EVIDENCE BASED PUBLIC HEALTH POLICY AND PRACTICE

Change in the total and independent effects of education and occupational social class on mortality: analyses of all Finnish men and women in the period 1971–2000

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Objectives: To estimate changes in the total and independent effects of education and occupational social class on mortality over 30 years, and to assess the causes of changes in the independent effects.

Methods: Census records linked with death records for 1971–2000 for all Finns aged 30–59 years were studied. The total and independent effects of education and social class on mortality were calculated from relative risks in nested Poisson regression models.

Results: Among men and women, the model shows that the total effects of education, and particularly occupational social class on mortality, have increased over time. Among 40–59-year-old people, the effects of education are currently less independent of social class than in the 1970s, but among younger Finns the independent effects have remained stable. The effects of social class on mortality that are independent of education have grown among people of older ages, particularly among men.

Conclusions: Changes in the independent effects of socioeconomic measures on mortality are determined by changes in their associations with mortality, and distributional changes that affect the strength of the associations between these measures. Distributional changes are driven by changes in educational systems and labour markets, and are of major importance for the understanding of socioeconomic inequalities in mortality.

Education and occupational social class—two key indicators of socioeconomic position^{1 2}—are strong predictors of mortality for most causes of death. Furthermore, relative and in some cases absolute differences in mortality have increased in the past 15–25 years in several European countries and in the US.^{3–15} However, the causes of trends in socioeconomic differences in mortality are not fully understood. Education and social class are not simply interchangeable, but emphasise different aspects of social stratification.^{1–2 16–25} Education reflects the experiences of early life, a time when educational qualifications are usually obtained and when seeds are laid for many health behaviours, attitudes and ability to obtain and make use of health knowledge that may last till later life. Occupational social class, on the other hand, mirrors experiences and exposures in adult life. These are often considered to reflect material resources relevant for health and status, but may partly relate to the sphere of work itself—for example, exposure to industrial accidents and poisonous substances, and also the degree of control over the pace and content of work.

However, the two measures are also closely associated. Education is strongly associated with the kinds of jobs that people can hold, and is thus a major determinant of adult occupational social class. Because of this causal primacy of education, part of the total effects of education on mortality are mediated through social class (ie, social class is on the causal pathway from education to mortality), and conversely also part of the effects of social class are explained by education (ie, education precedes social class on the causal pathway). The arrows in fig 1 depict the effects of education that are independent of social class (E_i), the effects of social class that are independent of education (SC_i) and the effects of education that are mediated by social class (E_m). From the point of view of social class differences in mortality, this latter pathway coincides with the effects of social class that are explained by education (SC_e). The total effect of education (E_t) is the sum of

the two pathways E_i and E_m , and the total effect of social class (SC_t) is the sum of pathways SC_i and SC_e .

In fig 1, the importance of these pathways is depicted by the relative size of the education and occupational social class boxes for independent, mediated and explained effects. For simplicity, this figure excludes other explanatory factors. In this example, the boxes are shown to be of equal size, but the sizes of the boxes are likely to vary—for example, between sexes and age groups. In particular, in the past 20–50 years, the importance of the different pathways from education and social class to mortality might have changed. In this paper, we measure changes in the relative size of these effects. In addition, we identify the role of two main factors that may contribute to these changes: (1) changes in the strength of the effects of education and occupational social class on mortality, and (2) changes in educational and occupational social class distributions, and associated changes in the degree to which education determines or is correlated with occupational social class. We expect the independent contributions of education and social class to have remained stable if the total effects of education and social class on mortality have grown at a similar pace. However, if the effects of social class have grown more rapidly than the effects of education, or the correlation between education and social class has weakened over time, we expect the independent effects of social class to have grown. We are not aware of previous analyses that have tried to analyse changes in these different pathways. This study has the following specific aims:

- to quantify the total effect of education on mortality, and partition this effect into the independent effect of education on mortality and the effect of education on mortality that is mediated by occupational social class;
- to quantify the total effect of occupational social class on mortality and partition this effect into the independent effect

of occupational social class on mortality and the effect of occupational social class on mortality that is explained by education;

- to assess to what extent these effects vary by age and sex, and whether they have changed in the past 30 years; and
- to assess to what extent the changes in the relative effects are due to (1) changes in the associations of education and occupational social class with mortality, and (2) changes in the education and occupational social class distributions.

DATA AND METHODS

Study population and mortality follow-up

The data consist of six subsets. The first subset is based on the population records of the 1970 census, which have been linked to the death records for 1971–5 by Statistics Finland.^{10–12} The other subsets were constructed in the same way by linking the 1975, 1980, 1985, 1990 and 1995 census records to death records for 1976–80, 1981–5, 1986–90, 1991–5 and 1996–2000, respectively. More than 99.5% of all death records were linked to the deceased persons' census records. Persons migrating from Finland in any of the 5-year periods were excluded from the analyses. This study is restricted to those aged 30–59 years because education and occupational social class are well established at this age and selective migration to other countries is unlikely to influence our results.

Measurement of education and occupational social class

Education and occupational social class were measured at the time of each census, with the same classifications used at all points of measurement. Three educational categories were based on the highest completed educational degree: (1) tertiary education lasting for >13 years, (2) secondary education lasting for 10–12 years, and (3) basic education lasting for <9 years. Also, three occupational social classes were used: (1) upper white collar, (2) lower white collar and (3) manual workers. Unemployed and retired persons were classified according to their previous occupations; housewives were categorised according to the occupation of the head of the household (the proportion of housewives among all women was about 25% in the 1970s, 8% in the 1980s and 5% in the 1990s). We excluded farmers, entrepreneurs and those whose class was unknown (9%, 6% and 2% of the total population, respectively), because they did not fall into a hierarchical social class schema.

Methods

The deaths and person-years were cross-tabulated according to the variables of interest. The cross-table was analysed by means of Poisson regression, with the cell as the unit of analyses. Each

cell in the table included information on the number of deaths and the number of person-years lived. To summarise the effects of education and occupational social class on mortality, we estimated continuous regression coefficients for education (e) and social class (sc), with the above-listed variable categories being given the values 1, 2 and 3. The regression models were estimated separately for men and women in nine age*period combinations of three 10-year age groups (30–39, 40–49, 50–59 years) and three 10-year periods (1971–80, 1981–90, 1991–2000). The following regression models were estimated in STATA (Release 8)

- $\log(E(d)/Y) = a + b \cdot \text{age} + c \cdot \text{period} + e_i \cdot \text{education} + sc_i \cdot \text{class}$,
- $\log(E(d)/Y) = a + b \cdot \text{age} + c \cdot \text{period} + e_i \cdot \text{education}$,
- $\log(E(d)/Y) = a + b \cdot \text{age} + c \cdot \text{period} + sc_i \cdot \text{class}$,

where $E(d)$ is the expected number of deaths and Y is the number of person-years lived.

By taking antilogarithms of the regression coefficients, we obtained summary indices—here called relative risks—for education (E) and social class (SC), which can be interpreted as the relative increase in mortality for each step down the social hierarchy. The relative risks obtained from the first model quantify the effects of education on mortality that are independent of social class ($E_i = \exp(e_i)$) and the effects of social class on mortality that are independent of education ($SC_i = \exp(sc_i)$). Relative risks from the following two models quantify the total effects of education ($E_t = \exp(e_t)$) and social class ($SC_t = \exp(sc_t)$) on mortality. Furthermore, we calculated the proportion of the total effect of each socioeconomic measure on mortality that is independent of the other. For education, this independent proportion is $(\exp(e_i) - 1) / (\exp(e_t) - 1)$, and for social class $(\exp(sc_i) - 1) / (\exp(sc_t) - 1)$.

For the period 1991–2000, we also calculated hypothetical values for the relative risks, while keeping the education and occupational social class distributions and the associations between the two constant at the 1971–80 level. This was achieved by applying the person-year distribution observed in 1971–80 by age, sex, education and social class to the death rates actually observed in the period 1991–2000. By comparing the observed and hypothetical relative risks, we could estimate how much of the change over time is due to distributional change, and how much is due to change in mortality rates.

We also carried out confirmatory analyses using education and occupational social class as categorical variables, but did not discover important non-linearities in the associations with mortality. Furthermore, these analyses did not show that the estimates of the independent effects of both socioeconomic measures would have been substantially different from those obtained from our main analyses. Thus, the choice to estimate relative risks from models that use continuous variables is justified, as they enable a more parsimonious presentation of the data and do not produce biased results.

RESULTS

Distributional change

Among men aged 30–39 years, the proportion of those with only basic education has declined from 52% to 22% (table 1). Among men in their 50s, this proportion has declined from 75% to 48%. Similar changes have occurred for occupational social class, although at a more modest pace. Over time, the correlation between education and social class has declined, particularly in the two youngest age-groups.

Similar distributional changes have also taken place among women (table 2), and this change has been more rapid than among men. The correlations between education and occupational social class have been much lower among women than

Figure 1 Pathways from education and social class to mortality. E_i = effect of education independent of social class; E_m = effect of education mediated by social class; E_t = total effect of education; SC_i = effect of social class independent of education; SC_e = effect of social class explained by education; SC_t = total effect of social class.

Table 1 Distributions (% of person-years) of education and social class and their correlations in three age groups and three periods and mortality rate ratios in 1991–2000*

			1991–2000	
Men	1971–1980 (%)	1981–1990 (%)	(%)	Mortality rate ratio†
Age 30–39 years				
Education (years)				
>13	13.1	14.3	17.6	1.00
10–12	35.1	50.8	60.4	2.97
<9	51.9	34.9	22.0	5.36
Total	100	100	100	
Social class				
Upper white collar	16.2	17.5	19.8	1.00
Lower white collar	23.1	21.4	22.7	1.50
Manual	60.8	61.1	57.5	3.19
Total	100	100	100	
Correlation between education and social class	0.667	0.588	0.558	
Number of person-years	2 713 980	3 591 555	3 175 404	
Number of deaths	6426	7926	6255	
Age 40–49 years				
Education (years)				
>13	10.1	14.7	16.9	1.00
10–12	21.8	36.6	50.2	2.45
<9	68.1	48.8	32.9	3.54
Total	100	100	100	
Social class				
Upper white collar	14.0	20.4	21.6	1.00
Lower white collar	19.5	21.4	21.7	1.70
Manual	66.6	58.1	56.7	2.92
Total	100	100	100	
Correlation between education and social class	0.704	0.646	0.596	
Number of person-years	2 108 192	2 649 958	3 331 403	
Number of deaths	13 381	12 152	14 483	
Age 50–59 years				
Education (years)				
>13	8.1	10.2	15.5	1.00
10–12	17.3	22.8	36.3	1.80
<9	74.6	66.9	48.2	2.36
Total	100	100	100	
Social class				
Upper white collar	11.7	15.4	21.2	1.00
Lower white collar	19.4	19.0	22.2	1.38
Manual	68.9	65.6	56.6	2.26
Total	100	100	100	
Correlation between education and social class	0.686	0.676	0.638	
Number of person-years	1 578 491	1 977 513	2 393 250	
Number of deaths	24 695	23 820	21 434	

*Farmers, entrepreneurs and persons with unknown occupation excluded.

†Mortality rate ratio compared with the first category during 1991–2000, adjusted for 5-year age group and and 5-year period.

among men, and their decline has been more modest, with no change in the oldest age group.

In accordance with previous literature on socioeconomic differences in mortality, the last column in tables 1 and 2 also confirms systematically lower mortality in higher than in lower socioeconomic groups.

Change in the effects of education and occupational social class on mortality among men

Relative educational and occupational social class differences in mortality are larger in younger than older age groups (table 3). Over time, relative social class differences in mortality have increased in all age groups. Educational differences have also increased, but at older ages these changes have been less pronounced than for social class. Furthermore, educational differences have increased only from the 1980s to the 1990s.

In the 1970s, about 58–68% of the effects of education on mortality were independent of social class. This proportion

declined in the 1980s, when the effects of social class on mortality increased but the effects of education remained stable. Among 30–49-year-old people, the independent effect of education increased again in the 1990s, when the total effects of education on mortality also increased, but continued to decline in the oldest age group. At the end of the study period, 66%, 51% and 36% of the total effects of education were independent of social class in the three age groups, respectively.

About 50% of the effects of occupational social class on mortality were independent of education in the 1970s. This proportion increased during the follow-up period and was about 60%, 70% and 80% in the three age-groups, respectively. In other words, the effects of social class on mortality that are explained by the educational composition of classes have declined strongly in the last 30 years of the last millennium.

Hypothetical calculations for the period 1991–2000 show that relative risks for education and social class would have been somewhat larger without distributional change. Actual change

Table 2 Distributions (% of person-years) of education and social class and their correlations in three age groups and three periods and mortality rate ratios in 1991–2000*

			1991–2000	
Women	1971–1980 (%)	1981–1990 (%)	%	Mortality rate ratio†
Age 30–39 years				
Education (years)				
>13	11.2	13.6	20.1	1.00
10–12	34.7	50.6	62.2	1.60
<9	54.2	35.7	17.7	3.47
Total	100	100	100	
Social class				
Upper white collar	12.6	14.0	18.4	1.00
Lower white collar	48.3	52.8	53.8	1.36
Manual	39.0	33.3	27.9	2.39
Total	100	100	100	
Correlation between education and social class	0.511	0.492	0.478	
Number of person-years	2 643 302	3 509 175	3 124 023	
Number of deaths	2163	2526	2169	
Age 40–49 years				
Education (years)				
>13	8.1	12.4	17.3	1.00
10–12	21.2	36.3	50.7	1.33
<9	70.7	51.3	32.0	2.05
Total	100	100	100	
Social class				
Upper white collar	10.4	13.9	16.9	1.00
Lower white collar	39.8	48.9	53.9	1.16
Manual	49.8	37.3	29.2	1.94
Total	100	100	100	
Correlation between education and social class	0.533	0.532	0.499	
Number of person-years	2 162 547	2 706 701	3 407 561	
Number of deaths	4448	4586	5809	
Age 50–59 years				
Education (years)				
>13	5.4	7.7	13.3	1.00
10–12	15.8	22.2	37.1	1.30
<9	78.9	70.2	49.5	1.75
Total	100	100	100	
Social class				
Upper white collar	8.7	10.2	14.6	1.00
Lower white collar	32.7	38.6	49.3	1.13
Manual	58.6	51.2	36.1	1.63
Total	100	100	100	
Correlation between education and social class	0.519	0.534	0.523	
Number of person-years	1 907 201	2 284 239	2 585 388	
Number of deaths	10 096	9345	9097	

*Farmers, entrepreneurs and persons with unknown occupation excluded.

†Mortality rate ratio compared with the first category during 1991–2000, adjusted for 5-year age group and 5-year period.

in population distribution has been away from the groups of high excess mortality (manual workers and persons with basic education) and towards groups with lower excess mortality. These effects are particularly strong in the youngest age group.

In the younger age groups, this distributional change and the declining association between education and occupational social class have also increased the independent effects of social class. The actual observed relative risks for the independent effects of social class are larger than those obtained under the hypothetical assumption of fixed 1971–80 distributions. For those aged 30–39 years, the increase in the independent effects of social class on mortality are almost fully due to distributional change. This can be judged from the observation that the proportions of the total effect of social class on mortality that is independent of education are similar in the 1971–80 data (48%) and the hypothetical 1991–2000 data (44%), but higher in the actually observed 1991–2000 data

(60%). At the same time, relative mortality differentials by education and social class have increased in tandem: from 1.66 to 2.04 for education and from 1.55 to 1.87 for social class. By similar observation among those aged 40–49 years, approximately half of the increase in the independent effect of social class is found to be due to distributional change. The results for 50–59-year-old people are unaffected by distributional change, and almost all of the increase in the independent effects of social class are due to more rapid increase in mortality differentials by social class.

For education, distributional change has had very little effect on the proportion of the total effect that is independent of occupational social class. Most of these changes are determined by changes in the relative mortality rates. For example, in the oldest age group, the rapid decline in the independent effects of education on mortality is largely due to very rapidly increasing associations between social class and mortality.

Table 3 Regression-based relative risks for educational and social class differences in mortality, adjusted for 5-year age groups and 5-year periods, for men

	1971–1980		1981–1990		1991–2000		1991–2000 with 1971–1980 population distribution*	
	Total effect†	Independent effect‡	% Independent§	Total effect†	Independent effect‡	% Independent§	Total effect†	Independent effect‡
Age 30–39 years								
Education	1.66	1.43	65.4	1.67	1.37	54.6	2.21	1.81
Social class	1.55	1.27	48.0	1.71	1.47	66.6	1.96	1.42
Age 40–49 years								
Education	1.52	1.30	58.3	1.50	1.21	41.2	1.79	1.39
Social class	1.45	1.24	53.1	1.56	1.41	72.9	1.74	1.45
Age 50–59 years								
Education	1.39	1.27	68.0	1.41	1.20	47.8	1.49	1.17
Social class	1.30	1.14	45.8	1.39	1.26	66.1	1.53	1.40

*Hypothetical values based on calculations that keep the education and social class population distributions, and the correlations between the two constant at the 1971–80 level (see Methods).

†Total effect = total effect of education or social class on mortality.

‡Independent effect = effect of education independent of social class or effect of social class independent of education.

§% independent = independent effect as a proportion of the total effect (see Methods).

Table 4 Regression-based relative risks for educational and social class differences in mortality, adjusted for 5-year age groups and 5-year periods, for women

	1971–1980		1981–1990		1991–2000		1991–2000 with 1971–1980 population distribution*	
	Total effect†	Independent effect‡	% Independent§	Total effect†	Independent effect‡	% Independent§	Total effect†	Independent effect‡
Age 30–39 years								
Education	1.42	1.33	79.1	1.49	1.30	61.6	1.96	1.76
Social class	1.31	1.14	47.2	1.54	1.37	69.2	1.61	1.31
Age 40–49 years								
Education	1.25	1.18	70.3	1.23	1.12	52.3	1.46	1.30
Social class	1.20	1.12	58.0	1.28	1.21	75.1	1.48	1.31
Age 50–59 years								
Education	1.30	1.21	70.2	1.21	1.12	58.7	1.33	1.22
Social class	1.21	1.12	59.3	1.20	1.14	70.1	1.33	1.21

*Hypothetical values based on calculations that keep the education and social class population distributions and the correlations between the two constant at the 1971–80 level (see Methods).

†Total effect = total effect of education or social class on mortality.

‡Independent effect = effect of education independent of social class or effect of social class independent of education.

§% independent = independent effect as a proportion of the total effect (see Methods).

Change in the effects of education and occupational social class on mortality among women

Among women, education and occupational social class differences in mortality have increased over time, with the increase being strongest at younger ages (table 4). The independent effects of education are larger among women than among men in all three periods and age groups. In the two oldest age groups, this proportion has declined slightly from the 1970s to the 1990s, with a low point in the 1980s. Conversely, the independent effects of social class on mortality have increased modestly, with a high point in the 1980s.

Hypothetical calculations show that relative risks for education and occupational social class would have been larger without distributional change. For both socioeconomic measures, changes in the independent effects are much smaller among women than among men. Nevertheless, among women, actual changes in the independent effects of social class are held back by distributional change—that is, the increase in the independent effects of social class would have been stronger without distributional change. This is in stark contrast to the trend in men in whom the decline in the independent effect of education would have been stronger without distributional change.

DISCUSSION

We have shown that among Finnish men and women aged 30–59 years, relative occupational social class differences in mortality have increased over the 30-year follow-up period even when education is adjusted for. The effects of education on mortality increased only towards the end of the study period. Among 40–59-year-old people, the effects of education in the 1990s were more mediated by social class than in the 1970s, but among younger men and women we observed no change in this effect. The independent effects of social class on mortality have simultaneously grown, particularly at older ages and among men. We assume that the changes in the independent effects of education and social class are associated with (1) changes in the strength of the associations of education and social class with mortality, and (2) changes in educational and social class distributions and associated changes in the correlations between education and occupational social class.

In Finland, and elsewhere in Western industrialised countries, changing educational opportunities and changing economic structures have led to large changes in educational and occupational social class distributions. These changes have been particularly striking for education. In the early 20th century, the economic structure in Finland was mainly agrarian and educational careers were severely disrupted by World War II. Opportunities beyond basic education remained fairly stagnant until the 1960s. Since then, access to education has been increasing rapidly, with 25–34-year-old people being among the best educated in Europe today.²⁶ When educational qualifications increase at a faster pace than high-status jobs, the association between education and social class will weaken. This phenomenon is often referred to as diminishing returns on education credentials.^{27–29} A decline in the association between education and social class was also observed in these data for men aged 30–59 years. Other research in Finland also shows that high education does not guarantee high incomes or labour market status stability to the same degree as before.²⁹ We also observed strong distributional change among women, but the associations between education and social class had changed only little; for women, the increase in white-collar jobs seems to have better matched the increase in educational credentials.

To estimate the contribution of these distributional changes to the changing inter-relationships between education and

occupational social class and mortality, we carried out hypothetical calculations for the period 1991–2000 under the assumption that educational and social class distributions, as well as associations between the two, had been the same as those observed for 1971–80. These results can be summarised in three points:

- Had no distributional change occurred in the study period, occupational social class and education differences in mortality would have grown more rapidly than actually observed, particularly among younger Finns and among men. Because the regression-based relative risks we used take account of the population size, the change in population distribution away from the groups of high relative excess mortality explains this finding.
- The decline in the independent effects of education among 40–59-year-old men is almost fully due to social class differences in mortality increasing at a much faster pace than education differences in mortality. Among women, the decline in the independent effect is much smaller, partly because actual distributional change has held back the decline of the independent effect.
- The driving forces for the increase in the independent effect of occupational social class on mortality among younger men are rapid distributional change and the diminishing association between education and social class. Among older men, more rapid increase in social class than in education differentials in mortality is of increasing importance. Among women, distributional change and the stable association between education and occupational social class over time have tended to restrict the increase in the independent effects of social class on mortality. Among older women, occupational social class differences in mortality have grown faster than educational differences in mortality, and have contributed to the increasing importance of social class.

Our data are of high quality, with practically no missing data and harmonised socioeconomic measures over time. For a more detailed understanding of the changing pathways between socioeconomic determinants of mortality, further work should incorporate more detailed classifications of the socioeconomic measures used here, and incorporate other socioeconomic measures such as last income or parental social class. Analyses of specific causes of death will also be fruitful. Furthermore, we have characterised the occupational social

What this paper adds

- Mortality varies strongly by education and occupational social class, and these differences have increased in several European countries and in the United States. However, little is known about changes in the relative importance of these two indicators of socioeconomic position on mortality over time.
- We show that among 40–59-year-old people, the effects of education are currently less independent of occupational social class than in the 1970s. The effects of social class on mortality that are independent of education have grown at older ages, particularly among men. These changes are determined by (1) changes in the strength of the associations of education and occupational social class with mortality, and (2) changes in distributions and correlations between these measures.

Policy implications

- Occupational social class differences in mortality are a public health threat that shows no waning over recent decades. Attempts to narrow social inequalities in mortality need to pay particular attention to the causes of occupational social class differences in mortality.

class of economically inactive individuals according to their previous occupations or occupations of their household head. This decision may have differential repercussions on the results of men than women, and these effects should be evaluated in future studies.

In summary, we have demonstrated that occupational social class exerts a powerful influence on mortality that shows no waning over the recent decades. Furthermore, our models show that this effect is, to a growing extent, independent of education. The increase in the independent effect is partly due to the more rapid increase in occupational social class rather than educational differences in mortality. In addition, increasing educational levels have, in some cases, led to a decline in the power of education to guarantee high-status jobs. To the extent that this has occurred—particularly among young men—it has also led to an increase in the independent effects of social class on mortality. These distributional changes are driven by changes in educational systems and labour market dynamics, and are of major importance for a better understanding of the causes and long-term changes of socioeconomic inequalities in health.

Our results imply that attempts to turn the tide of increasing social inequalities in mortality need to pay particular attention to differences in occupational social class. Previous evidence from these data show that those in lower social classes have experienced a slower decline in total mortality than those in higher social classes, and have even experienced increases in mortality for some causes of death (eg, alcohol-associated mortality).^{10–12} These cause-specific mortality differences may reflect growing social differences in material resources, access to care or changes in health-related behaviour,¹⁰ but also changes in the working environment may be relevant. Future work should attempt to quantify the contribution of these different possibilities.

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