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ORIGINAL ARTICLE

Educational inequalities in mortality by cause of death: first national data for the Netherlands

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Abstract
Objectives Using new facilities for linking large databases, we aimed to evaluate for the first time the magnitude of relative and absolute educational inequalities in mortality by sex and cause of death in the Netherlands.
Methods We analyzed data from Dutch Labour Force Surveys (1998–2002) with mortality follow-up 1998–2007 among people aged 30–79 years. We calculated hazard ratios using Cox proportional hazards model, age-standardized mortality rates and partial life expectancy by education. We compared results for the Netherlands with those for other European countries.
Results The relative risk of dying was about two times higher among primary educated men and women as compared to their tertiary educated counterparts, leading to a gap in partial life expectancy of 3.4 years (men) and 2.4 years (women). Inequalities in mortality are similar to those in other countries in North-Western Europe, but inequalities in lung cancer mortality are substantially larger in the Netherlands, particularly among men.
Conclusions The Netherlands has large inequalities in mortality, especially for smoking-related causes of death. These large inequalities require the urgent attention of policy makers.

Keywords Mortality · Education · Inequality · Causes of death · Netherlands

Introduction

Socioeconomic inequalities in total and cause-specific mortality have been reported from most European countries (Huisman et al. 2005; Mackenbach et al. 2008), but until recently these data were not available for the Netherlands, due to deficiencies in the national data collection system (Groenewold et al. 2008). The Netherlands has a strong tradition of research into socioeconomic inequalities in health but this is mainly built on national self-reported data (Dalstra et al. 2002; Mackenbach 1993), regional mortality data from specific cohorts such as the GLOBE (Bosma et al. 2001; van Lenthe et al. 2004) and MORGEN studies (Burger et al. 2011; van der A et al. 2013), or ecological studies (Kunst et al. 1990, 1993). Although these studies have clearly demonstrated that socioeconomic inequalities in mortality are present in the Netherlands, it is so far unclear whether the magnitude and cause-specific patterning of these inequalities are similar or different from those in other North-Western European countries, partly because these studies are not directly comparable to similar studies in other countries.

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Studies of mortality by socioeconomic position have found substantial differences in the magnitude of inequalities between European populations (Huisman et al. 2005; Mackenbach et al. 2008). Broadly speaking, three geographical areas, each with their own 'regime' of socioeconomic inequalities in cause-specific mortality and related risk factors, can be distinguished. North-Western Europe (e.g., the Scandinavian countries, England and Wales, Belgium) is characterized by large inequalities in mortality from cardiovascular diseases and cancer, and from conditions due to smoking and alcohol consumption, and by small inequalities in mortality from conditions amenable to health care. Southern Europe (e.g., Spain and Italy) is characterized by small inequalities in mortality from cardiovascular diseases and cancer (women only), from conditions due to smoking and alcohol consumption (women only), and from conditions amenable to health care. Finally, Central and Eastern Europe (e.g., Czech Republic, Hungary, Baltic states) is characterized by huge inequalities in mortality from cardiovascular diseases, cancer (men only), and injury, from conditions due to smoking (men only) and alcohol consumption, and from conditions amenable to health care (Borrell et al. 2005; Mackenbach et al. 2008; Stirbu et al. 2010).

The aim of this study was to quantify inequalities in total and cause-specific mortality by education in the Netherlands, in order to compare the Netherlands with other European countries, and in order to identify entry-points for tackling inequalities in mortality. We focused on education as a measure of socioeconomic status (instead of, e.g., income or occupational class) because it is the most stable measure and has several advantages over other measures of socioeconomic status. Education is easy to measure, is easily reported and is relevant for both men and women regardless of their employment conditions. It is completed in early adulthood; therefore, contrary to other socioeconomic indicators, reverse causality (ill-health leading to low socioeconomic position, instead of vice versa) is unlikely to happen, except for major mental disorders, and education avoids the problem of health-related social mobility later in life (Galobardes et al. 2007; Lahelma et al. 2004). Education is closely linked to mortality. An increasing body of the literature suggests that a large part of this association is causal (Gathmann et al. 2014; Lager and Torssander 2012). Education captures the knowledge-related assets of a person. Higher education can be interpreted as a better ability to understand and follow health prevention messages, to use the healthcare system and to modify his/her behavior. In addition, education is partly determined by childhood socioeconomic circumstances, it is associated with a lower probability of unemployment, better working conditions and higher income (Galobardes et al. 2007; Ross and Wu 1995).

Methods

Study population

To estimate socioeconomic inequalities in mortality, we linked death records to a large national survey containing information on education level, i.e., the Dutch Labour Force Survey (LFS). The Dutch LFS is a household survey carried out by Statistics Netherlands since 1987. Its representative sample of the Dutch population is drawn from the population administrations of Dutch municipalities. The target population consists of persons 15 years and older excluding people living in institutions. Although the main objective of the Dutch LFS is to collect statistics about the employment status of persons and households, it also covers persons 65 years and older. The information is gathered by means of a face-to-face or phone interview and checked for internal inconsistencies. The response rate fluctuates around 60 % over the years (Cobben 2009). An under- or over-representation of certain population groups in the response rate is corrected through weighting. Mortality data classified by sex, age and underlying cause of death were obtained from the death records collected by Statistics Netherlands. These death records were available for the years 1998–2007.

Statistics Netherlands assigns an encoded personal number to all death records and all respondents to the Dutch LFS which is unique to each person and identifies that person in the population register, and we used this to assess the survival status and cause of death of respondents to the Dutch LFS. Five baseline years of the Dutch LFS (1998–2002) were available for the linkage with the death records. We selected people at age 30 years and older at baseline and followed them 6 years from each baseline year (i.e., we followed the people included in the deaths registries for 1998–2003, 1999–2004, 2000–2005, 2001–2006 and 2002–2007). The individuals who died beyond the follow-up time for each baseline year were treated as alive.

Measures

Socioeconomic status was measured by the highest completed educational level. For the sake of comparability with data from other countries (see below), we recoded the Dutch educational level into four categories according to the International Standard Classification of Education (ISCED): primary education (ISCED 0, 1), lower secondary education (ISCED 2), upper secondary education (ISCED 3, 4), and tertiary education (ISCED 5, 6). The Netherlands' educational profile is on average comparable with that in other North-Western European countries for both men and women. However, 60–79-year old men in the Netherlands are less often low educated than men of the same age in

other North-Western European countries. Dutch women are more often low educated at younger ages (30–59 years) than their counterparts in the Nordic countries.

We investigated total as well as cause-specific mortality. The causes of death were classified according to the 10th Revision of the International Classification of Diseases. We analyzed five broader causes of death: cardiovascular diseases (CVD) (I00–I99), cancer (C00–D48), respiratory diseases (J00–J06, J10–J18, J20–J22, J40–J47), other diseases (rest of A00–R99), and external causes (V01–Y98). Specific causes of death were selected on the basis of their relative importance and a sufficient number of deaths: ischemic heart disease (IHD) (I20–I25), cerebrovascular disease (I60–I69), other cardiovascular diseases (rest of I00–I99), colorectal cancer (C18–C21), lung cancer (C33–C34), female breast cancer (C50), prostate cancer (C61), and other neoplasms (rest of C00–D48).

Statistical analysis

The statistical analyses were restricted to the ages between 30 and 79 years because education gradually loses its discriminatory power as a measure of socioeconomic status among the elderly, and because cause-specific analyses become more difficult due to the increasing number of multiple causes of death at older age. All analyses were conducted separately for men and women using the statistical package STATA version 11.0. Individuals with unknown educational level were excluded from the analysis (1.6 %). After the exclusion of persons who did not fulfill our criteria, the dataset includes 332,869 individuals (164,507 men; 168,362 women), and 9,875 deaths (6,079 men; 3,796 women) in 1,802,289 person-years (889,511 men; 912,778 women). More detailed characteristics of the dataset can be obtained from the electronic supplementary material (Supplementary Table 1). This represents approximately 2 % of the Dutch population, and about 1 % of all deaths occurring in these 6 years.

As a measure of absolute inequality, we calculated age-standardized mortality rates (ASMR) by educational level by means of direct standardization using the European standard population. Relative inequalities were calculated using the Cox proportional hazards model with cause-specific baseline hazard. We treated risks of dying of particular causes of death as independent and applied standard Cox proportional hazards model without taking into account competing risks (Cox 1972).

$$h(t) = h_0(t)\exp\left(\sum_{k=1}^{p}\beta_k x_k\right),$$

where $h(t)$ is the expected hazard at time t, $h_0(t)$ is the baseline hazard, β is the regression coefficient of an explanatory variable x and k is the number of the explanatory variables. Age was used as time variable. The cause-specific hazard rates are assumed to be proportional translating to covariate effects that are constant over time.

As a summary measure, we calculated population attributable fractions (PAF) and partial life expectancies between ages 30 and 79 years according to educational level. The PAF quantifies the proportion of all deaths in the population that would not occur if everyone had the mortality of the high educated (Murray et al. 2003).

$$\mathrm{PAF} = \frac{\sum_{i=1}^{n} P_i(\mathrm{RR}_i - 1)}{\sum_{i=1}^{n} P_i(\mathrm{RR}_i - 1) + 1}$$

where P_i is the prevalence and RR_i is the relative risk of each educational level i. The partial life expectancies were calculated by the following formula proposed by Arriaga (1984) using functions of the life tables.

$${}_ie_x = \frac{T_x - T_{x+i}}{l_x},$$

where ${}_ie_x$ is the partial life expectancy between exact ages x and $x + i$, T_x and T_{x+i} are the numbers of person-years lived after exact ages x and $x + i$, and l_x is the number of person-years surviving to the exact age x. We constructed abridged life tables for the exact ages between 30 and 79 years according to the standard life table technique (Chiang 1984) using the age- and education-specific death rates. In addition, we applied the method of life expectancy decomposition (Arriaga 1984) in order to obtain age- and cause-specific contributions to the difference in partial life expectancy between primary and tertiary educated individuals.

Comparison with other European countries

We compared absolute inequalities in mortality in the Netherlands with those in other European countries using data from the EURO-GBD-SE study (Eikemo and Mackenbach 2012). In this study, cause-specific mortality data by education from 21 European populations were collected and harmonized. In this harmonization process, we compared all variables available in the national studies, identified similarities and dissimilarities in their operationalization and constructed common variables that could be measured with the data available from different countries. We calculated ASMRs by sex, education and cause of death (total mortality, CVD, cancer and external causes) and rate differences between less than secondary and tertiary educated for each country. Countries were grouped by geographical region: North-West (Finland, Sweden, Norway, Denmark, England and Wales, Belgium, France, Switzerland, Austria), South (Barcelona, Basque Country, Madrid, Turin, Tuscany), and Central/East (Hungary, Czech Republic, Poland, Estonia). For the sake of comparability across European countries, we

grouped primary and lower secondary educated men and women together in all countries investigated.

Results

Relative inequalities in total mortality show a clear gradient of increasing mortality with decreasing level of education (Table 1). Primary educated men and women had a risk of dying twice as high as their tertiary educated counterparts. Mortality also decreased with increasing educational level for most causes of death, and in most cases, the 95 % confidence interval (CI) of the hazard ratio (HR) for the primary educated did not include one. The main exceptions were colorectal and prostate cancer among men, and colorectal cancer, breast cancer and external causes of death among women, for which no clear educational differences in mortality were found. On the other

Table 1 Hazard ratios (HR), 95 % confidence intervals (95 % CI) and number of deaths (D) for total and cause-specific mortality (reference category = tertiary education), men and women, 30–79 years, the Netherlands, 1998–2007

Causes of death	Education											
	Primary[a]			Lower secondary[b]			Upper secondary[c]			Tertiary[d]		
	HR	95 % CI	D	HR	95 % CI	D	HR	95 % CI	D	HR	95 % CI	D
Men												
All-cause mortality	1.98	(1.81–2.15)	1,163	1.65	(1.52–1.78)	1,814	1.32	(1.22–1.43)	2,153	1	–	949
Cardiovascular diseases	2.34	(1.99–2.74)	379	1.97	(1.70–2.29)	599	1.52	(1.32–1.76)	671	1	–	255
Ischemic heart disease	2.24	(1.77–2.84)	165	2.03	(1.63–2.52)	277	1.53	(1.24–1.90)	310	1	–	118
Cerebrovascular disease	2.51	(1.67–3.77)	63	2.11	(1.45–3.08)	100	1.95	(1.35–2.81)	127	1	–	37
Other cardiovascular diseases	2.38	(1.85–3.07)	151	1.87	(1.47–2.37)	222	1.35	(1.07–1.71)	234	1	–	100
Cancer	1.60	(1.39–1.83)	418	1.52	(1.35–1.71)	731	1.29	(1.15–1.45)	924	1	–	417
Lung cancer	2.83	(2.20–3.63)	174	2.38	(1.88–3.00)	268	1.69	(1.34–2.12)	282	1	–	97
Colorectal cancer	0.75	(0.49–1.15)	31	0.80	(0.57–1.14)	61	0.87	(0.63–1.18)	98	1	–	66
Prostate cancer	1.47	(0.87–2.48)	29	1.72	(1.09–2.70)	63	1.28	(0.82–2.02)	63	1	–	27
Other neoplasms	1.34	(1.10–1.63)	184	1.34	(1.13–1.59)	338	1.26	(1.07–1.47)	481	1	–	225
Respiratory diseases	4.85	(3.21–7.32)	103	3.09	(2.06–4.63)	125	1.79	(1.18–2.72)	94	1	–	29
Other diseases	1.85	(1.52–2.25)	215	1.26	(1.05–1.51)	274	1.13	(0.95–1.35)	372	1	–	193
External causes of death	2.10	(1.43–3.09)	51	1.69	(1.20–2.37)	85	1.03	(0.74–1.45)	92	1	–	55
Women												
All-cause mortality	2.03	(1.79–2.30)	1,122	1.39	(1.23–1.56)	1,425	1.17	(1.03–1.33)	914	1	–	335
Cardiovascular diseases	3.20	(2.40–4.27)	356	1.92	(1.44–2.55)	382	1.47	(1.09–1.98)	200	1	–	55
Ischemic heart disease	4.06	(2.44–6.76)	140	2.14	(1.28–3.55)	132	1.67	(0.98–2.83)	70	1	–	17
Cerebrovascular disease	2.32	(1.36–3.95)	79	1.63	(0.97–2.74)	99	1.25	(0.72–2.15)	52	1	–	17
Other cardiovascular diseases	3.21	(2.02–5.12)	137	1.98	(1.25–3.14)	151	1.49	(0.92–2.41)	78	1	–	21
Cancer	1.61	(1.36–1.92)	449	1.25	(1.06–1.47)	663	1.13	(0.96–1.34)	485	1	–	190
Lung cancer	3.33	(2.11–5.26)	107	1.92	(1.22–3.01)	119	1.86	(1.18–2.94)	95	1	–	23
Colorectal cancer	1.67	(0.89–3.14)	41	1.56	(0.86–2.83)	70	1.12	(0.59–2.11)	35	1	–	13
Breast cancer	1.12	(0.81–1.55)	89	0.86	(0.64–1.17)	136	0.82	(0.60–1.11)	115	1	–	65
Other neoplasms	1.53	(1.19–1.97)	212	1.29	(1.02–1.64)	338	1.18	(0.92–1.50)	240	1	–	89
Respiratory diseases	5.07	(2.33–11.05)	79	2.73	(1.25–5.95)	76	1.19	(0.51–2.80)	21	1	–	7
Other diseases	1.98	(1.48–2.64)	217	1.30	(0.98–1.72)	262	1.05	(0.78–1.41)	155	1	–	62
External causes of death	1.00	(0.54–1.87)	21	0.99	(0.58–1.69)	42	1.17	(0.71–1.95)	53	1	–	21

The four educational groups were constructed from the different school types in the educational system in the Netherlands

[a] Primary education includes BO = basisonderwijs (elementary education)

[b] Lower secondary education includes VMBO = voorbereidend middelbaar beroepsonderwijs (pre-vocational secondary education)

[c] Upper secondary education includes HAVO = hoger algemeen voortgezet onderwijs (senior general secondary education), VWO = voorbereidend wetenschappelijk onderwijs (pre-university education), MBO = middelbaar beroepsonderwijs (secondary vocational training)

[d] Tertiary education includes HBO = hoger beroepsonderwijs (higher professional education), WO = wetenschappelijk onderwijs (university education)

hand, relative inequalities in mortality were very large for respiratory diseases: the risk of dying from respiratory diseases was about five times higher among primary educated men (HR = 4.85; CI: 3.21–7.32) and women (HR = 5.07; CI: 2.33–11.05) than among their tertiary educated counterparts. For CVD and lung cancer, relative inequalities were also large, both among men and women.

Absolute inequalities in mortality are presented in Table 2. The absolute differences in ASMR between primary and tertiary educated were particularly large for CVD and cancer among both men and women and for lung cancer among men. Although relative inequalities in mortality are higher among women than among men for many causes of death, such as CVD, IHD and lung cancer (Table 1), absolute inequalities are usually lower among women. It is interesting to note that the ASMR of tertiary educated men (547.1 per 100,000 person-years) is in-between that of primary educated (663.4) and lower secondary educated women (455.2), and that mortality among primary educated men (1,094.3) is more than three times higher than that among tertiary educated women (342.0).

Table 2 also presents the PAFs. These show that if all men and women in the Netherlands would have the ASMR of the tertiary educated, mortality in the population as a whole would decreased by about a quarter (27.8 % among men, 24.9 % among women).

The results for partial life expectancy between ages 30 and 79 are in line with our findings on relative and absolute inequalities (Table 3). Tertiary educated men and women live longer than their less educated counterparts and

Table 2 Age-standardized mortality rates by education, rate difference between primary and tertiary educated and population attributable fraction (PAF) for total and cause-specific mortality, men and women, 30–79 years, the Netherlands, 1998–2007

Causes of death	Mortality rate by education[a]				Mortality rate difference primary vs. tertiary[a]	PAF (in %)
	Primary	Lower secondary	Upper secondary	Tertiary		
Men						
All-cause mortality	1,094.3	915.2	734.1	547.1	547.2	27.8
Cardiovascular diseases	352.0	302.6	236.3	156.7	195.3	36.7
Ischemic heart disease	151.1	139.2	107.8	69.2	81.8	37.0
Cerebrovascular disease	59.9	51.1	47.2	24.9	35.0	44.6
Other cardiovascular diseases	141.0	112.3	81.3	62.5	78.5	32.9
Cancer	385.2	368.3	310.9	235.9	149.3	23.2
Lung cancer	159.4	135.2	95.5	55.5	103.9	44.3
Colorectal cancer	28.1	30.3	32.0	38.3	−10.2	n.a.
Prostate cancer	26.7	32.3	24.2	17.2	9.5	24.8
Other neoplasms	171.0	169.9	159.2	123.6	47.5	18.1
Respiratory diseases	99.6	64.7	36.9	21.7	77.9	54.9
Other diseases	200.7	136.5	123.9	109.8	90.9	17.0
External causes of death	56.9	43.1	26.1	23.0	33.9	22.4
Women						
All-cause mortality	663.4	455.2	380.7	342.0	321.4	24.9
Cardiovascular diseases	204.2	123.0	96.2	70.0	134.2	43.6
Ischemic heart disease	80.9	41.9	32.8	22.7	58.2	50.9
Cerebrovascular disease	45.1	31.8	25.0	19.4	25.7	32.2
Other cardiovascular diseases	78.2	49.3	38.4	28.0	50.2	44.5
Cancer	272.7	210.1	190.6	174.2	98.6	17.5
Lung cancer	66.2	37.5	37.8	25.7	40.5	48.4
Colorectal cancer	23.2	21.8	15.7	11.8	11.4	23.8
Breast cancer	56.2	43.8	41.8	46.7	9.5	n.a.
Other neoplasms	127.1	107.1	95.3	89.9	37.2	18.8
Respiratory diseases	43.5	23.5	10.2	9.1	34.5	54.2
Other diseases	127.8	83.9	66.2	72.4	55.4	20.1
External causes of death	15.2	14.7	17.5	16.4	-1.2	5.7

n.a. not available

[a] per 100,000 person-years

Table 3 Partial life expectancy (in years) between ages 30 and 79 by sex and education, the Netherlands, 1998–2007

	Education				Total
	Primary	Lower secondary	Upper secondary	Tertiary	
Men	42.8	44.0	45.1	46.2	44.8
Women	45.1	46.5	47.1	47.5	46.6

women live longer than men regardless of education. Partial life expectancy was 42.8 years among primary and 46.2 years among tertiary educated men, giving a difference of 3.4 years. Among women, partial life expectancy was 45.1 years among primary and 47.5 years among tertiary educated, giving a difference of 2.4 years. The gap in partial life expectancy between men and women was 2.3 years among the primary educated, and only 1.3 years among the tertiary educated.

The contribution of different causes of deaths to differences in partial life expectancy are presented in Figs. 1 and 2. In total, CVD accounts for 35 and 37 % of the difference in partial life expectancy among men and women, respectively. Cancer was a second major contributor accounting for 27 and 35 % of the difference in partial life expectancy among men and women, with lung cancer making a particularly large contribution. Lung cancer accounts for 72 % of the cancer contribution among men and 47 % of the cancer contribution among women. We found a negative contribution of colorectal cancer to the difference in partial life expectancy among men, due to the reverse social gradient for this cause of death already noted in Table 1. Whereas CVD, in particular IHD, is a major contributor to the excess mortality of primary educated at middle and older ages (50–74 years), external causes contribute importantly to the differences between primary and tertiary educated at younger ages (30–44 years), particularly among men. Among women, we found negative contributions of external causes and breast cancer across all age groups, and of lung cancer at older ages (70–79 years), due to a reverse gradient for the latter cause of death among older women (results not shown).

Table 4 presents rate difference (per 100,000) between less than secondary and tertiary educated men and women in all-cause, CVD and cancer mortality, and external causes across European 'regimes' compared with the Netherlands. The rate difference in all-cause mortality is 430 for men and 185 for women in the Netherlands. These estimates fall within the range of rate differences reported for other North-Western European countries. The rate difference for all-cause mortality in the Netherlands was higher than the maximum observed in Southern Europe (men: 325; women: 98) and much lower than the minimum found in Eastern Europe (men: 1,158; women: 413). The same is true for mortality from CVD, cancer and external causes (men only).

Discussion

Summary of findings

In the Netherlands, the relative risk of dying of those with primary education only, as compared to those with tertiary education, is 1.98 (95 % CI: 1.81–2.15) among men, and 2.03 (95 % CI: 1.79–2.30) among women, leading to a gap in partial life expectancy of 3.4 and 2.4 years among men and women, respectively. The magnitude of relative and absolute inequalities in mortality by education is similar to that in other countries in North-Western Europe. Like in other European countries, educational inequalities in mortality in the Netherlands are mainly driven by CVD and cancer, but inequalities in lung cancer mortality are substantially larger in the Netherlands than in other countries of North-Western Europe, particularly among men. No inequalities in mortality were found for colorectal cancer (men and women), prostate cancer (men), breast cancer (women), and external causes (women).

Limitations

This is the first nationally representative study of socioeconomic inequalities in mortality in the Netherlands, which has become feasible because Statistics Netherlands has created new facilities for linking databases, in this case, databases with socioeconomic information to databases on mortality and causes of death (Bastiaans et al. 2006). However, because the Netherlands does not have a census, we had to rely on a large survey for information on the educational achievement of individuals. To a large extent, the validity of our findings depends on the representativeness of this survey. There are several potential problems. First, the institutionalized population is not included in the Dutch LFS, and because people living in institutions tend to have both a lower level of education (den Draak 2010) and a higher risk of mortality this could have biased our results. We believe that this bias is likely to be small, because in the Netherlands the proportion of institutionalized people under the age 80 years is negligible (den Draak 2010) and because we restricted the analysis to individuals aged 30–79 years.

Another potential problem affecting the representativeness of our findings is the high non-response (40–45 %) of the Dutch LFS. A low response rate does not necessarily mean that our estimates of inequalities in mortality are biased. This will only be the case if the magnitude of

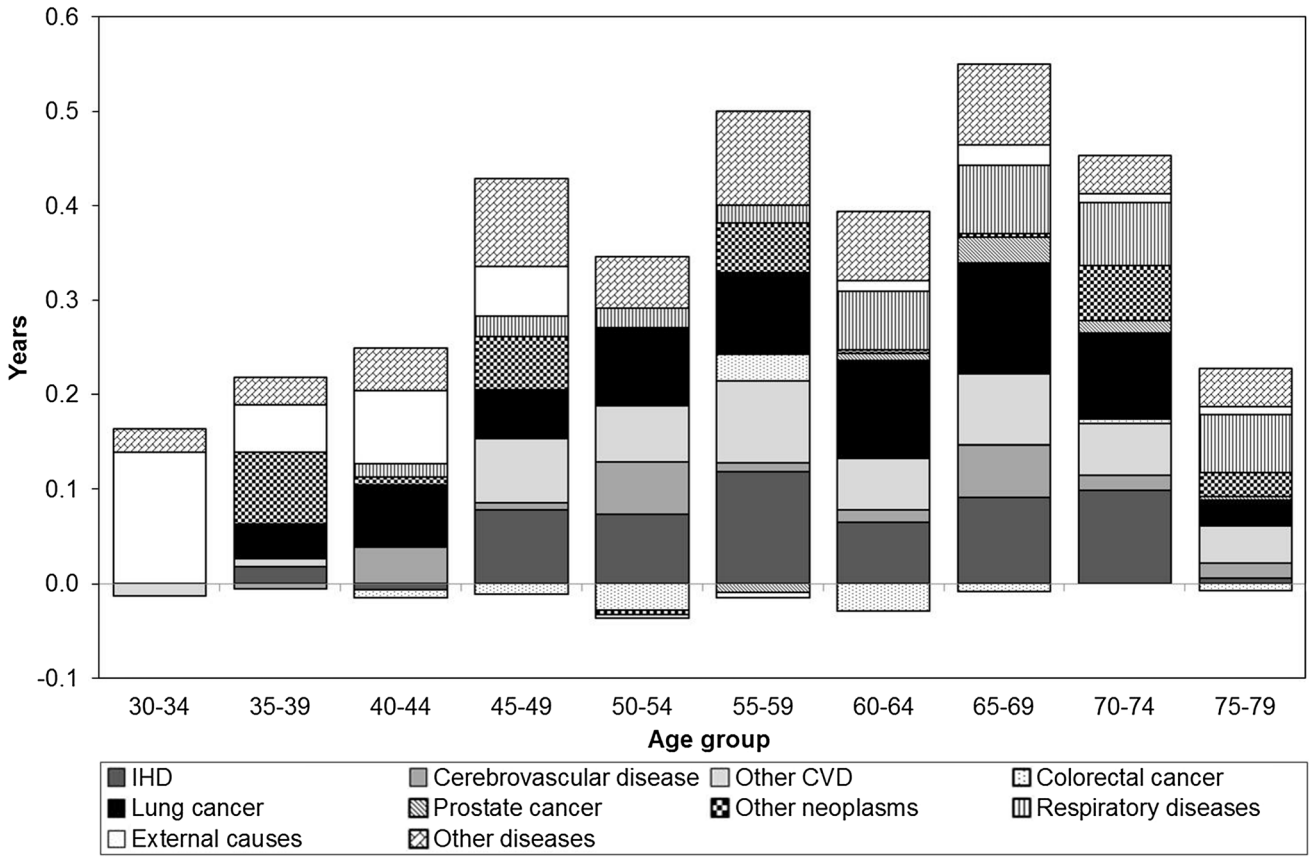

Fig. 1 Contribution (in years) of age groups and causes of death to the difference in partial life expectancy between ages 30 and 79 between primary and tertiary educated men, the Netherlands, 1998–2007. *IHD* ischemic heart disease, *CVD* cardiovascular diseases

relative and/or absolute inequalities in mortality differs between respondents and non-respondents. Studies of non-respondents to surveys have shown that these usually have higher rates of morbidity and mortality than respondents (Ferrie et al. 2009). We also know that the non-response rate in the Dutch LFS is higher among lower educated men and women (Visscher 1997). However, whether the association between education and mortality differs between respondents and non-respondents is unknown. We think that our estimates of relative inequalities may well be unbiased, but because of the likely under-representation of people with health problems among respondents to the Dutch LFS we may have underestimate absolute inequalities in mortality. We therefore compared the mortality rates observed in our study and those registered for the complete Dutch population by Statistics Netherlands and found that our study underestimates average mortality rates by approximately 12 %. This implies that we may have underestimated absolute inequalities in mortality between educational groups, as presented in Tables 2 and 4, by a similar percentage. In a sensitivity analysis, we have used this percentage to upwardly adjust the absolute inequalities in mortality in the Netherlands presented in Table 4. This brings the Dutch results closer to the middle of the range of North-Western European countries (results not shown) and shows that our substantive results are not seriously biased. Also, there is little reason to think that our estimates of relative inequalities in mortality are biased.

We used education as an indicator of socioeconomic position, but a single indicator of socioeconomic status does not comprehensively portray the entire picture of health inequalities (Lahelma et al. 2004). As mentioned above, education has several advantages compared to occupation and income (Cutler and Lleras-Muney 2008; Lahelma et al. 2004), but although education is highly correlated with occupation and income, we cannot assume that the same results will be obtained with other indicators of socioeconomic position.

Data on inequalities in cause-specific mortality might be biased if there are differences between educational groups in accuracy of diagnoses, certification of causes of death or coding of underlying cause of death. Harteloh and others studied the reliability of cause-of-death statistics in the Netherlands and found that for major causes of death such as cancer and heart diseases the reliability was higher than 90 % (Harteloh et al. 2010). International-comparative

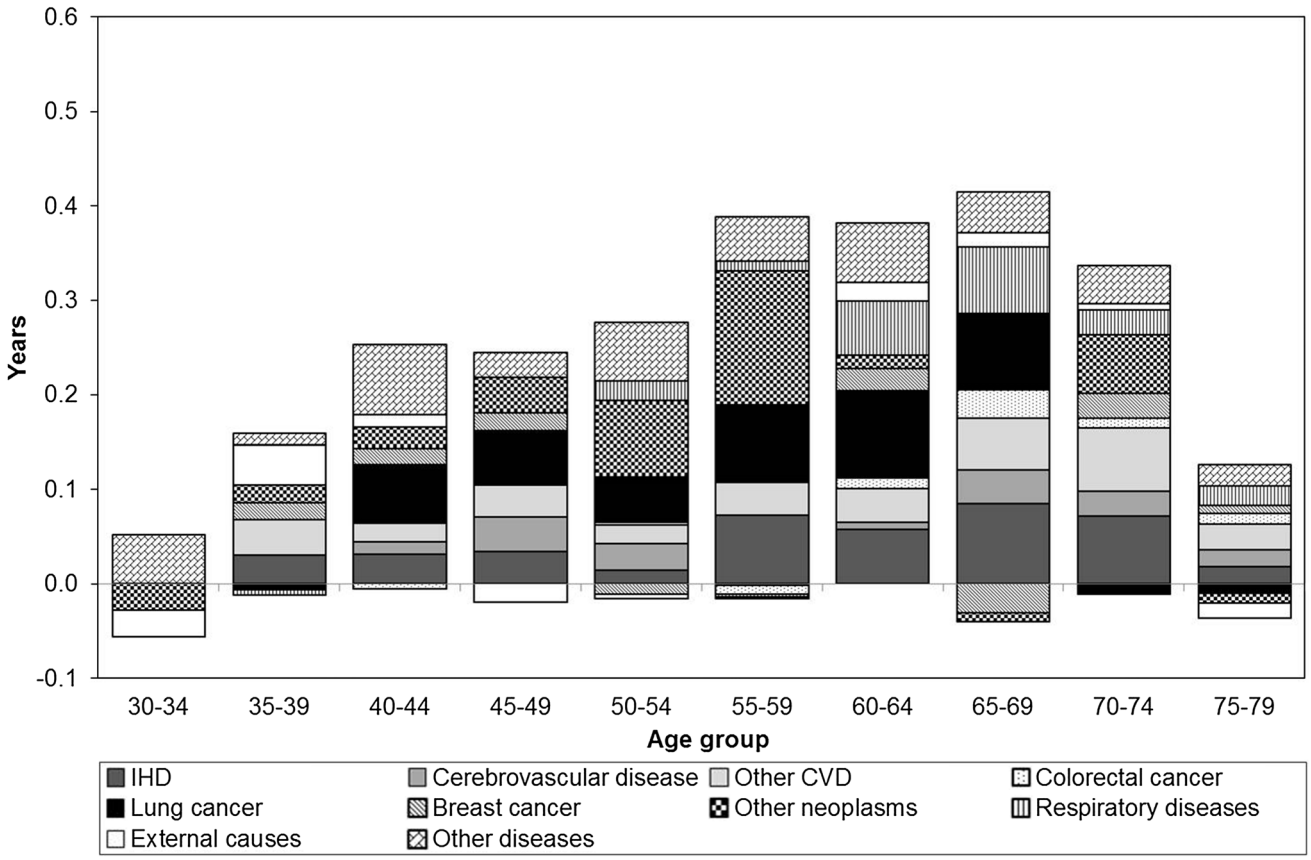

Fig. 2 Contribution (in years) of age groups and causes of death to the difference in partial life expectancy between ages 30 and 79 between primary and tertiary educated women, the Netherlands, 1998–2007. *IHD* ischemic heart disease, *CVD* cardiovascular diseases

studies showed that the reliability of cause-of-death statistics in the Netherlands compares favorably with that in other countries (Mackenbach et al. 1987). On the other hand, it is unknown, in the Netherlands as elsewhere, whether reliability of cause-of-death information differs between socioeconomic groups. We therefore assessed whether there are differences in the proportion of ill-defined causes of death across educational categories (results not shown). Although this proportion is higher in the Netherlands than in most other European countries, we did not find statistically significant differences in the proportion of these causes of death among educational groups (p value: men = 0.218; women = 0.597).

Interpretation

As noted in the introduction, an educational gradient in all-cause mortality has been reported from all European countries with available data. We show that this educational gradient can also be found in the Netherlands. The magnitude of educational inequalities in all-cause mortality in the Netherlands is comparable to that in other North-Western European countries (Mackenbach et al. 2008). Cause-specific patterns are also largely similar, both at the level of broad groups of causes of death (such as CVD and cancer), and at the level of specific causes. Whereas breast cancer was reported to have a reverse educational gradient in most European countries except France, Finland and Barcelona (Strand et al. 2007), we did not find statistically significant differences in breast cancer mortality between educational groups in the Netherlands. We found no differences by education in mortality from external causes among women in the Netherlands, as has been found before for injuries for Norway, Switzerland, Turin and Barcelona (Borrell et al. 2005).

A cause of death for which we found larger inequalities in the Netherlands than elsewhere is lung cancer. Like other North-Western European countries, the Netherlands is in the fourth stage of the smoking epidemic (Lopez et al. 1994), during which smoking increasingly becomes concentrated among those with lower socioeconomic positions (Giskes et al. 2005). In earlier stages of the epidemic, smoking prevalence rates have reached very high values in the Netherlands, which has led to a relative stagnation of life expectancy during the 1980s and 1990s in both men and women (Janssen et al. 2003), and which probably also

Table 4 Rate difference (per 100,000 person-years) between less than secondary and tertiary educated for total and cause-specific mortality, men and women, 30–79 years, comparison between the Netherlands and European 'regimes', 1998–2007

Cause of death	Netherlands	North-West[a]		South[b]		Central/East[c]	
		Min	Max	Min	Max	Min	Max
Men							
All-cause mortality	430	410	615	262	325	1,158	1,788
CVD	164	116	237	35	68	457	713
Cancer	138	73	210	96	147	248	448
External causes	24	10	116	13	37	90	431
Women							
All-cause mortality	185	160	319	51	98	413	691
CVD	82	51	103	15	40	208	359
Cancer	57	23	89	-5	23	45	116
External causes	−2	3	32	0	7	17	127

CVD cardiovascular diseases

[a] North-West 'regime' was represented by Finland, Sweden, Norway, Denmark, England and Wales, Belgium, France, Switzerland, Austria

[b] South 'regime' was represented by Spain (Barcelona, Basque Country, Madrid), Italy (Turin, Tuscany)

[c] Central/East 'regime' was represented by Hungary, Czech Republic, Poland, Estonia

explains the large contribution of lung cancer (20 % men; 16 % women) to inequalities in mortality in the Netherlands.

The Netherlands has a strong tradition of investigating inequalities in mortality, and there is therefore a lot of scientific evidence on the explanation of inequalities in mortality in this country. Studies have shown that people in lower educated groups have a higher prevalence of a less than good perceived general health, more chronic diseases, higher disability rates and higher risks of all-cause mortality compared to higher educated groups (Mackenbach 1992; van Lenthe et al. 2004). A substantial part of the worse health observed among lower educated groups has been found to be attributable to unhealthy behaviors, such as smoking (van Lenthe et al. 2004; van Oort et al. 2005), physical inactivity (Droomers et al. 1998; van Lenthe et al. 2004) or excessive alcohol consumption (Droomers et al. 1999; van Lenthe et al. 2004). Material living conditions, working conditions, psychosocial stress and social support contribute to the educational inequalities as well (Mackenbach 1992; van Oort et al. 2005). All this implies that the Netherlands is in a good position to start tackling the inequalities in mortality found in our study (Mackenbach and Stronks 2002).

Conclusion

Cross-country comparisons of socioeconomic inequalities in mortality are an important source of information for understanding the mechanisms that generate these inequalities. The exploration of such mechanisms is essential for policy makers in order to develop effective policies and large-scale interventions to reduce the observed burden in morality due to educational disparities. We reported large educational inequalities in mortality in the Netherlands and showed that their magnitude and cause-specific patterning are similar to those observed in other countries in North-Western Europe. These educational inequalities in mortality in the Netherlands are partly driven by cause of death attributable to lifestyle-related risk factors such as smoking. These findings are important for the development of efficient health interventions and require the urgent attention of policy makers.

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References

Arriaga EE (1984) Measuring and explaining the change in life expectancies. Demography 21:83–96. doi:10.2307/2061029

Bastiaans F, Engberts L, Linder F (eds) (2006) Sociale samenhang in beeld, het SSB nu en straks. [Social cohesion in focus, SSB now and later]. Centraal Bureau voor de Statistiek, Voorburg

Borrell C et al (2005) Education level inequalities and transportation injury mortality in the middle aged and elderly in European settings. Inj Prev 11:138–142. doi:10.1136/ip.2004.006346

Bosma H, van de Mheen HD, Borsboom GJJM, Mackenbach JP (2001) Neighborhood socioeconomic status and all-cause mortality. Am J Epidemiol 153:363–371. doi:10.1093/aje/153.4.363

Burger KN, Beulens JW, Boer JM, Spijkerman AM, van der A DL (2011) Dietary glycemic load and glycemic index and risk of coronary heart disease and stroke in Dutch men and women: the EPIC-MORGEN study. PLoS One 6:e25955

Chiang CL (1984) The life table and its applications. Krieger Publishing Company, Malabar, Florida

Cobben F (2009) Nonresponse in Sample Survey. Methods for Analyses. PhD thesis, Universiteit van Amsterdam

Cox DR (1972) Regression models and life-tables. J R Stat Soc, Series B (Methodological) 34:187–220. doi:10.2307/2985181

Cutler DM, Lleras-Muney A (2008) Education and health: evaluating theories and evidence. In: Schoeni RF, House JS, Kaplan GA, Pollack H (eds) Making Americans healthier: social and economic policy as health policy. Russell Sage Foundation, pp 29–60

Dalstra JA, Kunst AE, Geurts JJ, Frenken FJ, Mackenbach JP (2002) Trends in socioeconomic health inequalities in the Netherlands, 1981-1999. J Epidemiol Community Health 56:927–934

den Draak M (2010) Oudere tehuisbewoners: landelijk overzicht van de leefsituatie van ouderen in instellingen 2008/2009. [Elderly care home residents: a nationwide survey of living conditions of elderly in institutions 2008/2009]. Sociaal en Cultureel Planbureau, Den Haag

Droomers M, Schrijvers CTM, van de Mheen H, Mackenbach JP (1998) Educational differences in leisure-time physical inactivity: a descriptive and explanatory study. Soc Sci Med 47:1665–1676. doi:10.1016/S0277-9536(98)00272-X

Droomers M, Schrijvers CTM, Stronks K, van de Mheen D, Mackenbach JP (1999) Educational differences in excessive alcohol consumption: the role of psychosocial and material stressors. Prev Med 29:1–10. doi:10.1006/pmed.1999.0496

Eikemo TA, Mackenbach JP (2012) The potential for reduction of health inequalities in Europe. Department of Public Health, Erasmus University Medical Center Rotterdam, Rotterdam, The EURO-GBD-SE final report

Ferrie JE et al (2009) Non-response to baseline, non-response to follow-up and mortality in the Whitehall II cohort. Int J Epidemiol 38:831–837. doi:10.1093/ije/dyp153

Galobardes B, Lynch J, Smith GD (2007) Measuring socioeconomic position in health research. Br Med Bull 81–82:21–37. doi:10.1093/bmb/ldm001

Gathmann C, Jurges H, Reinhold S (2014) Compulsory schooling reforms, education and mortality in twentieth century Europe. Soc Sci Med. doi:10.1016/j.socscimed.2014.01.037

Giskes K et al (2005) Trends in smoking behaviour between 1985 and 2000 in nine European countries by education. J Epidemiol Community Health 59:395–401. doi:10.1136/jech.2004.025684

Groenewold G, van Ginneken J, Masseria C (2008) Towards comparable statistics on mortality by socioeconomic status in EU Member States Methodology Note—European Observatory on Demography and the Social Situation-Demography Network. European Commission, Brussels

Harteloh P, de Bruin K, Kardaun J (2010) The reliability of cause-of-death coding in The Netherlands. Eur J Epidemiol 25:531–538. doi:10.1007/s10654-010-9445-5

Huisman M et al (2005) Educational inequalities in cause-specific mortality in middle-aged and older men and women in eight western European populations. Lancet 365:493–500. doi:10.1016/S0140-6736(05)17867-2

Janssen F, Nusselder WJ, Looman CW, Mackenbach JP, Kunst AE (2003) Stagnation in mortality decline among elders in the Netherlands. Gerontologist 43:722–734

Kunst AE, Looman CW, Mackenbach JP (1990) Socio-economic mortality differences in The Netherlands in 1950–1984: a regional study of cause-specific mortality. Soc Sci Med 31:141–152

Kunst AE, Looman CW, Mackenbach JP (1993) Determinants of regional differences in lung cancer mortality in The Netherlands. Soc Sci Med 37:623–631

Lager AC, Torssander J (2012) Causal effect of education on mortality in a quasi-experiment on 1.2 million Swedes. Proc Natl Acad Sci USA 109:8461–8466. doi:10.1073/pnas.1105839109

Lahelma E, Martikainen P, Laaksonen M, Aittomaki A (2004) Pathways between socioeconomic determinants of health. J Epidemiol Community Health 58:327–332

Lopez AD, Collishaw N, Piha TA (1994) A descriptive model of the cigarette epidemic in developed countries. Tob Control 3:242–247

Mackenbach JP (1992) Socio-economic health differences in The Netherlands: a review of recent empirical findings. Soc Sci Med 34:213–226

Mackenbach JP (1993) Inequalities in health in The Netherlands according to age, gender, marital status, level of education, degree of urbanization, and region. Eur J Public Health 3:112–118. doi:10.1093/eurpub/3.2.112

Mackenbach JP, Stronks K (2002) A strategy for tackling health inequalities in the Netherlands. BMJ 325:1029–1032

Mackenbach JP, Van Duyne WM, Kelson MC (1987) Certification and coding of two underlying causes of death in The Netherlands and other countries of the European Community. J Epidemiol Community Health 41:156–160

Mackenbach JP et al (2008) Socioeconomic inequalities in health in 22 European countries. N Engl J Med 358:2468–2481. doi:10.1056/NEJMsa0707519

Murray C, Ezzati M, Lopez A, Rodgers A, Vander Hoorn S (2003) Comparative quantification of health risks: Conceptual framework and methodological issues. Popul Health Metr 1:1

Ross CE, Wu C (1995) The links between education and health. Am Sociol Rev 60:719–745. doi:10.2307/2096319

Stirbu I et al (2010) Educational inequalities in avoidable mortality in Europe. J Epidemiol Community Health 64:913–920. doi:10.1136/jech.2008.081737

Strand BH et al (2007) The reversed social gradient: higher breast cancer mortality in the higher educated compared to lower educated. A comparison of 11 European populations during the 1990s. Eur J Cancer 43:1200–1207. doi:10.1016/j.ejca.2007.01.021

van der A DL, Nooyens AC, van Duijnhoven FJ, Verschuren MM, Boer JM (2013) All-cause mortality risk of metabolically healthy abdominal obese individuals: the EPIC-MORGEN study. Obesity (Silver Spring). doi:10.1002/oby.20480

van Lenthe FJ, Schrijvers CT, Droomers M, Joung IM, Louwman MJ, Mackenbach JP (2004) Investigating explanations of socio-economic inequalities in health: the Dutch GLOBE study. Eur J Public Health 14:63–70

van Oort FV, van Lenthe FJ, Mackenbach JP (2005) Material, psychosocial, and behavioural factors in the explanation of educational inequalities in mortality in The Netherlands. J Epidemiol Community Health 59:214–220. doi:10.1136/jech.2003.016493

Visscher G (1997) De blinde vlek van het CBS: systematische vertekening in het opleidingsniveau. De nonrespons in de Enquête Beroepsbevolking. [Bias in the level of education: The Dutch case]. Sociologische gids 44:155–179