Trends in inequalities in premature mortality: a study of 3.2 million deaths in 13 European countries

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ABSTRACT

Background Over the last decades of the 20th century, a widening of the gap in death rates between upper and lower socioeconomic groups has been reported for many European countries. For most countries, it is unknown whether this widening has continued into the first decade of the 21st century.

Methods We collected and harmonised data on mortality by educational level among men and women aged 30–74 years in all countries with available data: Finland, Sweden, Norway, Denmark, England and Wales, Belgium, France, Switzerland, Spain, Italy, Hungary, Lithuania and Estonia.

Results Relative inequalities in premature mortality increased in most populations in the North, West and East of Europe, but not in the South. This was mostly due to smaller proportional reductions in mortality among the lower than the higher educated, but in the case of Lithuania and Estonia, mortality rose among the lower and declined among the higher educated. Mortality among the lower educated rose in many countries for conditions linked to smoking (lung cancer, women only) and excessive alcohol consumption (liver cirrhosis and external causes). In absolute terms, however, reductions in premature mortality were larger among the lower educated in many countries, mainly due to larger absolute reductions in mortality from cardiovascular disease and cancer (men only). Despite rising levels of education, population-attributable fractions of lower education for mortality rose in many countries.

Conclusions Relative inequalities in premature mortality have continued to rise in most European countries, and since the 1990s, the contrast between the South (with smaller inequalities) and the East (with larger inequalities) has become stronger. While the population impact of these inequalities has further increased, there are also some encouraging signs of larger absolute reductions in mortality among the lower educated in many countries. Reducing inequalities in mortality critically depends upon speeding up mortality declines among the lower educated, and countering mortality increases from conditions linked to smoking and excessive alcohol consumption such as lung cancer, liver cirrhosis and external causes.

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INTRODUCTION

During the 1980s and 1990s, socioeconomic inequalities in mortality have widened in many countries. This has been well documented for relative inequalities in mortality between educational or occupational groups in Northern, Western and Southern Europe.[1–5] For absolute inequalities in mortality, findings have been less consistent, with increases reported for some countries such as Finland[1–3 6] and Norway,[1 3 4] but not for others such as Sweden[1–3] and Italy.[1 2] Inequalities in life expectancy between socioeconomic groups have generally increased as well.[6–12] In Eastern Europe, inequalities in mortality have increased too, on a relative and on an absolute scale.[13 14] Widening inequalities have also been reported for non-European high-income countries, such as the USA[15–18] and New Zealand.[19 20]

Although some studies have started to look at trends into the 21st century, a comprehensive analysis of recent trends, allowing a comparison of these trends between countries, is lacking. We therefore studied changes in mortality by education in all European countries with available data between the 1990s and 2000s, and focused on whether relative and absolute inequalities in mortality have widened or narrowed, and if so, which causes of death have contributed to these developments. We consider relative and absolute inequalities to be relevant: while the first are independent from average rates of mortality and therefore useful for analytical purposes, the second indicate the real impact that these inequalities have on the mortality risks of people with a lower socioeconomic position, which is useful for informing public health decisions.[21]

DATA AND METHODS

Data

The data were obtained from official mortality registers and cover 13 countries: 4 countries in Northern Europe (Finland, Sweden, Norway, Denmark), 4 countries in Western Europe (England and Wales, Belgium, France and Switzerland), 2 countries in Southern Europe (Spain and Italy), and 3 countries in Eastern Europe (Hungary, Lithuania and Estonia). These are all European countries with comparable data for the 1990s and 2000s which, together, are likely to represent the full range of inequality trends in the subcontinent. Most data cover complete national populations, as in the case of the national longitudinal mortality registers of the Nordic countries. The exceptions are England

and Wales (a 1% representative sample of the population; known as the Office of National Statistics Longitudinal Mortality Study), France (a 1% representative sample of the population; the so-called Echantillon Démographique Permanent created by the French National Institute of Statistics (INSEE)), Spain (Barcelona, Madrid and Basque Country only; urban and regional mortality registers) and Italy (Turin only; known as the Turin Longitudinal Study). A full overview of data sources is given in table 1.

For each country, numbers of deaths by 5-year age group, sex and educational group were obtained for the 1990s and the 2000s. These data were mostly collected in the framework of a longitudinal mortality follow-up of population censuses carried out around 1991 and around 2000, respectively. Although around 2010, a more recent census has been held in many countries, mortality follow-up will only be complete after 5–10 years, and at the moment of writing (2014), our data, therefore, represent the most recent data available for those countries. Data for Hungary, Lithuania and Estonia derive from unlinked cross-sectional studies in which numerator data (deaths by educational group, as counted in the mortality register) and denominator data (persons by educational group, as counted in a census) have been collected at approximately the same point in time. In most countries, linkage between the population and death registries was more than 95% complete; for countries where linkage failure exceeded 5% (Madrid, Barcelona and the Basque Country) weights were used in the analysis to account for the difference. A total of around 3.2 million deaths are included in this study, deriving from around 360 million person-years of observation.

Socioeconomic status was indicated by highest level of completed education. We focused on educational inequalities in mortality (instead of, eg, occupational inequalities in mortality) because comparable data on educational attainment are available for men and women in all European populations under study. Additionally, education is the most stable measure of socioeconomic position because it is normally completed early in adulthood which avoids reverse causation problems (ie, health outcomes at older ages cannot change a person's level of education).[22] Education was classified according to the International Standard Classification of Education (ISCED-97). The categories

Table 1 Mortality data sources.

Country	Type of study	Years	Years of follow-up	Person-years	Deaths	Educational structure (in %)		
						Low	Mid	High
Finland	Longitudinal	1990–2000	10	25 874 201	270 232	50.1	29.3	20.6
Finland*	Longitudinal	2001–2007	7	15 435 298	105 379	33.9	36.8	29.3
Sweden	Longitudinal	1991–2000	10	43 042 216	393 038	40.6	41.7	17.7
Sweden	Longitudinal	2001–2006	6	28 087 496	187 168	27.1	50.3	22.6
Norway	Longitudinal	1990–2000	10	19 956 767	213 022	33.1	47.7	19.2
Norway	Longitudinal	2001–2006	5	11 645 682	70 191	19.7	55.0	25.3
Denmark	Longitudinal	1996–2000	5	13 926 291	136 065	45.1	34.9	20.0
Denmark	Longitudinal	2001–2005	5	14 498 528	122 728	38.6	37.7	23.7
England & Wales†	Longitudinal	1991–1996	5.5	1 530 278	14 966	85.1	-	14.9
England & Wales†	Longitudinal	2001–2006	5	1 432 977	9145	80.7	-	19.3
Belgium	Longitudinal	1991–1995	5	23 684 150	206 444	63.1	21.0	15.9
Belgium	Longitudinal	2004–2005	2	11 221 276	73 001	48.6	25.2	26.2
France‡	Longitudinal	1990–1999	10	2 478 782	20 215	56.1	32.3	11.6
France§	Longitudinal	1999–2005	6	1 521 946	8796	42.4	40.4	17.2
Switzerland¶	Longitudinal	1990–2000	10	27 910 587	255 275	30.3	54.5	15.2
Switzerland¶	Longitudinal	2001–2005	5	15 635 957	82 195	19.8	57.8	22.4
Barcelona	Repeated CS	1992–1998	7	6 285 178	39 830	64.9	18.0	17.1
Barcelona	Repeated CS	2000–2006	7	6 858 828	35 143	55.7	21.5	22.8
Basque C	Longitudinal	1996–2001	5	6 048 696	34 230	69.9	16.8	13.3
Basque C	Longitudinal	2001–2006	5	6 312 758	32 169	60.9	20.5	18.6
Madrid	Longitudinal	1996–1997	1.5	4 122 305	25 356	64.9	18.1	17.1
Madrid	Longitudinal	2001–2003	1.5	4 967 231	26 279	56.6	21.9	21.5
Turin	Longitudinal	1991–2001	10	4 873 109	50 621	71.5	19.8	8.6
Turin	Longitudinal	2001–2006	5	2 422 742	14 186	59.2	27.4	13.4
Hungary	CS unlinked	1988–1991	4	22 408 012	297 749	59.4	30.2	10.4
Hungary	CS unlinked	1999–2002	4	22 479 484	282 601	43.6	43.2	13.2
Lithuania**	CS unlinked	1988–1990	3	5 135 151	45 449	44.6	42.1	13.4
Lithuania**	CS unlinked	2000–2002	3	5 199 153	48 092	22.5	59.5	18.0
Estonia	CS unlinked	1987–1991	5	4 011 470	45 611	41.9	42.6	15.5
Estonia	CS unlinked	1998–2002	5	3 684 050	50 035	26.2	55.7	18.1

All data, unless otherwise mentioned, refer to the age group 30–74 years.
*20% of Finns are excluded (at random).
†1% representative sample of population.
‡1% representative sample of the population; people from overseas areas, military and students are excluded.
§1% representative sample of the population; people born outside France mainland are excluded.
¶Non-Swiss nationals excluded.
**Age range 30–69 years.
CS, cross-sectional.

used in this analysis were 'no, primary or lower secondary education' (ISCED 0, 1, 2; 'low'), 'upper secondary and post-secondary non-tertiary education' (ISCED 3, 4; 'mid') and 'tertiary education' (ISCED 5, 6; 'high'). In the 1990s dataset for England and Wales only two levels of education could be distinguished ('low and mid' vs 'high'), and we therefore also classified the English data for the 2000s in this way. In order to reduce problems with the educational classification of elderly people, the main analysis is limited to the age group 30–74 years. Because average life expectancy at birth exceeded 74 years in most European countries during the study period, we label mortality in this age-range as 'premature'.

In addition to all-cause mortality, we analysed four broad cause-of-death groups that together account for all deaths (cardiovascular diseases, cancer, other diseases and external causes), and five specific causes of death each that signal potential explanatory factors (ischaemic heart disease (smoking, diet, hypertension, hypertension detection and treatment, myocardial infarction treatment), cerebrovascular disease (hypertension, hypertension detection and treatment, stroke treatment), lung cancer (smoking), liver cirrhosis (excessive alcohol consumption), and road traffic accidents (excessive alcohol consumption, road safety)). Cause-of-death information was not available for mortality by education in France. Causes of death were classified according to the ninth or tenth revision of the International Classification of Diseases (ICD). ICD-code numbers are given in web appendix table A1.

Data for the 1990s were collected in the framework of the Eurothine study, and have been used for international comparative purposes before.[23] Data for the 2000s were collected in the

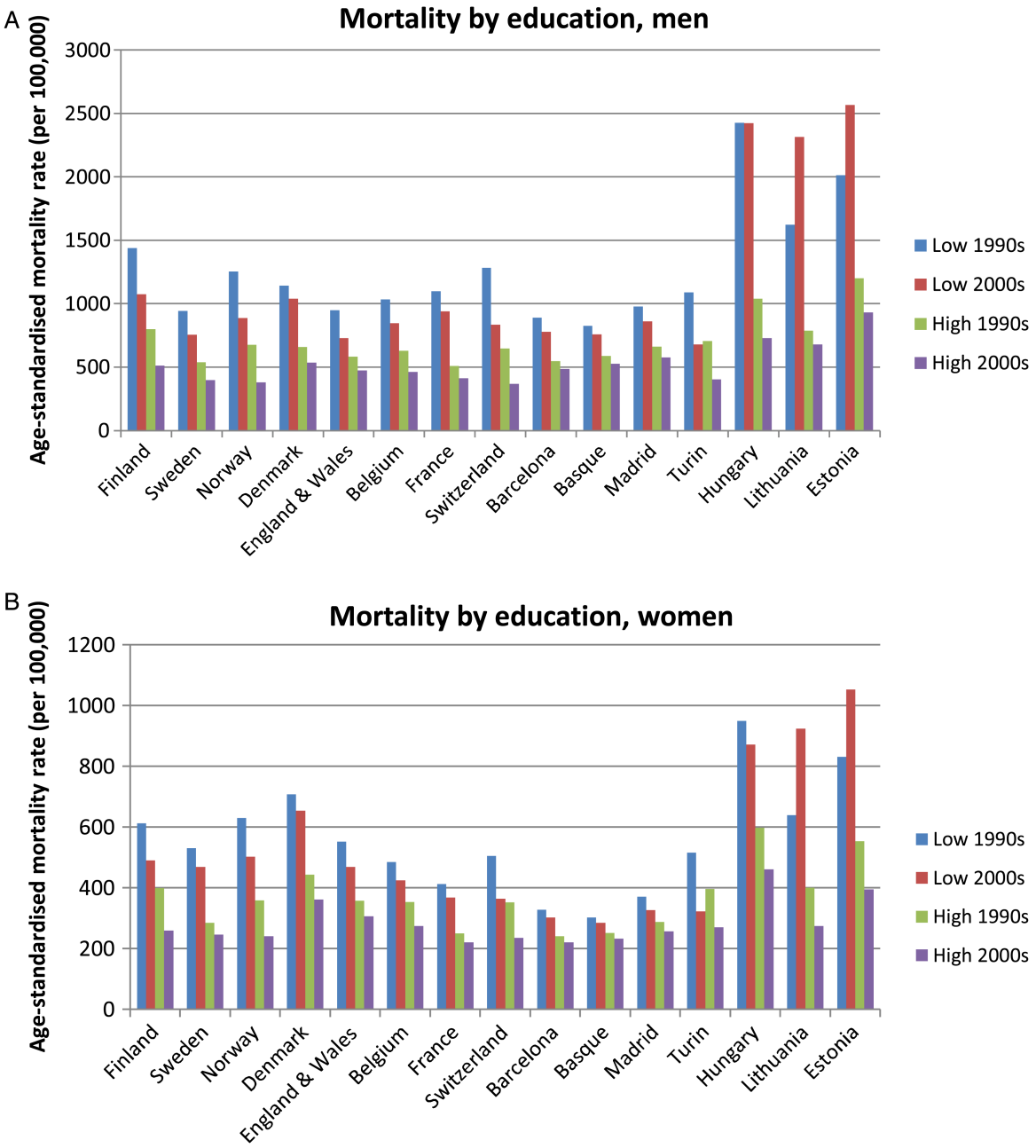

Figure 1 All-cause mortality among the low and high educated, by country and sex, 1990s and 2000s Notes: Mortality standardised to the European Standard Population. Low = 'no, primary or lower secondary education' (ISCED 0,1,2). High = 'tertiary education' (ISCED 5, 6). For full details, including 95% Confidence Intervals, see online supplementary appendix table A3.

framework of the EURO-GBD-SE study.[24] Data were centrally harmonised to enhance comparability between countries and over time.

Methods

We calculated age-standardised mortality rates and their 95% Confidence Intervals (CIs)[25] by period, country, level of education, and sex, using the European Standard Population as defined by WHO. Age-adjusted rate ratios comparing the 'low' and 'mid' educated with the 'high' educated and their 95% CIs were calculated with Poisson regression using STATA statistical software V.12.0.

The age-standardised mortality rates were used to calculate proportional and absolute changes in mortality by country, level of education and sex, and subtraction of these changes among the 'high' educated from those among the 'low' educated allowed us to evaluate differences in proportional and absolute mortality change between educational groups.

The age-standardised mortality rates were also used to calculate population-attributable fractions of education for mortality

Table 2 Changes between the 1990s and 2000s in rate ratios by education for all-cause mortality, by country and sex

		MEN				WOMEN			
		1990s		2000s		1990s		2000s	
Country	Education	Rate Ratio	95% CI	Rate Ratio	95% CI	Rate Ratio	95% CI	Rate Ratio	95% CI
North									
Finland	Low	1.97	(1.93 to 2.01)	**2.08**	(2.03 to 2.13)	1.59	(1.55 to 1.64)	**1.84**	(1.78 to 1.90)
	Mid	1.60	(1.57 to 1.64)	1.61	(1.57 to 1.65)	1.22	(1.19 to 1.26)	1.35	(1.30 to 1.39)
	High	1		1		1		1	
Sweden	Low	1.78	(1.75 to 1.81)	**1.90**	(1.86 to 1.94)	1.88	(1.84 to 1.93)	1.88	(1.83 to 1.93)
	Mid	1.42	(1.39 to 1.44)	1.47	(1.44 to 1.51)	1.47	(1.43 to 1.50)	1.42	(1.38 to 1.46)
	High	1		1		1		1	
Norway	Low	1.88	(1.83 to 1.92)	**2.35**	(2.27 to 2.44)	1.76	(1.70 to 1.82)	**2.12**	(2.02 to 2.22)
	Mid	1.43	(1.40 to 1.47)	**1.63**	(1.57 to 1.68)	1.30	(1.26 to 1.35)	**1.45**	(1.38 to 1.52)
	High	1		1		1		1	
Denmark	Low	1.77	(1.73 to 1.82)	**2.00**	(1.95 to 2.06)	1.62	(1.57 to 1.68)	**1.85**	(1.79 to 1.91)
	Mid	1.46	(1.42 to 1.50)	1.53	(1.49 to 1.57)	1.24	(1.20 to 1.29)	1.34	(1.29 to 1.39)
	High	1		1		1		1	
West									
England and Wales	Low*	1.65	(1.51 to 1.80)	1.55	(1.43 to 1.69)	1.55	(1.36 to 1.75)	1.52	(1.36 to 1.69)
	High	1		1		1		1	
Belgium	Low	1.69	(1.65 to 1.73)	**1.86**	(1.81 to 1.92)	1.40	(1.35 to 1.44)	**1.57**	(1.51 to 1.64)
	Mid	1.30	(1.27 to 1.34)	**1.40**	(1.36 to 1.46)	1.10	(1.06 to 1.14)	**1.25**	(1.19 to 1.31)
	High	1		1		1		1	
France	Low	2.23	(2.04 to 2.44)	2.37	(2.14 to 2.62)	1.64	(1.42 to 1.90)	1.80	(1.55 to 2.09)
	Mid	1.60	(1.46 to 1.76)	1.70	(1.54 to 1.89)	1.17	(1.00 to 1.36)	1.38	(1.18 to 1.62)
	High	1		1		1		1	
Switzerland	Low	1.95	(1.91 to 1.98)	**2.22**	(2.16 to 2.29)	1.43	(1.38 to 1.49)	1.54	(1.47 to 1.63)
	Mid	1.41	(1.38 to 1.43)	**1.52**	(1.48 to 1.56)	1.11	(1.07 to 1.15)	1.13	(1.08 to 1.19)
	High	1		1		1		1	
South									
Barcelona	Low	1.64	(1.57 to 1.71)	1.60	(1.54 to 1.66)	1.43	(1.33 to 1.54)	1.40	(1.32 to 1.49)
	Mid	1.29	(1.23 to 1.36)	1.18	(1.12 to 1.24)	1.16	(1.06 to 1.28)	1.09	(1.01 to 1.18)
	High			1		1		1	
Basque Country	Low	1.49	(1.42 to 1.57)	1.51	(1.44 to 1.58)	1.25	(1.14 to 1.38)	1.39	(1.28 to 1.51)
	Mid	1.20	(1.12 to 1.27)	1.16	(1.10 to 1.23)	1.12	(1.00 to 1.26)	1.22	(1.10 to 1.35)
	High	1		1		1		1	
Madrid	Low	1.55	(1.48 to 1.63)	1.56	(1.49 to 1.63)	1.37	(1.24 to 1.50)	1.30	(1.20 to 1.40)
	Mid	1.30	(1.22 to 1.38)	1.27	(1.20 to 1.35)	1.18	(1.05 to 1.32)	1.23	(1.11 to 1.35)
	High	1		1		1		1	
Turin	Low	1.58	(1.49 to 1.67)	1.66	(1.53 to 1.80)	1.28	(1.17 to 1.40)	1.22	(1.09 to 1.36)
	Mid	1.19	(1.12 to 1.27)	1.17	(1.07 to 1.28)	1.09	(0.99 to 1.21)	1.12	(0.98 to 1.27)
	High	1		1		1		1	
East									
Hungary	Low	2.35	(2.30 to 2.39)	**3.26**	(3.19 to 3.32)	1.67	(1.62 to 1.73)	**2.09**	(2.03 to 2.16)
	Mid	0.99	(0.97 to 1.02)	**1.49**	(1.46 to 1.53)	1.27	(1.22 to 1.32)	1.28	(1.24 to 1.32)
	High	1		1		1		1	
Lithuania†	Low	2.21	(2.10 to 2.32)	**3.09**	(2.96 to 3.23)	1.61	(1.50 to 1.73)	**2.66**	(2.50 to 2.84)
	Mid	1.69	(1.60 to 1.78)	**1.97**	(1.89 to 2.06)	1.28	(1.19 to 1.38)	**1.65**	(1.55 to 1.75)
	High	1		1		1		1	
Estonia	Low	1.83	(1.75 to 1.91)	**2.61**	(2.50 to 2.72)	1.51	(1.42 to 1.61)	**2.29**	(2.17 to 2.43)
	Mid	1.44	(1.37 to 1.51)	**2.04**	(1.95 to 2.13)	1.35	(1.26 to 1.44)	**1.77**	(1.67 to 1.88)
	High	1		1		1		1	

In **bold**: no overlap in 95% Confidence Interval (CI) of Rate Ratio between 2000s and 1990s.
*low and middle educated combined.
†age 30–69 years.

for the two points in time. This is a straightforward measure of the population impact of inequalities in mortality.[21] The population-attributable fraction takes into account inequalities in mortality between educational groups and the size of educational groups, and quantifies the proportion of all deaths in the population that could be avoided or postponed if everyone had the mortality rates of the high educated.[21 26]

Most countries with longitudinal data classified person-years and deaths by age at baseline, and as length of follow-up differed between studies (table 1) adjustment was necessary. This adjustment procedure was developed and validated within the EURO-GBD-SE study,[27] and was used wherever deaths were classified by age at baseline. Further details can be found in web appendix table A2.

RESULTS

All-cause mortality

Age-standardised mortality rates by education for the 1990s and 2000s can be found in figure 1 and online supplementary appendix table A3, whereas rate ratios are presented in table 3. Mortality declined between the 1990s and 2000s in all educational groups, except the low educated in Hungary, Lithuania and Estonia, among whom mortality remained stable or increased. Mortality among the high educated in Hungary, Lithuania and Estonia was similar to that among the low educated in many Western European countries (figure 1).

Among men, relative inequalities in mortality increased in most populations, with the exceptions of England and Wales, France, Barcelona, the Basque Country, Madrid and Turin, where no clear changes were found. Among women, about half the countries had widening and half had stable inequalities. The rise in relative inequalities was very strong in Hungary, Lithuania and Estonia, particularly for men (table 2).

As a result of these changes, the variation in magnitude of inequalities in mortality between European countries has increased considerably. In the 1990s, the South (represented by Barcelona, the Basque Country, Madrid and Turin) already tended to have smaller inequalities in mortality than the North and West, and the North and West than the East (represented by Hungary, Lithuania and Estonia), particularly among men. In the 2000s, the same pattern is still found, but with substantially larger differences between countries (table 2).

These changes in relative inequalities in mortality between the 1990s and 2000s are the result of large differences between educational groups in *proportional* mortality change (see the column for all causes in tables 3A, B). For example, in the case of Finnish men, mortality declined 10.7%-points more among the high than among the low educated, as mortality declined by 35.9% among the high and 25.2% among the low educated. Light grey shading in table 3 indicates that mortality declined less among the low than among the high educated; dark grey shading indicates that mortality actually increased among the low educated. The latter is seen for all-cause mortality in Lithuania and Estonia

Table 3A Differences between low and high educated in proportional and absolute mortality decline between the 1990s and 2000s, by cause of death, country and sex

	Difference between low and high educated in proportional mortality decline (%-points)									
Men	All causes	All cardio-vascular	Ischaemic heart disease	Cerebro-vascular disease	All cancer	Lung cancer	All other diseases	Liver cirrhosis	All external	Road traffic accidents
(A) Proportional mortality decline, men										
North										
Finland	−10.74	−10.86	−9.48	−6.70	−6.18	−10.96	−14.52	−22.80	−8.97	−24.21
Sweden	−6.19	−5.70	−6.43	−7.05	−3.22	−9.12	−12.36	−20.08	−18.84	−25.66
Norway	−14.47	−10.85	−10.01	−7.88	−14.34	−27.40	−22.42	−15.43	−24.05	−21.85
Denmark	−9.83	−4.96	−2.96	−6.62	−8.00	−1.36	−14.41	−26.54	−3.92	−7.27
West										
England & W	4.13	−1.94	−0.75	6.98	−1.32	−4.67	28.36	−20.30	48.31	−32.04
Belgium	−8.37	−8.98	−9.24	−4.51	−4.48	−2.33	−7.17	13.00	−13.73	−30.63
France	−4.50	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
Switzerland	−8.15	−8.68	−7.73	−11.42	−4.86	−5.04	−15.96	−18.73	1.65	−14.69
South										
Barcelona	1.39	−10.14	−12.34	−18.11	5.91	11.29	8.20	−13.32	1.73	8.26
Basque C	−2.48	−8.89	−10.98	−22.69	1.82	−2.17	−0.28	15.84	−4.23	−17.72
Madrid	−0.81	−8.00	−11.33	−27.22	2.58	−9.26	10.05	−35.91	−20.71	−25.77
Turin	−5.04	−0.65	3.88	11.01	−8.60	−22.59	−6.18	46.18	6.18	18.54
East										
Hungary	−29.90	−37.23	−41.35	−26.35	−38.82	−42.03	−17.39	3.71	−10.52	−9.76
Lithuania	−56.61	−48.18	−41.14	−38.13	−28.00	−32.16	−69.52	n.a.	−50.70	−45.01
Estonia	−49.81	−43.87	−40.21	−33.15	−26.21	−22.43	−83.88	n.a.	−53.07	−19.74

More mortality decline (or less mortality increase) among low than among high educated.
Less mortality decline among low than among high educated.
Mortality increase among low educated, mortality decline (or less mortality increase) among high educated.

Difference between low and high educated in proportional mortality decline was calculated by subtracting the percentage mortality decline among the high educated from the percentage mortality decline among the low educated. In algebraic form: $100*(R_{1990,L}-R_{2000,L})/R_{1990,L} - 100*(R_{1990,H} - R_{2000,H})/R_{1990,H}$ in which R=age-standardized mortality rate, 1990=1990s, 2000=2000s, L=low educated, and H=high educated. For example, in the case of Finnish men, mortality declined by 35.9% among the high and 25.2% among the low educated, which is 10.7%-points more among the high than among the low educated. Grey shading indicates a disadvantage for the low educated; no shading indicates a disadvantage for the high educated. Difference in mortality decline could not be calculated for liver cirrhosis among women in Turin because of 0 deaths among high educated women in this population in the 2000s. Please note that the sum of the cause-specific changes does not always exactly equal the change for all-cause mortality, because of various adjustments and rounding.

Table 3B

Women	Difference between low and high educated in proportional mortality decline (%-points)									
	All causes	All cardio-vascular	Ischaemic heart disease	Cerebro-vascular disease	All cancer	Lung cancer	All other diseases	Liver cirrhosis	All external	Road traffic accidents
(B) Proportional mortality decline, women										
North										
Finland	−14.7	−15.9	−12.9	−14.8	−8.4	−31.0	−30.8	−62.2	−35.5	−24.5
Sweden	−2.1	−11.4	−14.5	−3.0	−9.3	−19.5	−18.5	25.2	−16.5	−10.5
Norway	−12.8	−6.1	−7.6	−5.7	−14.2	−35.0	−24.7	−53.6	−54.2	−32.9
Denmark	−10.8	−6.0	−6.7	0.0	−12.9	−21.6	−14.0	−19.8	−6.4	14.0
West										
England & W	0.9	−7.6	−7.8	2.4	−4.2	69.3	25.2	16.1	−12.9	333.2
Belgium	−10.0	−8.0	−11.9	−2.7	−10.0	−8.2	−16.4	−37.2	−10.5	−28.3
France	−1.5	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
Switzerland	−5.4	−4.8	1.9	−11.3	−4.8	−21.4	−14.7	−4.9	−9.3	0.8
South										
Barcelona	−0.8	13.1	22.5	11.7	−7.3	−31.2	5.4	−42.7	−22.3	−17.3
Basque C	−2.2	9.4	9.5	42.9	−1.8	−57.9	−15.2	−2.9	−6.8	51.4
Madrid	1.4	−16.2	14.5	−9.2	−0.4	−8.9	20.7	72.4	5.9	65.4
Turin	5.7	5.3	15.1	−13.7	9.9	−4.9	−2.2	n.a.	1.8	16.0
East										
Hungary	−14.9	−12.1	−22.7	2.8	−23.2	−68.5	−11.5	12.9	−25.8	−22.6
Lithuania	−76.1	−62.9	−47.8	−48.0	−62.0	−52.7	−78.2	n.a.	−121.3	−71.0
Estonia	−55.3	−49.5	−48.4	−28.2	−24.1	−62.9	−102.4	n.a.	−124.4	−27.1

More mortality decline (or less mortality increase) among low than among high educated.
Less mortality decline among low than among high educated.
Mortality increase among low educated, mortality decline (or less mortality increase) among high educated.

Difference between low and high educated in proportional mortality decline was calculated by subtracting the percentage mortality decline among the high educated from the percentage mortality decline among the low educated. In algebraic form: $100*(R_{1990,L}-R_{2000,L})/R_{1990,L} - 100*(R_{1990,H} - R_{2000,H})/R_{1990,H}$ in which R=age-standardized mortality rate, 1990=1990s, 2000=2000s, L=low educated, and H=high educated. For example, in the case of Finnish men, mortality declined by 35.9% among the high and 25.2% among the low educated, which is 10.7%-points more among the high than among the low educated. Grey shading indicates a disadvantage for the low educated; no shading indicates a disadvantage for the high educated. Difference in mortality decline could not be calculated for liver cirrhosis among women in Turin because of 0 deaths among high educated women in this population in the 2000s. Please note that the sum of the cause-specific changes does not always exactly equal the change for all-cause mortality, because of various adjustments and rounding.

only. In other countries, widening relative inequalities in all-cause mortality are due to less declines among the low than among the high educated. Among men in England & Wales and Barcelona and among women in England & Wales, Madrid and Turin, there was more proportional decline in all-cause mortality among the low than among the high educated.

However, tables 3C, D show that differences between educational groups in *absolute* mortality change have often favoured the low educated. For example, in the case of Finnish men, mortality declined by 75.3 deaths per 100 000 more among the low than among the high educated, as it went down by 361.9 and 286.6 deaths per 100 000, respectively. In many populations, including Finland (men only), Sweden, Norway, England and Wales, Belgium (men only), France, Switzerland, Barcelona, Basque Country (men only), Madrid, and Turin, absolute reductions in mortality have been larger among the low than among the high educated. Please note that there is no contradiction between smaller proportional reductions and larger absolute reductions in mortality: the latter also depend on starting levels of mortality which are always higher among the low educated.

Cause-specific mortality

A pattern of generally smaller proportional reductions in mortality among the low educated is found for many specific causes of death, including all cardiovascular disease, ischaemic heart disease, cerebrovascular disease, all cancer, lung cancer (men only), and all other diseases (tables 3A, B). Among men, the main exceptions are liver cirrhosis and external causes, for which several countries have experienced increases in mortality among the low educated. Among women, mortality has increased among the lower educated for liver cirrhosis and external causes, and also for lung cancer in many countries. Rising all-cause mortality among the low educated in Lithuania and Estonia is due to rising mortality from a wide range of causes of death.

As mentioned above, in Northern, Western and Southern Europe, absolute reductions in all-cause mortality have been larger among the low than among the high educated in many countries. This was often due, in large part, to larger absolute reductions for cardiovascular disease (tables 3C, D). Among Finnish men, for example, the difference in decline of mortality between low and high educated was 75.3 deaths per 100 000 for all-cause mortality, of which 61.3 deaths per 100 000 are accounted for by cardiovascular disease mortality. In many countries, other causes of death, mainly cancer and all other diseases, contributed as well, but less so among women, which partly explains why larger absolute reductions in all-cause mortality among the low educated are more clearly and more often seen among men than among women.

Population-attributable fractions

Over time, the proportion of higher educated has increased in all populations (table 1), and larger inequalities in mortality between educational groups, therefore, do not necessarily imply that the population impact of these inequalities has become larger. However, as figure 2 shows, the population-attributable fractions

Table 3C

Men	Difference between low and high educated in absolute mortality decline (deaths per 100 000)									
	All causes	All cardio-vascular	Ischaemic heart disease	Cerebro-vascular disease	All cancer	Lung cancer	All other diseases	Liver cirrhosis	All external	Road traffic accidents
(C) Absolute mortality decline, men										
North										
Finland	75.3	61.3	61.8	12.7	13.8	17.3	−3.7	−14.5	−5.5	−1.9
Sweden	48.4	52.7	42.3	5.2	2.9	0.2	−5.1	−2.3	−11.1	−1.9
Norway	70.8	98.2	77.7	15.1	−12.7	−6.1	−7.3	−0.4	−12.7	−0.9
Denmark	−21.3	14.8	25.9	−1.9	−14.4	4.8	−18.7	−8.5	7.1	0.7
West										
England & W	108.4	59.0	48.9	9.7	16.0	18.6	31.2	−3.3	8.0	−0.7
Belgium	21.6	17.4	7.2	5.0	14.7	22.8	6.6	−1.1	−8.9	−3.7
France	62.9	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
Switzerland	170.2	66.6	32.6	9.3	44.1	25.7	26.1	3.8	22.8	−0.9
South										
Barcelona	50.8	−7.8	−6.3	−2.5	25.4	13.1	35.1	−1.2	−1.9	0.6
Basque C	4.4	−13.7	−7.9	−9.6	8.9	−1.5	3.8	0.2	5.3	−1.3
Madrid	33.0	−7.9	−10.2	−9.5	11.9	−5.4	35.1	−1.7	−6.1	−3.5
Turin	109.3	42.0	19.8	22.1	10.5	−1.3	55.3	−0.2	6.6	3.2
East										
Hungary	−309.5	−157.5	−110.6	−12.6	−179.6	−64.6	−39.6	−42.8	67.2	17.0
Lithuania	−802.6	−223.4	−120.1	−26.4	−81.3	−20.3	−186.8	n.a.	−311.1	−20.4
Estonia	−821.2	−304.4	−161.8	−48.6	−87.9	−14.5	−208.0	n.a.	−220.9	−2.9

More mortality decline (or less mortality increase) among low than among high educated.
Less mortality decline among low than among high educated.
Mortality increase among low educated, mortality decline (or less mortality increase) among high educated.

Difference between low and high educated in absolute mortality decline was calculated by subtracting the absolute mortality decline among the high educated from the absolute mortality decline among the low educated. In algebraic form: $(R_{1990,L} - R_{2000,L}) - (R_{1990,H} - R_{2000,H})$ in which R=age-standardized mortality rate, 1990=1990s, 2000=2000s, L=low educated, and H=high educated. For example, in the case of Finnish men, mortality declined by 361.9 and 286.6 deaths per 100,000 among the low and the high educated, respectively, and thus by 75.3 deaths per 100,000 more among the low educated. Grey shading indicates a disadvantage for the low educated; no shading indicates a disadvantage for the high educated. Difference in mortality decline could not be calculated for liver cirrhosis among women in Turin because of 0 deaths among high educated women in this population in the 2000s. Please note that the sum of the cause-specific changes does not always exactly equal the change for all-cause mortality, because of various adjustments and rounding.

have risen somewhat in many countries, among men and among women, particularly in Hungary, Lithuania and Estonia.

DISCUSSION

Summary of findings

Relative inequalities in premature mortality increased in most populations in the North, West and East of Europe, but not in the South. This was mostly due to smaller proportional reductions in mortality among the lower than the higher educated, but in the case of Lithuania and Estonia mortality rose among the lower and declined among the higher educated. Mortality among the lower educated rose in many countries for conditions linked to smoking (lung cancer, women only) and excessive alcohol consumption (liver cirrhosis and external causes). In absolute terms, however, reductions in premature mortality were larger among the lower educated in many countries, mainly due to larger absolute reductions in mortality from cardiovascular disease and cancer (men only). Despite rising levels of education, population-attributable fractions of lower education for mortality rose in many countries.

Strengths and limitations

This is the most comprehensive analysis of trends in inequalities in mortality ever conducted, covering 13 countries with different socioeconomic and health conditions. However, its broad international scope inevitably raises issues of data comparability. Despite extensive harmonisation efforts, our comparisons between countries and over time may be biased by differences in data collection, for example, with regard to study design, population coverage, time-periods covered, and data classification. For example, in Hungary, Lithuania and Estonia, mortality data were collected in a cross-sectional unlinked design. A study comparing cross-sectional unlinked and longitudinal mortality data in Lithuania found that the former overestimated inequalities in mortality, but the bias was larger at older ages and significantly attenuated when the age limits were set to 30–74 years as in our study.[28]

There are also differences between countries in population coverage. The most notable relate to Spain and Italy, for which only a few urban and relatively prosperous populations could be included that are not necessarily representative of the whole of Spain or Italy. However, studies of the situation in the 1980s, which used national data for Spain and Italy from methodologically less-refined sources, also found smaller inequalities in mortality there than in other European countries,[2 29] as did recent national-level studies from Spain[30] and Italy,[31 32] so there is no reason to think that our study misrepresents the situation in these Southern European countries.

Information on education was fairly complete in all countries, and the proportion of individuals with missing education ranged between 2% and 6% only. We reclassified national educational levels into the ISCED scheme, and this should have removed most differences in classification between countries. The main problem in our study concerns England and Wales, for which we had to pool together the 'low' and 'mid' educated because of the crude educational classification used in the 1990s

Table 3D

Women	Difference between low and high educated in absolute mortality decline (deaths per 100 000)									
	All causes	All cardio-vascular	Ischaemic heart disease	Cerebro-vascular disease	All cancer	Lung cancer	All other diseases	Liver cirrhosis	All external	Road traffic accidents
(D) Absolute mortality decline, women										
North										
Finland	−15.6	29.3	28.9	5.5	−10.9	−5.2	−22.1	−9.7	−15.6	−1.2
Sweden	22.6	15.9	11.1	4.3	−13.9	−8.0	−13.4	−0.7	−4.0	−0.3
Norway	8.9	51.1	32.1	10.5	−19.8	−13.1	−13.6	−2.3	−14.0	−2.0
Denmark	−28.0	6.9	11.1	0.9	−27.2	−10.5	−15.7	−3.1	0.2	1.0
West										
England & W	32.6	17.8	20.8	4.9	−1.4	19.1	13.4	1.2	−2.6	2.2
Belgium	−18.7	14.2	5.3	3.9	−16.1	−3.8	−12.1	−2.2	−3.5	−2.2
France	13.4	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
Switzerland	23.7	31.6	18.2	3.9	−1.7	−4.8	−1.5	0.8	−2.4	−0.2
South										
Barcelona	4.5	14.2	6.2	4.0	−10.5	−1.6	4.1	−0.9	−3.3	−0.7
Basque C	−2.8	8.1	3.1	7.2	−3.1	−7.1	−6.7	0.1	−1.1	2.1
Madrid	14.1	−2.3	3.6	−1.3	0.0	−0.3	15.5	0.8	0.9	3.2
Turin	67.5	27.1	10.4	0.4	24.5	−1.8	27.8	n.a.	0.1	1.1
East										
Hungary	−60.6	16.2	−15.4	21.4	−61.9	−22.4	−8.1	−5.3	−6.8	−4.1
Lithuania	−410.9	−98.8	−26.1	−21.1	−117.4	−5.7	−75.2	n.a.	−119.4	−12.6
Estonia	−380.0	−130.6	−60.7	−15.1	−51.0	−10.6	−105.9	n.a.	−92.6	−2.9

More mortality decline (or less mortality increase) among low than among high educated.
Less mortality decline among low than among high educated.
Mortality increase among low educated, mortality decline (or less mortality increase) among high educated.

Difference between low and high educated in absolute mortality decline was calculated by subtracting the absolute mortality decline among the high educated from the absolute mortality decline among the low educated. In algebraic form: $(R_{1990,L} - R_{2000,L}) - (R_{1990,H} - R_{2000,H})$ in which R=age-standardized mortality rate, 1990=1990s, 2000=2000s, L=low educated, and H=high educated. For example, in the case of Finnish men, mortality declined by 361.9 and 286.6 deaths per 100,000 among the low and the high educated, respectively, and thus by 75.3 deaths per 100,000 more among the low educated. Grey shading indicates a disadvantage for the low educated; no shading indicates a disadvantage for the high educated. Difference in mortality decline could not be calculated for liver cirrhosis among women in Turin because of 0 deaths among high educated women in this population in the 2000s. Please note that the sum of the cause-specific changes does not always exactly equal the change for all-cause mortality, because of various adjustments and rounding.

mortality data. However, the sensitivity analysis reported in online supplementary appendix table A4, in which a two-group classification was used in all countries, confirms that whereas many other countries experienced an increase in relative inequalities in all-cause mortality, England and Wales did not, and its absolute inequalities therefore also went down more than elsewhere. It would have been useful to add another indicator of socioeconomic position to our analysis, such as occupational class or income, but income is generally unavailable in mortality registers, whereas data on occupational class that are comparable between countries and over time are available for a small number of countries only.[23]

As our analysis has focused on changes over time within countries, between-country variations in data collection do not pose a major risk of bias. Potentially more important are changes over time in data collection, but these have been minimal (table 1). The main change has been in the length of follow-up and in the classification of person-years and deaths by age (see online supplementary appendix table A2). As our adjustment method for the latter problem could not be validated for the 1990s, and some uncertainty therefore remains concerning the comparability of absolute levels of mortality between the 1990s and 2000s, we have restricted analyses of absolute changes to within-country comparisons between the low and high educated, which are unlikely to be substantially biased. Still, our results require confirmation from national-level studies that are more strictly harmonised over time than is feasible in an international comparative study.

Our analysis covers the age group 30–74 years at baseline, and thereby excludes younger age groups, and also underrepresents older age groups which currently carry the largest share of the burden of mortality, particularly in Western Europe where average life expectancy at birth in the 2000s exceeded 75 years for men and 80 years for women. This implies that our results cannot necessarily be generalised to mortality in the whole population, and this may also explain discrepancies with the few national studies which have followed trends in inequalities in life expectancy into the 2000s and which cover a wider age range.[8 11] In our data, educational inequalities in life expectancy from the age of 30 years have increased in most countries, whereas inequalities in partial life expectancy between age 30 and 75 years have been stable or declined (results not shown).

Interpretation

This is the first study to systematically document and compare trends since the 1990s in inequalities in mortality for a larger number of countries. It shows that after the turn of the century, relative inequalities have continued to widen in most European countries, but that in contrast to previous periods[1] absolute reductions of mortality seem to have been larger among the low educated in many countries in the North, West and South of Europe. This may announce a future narrowing of the gap in mortality between educational groups, but for the time being, rising population-attributable fractions indicate an increasing, not a diminishing public health problem.

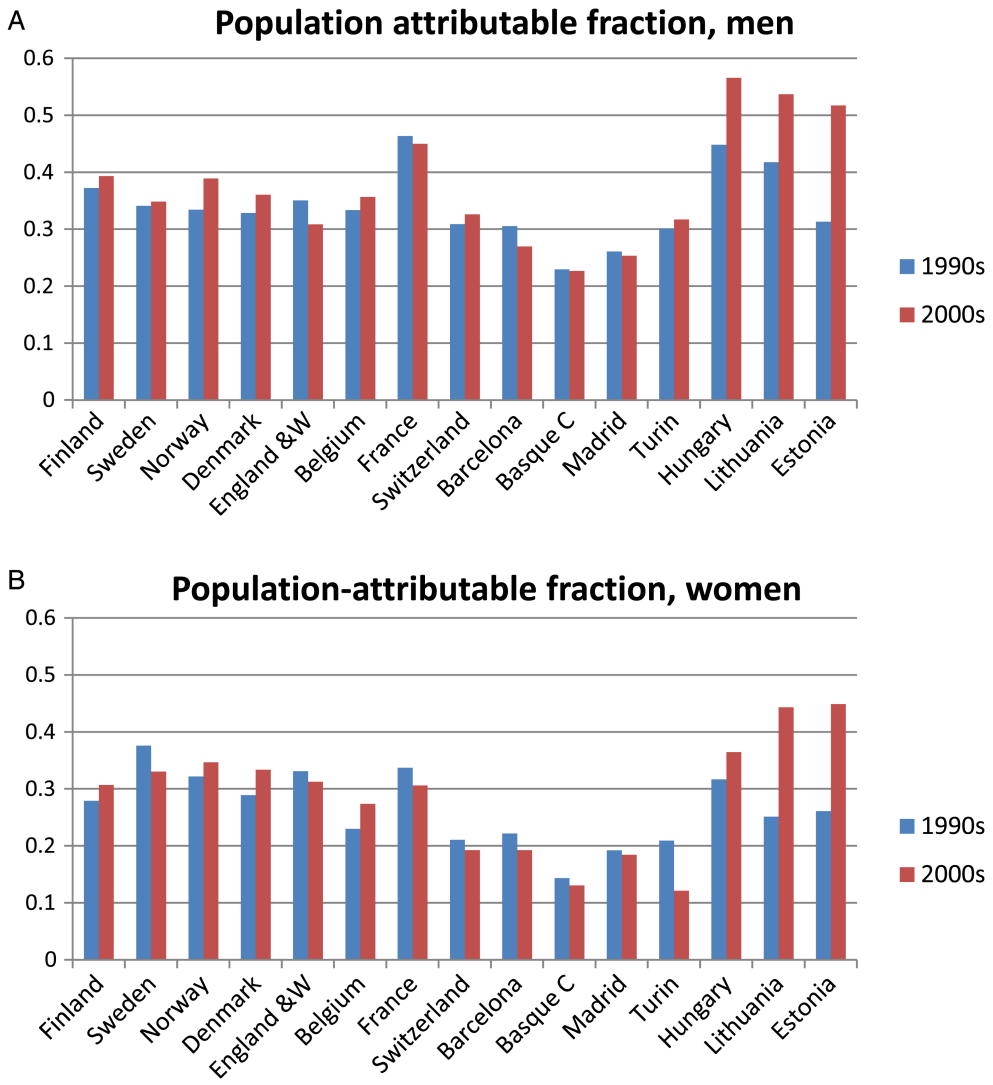

Figure 2 Changes between the 1990s and 2000s in population-attributable fraction of education for all-cause mortality, by country and gender. Note: Population-attributable fractions were calculated as $(M—M_{high})/M$, in which M=Age-standardised mortality rate in the whole population, and M_{high}=Age-standardised mortality rate among the high educated.[26]

As these larger absolute declines were often partly due to larger absolute reductions in mortality from cardiovascular disease, changes in 'proximate' determinants of cardiovascular disease, such as health-related behaviours (eg, smoking, diet, exercise) and/or healthcare interventions (eg, hypertension detection and treatment, thrombolytic therapy), must have been larger among the low educated. Smoking-related inequalities are widening in many European countries,[33 34] so smoking is an implausible explanation. A recent narrowing of absolute inequalities in cardiovascular disease mortality has previously been reported for England,[33 35] and has more likely been caused by an even distribution of treatment benefits[35] than of risk factor changes.[36] It is unlikely, on the other hand, that England's more favourable trends are related to its national policy to tackle health inequalities because the latter has not had clear population-wide effects.[6 37 38]

Southern Europe presents a partly different pattern. Inequalities in mortality are smaller than elsewhere, and the relative gap has also widened less over time, as has been shown before for Barcelona.[39] Part of the explanation for smaller inequalities in mortality in Southern Europe is that inequalities in mortality from smoking-related and alcohol-related conditions, and from conditions amenable to medical intervention are relatively small, particularly among women.[23] Despite rising mortality from lung cancer among low educated women, and from liver cirrhosis among low educated men, Barcelona, the Basque Country, Madrid and Turin have been able to strengthen their favourable positions because differences in mortality decline between the low and high educated often were smaller than in other countries (tables 3A, B). Further study of downstream and upstream determinants of inequalities in mortality in Southern Europe may help to better exploit this 'good practice' for mutual learning.

Inequalities in mortality in Eastern Europe have exploded during the study period, and in Lithuania and Estonia this was not due to differential mortality decline, as in other parts of Europe and in Hungary, but to a combination of rising mortality among the low, and declining mortality among the high educated.[13] The same has been observed in Russia.[40] It is likely that these unfavourable developments were caused by the economic crisis and the subsequent economic reforms that followed the collapse of the Soviet Union. In the early 1990s, Estonia and Lithuania experienced large declines in national income and large increases in unemployment rates, and more so than

Eastern European countries that had not been part of the Soviet Union.[13] Our results point to the important contribution of mortality from external causes to the widening gap in all-cause mortality in these two countries (table 3), which suggests a mediating role of excessive alcohol consumption. Migration patterns (eg, selective emigration of higher educated and relatively healthier persons towards the West) may also have played a role.

CONCLUSIONS

Relative inequalities in premature mortality have continued to rise in most European countries, and since the 1990s, the contrast between the South (with smaller inequalities) and the East (with larger inequalities) has become stronger. While the population impact of these inequalities has further increased, there are also some encouraging signs of larger absolute reductions in mortality among the lower educated in many countries. Reducing inequalities in mortality critically depends upon speeding up mortality declines among the lower educated, and countering mortality increases from conditions linked to smoking and excessive alcohol consumption such as lung cancer, liver cirrhosis and external causes.

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Contributors JPM had the original idea for the study, performed some the analyses, and wrote and revised the paper. IK performed most of the analyses. GM harmonised the data. OO and OL developed an adjustment method. GM, MB, CB, GC, PD, SE, RK, KK, ML, PM, ER, MR-S, B-HS, RH, OO and OL each prepared the data for one of the populations included in the study. TE coordinated the study. All authors contributed to the interpretation of the results, commented on the first version of the paper, and approved the final version of the paper. JPM is guarantor of the paper.

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