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Trends in educational inequalities in premature mortality in Belgium between the 1990s and the 2000s: the contribution of specific causes of deaths

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ABSTRACT

Background Reducing socioeconomic inequalities in mortality, a key public health objective may be supported by a careful monitoring and assessment of the contributions of specific causes of death to the global inequality.

Methods The 1991 and 2001 Belgian censuses were linked with cause-of-death data, each yielding a study population of over 5 million individuals aged 25–64, followed up for 5 years. Age-standardised mortality rates (ASMR) were computed by educational level (EL) and cause. Inequalities were measured through rate differences (RDs), rate ratios (RRs) and population attributable fractions (PAFs). We analysed changes in educational inequalities between the 1990s and the 2000s, and decomposed the PAF into the main causes of death.

Results All-cause and avoidable ASMR decreased in all ELs and both sexes. Lung cancer, ischaemic heart disease (IHD), chronic obstructive pulmonary disease (COPD) and suicide in men, and IHD, stroke, lung cancer and COPD in women had the highest impact on population mortality. RDs decreased in men but increased in women. RRs and PAFs increased in both sexes, albeit more in women. In men, the impact of lung cancer and COPD inequalities on population mortality decreased while that of suicide and IHD increased. In women, the impact of all causes except IHD increased.

Conclusion Absolute inequalities decreased in men while increasing in women; relative inequalities increased in both sexes. The PAFs decomposition revealed that targeting mortality inequalities from lung cancer, IHD, COPD in both sexes, suicide in men and stroke in women would have the largest impact at population level.

BACKGROUND

Reducing socioeconomic (SE) health inequalities is a key public health objective[1–3] requiring careful monitoring.[4] Up to the late 20th century, studies reported a widening of inequalities over time,[5–7] while more complex and country-specific patterns were observed at the turn of the century.[8–10]

Interpreting changes in inequalities is a complex issue.[11–13] Health inequality is a multidimensional concept and can be measured from several perspectives[14]—for instance, a simple two social groups comparison versus a population-wide perspective, or absolute versus relative inequalities measurement. Since single indexes only capture a few aspects of health inequality, it is recommended to use a set of complementary indexes,[12 14 15] ideally including simple absolute and relative between-groups measures and indexes summarising inequalities across the whole population.

Assessing changes in health inequalities is even more challenging, as indices may evolve in different ways. Furthermore, shifts can occur in the SE composition of the population, complicating the interpretation of trends in health inequalities. Changes in group size over time will lead to a different population-level impact. A shift in the SE distribution can also alter the meaning of the social position defined by the SE variable.[16] Finally, from a societal perspective, reducing inequalities in health is not the only thing that matters: an improvement of health that benefits all SE groups, including the lowest ones, is a valuable outcome regardless of whether inequalities decrease or not.[8 12] Also, improvements in the SE distribution is a valuable outcome.

The aim of this study is threefold. First, we aim to describe the change in health outcomes—the all-cause and cause-specific premature mortality—by SE status, between the 1990s and the 2000s in Belgium. Second, we want to assess changes in relative, absolute and population-level SE inequality, and third, estimate and rank the potential impact on population health that would result from an inequality reduction for 12 important avoidable causes. This latter objective is of particular public health relevance, as it would provide crucial information for priority setting in policies tackling health inequalities. To achieve this ranking, we performed a decomposition of the population attributable fraction (PAF) by specific causes.

MATERIALS AND METHODS

Data

Data were obtained by linking the following databases: (a) 1991 and 2001 Belgian censuses, (b) National Population Register and (c) causes of death database for the periods 1991–1997 and 2001–2011.[17 18] Although a more recent census has been held in 2011, it has not been used as the databases linkages could not be performed yet.

The study population comprised all respondents officially residing in Belgium aged 25–64 at census (see online supplementary appendix table 1). The follow-up periods consisted of the 5-year period between the third and the seventh years after the respective census date. The first 2 years after the census were left out to minimise a possible health selection in non-response, since people at high risk of dying in the months following the census are less likely to answer the census.[18] The years after the seventh year were also dropped because of the poor quality of causes of death in 1998 and 1999 (time when the change in the International Classification of Diseases (ICD) code version occurred). For consistency, the same years were dropped for the follow-up of the 2001 census.

Causes of death were classified according to the ICD, using the 9th version in the 1990s and the 10th in the 2000s.[19 20] We divided all-cause premature mortality into avoidable and non-avoidable mortality according to the recent UK Office of Statistics definition of avoidable mortality[21] also adopted by Eurostat.[22] In addition, we analysed four broad cause groups, accounting for all deaths (circulatory diseases, cancers, other natural causes of deaths and external causes) and 12 specific avoidable causes of deaths (lung cancer, lip, oral cavity and pharynx cancer, colorectal cancer, liver cancer, ischaemic heart diseases (IHD), cerebrovascular diseases that were grouped with hypertension (HTA) as usually recommended,[23 24] alcohol-related deaths, diabetes, chronic obstructive pulmonary diseases (COPD), suicide and transport accidents). In women, breast cancer was analysed as well. The corresponding ICD-9 and ICD-10 codes are given in online supplementary appendix table 2. SE status was measured using the highest level of completed education. Educational attainment is a relatively stable measure of SE position, as usually achieved early in adulthood, and is usually of rather good quality. Educational level (EL) was categorised according to the obtained degree using the International Standard Classification of Education (ISCED), V.1997:[25] lower secondary education or less (ISCED 0–2; 'low'), higher secondary education (ISCED 3–4; 'mid') and tertiary education (ISCED 5–6; 'high'). Cases with missing information on educational attainment (9% in the 1990s and 7% in the 2000s) were excluded from the analyses.

Analyses

We computed age-standardised mortality rates (ASMR) by EL, sex and cause of death, using the European population as reference population.[26]Rates were expressed per 100 000 person-years (PYs); the PYs were calculated as the sum across all people included in the census cohorts, of individual times between census date and date of death, emigration date or last day of the study. People having emigrated were censored at emigration date. To take into account the ageing during the follow-up time, age was introduced as a time-varying variable. SEs were computed in Stata assuming a binomial distribution.

For each study period, 1993–1997 and 2003–2007, three inequality indices were calculated for all-cause mortality, for each broad cause group and for each specific cause of death. Mortality inequalities were measured using two pairwise inequality indices, that is, the low versus high EL absolute rate difference (RD) and rate ratio (RR), and one composite measure, that is, the PAF, measuring the population impact of inequality on mortality. The global PAF indicates which fraction of all deaths could have been avoided (in people aged 25–64 at baseline) if the mortality of the whole population was equal to the one observed in the highest EL. The global PAF is calculated as:

$$\frac{\text{ASMR in the total population} - \text{ASMR in the highest EL}}{\text{Overall mortality in the total population}}$$

We also calculated the specific contributions of the 12 main avoidable causes of death to the PAF, by calculating the cause-specific PAFs. This measure indicates which fraction of all deaths could have been avoided (in people aged 25–64 at baseline) if the mortality from this cause in the whole population was equal to the one observed in the highest EL. The cause-specific PAFs are calculated as:

$$\frac{\begin{array}{c}\text{ASMR of a specific cause in the total population}\\ -\text{ASMR of a specific cause in the highest EL}\end{array}}{\text{Overall mortality in the total population}}$$

SEs on the PAFs were calculated by a Monte Carlo simulation approach.[27]

Finally, changes over time were calculated: relative changes to the 1990s values were computed for all three indices; absolute changes between the 1990s and 2000s were computed for the RD and the PAF. Statistical significance of time trends was calculated following Altman.[28]

Analyses were performed in Stata, V.14.

RESULTS

Evolution of health outcomes and educational attainment

All-cause premature mortality *in men* (table 1, 'Adjusted mortality rates') declined between the 1990s and the 2000s, faster among the group with the lowest EL. This faster decline was exclusively due to a larger decline in the lowest EL for avoidable mortality, while declines in non-avoidable mortality were similar in all ELs. *In women*, all-cause avoidable and non-avoidable premature mortality rates also declined in all ELs, but, contrarily to men, declines were less pronounced in the low and mid EL compared with the highest EL. Most cause-specific premature mortality rates declined in both sexes and in all EL, except liver cancer (increase in both sexes and all EL, except among the highest educated women), suicide (increase in men in low and mid ELs), lung cancer and COPD (strong increase in women in all ELs).

Figure 1 reveals a shift in the educational distribution of the population aged 25–65 between the 1990s and the 2000s: the share of people in the low EL decreased from 55% to 40%, while the mid and high EL each attained a share of 30%. The pattern was similar for both sexes.

Trends in absolute and relative pairwise indices: RDs and RRs

Among men, the 1990s RD (table 1, 'Absolute rate difference') between the lowest and the highest EL (LH-RD) reached 300 per 100 000 PYs for all-cause mortality and 230 for avoidable mortality, corresponding to RRs (LH-RR) of 1.74 and 1.89 (table 1, 'Rate ratio'). For non-avoidable causes, the LH-RD and LH-RR were smaller (70 and 1.5). In the 2000s, the LH-RD decreased by 21 per 100 000 PYs for all-cause and avoidable mortality (−7% and −9%) and remained stable for non-avoidable causes. The LH-RR increased to 1.9 (+8%), 2 (+8%) and 1.6 (+10%) for all-cause mortality, avoidable and non-avoidable causes, respectively.

Cancer was the main broad group of causes of death driving absolute inequalities in men in the 1990s, with a 34% share to the total RD, followed by other natural causes (27%), circulatory diseases (24%) and external causes (16%). In the 2000s, the share of cancers decreased slightly while that of external causes increased.

For specific causes of death, the largest RDs in the 1990s were observed for lung cancer, IHD, COPD, suicide, transport accidents, cerebrovascular disease and alcohol-related deaths. The RD in the 2000s decreased for lung cancer, COPD, cerebrovascular diseases, alcohol-related deaths and transport

Table 1 Premature mortality rates by educational level, rate differences and rate ratios (low vs high educational level) by cause of death in Belgium, 1990s, 2000s and change

	Adjusted mortality rates									Absolute rate difference					Rate ratio			
	1990s			2000s			Change											
	Low	Mid	High	Low	Mid	High	Low	Mid	High	1990s	2000s	Absolute change	Percentage change	p Value	1990s	2000s	Percentage change	p Value
Males																		
All-cause																		
All causes	706.7	521.1	406.9	595.3	448.3	316.4	−111.5	−72.8	−90.6	299.8	278.9	−20.9	−7	0.008	1.74	1.88	8	<0.001
Avoidable	489.3	353.6	259.2	410.4	304.9	201.8	−78.9	−48.6	−57.4	230.1	208.6	−21.5	−9	0.001	1.89	2.03	8	0.001
Not avoidable	217.4	167.5	147.7	184.9	143.4	114.6	−32.5	−24.1	−33.1	69.7	70.3	0.6	1	0.897	1.47	1.61	10	0.003
Broad classes																		
All cancers	256.4	196.4	154.4	210.5	162.0	123.8	−45.9	−34.4	−30.5	102.0	86.6	−15.4	−15	0.001	1.66	1.7	2	0.431
All circulatory diseases	179.7	139.3	109.0	130.9	98.9	67.1	−48.8	−40.4	−41.9	70.8	63.9	−6.9	−10	0.07	1.65	1.95	18	<0.001
Other natural causes of deaths	170.7	110.8	91.2	158.3	114.7	80.2	−12.4	3.9	−11.0	79.5	78.1	−1.4	−2	0.721	1.87	1.97	5	0.154
External causes	100.0	74.5	52.4	95.6	72.7	45.3	−4.4	−1.8	−7.1	47.5	50.3	2.7	6	0.428	1.91	2.11	11	0.05
Detailed																		
Lung cancer	108.4	67.4	45.1	81.7	54.0	33.3	−26.7	−13.4	−11.8	63.3	48.4	−14.9	−24	<0.001	2.41	2.46	2	0.7
Colorectal cancer	19.5	18.9	14.2	16.1	15.1	13.0	−3.4	−3.8	−1.3	5.3	3.1	−2.2	−41	0.127	1.37	1.24	−9	0.306
Lip, oral cavity and pharynx cancer	12.4	10.1	6.7	11.0	7.8	5.1	−1.4	−2.3	−1.6	5.8	5.9	0.2	3	0.847	1.86	2.17	17	0.253
Liver cancer	5.2	5.4	4.2	6.1	5.6	4.5	0.9	0.2	0.3	1.0	1.6	0.6	65	0.428	1.23	1.35	10	0.578
Ischaemic heart disease	92.9	72.9	57.0	64.9	47.3	30.6	−28.0	−25.6	−26.3	35.9	34.2	−1.7	−5	0.538	1.63	2.12	30	<0.001
Cerebrovascular diseases/HTA	28.8	23.4	16.5	21.8	17.2	12.4	−7.0	−6.2	−4.2	12.3	9.4	−2.8	−23	0.062	1.74	1.76	1	0.892
COPD	29.6	12.5	7.5	21.5	10.0	5.4	−8.1	−2.5	−2.1	22.1	16.1	−6.0	−27	0	3.93	3.98	1	0.915
Alcohol-related deaths	30.9	23.8	17.9	26.8	24.5	15.9	−4.1	0.8	−2.1	13.0	11.0	−2.0	−15	0.209	1.73	1.69	−2	0.818
Diabetes	7.6	4.7	3.6	7.4	5.2	3.2	−0.2	0.5	−0.4	4.0	4.3	0.3	6	0.746	2.11	2.33	10	0.599
Suicide	47.3	36.4	27.2	47.5	38.7	25.3	0.3	2.2	−1.9	20.1	22.2	2.1	11	0.368	1.74	1.88	8	0.268
Transport accidents	28.3	23.1	14.4	22.3	17.3	9.6	−6.0	−5.8	−4.8	13.9	12.7	−1.2	−9	0.515	1.96	2.32	18	0.14
Females																		
All-cause																		
All causes	332.9	266.2	239.2	304.8	242.8	191.3	−28.2	−23.3	−47.9	93.8	113.5	19.7	21	0.002	1.39	1.59	14	<0.001
Avoidable	214.3	169.1	152.9	199.4	157.5	123.6	−14.9	−11.6	−29.4	61.4	75.8	14.4	24	0.005	1.4	1.61	15	<0.001
Not avoidable	118.6	97.0	86.3	105.4	85.3	67.7	−13.2	−11.7	−18.5	32.4	37.7	5.3	16	0.167	1.38	1.56	13	0.006
Broad classes																		
All cancers	144.2	136.9	129.3	132.1	116.6	102.2	−12.0	−20.3	−27.1	14.9	30.0	15.1	101	0.001	1.12	1.29	16	<0.001
All circulatory diseases	70.9	45.0	35.3	54.8	40.2	23.4	−16.2	−4.7	−11.9	35.6	31.4	−4.3	−12	0.093	2.01	2.34	17	0.031
Other natural causes of deaths	81.5	56.1	45.9	83.1	58.1	42.0	1.6	2.0	−3.9	35.6	41.2	5.6	16	0.065	1.78	1.98	12	0.059
External causes	36.3	28.2	28.7	34.7	27.9	23.7	−1.6	−0.3	−4.9	7.7	11.0	3.3	44	0.171	1.27	1.46	15	0.073
Detailed																		
Lung cancer	17.1	13.4	10.3	25.7	18.4	13.9	8.6	5.0	3.6	6.8	11.8	5.0	74	<0.001	1.66	1.85	11	0.34
Colorectal cancer	13.2	12.3	11.7	11.1	9.8	8.5	−2.1	−2.5	−3.2	1.5	2.7	1.2	81	0.371	1.13	1.31	17	0.208
Lip, oral cavity and pharynx cancer	2.3	2.5	2.0	2.1	2.1	1.0	−0.2	−0.4	−1.0	0.3	1.1	0.8	248	0.117	1.17	2.17	86	0.045

Continued

Table 1 Continued

	Adjusted mortality rates									Absolute rate difference					Rate ratio			
	1990s			2000s			Change											
	Low	Mid	High	Low	Mid	High	Low	Mid	High	1990s	2000s	Absolute change	Percentage change	p Value	1990s	2000s	Percentage change	p Value
Liver cancer	2.2	1.6	1.6	2.3	1.9	1.2	0.1	0.4	−0.5	0.6	1.2	0.6	96	0.276	1.36	1.99	46	0.241
Breast cancer	42.5	44.5	46.2	33.3	32.9	33.0	−9.2	−11.6	−13.2	−3.7	0.3	4.0	109	0.107	0.92	1.01	10	0.13
Ischaemic heart disease	26.4	15.1	10.2	17.5	10.8	6.3	−8.9	−4.3	−3.9	16.2	11.2	−5.0	−31	<0.001	2.6	2.79	7	0.594
Cerebrovascular diseases/HTA	19.6	13.3	12.1	15.7	12.2	7.8	−3.8	−1.1	−4.3	7.4	7.9	0.5	7	0.723	1.61	2.02	25	0.067
COPD	7.3	3.6	2.3	8.9	5.3	3.0	1.6	1.7	0.7	5.0	5.9	0.9	17	0.262	3.16	2.94	−7	0.771
Alcohol-related deaths	12.9	11.5	9.7	11.5	10.9	7.7	−1.4	−0.7	−1.9	3.2	3.8	0.5	17	0.645	1.33	1.49	11	0.379
Diabetes	5.3	2.3	2.2	3.7	1.8	1.3	−1.6	−0.5	−0.9	3.0	2.4	−0.7	−22	0.27	2.36	2.78	18	0.562
Suicide	17.6	14.0	15.7	16.8	15.2	13.8	−0.8	1.3	−1.8	1.9	3.0	1.0	54	0.55	1.12	1.21	8	0.473
Transport accidents	8.3	7.1	7.3	7.4	4.4	3.7	−0.8	−2.7	−3.7	0.9	3.8	2.8	308	0.027	1.13	2.02	79	0.002

Rates are expressed per 100 000 person-years.
COPD, chronic obstructive pulmonary disease; HTA, hypertension.

accidents, and increased for suicide. The largest RRs in the 1990s were observed for COPD and lung cancer. In the 2000s, the RRs increased for many conditions, but remained stable (change ≤2%) for lung cancer, COPD, cerebrovascular diseases and alcohol-related deaths, and decreased for colorectal cancer. Owing to of the small numbers, most of the changes were not significant.

In women in the 1990s, inequalities were less pronounced than in men: the RDs reached 94, 61 and 32 per 100 000 PYs, with RRs of 1.39, 1.40 and 1.38 for all-cause, avoidable and non-avoidable mortality, respectively. All inequalities increased, with an RD increase of 21%, 23% and 16%, and an RR increase of 14%, 15% and 13% for all-cause, avoidable and non-avoidable mortality, respectively.

The main broad cause groups driving mortality inequalities in women were circulatory diseases and other natural causes (both with a 35% share), while cancers and external causes only accounted for 14% and 8% of the RD. In the 2000s, the share of cancers increased to 26%, while that of circulatory diseases dropped to 28% and that of external causes increased slightly.

Among specific causes of death, the largest RDs in females in the 1990s were observed for IHD, cerebrovascular disease, lung cancer, COPD and alcohol-related mortality. Breast cancer mortality showed an opposite gradient (with highest mortality rates in the highest EL). In the 2000s, the RDs increased for almost all specific causes, the only notable exception being IHD (−31%). The largest RRs were observed for COPD, IHD and diabetes. In the 2000s, all cause-specific RRs increased (significant increase for lip, oral cavity and pharynx cancers and transport accidents).

Trends in PAF for all-cause, avoidable and non-avoidable deaths

In men, the all-cause PAF (table 2, 'Males') was 35% in the 1990s, meaning that 35% of the deaths could have been eliminated if the mortality of the whole population was equal to the one of the group of people in the highest education level. The all-cause PAF increased to 38% in the 2000s (a 7% increase). Avoidable deaths contributed 75% to the PAF. The PAF increased less in avoidable than non-avoidable deaths (+6 and +13%, respectively).

In women, the all-cause PAF was lower than in men in the 1990s (23%) and increased to 29% in the 2000s, representing a 28% increase of the population-level inequalities. Contrary to men, there was a sharper increase of the PAF in avoidable than non-avoidable mortality (+33% vs +20%).

Decomposition of the PAFs by specific cause of death and trends in the cause contribution

Figure 2 shows the decomposition of the PAF into specific causes in each period, ranked by their importance in the 1990s. In men, the main specific causes contributing to the PAF in the 1990s were lung cancer, IHD, COPD and suicide. The same four causes remained on top in the 2000s, with now a higher contribution of suicide than of COPD.

Figure 3 illustrates the change in the PAF contribution of each cause between the 1990s and the 2000s. The largest decreases in the contribution to the PAF were observed for lung cancer, followed by COPD, cerebrovascular diseases and colorectal cancer; the largest increases were observed for IHD, suicide and alcohol-related deaths.

In women, the main contributors in the 1990s were IHD, cerebrovascular diseases, lung cancer and COPD. The same top causes were observed in the 2000s, but with a higher

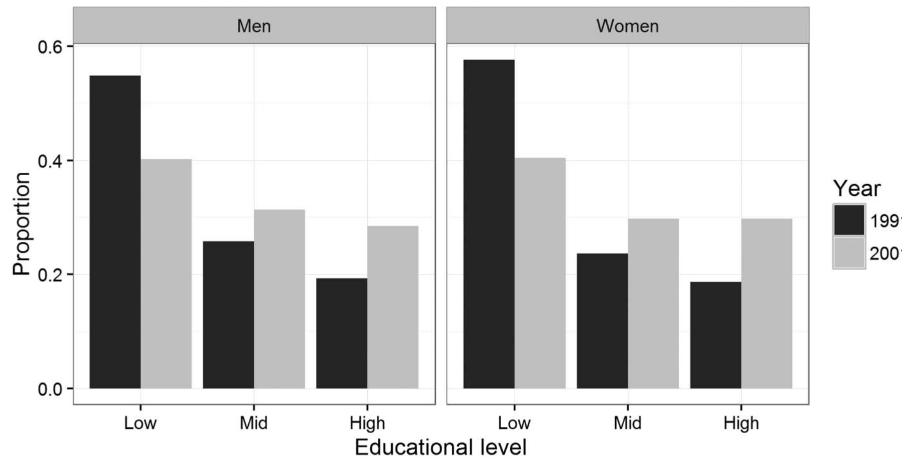

Figure 1 Evolution of the educational distribution in men and women aged 25–65, between the census 1991 and the census 2001, Belgium.

contribution of lung cancer, which now almost reached the level of IHD. For breast cancer, the inequality was reversed in the 1990s, with lowest mortality rates in the lowest EL, leading to a negative PAF, while in the 2000s the PAF was null. For transport accidents, the PAF was null in the 1990s but reached 0.5% in the 2000s.

Between 1990 and 2000, a decrease in the absolute contribution to the PAF was only observed for IHD and diabetes; the contribution of all other causes increased, with the highest increase observed in lung cancer and COPD.

DISCUSSION

The first study[18] to analyse changes in life expectancy inequalities between the 1990s and the 2000s in Belgium was published in 2007, revealing a general increase in life expectancy together with a widening social gap. A European comparative study including Belgium only for a limited follow-up time was published in 2015.[10] Building up on this previous work, we provide a comprehensive picture of trends in inequalities for premature, avoidable and cause-specific mortality in Belgium at the turn of the century, updating former results with a longer follow-up period. The main added value of the current work was the decomposition of the PAF into the main contributing causes, providing crucial information to set up priorities and to evaluate past actions in inequality reduction policies.

Summary of main findings

From a societal point of view, two favourable evolutions are noteworthy. First, there is a global shift towards a more favourable distribution of the educational attainment at the population level, and second, there is an improvement of the health outcome (premature mortality level) in all ELs between the 1990s and the 2000s. The narrowing of absolute inequalities in men is another valuable outcome, but is quite limited (−7%), compared with other countries sometimes characterised by a 35% decrease.[8] Absolute inequalities in women have, on the contrary, increased. Relative inequalities, already important in the 1990s, still increased in both sexes, although this increase was not larger than in the surrounding countries (the only exception being the UK, and a few places in South Europe, where RRs decreased).

The PAFs increased by 10% and 28% in men and women, respectively, indicating an increase of relative inequalities after having accounted for the change in EL distribution.

Mortality from avoidable causes revealed stronger educational inequalities than mortality from non-avoidable causes. In men, absolute inequalities decreased more for avoidable than non-avoidable causes, while the opposite was observed in women.

Cancers were driving the absolute inequalities in men in the 1990s and still dominated in the 2000s. In women, the circulatory diseases and the 'other natural causes' were equally drivers of absolute inequalities in the 1990s while in the 2000s, the share of circulatory diseases decreased strongly, together with a huge increase of the cancer importance.

Lung cancer, IHD, COPD and suicide were the main contributors to the PAF in men in the 1990s, meaning that a reduction of inequalities for those causes would have a maximal impact on the global level of mortality. IHD and suicide were the major contributors to the increase in PAF between the 1990s and the 2000s, designing causes that should be given priority, with a decline in the contribution of lung cancer and COPD, indicating progress towards the right direction. In women, IHD, lung cancer, cerebrovascular diseases and COPD were the main contributors to the PAF in the 1990s. Except for IHD, all specific causes contributed to the increase in PAF in women. For breast cancer, lower rates in the lowest EL were observed in the 1990s, corresponding to a well-known reverse social gradient;[29] this gradient was mostly attributable to a higher incidence of breast cancer in lower educated women. The evolution we observed in the 2000s towards a same mortality level in the lowest and highest ELs has been observed in other studies as well,[30 31] and may reflect a survival disadvantage in lower educated women, possibly due to a worse stage at presentation and/or lower access to healthcare.

Strengths and limitations

This is the most detailed and comprehensive study on recent trends in premature mortality inequalities in Belgium. To the best of our knowledge, it is also the first time that the cause-specific contribution to mortality inequalities was expressed in terms of a decomposition of the total PAF. By taking into account the EL shift, the PAF is probably the best population-based measure to estimate the change of the inequalities impact on the total population health. The PAF decomposition in specific causes is of major interest for policymaking since it can help set priorities regarding the causes with the largest expected population-level impact.

The approach we took considers, above the measurements of inequalities, also health and societal evolution, by including the evolution of the health status by EL and the shift in the distribution of the EL.

Table 2 Contribution of causes of death to the total PAF in the 1990s and the 2000s, and contribution to the total change in PAF

	1990s (%)		2000s (%)		Change (%)		
	Contribution to PAF	Share	Contribution to PAF	Share	Absolute change	Relative change	Share of change
Males							
All-cause							
All causes	35.40	100	38.10	100	2.70	7.70	100
Avoidable	26.80	75.60	28.40	74.40	1.60	6.00	58.20
Not avoidable	8.60	24.30	9.80	25.60	1.20	13.40	42.10
Broad classes							
All cancers	12.30	34.60	11.50	30.10	−0.80	−6.20	−27.60
All circulatory diseases	8.30	23.60	9.10	23.90	0.80	9.20	28.00
Other natural causes of deaths	9.80	27.80	11.40	30.00	1.60	16.50	59.20
External causes	5.00	14.00	6.10	15.90	1.10	22.50	40.70
Detailed							
Lung cancer	7.50	21.20	6.50	17.10	−1.00	−12.80	−35.00
Colorectal cancer	0.70	2.00	0.40	1.20	−0.30	−36.80	−9.50
Lip, oral cavity and pharynx cancer	0.70	2.00	0.80	2.00	0.10	10.40	2.70
Liver cancer	0.10	0.40	0.20	0.60	0.10	60.90	3.20
Ischaemic heart disease	4.10	11.70	4.70	12.30	0.60	14.00	21.00
Cerebrovascular diseases/HTA	1.60	4.40	1.40	3.80	−0.10	−7.80	−4.40
COPD	2.70	7.50	2.30	6.00	−0.30	−13.20	−12.70
Alcohol-related deaths	1.50	4.40	1.80	4.70	0.30	16.90	9.50
Diabetes	0.50	1.40	0.60	1.60	0.10	26.60	4.70
Suicide	2.10	5.80	2.70	7.10	0.60	30.80	23.20
Transport accidents	1.50	4.10	1.40	3.80	0.00	−0.60	−0.30
Females							
All-cause							
All causes	22.80	100	29.20	100	6.40	28.20	100
Avoidable	14.30	62.60	19.00	64.90	4.70	33.00	73.30
Not avoidable	8.50	37.40	10.30	35.10	1.70	20.30	26.90
Broad classes							
All cancers	3.30	14.60	7.30	25.10	4.00	121	62.50
All circulatory diseases	8.90	39.00	8.80	30.20	−0.10	−0.70	−1.00
Other natural causes of deaths	9.40	41.30	11.00	37.80	1.60	17.30	25.40
External Causes	1.10	5.00	2.00	6.80	0.90	74.80	13.30
Detailed							
Lung cancer	1.80	7.80	2.90	9.90	1.10	62.90	17.30
Colorectal cancer	0.30	1.50	0.60	2.10	0.30	84.50	4.50
Lip, oral cavity and pharynx cancer	0.10	0.60	0.30	1.10	0.20	149	3.10
Liver cancer	0.10	0.50	0.30	1.10	0.20	181	3.30
Breast cancer	−1.20	−5.20	−0.10	−0.20	1.10	−95.80	17.80
Cervix cancer	0.60	2.80	0.50	1.90	−0.10	−14.70	−1.50
Ischaemic heart disease	4.20	18.30	3.10	10.60	−1.10	−25.50	−16.50
Cerebrovascular diseases/HTA	1.80	7.80	2.10	7.10	0.30	17.70	4.90
COPD	1.30	5.60	1.70	5.80	0.40	31.90	6.30
Alcohol-related deaths	0.80	3.70	1.10	3.70	0.20	27.00	3.60
Diabetes	0.80	3.30	0.60	2.10	−0.10	−19.50	−2.30
Suicide	0.10	0.60	0.50	1.90	0.40	318	6.40
Transport accidents	0.00	0.00	0.50	1.70	0.50	120	7.40

COPD, chronic obstructive pulmonary disease; HTA, hypertension; PAF, population attributable fraction.

Combining national census data with mortality data allows one to cover practically the complete resident population. Its large size ensures a good statistical power. However, people living in Belgium without being registered make no part of the studied population. This small subpopulation includes very different groups, for example, short-term students, international expats and illegal migrants. The group of illegal migrants is likely to increase in the coming years, and probably comprises relatively more disadvantaged people, in which health disadvantages deserve to be studied by an ad hoc methodology.

A change in the ICD version occurred between the two censuses. A good correspondence between the two versions could be found for most of the selected causes of death, but is not perfect for alcohol-related death. Since code comparability issues will probably affect mortality rates equally in all ELs in each period, the impact on the EL differentials is, however, assumed to be small. Some inaccuracy in cause of deaths

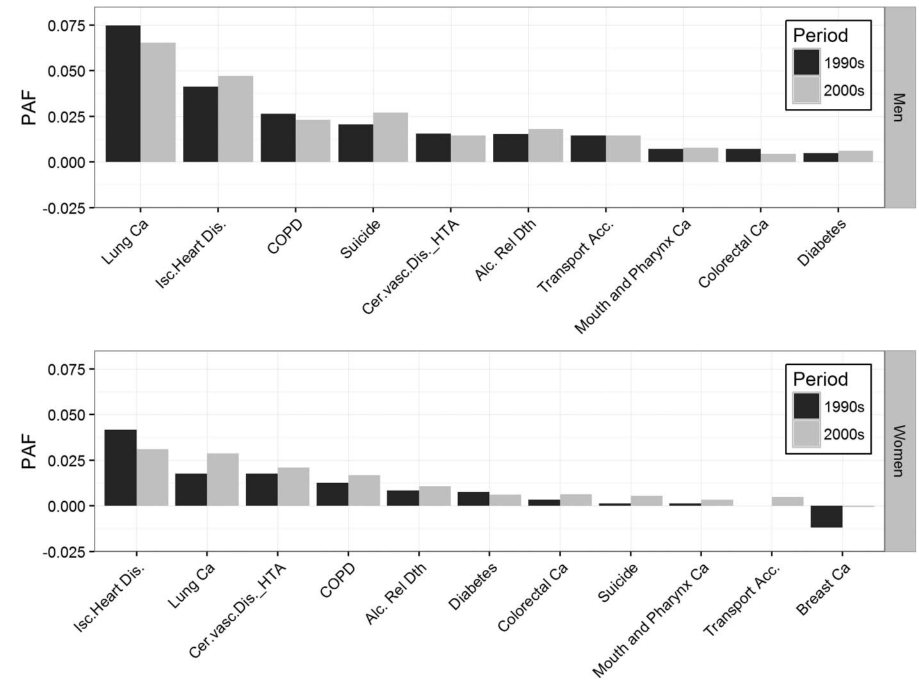

Figure 2 Decomposition of the overall PAF into the main specific causes. COPD, chronic obstructive pulmonary disease; HTA, hypertension; PAF, population attributable fraction.

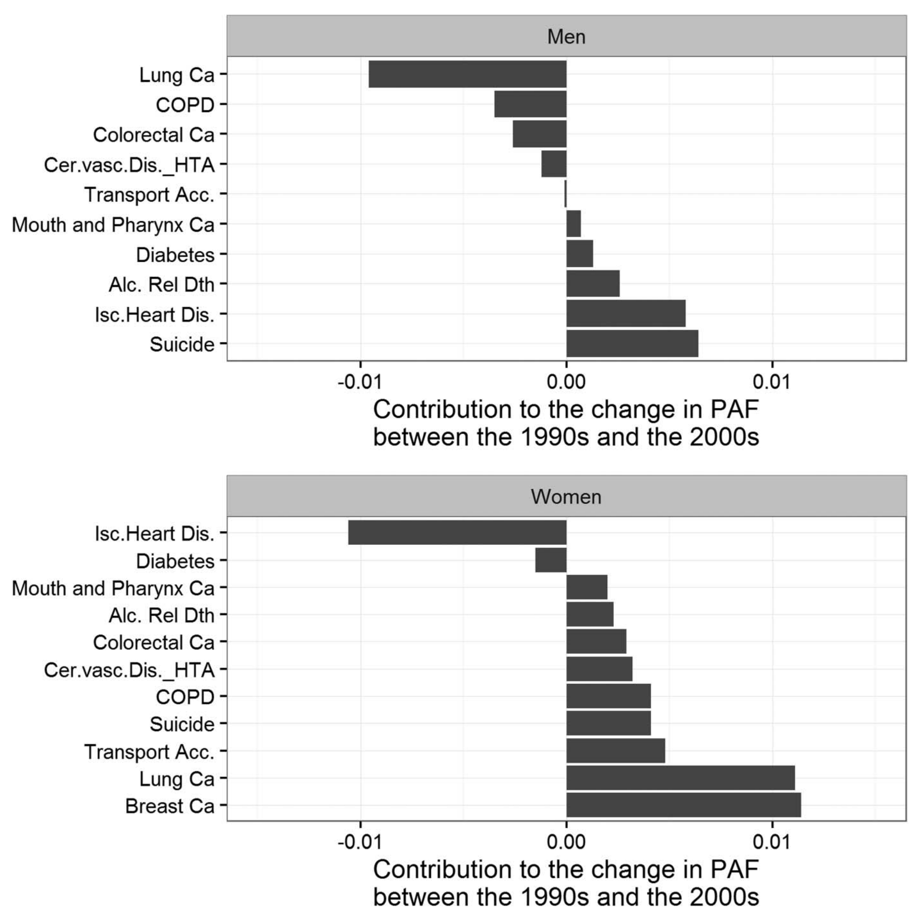

Figure 3 Cause-specific contribution to the change in PAF between the 1990s and the 2000s. COPD, chronic obstructive pulmonary disease; HTA, hypertension; PAF, population attributable fraction.

codification exists, resulting in a proportion of vague codes and underestimation of cause-specific rates. This could possibly be more the case in lower SE classes, resulting in underestimated cause-specific inequalities (conservative effect).

Age limits for 'premature mortality' vary in the literature. Our study covers people aged 25–64 at baseline, allowing them to reach at maximum 72 years at the end of the follow-up period. Our findings cannot be generalised to other age groups, and the comparison with other studies has to take the age range into consideration.

The EL indicator was missing for 9% and 7% of the respondents in 1991 and 2001, respectively. This can lead to some bias if the reason for missing information is linked both to the EL and to the health outcome. A sensitivity analysis including cases with missing data and the first 2 years of follow-up revealed that people with missing value for education had a poorer mortality rate than the other categories, possibly leading to a conservative bias, underestimating the EL inequalities since cases with missing education are more likely to pertain to the lowest EL.[18] The exclusion of the first 2 years, however, had no impact on the mortality differentials by ELs for people with a known EL as shown by the absence of interaction between EL and the year of follow-up.

We did not add other SE indicators (as income, activity status or occupation category), which is a limitation of our study. Income was not available in the Belgian census. It could, however, be approached by some wealth proxies (like the comfort of the habitation), but the stability over time was not insured. Occupational categories were only partially available in the 2001 census.

Comparisons with other studies

A recent comparative study[8 10] examined trends in all-cause and cause-specific mortality inequalities in people aged 30–74 at baseline, across European countries, including a short-term follow-up for Belgium. This study revealed an increase of the relative inequalities in most European countries, except in the South of Europe and in England, and heterogeneous trends in absolute inequalities. Our study, including a longer follow-up and younger people (25–64 at baseline), is mostly in line with the earlier findings related to Belgium published in the European study, except that they observed a larger RD decline for circulatory diseases in men, probably due to the inclusion of an older age group in the European study than in ours.

Tarkiainen *et al*[32] found a strong increase in the life expectancy gap in Finland, mainly explained by alcohol-related deaths in both sexes, cancers in women and IHD only in old men. Fawcett *et al*[33] explored the cause-specific contribution to changes in RII and SII in New Zealand, and found CVD to be the major contributor to the increase in relative inequalities, while CVD and other causes of deaths were important drivers of increasing inequalities in the Nordic countries. In another study, she showed the increasing role of cancers as inequality drivers,[34] which is in line with our findings in women. In a recent paper, Layte and Banks[35] showed that increasing inequalities in Ireland are accounted for by increased inequalities in CVD as well as in digestive diseases, neoplasms and external deaths.

Interpretation and policy implication

The apparent paradox between the evolution in absolute (decrease of RDs) versus relative measures (increase of RRs and PAFs) results from the fact that, with reasonable efforts, a stronger absolute mortality reduction in the lowest SES can be achieved since the starting mortality level in this group is very high. This can be viewed as a first step towards reducing inequalities. Reaching the second step, that is, reducing relative inequalities, will only be obtained when a higher proportional decline in the lowest than in the highest SES group will also be achieved, necessitating much stronger efforts. Mackenbach *et al*[10] describe three patterns of mortality inequality trends: a narrowing of both absolute and relative inequalities (ideal evolution), a narrowing of absolute but widening of relative inequalities, and a widening of both absolute and relative inequalities. Even in this latter situation, a mortality decline in the lowest SE group is still a valuable outcome, contrary to the rise observed in some Eastern Europe countries. According to this classification, Belgium is situated in the second group for men and in the third group for women. The evolution in men may announce a future narrowing of the EL gap in mortality but, for the time being, the rise of the PAFs indicates an increasing public health problem.

The inequalities, much higher in men than in women during the 1990s, evolved in the opposite direction in both sexes, narrowing the gender inequality difference in the 2000s. In particular, inequalities in smoking-related causes (lung cancer and COPD) decreased in men and increased in women. Men and women are in different stages of the smoking epidemic in Belgium, as attested by the differential evolution of recent lung cancer premature mortality in men (−25% in 15 years) and in women (+50%);[36] however, since the important time lag for developing lung cancer, historical data on the smoking patterns by EL should be reconstructed to explain the different gender trends in inequalities. The recent Health Interview Surveys confirm a persisting educational gradient in tobacco consumption.[37] Attention should be paid to smoking behaviour, particularly in the lowest educated people.

Tackling health inequalities is a difficult task, necessitating the set-up of country-tailored strategies,[38] which should address macro-level areas like the labour market, working conditions, taxation policies, as well as specific health behaviour (eg, smoking, alcohol consumption, healthy food consumption, physical activity, preventive behaviours). Mackenbach and Bakker[39] have shown that the European Union (EU) countries were in different stages of awareness and willingness to take action on health inequalities. In Belgium, the public health authorities are aware and concerned about health inequalities since the late 1990s, as seen from the development of several governmental declarations and plans to tackle social exclusion. So far, however, these developments have resulted in only few concrete actions, and in particular, limited progress has been made in the improvement of financial access to care. Therefore, the rather poor evolution between the two periods was not unexpected, and indicates that more efforts remain to be made.

The cause-specific decomposition of the PAF and its ranking provides useful information for setting priorities: tackling the inequalities in lung cancer, COPD and IHD in both sexes would result in the largest impact on the premature mortality level.

The direction and the extent of the changes that have occurred, provides information for evaluating past actions, and decide for for orienting new policies. The opposite male–female trend in inequality from smoking-related causes should be further studied to take rapid action, since cancer mortality has quite a long lag-time, and any measure will require a long time before producing an effect. The increase in suicide inequalities, probably resulting from a recent worsening of the social situation, should certainly be further examined by the health authorities.

CONCLUSIONS

The global assessment of the evolution of mortality inequalities in Belgium reveals a nuanced picture. Positive evolutions are the shift of the educational distribution towards higher educational attainment, together with a decrease of mortality in all EL. Absolute inequalities decreased in men but increased in women, while relative and population-level inequalities increased in both sexes, and more so in women. Using the cause-specific PAF revealed that a reduction of inequalities in mortality from lung cancer, IHD, COPD and suicide in men and in IHD, lung cancer, cerebrovascular diseases/HTA and COPD in women would have the largest impact at the population level.

What is already known on this subject

- Reducing socioeconomic health inequalities is a key public health objective in Europe.
- Measuring progress towards this aim necessitates looking at the evolution of the health outcomes by socioeconomic status, and of absolute, relative and population-based inequalities (as measured by the population attributable fraction (PAF)).
- Tackling the inequalities in mortality from avoidable causes is of particular importance, as it is a feasible aim.
- The specific contribution of each cause of death to the total inequality and to its change is crucial to orient policies.
- The decomposition of the PAF and its change into their specific contributors has not yet been published before.

What this study adds

- In Belgium, the assessment of changes in educational inequalities between the 1990s and the 2000s reveal a nuanced picture:
  - Health outcomes (premature/avoidable mortality) improved in all educational levels (ELs) for both sexes;
  - The educational distribution shifted towards a larger share of highly educated people;
  - Absolute inequalities in premature mortality decreased in men, but increased in women;
  - Relative inequalities and population-level impact of inequalities, as measured by the population attributable fraction (PAF), increased in both sexes.
- Decomposing the PAF by cause provides evidence for policy-making and evaluation:
  - The ranking of the cause-specific contribution to the PAF may inform policy priorities for tackling inequalities;
  - The direction and extent of the cause-specific contribution to the change in PAF provides information for evaluating past actions and for orienting future policies.

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