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More variation in lifespan in lower educated groups: evidence from 10 European countries

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Background Whereas it is well established that people with a lower socio-economic position have a shorter average lifespan, it is less clear what the variability surrounding these averages is. We set out to examine whether lower educated groups face greater variation in lifespans in addition to having a shorter life expectancy, in order to identify entry points for policies to reduce the impact of socio-economic position on mortality.

Methods We used harmonized, census-based mortality data from 10 European countries to construct life tables by sex and educational level (low, medium, high). Variation in lifespan was measured by the standard deviation conditional upon survival to age 35 years. We also decomposed differences between educational groups in lifespan variation by age and cause of death.

Results Lifespan variation was higher among the lower educated in every country, but more so among men and in Eastern Europe. Although there was an inverse relationship between average life expectancy and its standard deviation, the first did not completely predict the latter. Greater lifespan variation in lower educated groups was largely driven by conditions causing death at younger ages, such as injuries and neoplasms.

Conclusions Lower educated individuals not only have shorter life expectancies, but also face greater uncertainty about the age at which they will die. More priority should be given to efforts to reduce the risk of an early death among the lower educated, e.g. by strengthening protective policies within and outside the health-care system.

Keywords Lifespan variation, life expectancy, socio-economic inequality, education, international variation, mortality

Introduction

By now, it is well established that on average higher socio-economic groups live longer than lower socio-economic groups. Regardless, if the proxy used for socio-economic status is education, wealth, income, occupation or even housing tenure, the more advantaged groups have higher survival probabilities at every age, and from most causes of death.[1–9]

Yet, conventional research employing measures of average age of death such as life expectancy overlook the distribution around these averages. This matters because larger lifespan variation (differences between individuals in their age at death) implies greater uncertainty in the timing of death at the individual level, and thus in the planning of life's events. At the societal level, larger lifespan variation suggests lack of effectiveness of policies which aim at protecting vulnerable individuals against the vicissitudes of life, such as social safety nets.[10]

To date, a scattering of evidence from Russia[11] and the USA[12,13] suggests that lower socio-economic groups indeed face greater lifespan variation. But up until now, no large international study has examined the association between socio-economic status and lifespan variation. It is also not known whether the same causes that are leading to lower life expectancies are also causing the presumed higher lifespan variation. In this article, we set out to examine whether the finding of a socio-economic gradient to lifespan variation is a replicable finding, across a range of European countries, using educational level as a proxy for socio-economic status. In order to determine the added value of lifespan variation as a measure of inequalities in health, we also analyse the association between lifespan variation and average life expectancy by educational group. Finally, we decompose the differences between educational groups in lifespan variation by age and cause of death.

Data and Methods

We used data from 10 European countries, harmonized as part of the Eurothine project. This consisted of census-based death and exposure counts by sex, cause of death and level of education. For some countries, we had census-linked longitudinal data following individuals aged $\geqslant$30 years for 5–10 years beginning around 1990 (average age during the study $\geqslant$35 years); for other countries, we had census-unlinked cross-sectional data aggregated over a few years around 2000. For France, we had a permanent census-linked demographic sample that included 1% of the population. In all cases, data were aggregated into 5-year age intervals with an open-aged interval at age $\geqslant$85 years. The education levels were coded according to the ISCED classifications, and split into three internationally comparable categories. These corresponded to: less than secondary education (low), complete secondary education (medium) and some tertiary education (high). We regrouped the causes of death into four broad causes: neoplasm (140–239 ICD 9; C00–D48 ICD 10), circulatory diseases (390–459 ICD 9; I00–I99 ICD 10), external causes (E800–999 ICD 9; V01–Y98 ICD 10) and all remaining other causes including missing or ill-defined. More details on the data are available as supplementary data at *IJE* online.

In order to get a more continuous age-at-death distribution, we proportioned out the corresponding shares of the total death and exposure counts by level of education from the Eurothine data to the national data reported by single year of age in the Human Mortality Database[14] for the equivalent time period. We assumed that the proportion of the total deaths and exposures by educational level remained constant within each 5-year age interval and within the open-aged category $\geqslant$85 years ($\geqslant$75 years in Sweden). A previous study showed this to be the case for women, but to risk overestimating differences for men, who were shown to have decreasing rate ratios between educational groups up to ages $\geqslant$90 years.[15] This gave us death and exposure counts by single year of age (35 to $\geqslant$110 years), sex and educational level, which we used to calculate death rates. The starting age used was 35 years since this was the youngest average age possible from all data sets (the individuals aged 30 years at the beginning of the 10-year census-linked studies had an average age of 35 years). From these death rates, we constructed life tables using conventional methods, including fitting a Kannisto model of mortality from age x years at which death counts first fell below 100 ($80 \leqslant x \leqslant 95$).[16,17]

The correlation between lifespan variation and average lifespan has led some to argue that one should be examined within the context of the other.[18] Thus, for each subgroup, we calculated both the average lifespan conditional upon survival to age 35 years ($e_{35} + 35$ in conventional life table notation) and lifespan variation, measured by the standard deviation (SD) (S_{35}), also conditional upon survival to age 35 years. Both measures were calculated from the life table death density. In this way, our age-at-death distributions were not confounded by differences in the underlying age structure of each subpopulation. The SD has become a popular measure to quantify the dispersion in the age-at-death distribution.[12,19–22] From life tables, the SD is calculated by taking the square root of the variance—itself the squared distance of each individual's lifespan to the subgroup average lifespan divided by the population size. S_{35} is measured in years with higher values indicating greater lifespan variation. Monte Carlo simulation methods were used to determine 95% confidence intervals (95% CIs) around our estimates of $e_{35} + 35$ and S_{35}.[23–25]

The overall level of lifespan variation comes from the balance of postponing premature deaths (compressing the age-at-death distribution) and saving lives at older ages (which expands this distribution). Separating the two is a unique threshold age, generally found slightly below the population life expectancy.[26] In the countries and years used in our analysis for men, this age ranged between 65 and 70 years in most Western European countries and between 60 and 65 years in Finland and in Eastern European countries (younger in Estonia). For women, the threshold age ranged between 70 and 75 years in all countries but Estonia (Supplementary Table S3, available as supplementary data at *IJE* online).

To get a better interpretation of the reasons behind differences in lifespan variation by levels of education, we decomposed the Eurothine data by age and cause of death. We compared differences in S_{35} between the low-educated group and the combined middle and high-educated groups over ages 35–69 years for men, and 35–74 years for women, the same upper age limits used by Shkolnikov *et al*.[27] These ages broadly corresponded to the middle adult ages that both reduced lifespan variation and increased life expectancy. Moreover, causes could not be distinguished by age much beyond these ages because of the open-aged interval ($\geqslant$85 years). In any event, causes of death at older ages are generally more difficult to determine because of the interaction of multiple underlying causes.[28,29]

All decompositions were performed using a stepwise decomposition algorithm[27,30] by modifying the Visual Basic for Applications program developed by Shkolnikov and Andreev.[31] Essentially, this method determines the age and cause of death contribution to the overall total difference in S_{35} (in years) between two populations, by stepwise replacing each element of the age and cause-specific death rate matrix of one population with the corresponding elements in a second population. By recalculating the resulting S_{35} after every replacement, the elementary contributions from each age and cause of death can be determined. The replacements were performed first from the lower to higher educated groups. A second round was performed from higher to lower educated groups. The final contributions from each age and cause of death combination to the total difference in S_{35} were determined by taking the average of the two.

Results

A clear educational gradient existed not only in the average lifespan (Table 1) but also in lifespan variation (Table 2). This was the case for both men and women, in every country examined. Low-educated men had an S_{35} in lifespans of 12–14 years (and even 15.1 years in Estonia), which is on average 13.5% higher (1.5 years) than high-educated men in the same country. Low-educated women fared a little better—with S_{35} levels of around 11–12 years—but

Table 1 Average lifespan conditional upon survival to age 35 years for each educational subgroup

Country	Males				Females			
	Low	Medium	High	Total population	Low	Medium	High	Total population
Belgium (1991–95)	74.1 (74.0–74.1)	76.3 (76.2–76.4)	78.4 (78.3–78.6)	75.0 (74.9–75.0)	80.5 (80.4–80.5)	82.5 (82.4–82.6)	83.0 (82.9–83.2)	80.9 (80.9–81.0)
Czech Republic[a] (1999–2003)	71.1 (71.1–71.2)	77.5 (77.4–77.6)	80.9 (80.7–81.0)	73.3 (73.2–73.3)	78.5 (78.4–78.5)	81.9 (81.8–82.0)	84.0 (83.7–84.2)	79.3 (79.2–79.3)
Estonia[a] (1998–2002)	63.7 (63.4–64.0)	68.0 (67.8–68.2)	75.6 (75.2–75.9)	67.8 (67.7–68.0)	74.5 (74.2–74.9)	78.1 (77.9–78.2)	81.7 (81.4–82.2)	77.7 (77.6–77.9)
Finland (1991–2000)	73.0 (72.9–78.1)	75.1 (75.0–75.2)	78.1 (78.0–78.3)	74.4 (74.3–74.4)	80.3 (80.3–80.4)	82.1 (82.0–82.2)	83.2 (83.1–83.3)	81.1 (81.1–81.1)
France (1990–1999)	74.1 (73.8–74.3)	77.1 (77.0–77.3)	80.5 (80.0–81.1)	75.6 (75.5–75.8)	82.3 (82.1–82.4)	84.6 (84.1–85.0)	85.0 (84.3–85.8)	82.8 (82.7–83.0)
Norway (1991–2000)	74.5 (74.5–74.6)	77.0 (76.9–77.1)	79.4 (79.3–79.5)	76.5 (76.4–76.5)	80.4 (80.3–80.5)	82.5 (82.4–82.6)	83.9 (83.8–84.1)	81.6 (81.6–81.7)
Poland[a] (2001–2003)	69.9 (69.8–69.9)	76.4 (76.3–76.5)	79.7 (80.6–80.9)	72.1 (72.1–72.2)	78.5 (78.5–78.6)	82.3 (82.2–82.4)	83.9 (83.8–84.1)	79.7 (79.7–79.7)
Slovenia (1991–2000)	70.0 (69.8–70.1)	73.6 (73.5–73.7)	77.4 (77.2–77.6)	72.4 (72.4–72.5)	78.7 (78.6–78.8)	80.8 (80.7–81.0)	82.4 (82.0–82.9)	79.4 (79.3–79.5)
Sweden (1991–2000)	76.2 (76.2–76.3)	78.1 (78.0–78.1)	80.6 (80.5–80.7)	77.5 (77.4–77.5)	81.2 (81.1–81.2)	83.0 (82.9– 83.0)	84.7 (84.6–84.8)	82.1 (82.1–82.2)
Switzerland (1991–2000)	74.5 (74.4–74.6)	77.6 (77.6–77.7)	80.0 (80.0–80.1)	77.3 (77.3–77.4)	82.1 (82.0–82.1)	83.7 (83.7–83.8)	84.6 (84.4–84.8)	82.9 (82.8–82.9)
Average	72.1	75.7	79.0	74.2	79.7	82.1	83.6	80.8
Range (years)	12.5	10.1	5.3	9.6	7.7	6.5	3.3	5.1

[a]Estimated from census-unlinked data and might be less reliable due to numerator/denominator biases.

Table 2 SD in lifespan conditional upon survival to age 35 years for each educational subgroup

Country	Males				Females			
	Low	Medium	High	Total population	Low	Medium	High	Total population
Belgium (1991–95)	12.2 (12.1–12.2)	11.9 (11.8–12.0)	11.5 (11.4–11.6)	11.8 (11.8–11.8)	11.7 (11.6–11.7)	11.5 (11.4–11.6)	11.3 (11.2–11.4)	11.4 (11.4–11.5)
Czech Republic[a] (1999–2003)	12.4 (12.4–12.5)	12.4 (12.3–12.5)	11.5 (11.3–11.6)	12.4 (12.3–12.4)	11.6 (11.6–11.7)	11.7 (11.6–11.7)	10.2 (10.0–10.4)	11.2 (11.2–11.2)
Estonia[a] (1998–2002)	15.1 (15.0–15.3)	14.2 (14.0–14.3)	12.8 (12.6–13.1)	14.1 (14.1–14.2)	15.0 (14.7–15.3)	12.8 (12.7–12.9)	11.1 (10.8–11.4)	12.7 (12.6–12.8)
Finland (1991–2000)	13.2 (13.1–13.2)	12.9 (12.8–12.9)	11.5 (11.4–11.5)	12.5 (12.5–12.5)	11.8 (11.7–11.9)	11.0 (10.9–11.1)	10.6 (10.5–10.7)	11.1 (11.1–11.1)
France (1990–1999)	13.8 (13.6–13.9)	13.1 (13.0–13.3)	12.0 (11.7–12.4)	13.1 (13.0–13.2)	12.2 (12.1–12.4)	11.4 (11.1–11.7)	10.8 (10.3–11.4)	11.7 (11.6–11.9)
Norway (1991–2000)	12.5 (12.4–12.6)	11.7 (11.7–11.8)	11.0 (10.9–11.0)	11.6 (11.6–11.7)	12.1 (12.0–12.2)	11.2 (11.2–11.3)	10.6 (10.5–10.8)	11.3 (11.3–11.4)
Poland[a] (2001–2003)	13.5 (13.5–13.6)	13.1 (13.1–13.2)	12.2 (12.2–12.4)	13.3 (13.3–13.3)	12.4 (12.4–12.5)	12.1 (12.1–12.2)	11.0 (10.9–11.1)	11.8 (11.8–11.8)
Slovenia (1991–2000)	13.2 (13.1–13.3)	12.4 (12.4–12.5)	11.6 (11.5–11.8)	12.6 (12.5–12.6)	11.9 (11.8–12.0)	11.6 (11.5–11.7)	11.2 (11.0–11.5)	11.5 (11.4–11.6)
Sweden (1991–2000)	12.2 (12.2–12.3)	11.7 (11.6–11.7)	10.9 (10.9–11.0)	11.6 (11.5–11.6)	12.0 (11.9–12.0)	11.4 (11.3–11.4)	10.8 (10.7–10.9)	11.3 (11.3–11.3)
Switzerland (1991–2000)	13.2 (13.2–13.3)	12.1 (12.0–12.1)	11.3 (11.3–11.4)	12.0 (12.0–12.0)	11.7 (11.6–11.8)	11.1 (11.1–11.2)	11.1 (11.0–11.2)	11.2 (11.2–11.3)
Average	13.1	12.5	11.6	12.5	12.2	11.6	10.8	11.5
Range (years)	2.9	2.5	1.9	2.6	3.4	1.8	0.9	1.6

[a]Estimated from census-unlinked data and might be less reliable due to numerator/denominator biases.

this is still on average 1.4 years higher than the S_{35} of the high-educated. There were only two exceptions to this gradient: in the Czech Republic the low- and medium-educated women had similar S_{35} levels, whereas the same held true for medium- and high-educated women in Switzerland.

Men in Sweden, Norway and Belgium had lower overall levels of S_{35} than men in the rest of the countries. Women always had lower S_{35} than men in the same country. Women also had a less pronounced educational gradient everywhere except in Estonia, where the S_{35} was exceptionally high among low-educated women, and the levels were comparable with Western Europe among the high-educated. Generally, countries with high overall S_{35} also had a larger educational gradient in S_{35}.

Looking across countries, the range in S_{35} was larger across low-educated groups than it was across high-educated groups. Lifespan variation was particularly high for low-educated men in Eastern Europe (with the exception of the Czech Republic) and in Finland, France and Switzerland (men).

The main reason for the differences between educational subgroups in S_{35} is the longer left tail of the lifespan distribution among the lower educated, aspects that can be hidden in summary measures such as the mean or median. To better visualize these differences, we plotted the lifespan distributions for men in Sweden and the Czech Republic (Figure 1). Of course, saving lives at older ages can also bring about higher lifespan variation. In our data, the highest educated Swiss women showed some evidence of this, and this partially explains why the Swiss high- and medium-educated women had similar S_{35}.

In Figure 2, we plotted the average lifespan vs S_{35} for each sex, educational group and country combination. Whereas there is a strong relationship between high lifespans and low S_{35}, some populations show high levels of lifespan variation for their average lifespan (Tables 1 and 2 for country points that are not labelled). For example, S_{35} was >0.5 years higher for low-educated men in Switzerland than in Norway, despite both groups having the same average lifespan (points depicted within the grey rectangle).

The ages and causes of death contributing to the higher lifespan variation of the low-educated groups can be seen in Figure 3 for men and Figure 4 for women, which decomposes the differences (in years) of the higher S_{35} of the lower educated group compared with the combined medium- and high-educated group. In general, differences between educational groups appeared at earlier ages among men. Women had a flatter age gradient, meaning that all ages were equally contributing to the differences in S_{35} between educational groups. Over these ages, mortality from external causes was responsible on average for about a quarter of the larger S_{35} among lower educated men (11% for women), with especially high contributions in Estonia, Finland, Slovenia (men), Poland (men)

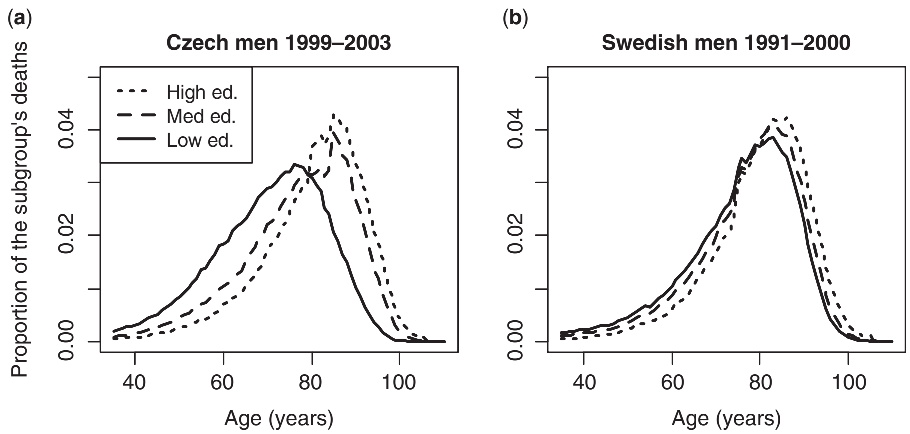

Figure 1 Life table death densities of the different educational subgroups in the (a) Czech Republic and (b) Sweden

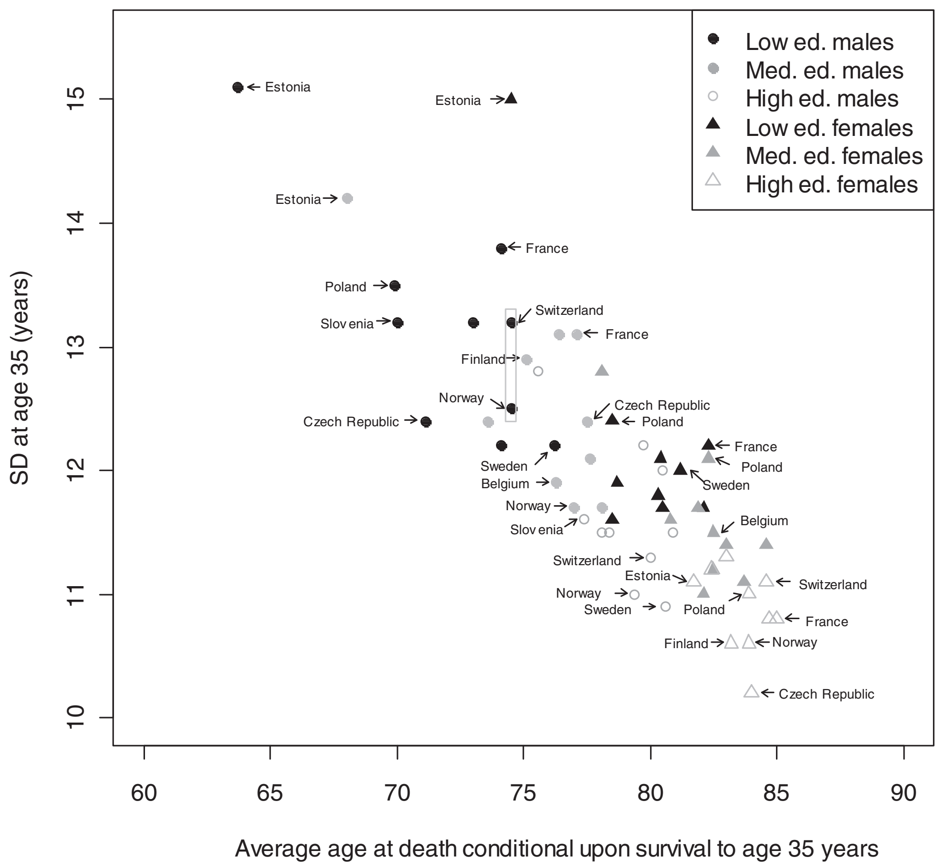

Figure 2 Relationship between lifespan variation (SD at age 35 years) and average lifespan (conditional upon survival to age 35 years) by sex and level of education. All data points in Tables 1 and 2 are plotted, but some are not labelled to avoid clutter

and Switzerland (men). Neoplasms were important contributors to the educational gradient in S_{35} for both sexes in the Czech Republic, Poland and Switzerland and also among women in Norway and men in Belgium. Circulatory diseases played a similar, non-trivial role in all countries.

After the age of ~65–70 years for men and ~70–75 years for women (in some countries earlier), the age contribution became negative. This has to do with the threshold age separating compression and expansion of the lifespan distribution. Beyond this age increases in mortality compress the age-at-death

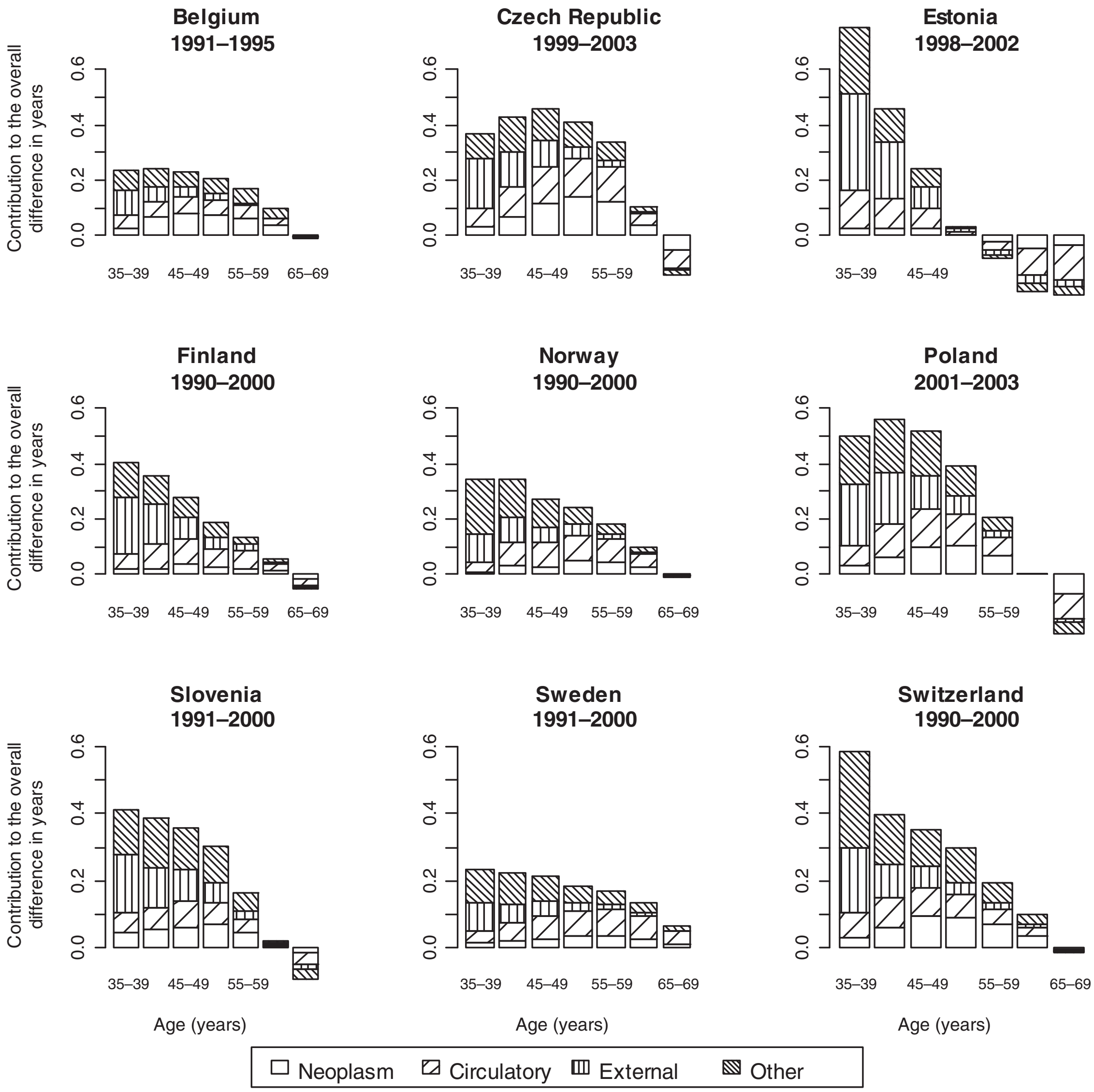

Figure 3 The contribution by age and cause of death in years to the higher male S_{35} of the lower educated group compared with the medium- and high-educated groups combined, over age range 35–70 years. The data were collected as part of the Eurothine project

distribution as individuals die at ages closer to the average age at death. Thus, the higher mortality from the depicted causes at older ages among the lower educated group actually decreases the overall difference in lifespan variation between the groups. On balance, the lower educated have higher lifespan variation, because the positive contributions from higher mortality over the younger ages are larger than the negative contributions from higher mortality at older ages.

We also decomposed differences between the low-educated and the combined medium- and high-educated groups in average lifespan, instead of lifespan variation (Supplementary Figures S1 and S2, available as supplementary data at *IJE* online). By comparison, educational differences in average lifespan tended to be driven by inequalities in mortality above the age of 50 years, and as a result, circulatory diseases played a greater role in explaining the lower lifespans of the low-educated than they did for the higher S_{35}.

Discussion

Summary of results

Lifespan variation was higher among the lower educated in every country, but more so among men and in Eastern Europe. Although there was an inverse relationship between average life expectancy and its SD,

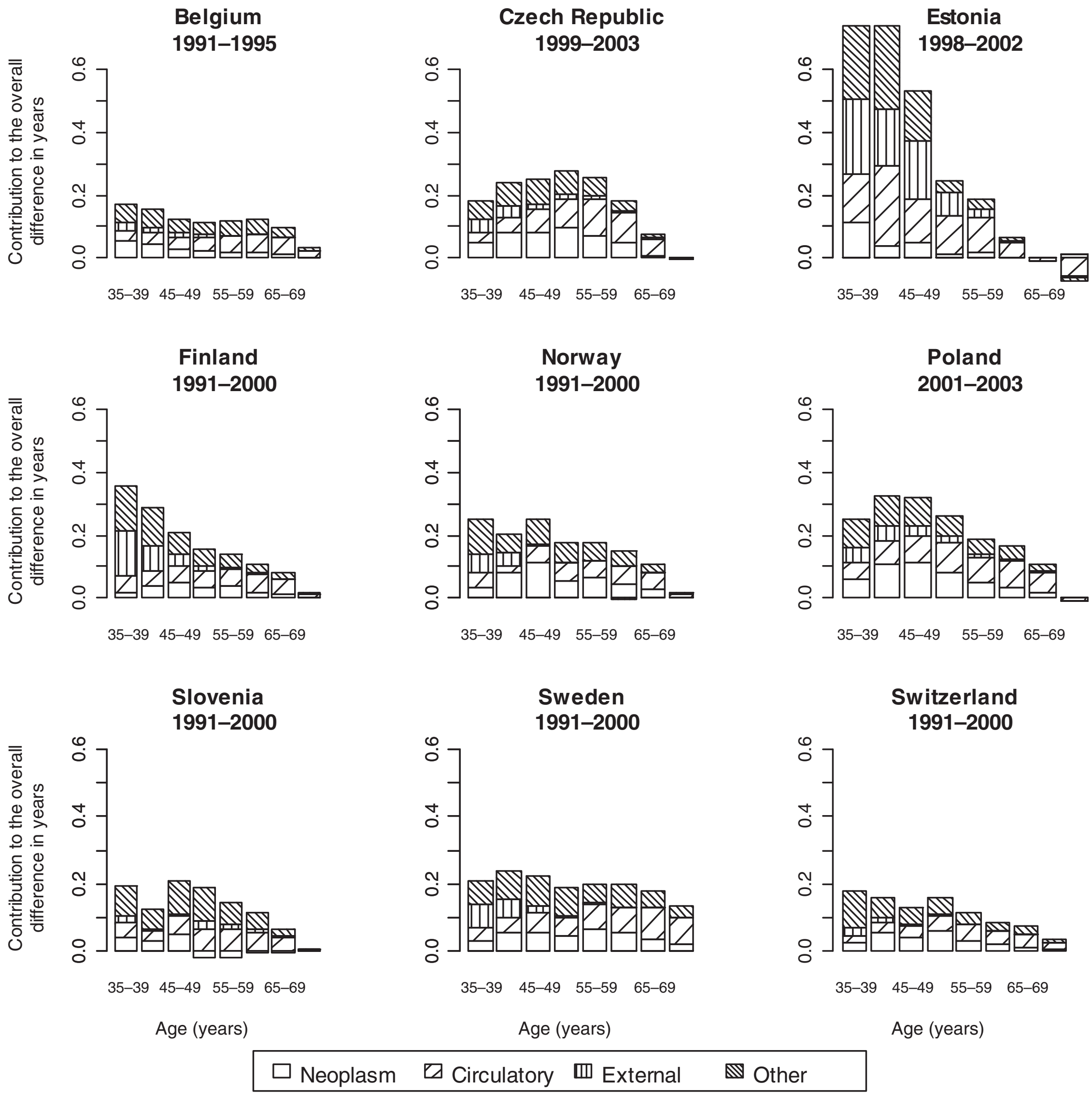

Figure 4 The contribution by age and cause of death in years to the higher female S_{35} of the low-educated groups compared with the medium- and high-educated groups combined, over age range 35–75 years. The data were collected as part of the Eurothine project

the first did not completely predict the latter. Greater lifespan variation in lower educated groups was largely driven by conditions causing death at younger ages, such as injuries and neoplasms.

Comparison with other studies

Ours is the first large-scale comparative study of lifespan variation by an indicator of socio-economic position. It confirms earlier findings from Russia and the USA that lower socio-economic status is associated with larger variability in the timing of death.[11–13] A socio-economic gradient in lifespan variation was found in all European countries participating in our study, but it was larger in Eastern Europe than in Western Europe.

No previous study has examined the contribution of causes of death to socio-economic inequalities in lifespan variation. A few studies have examined the contribution of causes of death to lifespan variation within whole national populations. Shkolnikov *et al.*[11] found that external causes explained more of the differences in the Gini coefficient of mortality between the USA and England and Wales than it did in explaining differences in average life expectancy. Edwards and Tuljapurkar[12] found that external-cause mortality explained as much as 10% of the total lifespan variation in the USA, but did not explain the differences in rankings between a number of high-income countries. Our findings show that external causes also contribute importantly to socio-economic inequalities in lifespan variation.

Explanation

Lower educated individuals not only have shorter life expectancies, but also face greater uncertainty about the age at which they will die. This is caused primarily by their elevated premature mortality. Relative inequalities between socio-economic groups are generally larger in younger age groups than in older age groups.[6] In our study, the specifically high lifespan variation of low-educated men was due to higher mortality over ages 35–55 years. This is in contrast to differences in life expectancy between populations, which tend to be driven by mortality over age ranges that have the most deaths,[32,33] as we have also shown here. Thus, reducing premature mortality is even more important for equalizing lifespan variation across educational groups than it is for equalizing average lifespans.

The higher premature mortality of lower socio-economic groups is caused in part by behavioural differences (especially regarding cigarette smoking, diet, exercise and alcohol abuse),[34–41] material factors (such as financial difficulties and hazardous housing and working conditions)[42–44] and psychosocial pathways (such as psychosocial stress and lack of social support).[45–48] Socio-economic inequalities in premature mortality, and thus in lifespan variation, are larger among men than among women, because many determinants of premature mortality are more strongly socially patterned among men.[5,49,50]

Country differences in average lifespan as well as in lifespan variation were largest among low-educated men. This suggests, first, that the higher educated are less dependent on country-specific circumstances for their survival than the lower educated, and, second, that some countries are more effective than others in protecting lower socio-economic groups against premature mortality. The much higher lifespan variation among lower educated groups in Eastern Europe could well be a sign of failing social security or failing health and health-care policies. It has been found that the considerably higher rate of external mortality among lower educated men in Eastern Europe, which contributes to their higher lifespan variation, is related to a pattern of hazardous drinking,[8,51] which in its turn probably reflects the stress which the lower educated have experienced since the economic and political transition of the early 1990s and the breakdown of former social protection schemes.[52–54] Higher rates of mortality from conditions amenable to medical intervention in lower educated groups in Eastern Europe[8,55] suggest that lack of access to effective health care also plays a role.

Limitations

For most of the Western and Northern European countries, we had census-linked longitudinal data aggregated over a 10-year period in the 1990s. For the Czech Republic, Estonia and Poland, however, we had census-unlinked data gathered in a cross-sectional manner, aggregated for a few years around the Year 2000. During the 1990s, relative inequalities in mortality between educational groups increased throughout Europe,[52,56] especially in Central and Eastern European countries.[53,54] Thus, the stronger educational gradient in life expectancy found for Eastern Europe may in part be due to the later time period pertaining to these data. It is more difficult to estimate the possible effects on estimates of lifespan variation, because it depends on the age-specific nature of these widening relative inequalities.

Census-unlinked mortality data are less reliable than census-linked data, because of possible numerator/denominator biases. This bias, caused by differences between self-reported information on the census and information reported by next of kin on death certificates, could go either way.[57–59] A recent study on unlinked Lithuanian data found an overestimation of inequality in life expectancy, due in part to the poor correspondence between the census (11 educational categories) and death records (5 broad categories).[60,61] This overestimation of inequality in life expectancy would also result in an overestimation in differences in lifespan variation (i.e. the SD would be overestimated for the low-educated group and underestimated for the high-educated group due to the negative correlation between the two dimensions). Such a bias is also likely to have occurred in Estonia, given that both countries are post-Soviet Baltic republics and experienced similar changes both in mortality and in the educational system. It is more difficult to ascertain the existence and direction of a numerator/denominator bias for the Czech Republic and Poland.

In the analysis reported in this article, we used a readily understandable measure of lifespan variation, the SD. Differences in lifespan variation tend to be driven by premature mortality, which skews the age distribution of death.[62] This might call into question whether the SD is an appropriate measure. In general, different measures of lifespan variation are highly correlated.[62,63] Nevertheless, we checked whether our findings would change if we would quantify lifespan variation by the Gini coefficient,[11] which compares differences in ages at death between individuals rather than with any average age at death. Moreover, the Gini is more sensitive to changes in mortality at older ages than the SD and measures relative, rather than absolute differences in lifespan variation.[11] Applying the Gini coefficient produced only a few differences in country ranking, and the substantive conclusions remained the same (results not shown).

The age distribution of education varied in the 10 countries, although no systematic East/West differences could be found to explain further the geographical differences in lifespan variation. Generally, since we used the life table death distributions, having different proportions of individuals by education in each age category should not matter, especially if absolute vs relative educational levels are driving mortality differences. However, among females, <3% of the population in ages ⩾85 years were tertiary educated in Estonia, Czech Republic, Poland, Slovenia and Switzerland. This would suggest that these women are highly selected and could account for the low variation found in some of these countries.

The starting age at which an age-at-death distribution is examined can affect conclusions about the level of lifespan variation in a population.[19,64,65] We examined lifespan variation in adult ages—ages young enough to capture most of the adult distribution of death, but old enough to be beyond completed education. Extending back to age 30 years, which was possible for the unlinked studies, did not change the rankings or affect our conclusions (available as supplementary data at *IJE* online).

Implications

Our analysis sheds new light on the frequently studied phenomenon of socio-economic inequalities in mortality. We show that higher and lower educated groups not only differ in average life expectancy, but also in lifespan variation. Larger lifespan variation in lower socio-economic groups has potential implications both for individuals and for society as a whole.

At the individual level, greater uncertainty in the timing of death makes long-term investments such as education, healthy behaviour and retirement planning less sensible. This greater uncertainty could well be one of the determinants of the lower sense of control (or greater powerlessness and fatalism) among lower socio-economic groups,[66,67] which has been shown to be one of the determinants of their higher rates of unhealthy behaviour.[68–70] Future research should examine whether individuals of lower socio-economic status indeed perceive their higher lifetime uncertainty, and whether this contributes to a lower sense of control, and indirectly to riskier behaviour.

At the societal level, the existence of substantial inequalities in lifespan variation points to possible failures of social protection policies, particularly those that reduce premature mortality among lower socio-economic groups. These policies should pay more attention to determinants of premature mortality, such as risky behaviour, hazardous housing and working conditions, psychosocial factors and lack of access to effective health care. Countries where the low-educated had a higher average life expectancy also tended to be the ones with less lifespan variation, both among the low-educated and in the population as a whole. Sweden is a clear example. This lends support to the idea that universal social policies protect vulnerable groups by 'raising the floor'.[71] Yet the pattern is less clear for women than for men, and not all countries with universal social policies fare well on these counts (e.g. Finland). Further research is needed to see whether or not universal social policies are indeed better in reducing lifespan variation than targeted social policies.

In most wealthy countries, life expectancy at birth now stands at ∼80 years. A reasonable question to ask is what our social preferences are for research and policies directed at increasing our average longevity vs reducing uncertainty about the timing of death. A strong risk aversion to early death would call for more attention to the variability in longevity. Social protection policies would then have to be designed specifically to address the needs of the most vulnerable individuals and social groups. Moreover, as early deaths bring down the average, reducing mortality at early ages would have the double benefit of reducing lifespan variation and increasing life expectancy.

By definition, reducing lifespan variation requires that reductions in premature mortality continue at a higher pace than reductions in old age mortality. With finite budgets, targeting premature mortality would imply a degree of age rationing in health priorities. Given a choice, would individuals rather public spending be directed to equalizing life chances or to improving survival probabilities at the oldest ages? Ethical analysis and measuring preferences of the population on this matter would dictate to a large extent how trends in survivorship should be monitored, and where interventions should be prioritized.

Conclusions

Lower educated individuals not only have shorter life expectancies, but also face greater uncertainty about the age at which they will die. More priority should be given to efforts to reduce the risk of an early death among the lower educated, e.g. by strengthening protective policies within and outside the health-care system.

Supplementary Data

Supplementary Data are available at *IJE* online.

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KEY MESSAGES

- Lower educated groups not only have lower life expectancies but also face greater uncertainty about the age at which they will die.
- Greater lifespan variation in lower educated groups was largely driven by conditions causing death at younger ages, such as injuries and neoplasms.
- At the individual level, this greater uncertainty may act as a disincentive for investments in long-term health.
- At the societal level, it points to the failure of the health-care system and other policy sectors to protect lower socio-economic groups against premature death, e.g. from injuries and cancers.

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