortality. Other increased social inequalities in diseases may also be responsible for the widening social gap in mortality. For instance, lung-cancer mortality contributed to the increase in the gap in Norway and England (Valkonen 2001). However, Valkonen (2001) suggests in his comparative European study that the contribution of causes is not systematic and one should not generalize.

The single most responsible factor for the trend in cause-specific mortality may be the divergence in health behavior. Feldman et al. (1989) assume that people of higher socioeconomic status may have adopted healthy lifestyles more rapidly. Valkonen (2001) suggests that the upper socioeconomic groups have benefited more from the trend in declining cardiovascular disease mortality because they may have more quickly adopted the recommended health behaviors with regard to diet, smoking and physical activities, and they may have had better access to new medical treatments. Valkonen (2001) assumes, however, that the lower social classes may perhaps adopt the same health behaviors as the higher classes and will benefit from modern medical treatments when they become standard techniques. As a result, the gap in mortality may decline in the future.

Changes in the relative position among educational groups may also be partly responsible for the increased gap. For instance, a decreasing percentage of people with a low education means that their relative position worsens. As a result, they may become an even more disadvantaged group. By using the regression-based *Relative Index of Inequality* the relative position of the educational groups was taken into account

The purpose of this study, however, was not to find explanations for the trends in educational inequalities in mortality but to confirm the patterns of a widening of the gap in the industrialized countries. The patterns may be mixed among countries when we distinguish between age groups and men and women, but the general trend points to increasing inequalities. The increase in socioeconomic mortality disparities indicates greater social inequalities in general, which require considerable political and societal efforts. Equal access to national health-care systems may improve health for the disadvantaged. However, Pamuk (1985) showed that in England, social inequalities in mortality were increasing despite of the introduction of the *National Health Service* in 1948. The *US Social Security Act* that established *Medicare* and *Medicaid* in the USA in 1965 could not prevent increasing mortality disparities, either (Feldman et al. 1989). In Austria, everyone has a basic right to use the facilities made available by the Austrian health system. This means that everybody is entitled to preventive examinations, medical treatment, free medicine, dental treatment, nursing care at home or as an in-patient, payment of ambulance costs, etc. Regardless of these positive health-care conditions, the differentials have increased.

To find reliable explanations for the increasing educational gap in mortality, more studies are required. Accordingly, the next chapters examine the educational gradient in cause-specific mortality and changes over time. Future research will also study education-specific health and lifestyle trends over the last decades.

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