Assessing socio-economic inequalities in mortality and other health outcomes at the Scottish national level.

Final report for the Scottish Collaboration for Public Health Research and Policy

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Introduction

Scotland has very poor health for a European country highlighted by it ranking lowest for life expectancy at birth for women and second lowest for men in a recent comparative review[1]. Importantly, Scotland has not always held such a relatively poor position[1]. Within Scotland there are also large inequalities in mortality that have been widening in recent years[2]. However, the comparative position of Scotland in terms of inequalities in health is not clear as it has not been included in European comparative projects aimed at comparing inequalities in mortality, health and health behaviours across the continent. The most recent comparative analysis was conducted using data from the 1990s, with census data from the start of the decade being linked to subsequent death records for the comparative mortality analysis [3]. With the introduction of the Scottish Longitudinal Study, Scotland now has a dataset linking 1991 (and 2001) census records to mortality[4]. The main aim of this analysis was then to replicate for Scotland the analysis of the most recent European work by Mackenbach *et al.* [3] to give a comparative perspective on Scotland's inequalities. Additionally, we updated the Scottish mortality analysis from the 2001 census and also looked at self rated health and health behaviours using the 2003 Scottish Health Survey to replicate the analysis presented in Mackenbach *et al.* for self rated health and health behaviours[3].

Given that even with the above analysis, information on Scotland's relative position in Europe in terms of mortality inequalities would only be available for people in the 1990s, we sought another way of assessing Scotland's relative position both now and back through time. In addition to inequalities in mortality by socio-economic group, mortality inequalities can also be assessed by looking at variation in the age of death[5]. In this analysis, we use average life expectancy lost per death that in years gives the average life expectancy a person losses at their death in that year[6]. If everyone in the society died at the same age, this would then be zero. Because all that is needed to derive this measure is a life table we were able to compare Scottish trends from 1950 to 2006 to those of a number of European and other high income countries. Not relying on have comparable socio-economic groups is an advantage as even in carefully conducted studies such as Mackenbach *et al.* there may be well be concerns about the comparability of the groups across countries. However, a disadvantage is that there is a lack of information on how different socio-economic groups contribute to inequalities.

Finally, Scotland's poor mortality record has often been contrasted with that in England and Wales. A seminal study explored whether differences in the level of small area deprivation between the countries could explain Scotland's mortality excess in the early 1980s and concluded that it mostly did[7]. However, follow-up studies found that differences in the levels of deprivation between the countries explained less of the excess in the 1990s and 2000s, leading to the idea that there is "Scottish effect" responsible for this unexplained mortality excess[8]. To date, these studies have not adopted a lifecourse approach, which may be important, as those born in Scotland but living in England have higher death rates than those born in England[9], while the English born living in Scotland have lower rates than the Scottish born[10]. Moreover, studies to date have been based on unlinked census mortality data rather than linked census mortality data which may be preferable methodologically. So we present two analyses, one based on unlinked data and one based on linked data using combined analysis of the Scottish Longitudinal Study and the ONS England and Wales Longitudinal Study. The results are presented in papers separate to this report.

Methods

In replicating the Mackenbach *et al.* analysis for Scotland we drew on methodological details in the main paper published in the New England Journal of Medicine [3] and those included in the various reports and technical papers on the Eurothine project website (the associated Mackenbach *et al.* project http://survey.erasmusmc.nl/eurothine/).

Scottish Longitudinal Study – Mortality analysis

To assess mortality differences by socio-economic group we used the Scottish Longitudinal Study which is based on a 5.3% sample of the Scottish population for whom data are linked from the 1991 and 2001 Scottish censuses and other administrative records, including subsequent mortality and emigration from Scotland[4]. Two analysis cohorts were created, the first following people to emigration, death or the end of 1999 from the 1991 census. The end of 1999 was chosen as the end of follow-up as this was the period used in many countries in the Mackenbach *et al.* analysis. The second followed people to emigration, death or end of 2007 (the latest date deaths were recorded for in the SLS at time of project start) from the 2001 census. Each was limited to those aged 30 to 74 at the census who were not long term residents in communal establishments (this relatively small group have high levels of missing data). Age was categorised in five year periods and adjusted for in all analyses. The age standardised mortality rates were calculated using the European standard population and separate analyses were conducted for men and women.

Education qualification was the main socio-economic variable used by Mackenbach *et al.* to compare the gradient of mortality outcomes across countries. In each country people were categorised as having achieved no or primary only, lower secondary, upper secondary or tertiary qualifications. Although the detailed question on education in the 2001 Scottish census allowed such a classification (with lower secondary equating to Standard grade or equivalent and higher secondary to Higher grade or equivalent), the 1991 Scottish (and other UK) census had a more limited question on education, focused on whether the respondent had tertiary education level qualifications. In the Scottish Longitudinal study this 1991 variable is coded in three categories (see Table 1). This raises some comparability concerns for the 1991 analysis, as this is not directly equivalent to the variable used by Mackenbach *et al.* for the other countries (the same issue is pertinent for the original analysis for England and Wales in 1991). Of course, given differences in education systems comparability is an issue across all countries and so to try to combat this Mackenbach *et al.* used the rank of education (and other socio-economic variables) in their analysis rather than the categories themselves. The use of the rank variable (as a continuous variable in the analysis) assumes a linearity of the relationship between categories of the socio-economic variable and mortality – this assumption is currently being assessed in further work linked to this project.

The rank variable is constructed by assigning a value to each category of the original socio-economic variable. This is done as follows. First, the categories of the socio-economic variable are arranged in order (from highest to lowest in Mackenbach *et al.*), and second a value is assigned to each variable that represents the midpoint of the category in the cumulative distribution of the variable. For example, assuming the education variable had five categories each representing 20% of the population, the highest socio-economic category in the rank variable would be coded as 0.2/2 = 0.1 (i.e. it represents 20% of the population and we take its midpoint), the next highest category 0.2+0.2/2 = 0.3 and so on. This variable, when included in the regression analysis as a continuous variable, then measures inequality from 0 (the theoretically

highest socio-economic position) to 1 (the theoretically lowest socio-economic position).

In this analysis, Poisson regression was used to assess the relative risk of death by education rank (using person-years of exposure as the offset), so the measure of inequality is the relative index of inequality and measures the relative difference in health between the theoretically highest and lowest socio-economic groups. Using Cox regression yielded very similar results. To derive the absolute version of the inequality measure (the slope index of inequality) we used the same equation as Mackenbach *et al.*:

2*age-adjusted mortality rate*(relative index of inequality-1)/(relative index of inequality+1)

As the size of the relative index of inequality is also somewhat dependent on the number of categories in the original variable[11] the fact that the 1991 education relative index of inequality is based on three rather than four categories may slightly inflate its level for Scotland.

In the analysis the slope index of inequality is used to assess the contribution of various causes of disease to inequalities (each cause's contribution to the overall inequality can be assessed, in this analysis as a percentage of the total). A number of causes of disease were included with categories based on ICD 9 (for the 1991 to 1999 analysis) and ICD 10 (2001 to 2007) and specific definitions followed those in the Mackenbach *et al.* paper. Their definition of smoking related causes, also used here, is narrow as it does not include major diseases such as cardiovascular disease for which smoking is major risk factor. In the results we do discuss the impact of smoking in relation to a wider set of diseases.

The causes were as follows:

- all cancers, breast cancer, lung cancer.
- all cardiovascular, ischemic heart disease, cerebrovascular disease (stroke).
- all external causes (injuries).
- alcohol related causes (accidental poisoning by alcohol, alcoholic psychosis, dependence and abuse, alcoholic cardiomyopathy, alcoholic cirrhosis of the liver and pancreas)
- smoking related causes (chronic obstructive pulmonary disease and cancer of the buccal cavity, pharynx, esophagus, larynx, trachea, bronchus, and lung)
- and causes amenable to medical intervention (for ages 30 to 64 only at baseline – infectious disease, cervical and breast cancer, Hodgkin's disease, leukaemia, hypertension, cerebrovascular disease, pneumonia or influenza, appendicitis, hernia, peptic ulcer, cholelithiasis and cholecystitis, and complications of childbirth).

In addition to education, Mackenbach *et al.* also assessed inequality by occupational class for men aged 30 to 59 at baseline. This age group was chosen to avoid problems of missing data due to being out of the labour market for study or retirement. These problems were minimised in Scotland as those out of work were asked to report their previous occupation (in the preceding 10 years in the 1991 census and ever in the 2001 census), making it possible to identify their social class more easily. Social class was categorised as non-manual versus manual, and for Scotland we used the Registrar General's Socio-economic Classification to code people's occupation into one of these groups. In addition, we also assessed inequalities using housing tenure, car access and the area based Carstairs score of deprivation (derived at postcode sector level and categorised using population level weighted quintiles). Table 1 gives the categories of all the socio-economic variables and their distributions.

Table 1 Distribution of the socio-economic variables included in the mortality analysis for men and women aged 30 to 74 at baseline in 1991 and 2001

	Men		Women	
	1991 to 1999 (%)	*2001 to 2007 (%)*	*1991 to 1999 (%)*	*2001 to 2007 (%)*
Education (1991 definition)				
Degree	8.4	-	4.7	-
Other higher	7.9	-	9.9	-
None of the above	83.8	-	85.4	-
Education (2001 definition)				
Degree / other higher	-	28.6	-	25.7
Upper secondary	-	13.1	-	11.0
Lower secondary	-	20.7	-	23.3
No qualifications	-	37.6	-	40.0
Social class (30 to 59)				
Non manual	44.4	47.4	-	-
Manual	55.6	52.6	-	-
Tenure				
Owned	60.4	74.0	57.7	71.7
Private rented	5.6	6.1	4.7	5.8
Social rented	34.1	19.9	37.6	22.5
Car access				
Car	72.3	81.6	65.5	75.7
No car	27.7	18.4	34.5	24.3
Carstairs				
1 (least deprived)	21.1	21.1	20.6	20.3
2	20.8	21.3	20.4	20.8
3	19.9	20.0	19.9	20.4
4	19.8	19.4	20.2	19.5
5 (most deprived)	18.5	18.3	18.9	19.0

Source: Scottish Longitudinal Study

Scottish Health Survey – Morbidity and health behaviours analysis

We used the 2003 Scottish Health Survey to analyse the relative inequalities in the prevalence of smoking (defined as current smoking) and obesity (a BMI of 30 or over) and self-rated health, also in line with Mackenbach *et al.*'s paper.

Education (see Table 2), based on the same four categories used in the mortality analysis for 2001, was the main socio-economic comparator and the relative index of inequality was calculated to summarise the level of inequality. For smoking and obesity, a generalised linear model with a log link and binomial distribution was used to obtain the relative index of inequality. All analysis adjusted for age (five year age groups) and was limited to ages 30 to 69 (as this was the age range used by Mackenbach *et al.* for this part of the analysis) with separate analysis conducted for each sex. For analysis by income (that covered earnings, state benefits and income from savings and investments), we divided the household income of the age range and both sexes combined into quintiles of approximately equal size. Account was taken of household size by multiplying household income by the correction factor of household size to the power of 0.36 as in Mackenbach *et al.* Note, however, that only gross income (before tax) was available in the Scottish Health Survey rather than net income which was used by Mackenbach *et al.* and so the comparability of the income analysis is not perfect (Mackenbach *et al.*, only presented results for income for self assessed health and we follow suit here).

Mackenbach *et al.* conducted analyses of the self-rated health variable in terms of the average number of diseases reported for each category of the response. Across Europe they found evidence that each category was related to a similar number of average diseases and so the responses were coded: very good = 1, good = 1.85, fair = 3.42, bad or very bad = 6.33. Poisson regression was used to calculate the relative index of inequality for this variable.

Table 2 Distribution of the socio-economic variables included in the morbidity and health behaviours analysis for men and women aged 30 to 69 at baseline in 2003

	Men (%)	Women (%)
Education		
Degree / other higher	33.5	31.9
Upper secondary	20.2	13.3
Lower secondary	12.1	17.9
No qualifications	34.2	36.9
Gross income quintiles		
1 (richest)	23.0	18.9
2	21.1	18.9
3	21.9	21.7
4	17.1	19.3
5 (poorest)	17.0	21.3

Source: Scottish Health Survey 2003

Inequalities in life expectancy – analysis of the Human Mortality Database

As outlined in the introduction, replicating Mackenbach et al.'s analysis for Scotland only provided a comparison for the 1990s and so in order to update the analysis and to show longer term trends we sought another method. Therefore, we assessed the mortality variability using historic sex-specific life tables for Scotland and other countries, published in the Human Mortality Database [12]. This provides an analysis of Scotland's relative position, in terms of mortality inequalities across all ages (using single year of age from 0 through to 110+), which is free of the inherent difficulties involved in comparing socio-economic groups in different countries. It also provides a longer-term perspective from 1950 to 2006.

The measure of variability chosen was average life expectancy lost per death [6 13]. This is based on the idea that when a person dies they will lose a certain number of potential years of life and is derived as follows. The life expectancy lost for deaths in each age group is calculated and then multiplied by the proportion of life table deaths occurring in this age group. If life expectancy at birth was 79 and at age one 78, each death of someone aged 0 to 1 would cost an average of 78.5 years of potential life (for the last age group (110+) their life expectancy was used). Then, if 1% of annual deaths in a country occur in the first year of life, the weighted years of life lost for that age group equals 0.785 (78.5*0.01). Calculating this figure for every age group in a year and summing it gives the average years of life lost per death for the country that year. This measure therefore compares the spread of deaths across the age span in different countries.

We compared Scotland's position to that of the following countries chosen because they had data from at least 1960 (most had data from 1950), they were high income countries and because they were not ex-Soviet or Yugoslavian bloc: Australia, Austria, Belgium, Canada, Switzerland, (West) Germany, Denmark, Spain, Finland, France, England and Wales, Northern Ireland, Ireland, Iceland, Italy, Japan, Luxembourg, Netherlands, Norway, New Zealand, Portugal, Sweden, and the USA.

To assess Scotland's inequalities in more depth we also compared it over time England and Wales, as its social and geographical neighbour, and Sweden, as a northern European country that at least for this measure of inequality has been a leader (lowest inequalities) for much of the 20th Century.

In further analysis we assessed the age specific contribution to changes and differences in this measure of inequality over time within and between the countries. These results are not reported here but further information can be obtained from the first author.

Results

Mortality results from the Scottish Longitudinal Study

For the 1991 census cohort followed to the end of 1999 there were 13,762 deaths recorded for 137,869 people who contributed 1,137,432 person-years. For the 2001 census cohort followed to the end of 2007 there were 8,234 deaths for 144,610 people who contributed 928,155 person-years.

Table 3 shows the relative index of inequalities for men and women in each of the time periods by the different measures of socio-economic position used. Imposing the result for Scotland (the red line) onto Mackenbach *et al.*'s results (Figures 1 and 2) suggests that Scotland had higher relative educational inequalities in mortality in the 1990s than found in most other European countries apart from some in Eastern Europe. However, as outlined in the methods section the direct comparability of the education variable in 1991 with those in the other countries is debatable and should be treated with caution; indeed, it is likely that the education gradient in Scotland is overstated. Some support for this suggestion is implied by the result for the 2001 education gradient which is lower (at least for men) than the 1990s and is based on a far more comparable education variable. As the relative indices of inequality for the other socio-economic variables see rises over time this suggests that the education relative index of inequality should have also risen. We expect that the comparable education gradient in Scotland (at least for men) in the 1990s would have been lower than stated in Table 3 but probably still relatively high in European terms. Support for this conclusion comes from the result for social class that places Scotland as having slightly higher inequalities than the more limited range of comparison countries (Table 3 and Figure 3).

In summary, it seems fair to conclude that relative inequalities may have risen over time in Scotland and that Scotland has higher relative inequalities in mortality than many other European countries. It is also apparent from Table 3 that inequalities worsened between the 1990s and 2000s for both men and women across all the measures captured in both 1991 and 2001.

Table 3 Relative index of inequality for mortality 1991 to 1999 and 2001 to 2007

	Men		Women	
	1991 to 1999	*2001 to 2007*	*1991 to 1999*	*2001 to 2007*
Education (1991 definition)	3.19 (2.67 to 3.81)	-	2.21 (1.79 to 2.73)	-
Education (2001 definition)	-	2.59 (2.28 to 2.93)	-	2.85 (2.44 to 3.32)
Social class (30 to 59 only)	2.25 (1.86 to 2.72)	3.67 (2.90 to 4.65)	-	-
Tenure	2.97 (2.72 to 3.24)	3.97 (3.53 to 4.46)	2.68 (2.42 to 2.97)	3.86 (3.39 to 4.40)
Car access	3.30 (3.01 to 3.61)	5.16 (4.57 to 5.83)	2.41 (2.17 to 2.69)	3.19 (2.78 to 3.67)
Carstairs quintile	2.07 (1.91 to 2.25)	2.46 (2.22 to 2.73)	1.96 (1.79 to 2.15)	2.17 (1.93 to 2.44)

Source: Scottish Longitudinal Study

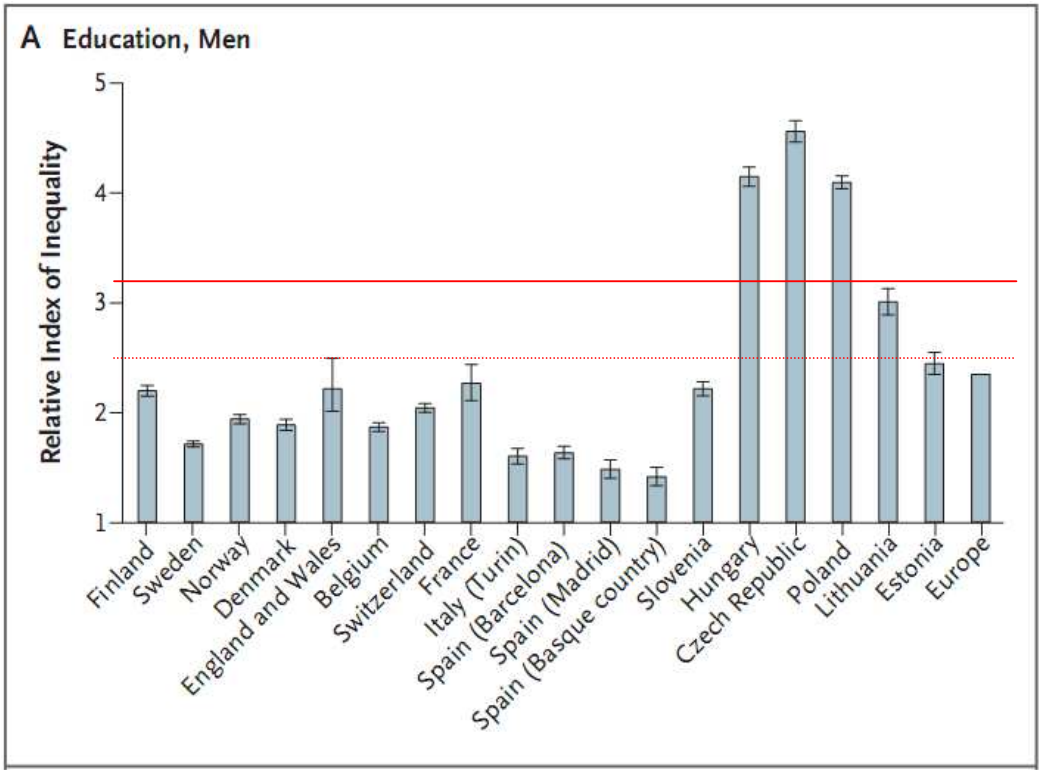

Figure 1 The Scottish education relative index of inequality (red line) for men 1991 to 1999 plotted against results for Europe from Mackenbach *et al.* 2008 (the dotted red line represents the 2001-2007 result)

Source: Mackenbach et al. 2008 and the Scottish result from the Scottish Longitudinal Study

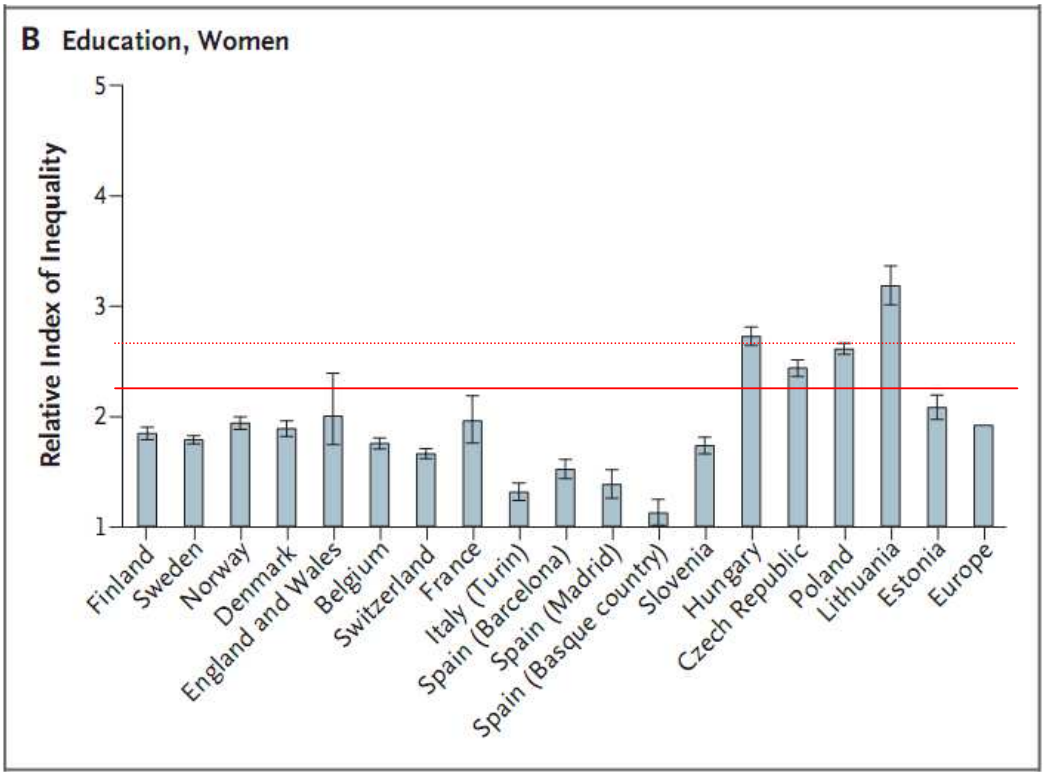

Figure 2 The Scottish education relative index of inequality (red line) for women 1991 to 1999 plotted against results for Europe from Mackenbach *et al.* 2008 (the dotted red line represents the 2001-2007 result)

Source: Mackenbach et al. 2008 and the Scottish result from the Scottish Longitudinal Study

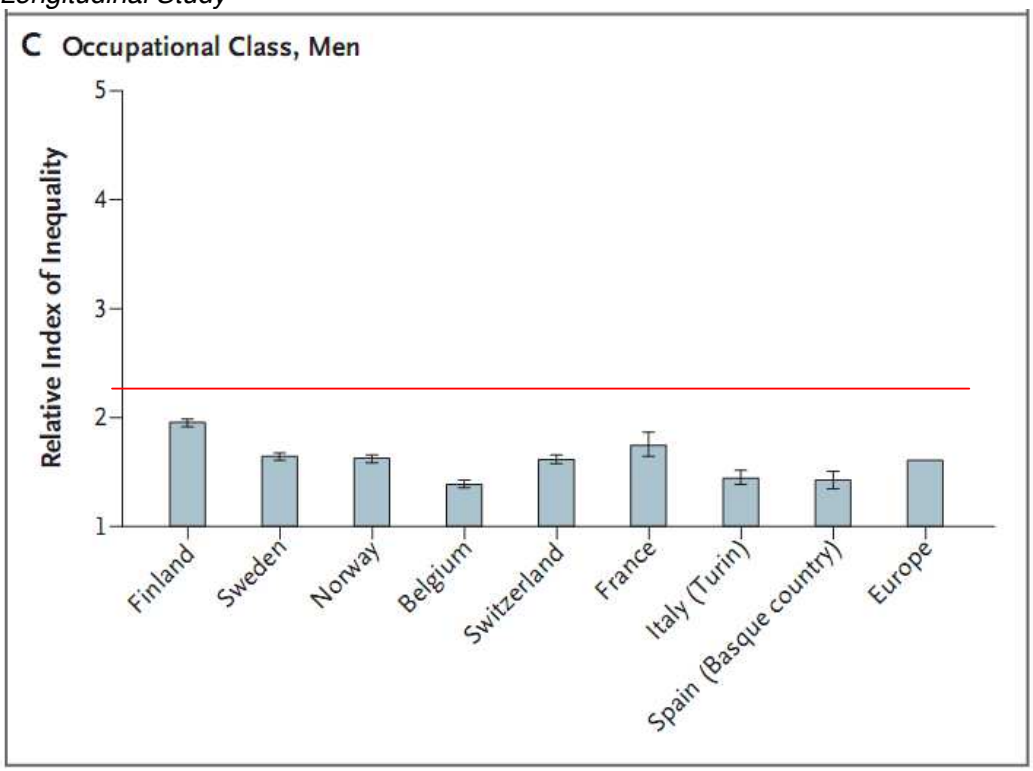

Figure 3 The Scottish occupational class relative index of inequality (red line) for men (aged 30 to 59) 1991 to 1999 plotted against results for Europe from Mackenbach *et al.* 2008

Source: Mackenbach et al. 2008 and the Scottish result from the Scottish Longitudinal Study

Tables 4 and 5 provide the Scottish cause-specific education slope indices of inequality for men and women, in addition to those published for the other European countries in Mackenbach's *et al*. paper. Table 6 presents the Scottish results for the 2000s. While the caveats on the comparability of the education variable in the 1990s for Scotland still apply, similar patterns (with some variation) by cause were seen when the cause-specific slope indices of inequality were derived from the other socio-economic measures (see Tables A1 and A2 in the appendix). Of note however, is the higher relative and slope indices of inequality for alcohol related mortality when calculated for car access, tenure and Carstairs score compared to when calculated for education.

As the level of the slope index of inequality is dependent on the mortality rate the raw absolute rates can be difficult to compare. However, comparing how the various causes of death contribute (as a percentage) to the overall slope index of inequality for Scotland to Mackenbach *et al.'s.* European average gives more of an insight.

In Scotland in the 1990s, a higher percentage of the slope indices of inequality for men and women were due to smoking. Lung cancer accounted for 17% of the slope index of inequality in Scottish men compared to only 11% in Europe as a whole. For women these figures were 17% versus 2%, respectively. Similar comparisons for smoking related deaths were 27% for Scottish men compared to 22% for Europe and 29% versus 6% for women. Smoking will also likely play a part in influencing the higher than average contribution of IHD to the slope index of inequality for Scottish men (35% versus 17%) and women (32% versus 24%). It should be remembered that smoking related diseases' contribution to inequalities varies widely in the rest of Europe. In some southern European countries there are low gradients influenced by the shallow gradients in smoking behaviour, perhaps reflecting an earlier stage in the smoking epidemic in these countries. So while Scotland's smoking related inequalities are high compared to the European average some other northern European countries also have high smoking related mortality inequalities. Table 6 gives the slope indices of inequality for Scotland in the 2000s and again suggests the strong influence of smoking on inequalities.

Figures 4 to 7 show for Scotland, the cause-specific slope indices of inequality for the 1990s and 2000s as a percentage of the overall slope index of inequality and compares this to the proportion of overall mortality rate (all age adjusted) that is due to each cause of death. So a higher percentage for the slope index of inequality compared to the mortality rate suggests this cause is relatively more important for inequalities compared to its contribution to the overall mortality rate. Focusing on the 2000s results highlights the larger relative contribution of smoking-related disease to inequality compared to the contribution to the mortality rate. Overall, cancer deaths contribute less to the slope index than the mortality rate reflecting shallow or negative inequalities for some cancers. For example, there is a negative gradient for breast cancer amongst women and so breast cancer reduces overall inequality slightly, while remaining a significant cause of death for women. Overall cardiovascular diseases were also a particular contributor to inequalities in mortality for women as has been shown in other European countries because of the contribution of both inequalities in heart disease and stroke [14].

Table 4: The education slope index of inequality for all cause and cause specific mortality 1991 to 1999 for men.

	Mortality rate	All causes	All cancer	Breast	Lung	All cardio	IHD	Stroke	All external	All other	Alcohol	Smoke	Amenable
Scotland	*1478*	*1545*	*391*	-	*263*	*683*	*535*	*105*	*70*	*388*	*47*	*413*	*117*
Finland	1673	1255	213	-	135	533	393	94	143	347	101	215	88
Sweden	1188	625	90	-	37	309	229	50	52	175	50	71	26
Norway	1529	980	169	-	95	434	307	78	70	305	62	166	49
Denmark	1344	828	126	-	75	235	157	39	89	363	23	60	44
England and Wales	1124	862	225	-	141	401	284	67	19	157	28	241	NA
Belgium	1510	915	274	-	179	233	99	55	64	340	36	302	28
Switzerland	1475	1012	283	-	136	401	132	61	91	348	117	260	61
France	1241	1044	333	-	71	232	67	68	109	357	196	204	114
Italy (Turin)	1377	639	232	-	107	140	57	52	23	243	63	177	24
Spain (Barcelona)	1370	662	230	-	90	88	26	40	38	304	77	218	36
Spain (Madrid)	1355	530	181	-	56	38	–16	11	26	278	75	170	34
Spain (Basque Country)	1108	384	107	-	39	16	–6	3	63	177	46	107	24
Slovenia	1902	1439	303	-	124	405	67	219	203	482	224	327	83
Hungary	2110	2580	666	-	260	1003	482	385	222	671	420	508	66
Czech Republic	1664	2130	676	-	247	825	472	259	138	489	146	364	73
Poland	1804	2192	589	-	260	750	295	223	187	637	145	408	75
Lithuania	2531	2536	383	-	197	807	505	159	643	677	304	424	195
Estonia	2799	2349	355	-	191	929	610	263	436	618	286	323	162
Europe total (excluding Scotland)	1635	1333	328	-	153	451	233	131	147	425	141	288	72

Source: Mackenbach et al, 2008 and the Scottish result from the Scottish Longitudinal Study

Table 5: The education slope index of inequality for all cause and cause specific mortality 1991 to 1999 for women

	Mortality rate	All causes	All cancer	Breast	Lung	All cardio	IHD	Stroke	All external	All other	Alcohol	Smoke	Amenable
Scotland	917	691	94	-22	115	340	223	75	7	265	12	198	67
Finland	811	483	49	–8	14	262	168	72	25	161	31	28	42
Sweden	673	381	73	–6	20	172	104	44	8	128	15	39	18
Norway	811	518	103	–14	44	239	141	62	5	169	16	79	30
Denmark	830	511	103	–12	63	160	90	42	22	230	9	70	27
England and Wales	672	462	111	–22	59	236	154	31	1	96	7	103	NA
Belgium	761	417	47	–11	11	198	77	55	11	163	6	29	10
Switzerland	676	337	53	–3	10	158	74	46	5	120	10	21	22
France	536	375	50	35	6	130	33	44	36	163	30	17	82
Italy (Turin)	721	197	15	–17	–9	94	34	34	–3	94	8	–4	11
Spain (Barcelona)	569	236	7	–12	–14	103	36	34	5	126	7	–14	12
Spain (Madrid)	543	175	–12	–29	–17	96	30	29	–1	94	–3	–17	9
Spain (Basque country)	422	51	–76	–19	–20	56	23	17	7	74	3	–24	2
Slovenia	853	459	–13	–21	–18	263	62	127	28	180	44	–3	33
Hungary	1023	948	120	–17	20	511	237	216	51	258	82	61	26
Czech Republic	868	726	144	10	17	356	182	134	26	203	23	33	32
Poland	840	750	139	6	10	356	117	142	29	222	23	28	27
Lithuania	1053	1099	130	7	7	535	297	162	178	251	87	39	51
Estonia	1213	851	7	–5	4	493	273	187	109	252	101	16	48
Europe total (excluding Scotland)	778	492	55	–9	10	251	120	85	30	172	30	28	27

Source: Mackenbach et al, 2008 and the Scottish result from the Scottish Longitudinal Study

Table 6 The education slope index of inequality for all cause and cause specific mortality 2001 to 2007 for men and women

	Mortality rate	All causes	All cancer	Breast	Lung	All cardio	IHD	Stroke	All external	All other	Alcohol	Smoke	Amenable
Scotland (men)	999	884	270	-	151	317	212	50	39	256	39	252	48
Scotland (women)	668	641	156	-9	109	222	121	58	11	243	28	190	55

Source: Scottish Longitudinal Study

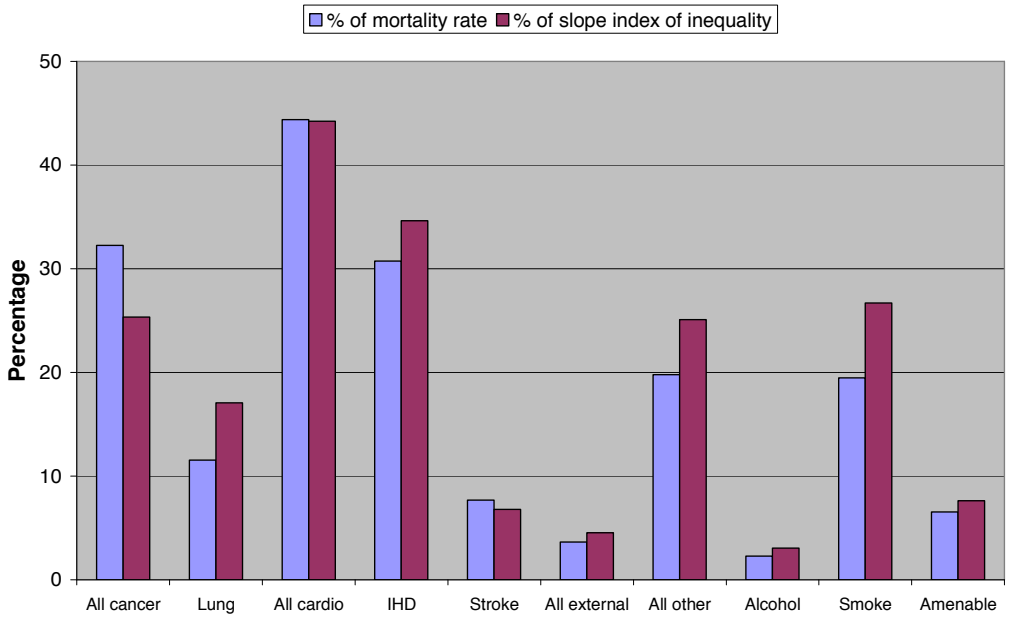

Figure 4 –Contribution of causes of death to the age adjusted mortality rate and the education slope index of inequality for men, 1991 to 1999
Source: Scottish Longitudinal Study

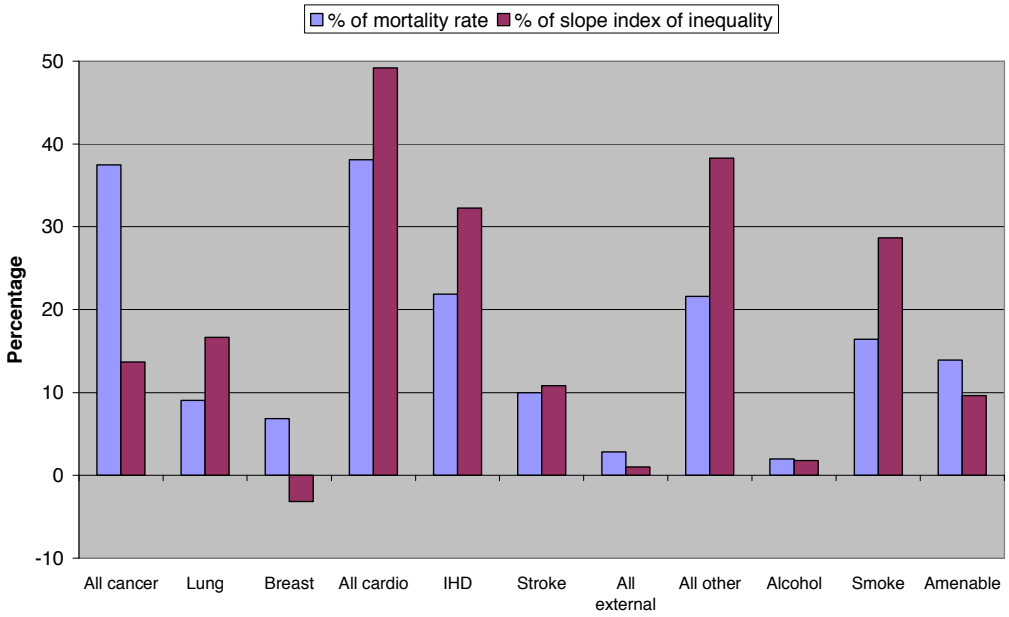

Figure 5 –Contribution of causes of death to the age adjusted mortality rate and the education slope index of inequality for women, 1991 to 1999
Source: Scottish Longitudinal Study

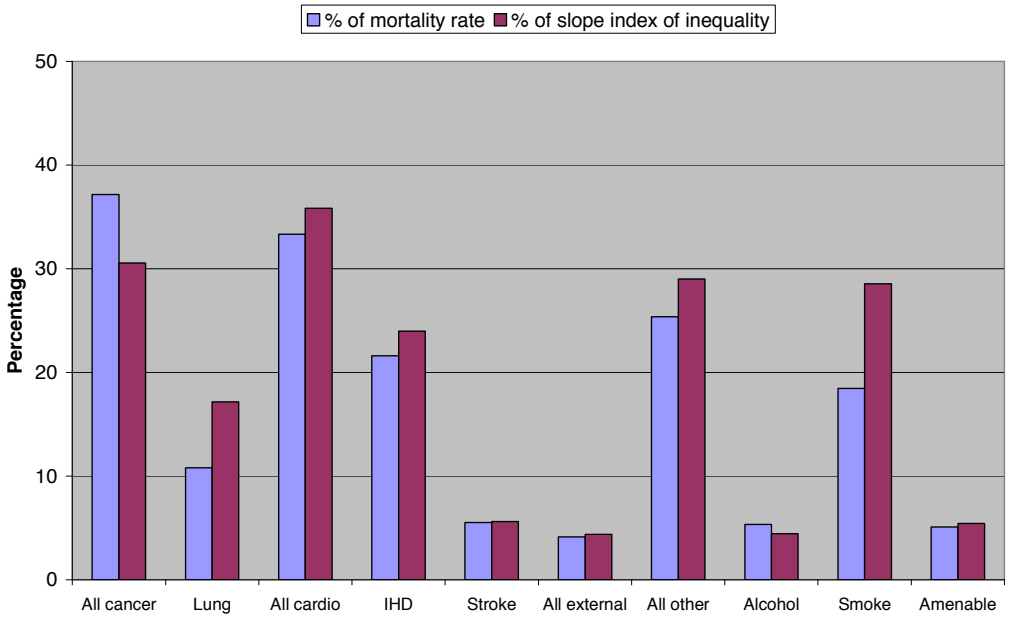

Figure 6 –Contribution of causes of death to the age adjusted mortality rate and the education slope index of inequality for men, 2001 to 2007
Source: Scottish Longitudinal Study

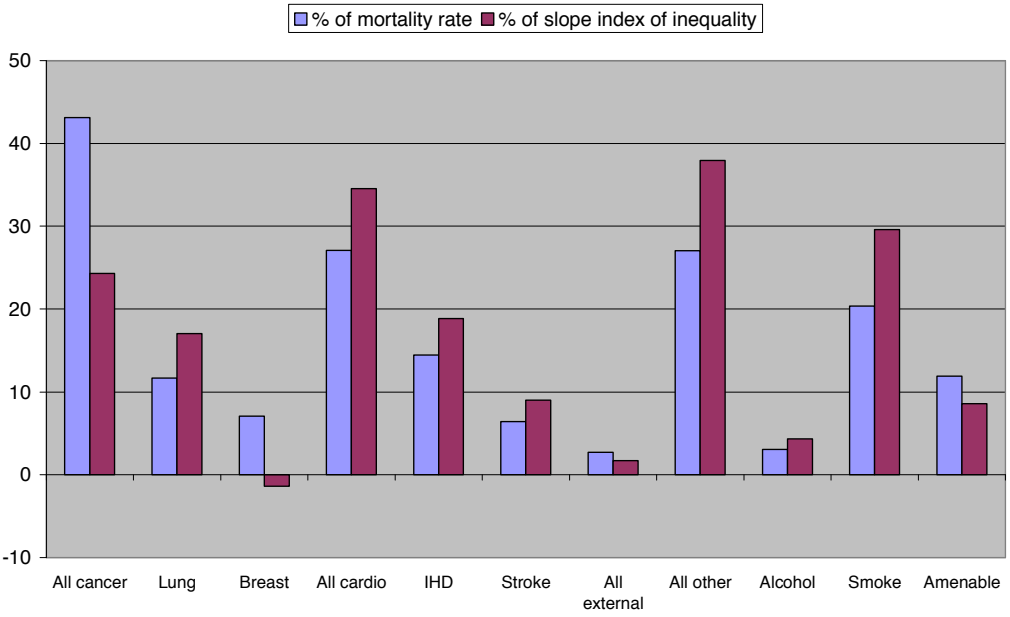

Figure 7 –Contribution of causes of death to the age adjusted mortality rate and the education slope index of inequality for women, 2001 to 2007
Source: Scottish Longitudinal Study

Morbidity and health behaviours from the Scottish Health Survey 2003

There were 5,638 people aged 30 to 69 in the Scottish Health Survey 2003.

Table 7 shows the relative indices of inequality from the analysis of the Scottish Health Survey 2003 by education and income in line with Mackenbach *et al.*'s analysis.

Starting with self assessed health, Table 6 and Figure 8 show the results by education and suggest that Scotland had the highest relative inequalities for men and nearly the highest for women. The results for income in Table 6 also suggests large inequalities in Scotland although as mentioned in the methods section only gross income was available for Scotland and so we have not made a direct comparison with the Mackenbach *et al.* results.

In line with the mortality analysis, the analysis of the relative index of inequality for current smoking suggests very high inequalities for both men and women in Scotland compared to Europe as a whole (Table 7 and Figure 9). On the other hand the inequalities in obesity are relative low in Scotland compared to some European countries (Table 7 and Figure 9).

Table 6. Relative index of inequalities for general health, smoking and obesity, men and women aged 30 to 69 in 2003

	Men	Women
General health		
Education	1.80 (1.62 to 1.99)	1.71 (1.56 to 1.88)
Gross Income	2.48 (2.23 to 2.75)	2.19 (1.99 to 2.41)
Smoking		
Education	4.31 (3.40 to 5.47)	4.33 (3.48 to 5.39)
Obesity		
Education	1.46 (1.12 to 1.89)	1.58 (1.25 to 2.01)

Source: Scottish Health Survey

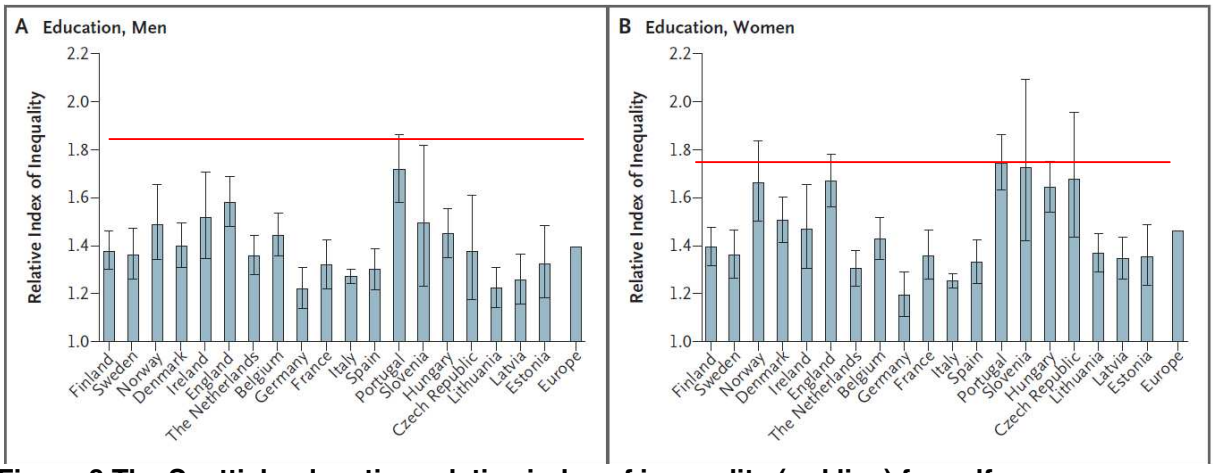

Figure 8 The Scottish education relative index of inequality (red line) for self rated general health plotted against results for Europe from Mackenbach *et al.* 2008

Source: Mackenbach et al., 2008 and the Scottish result from the Scottish Health Survey

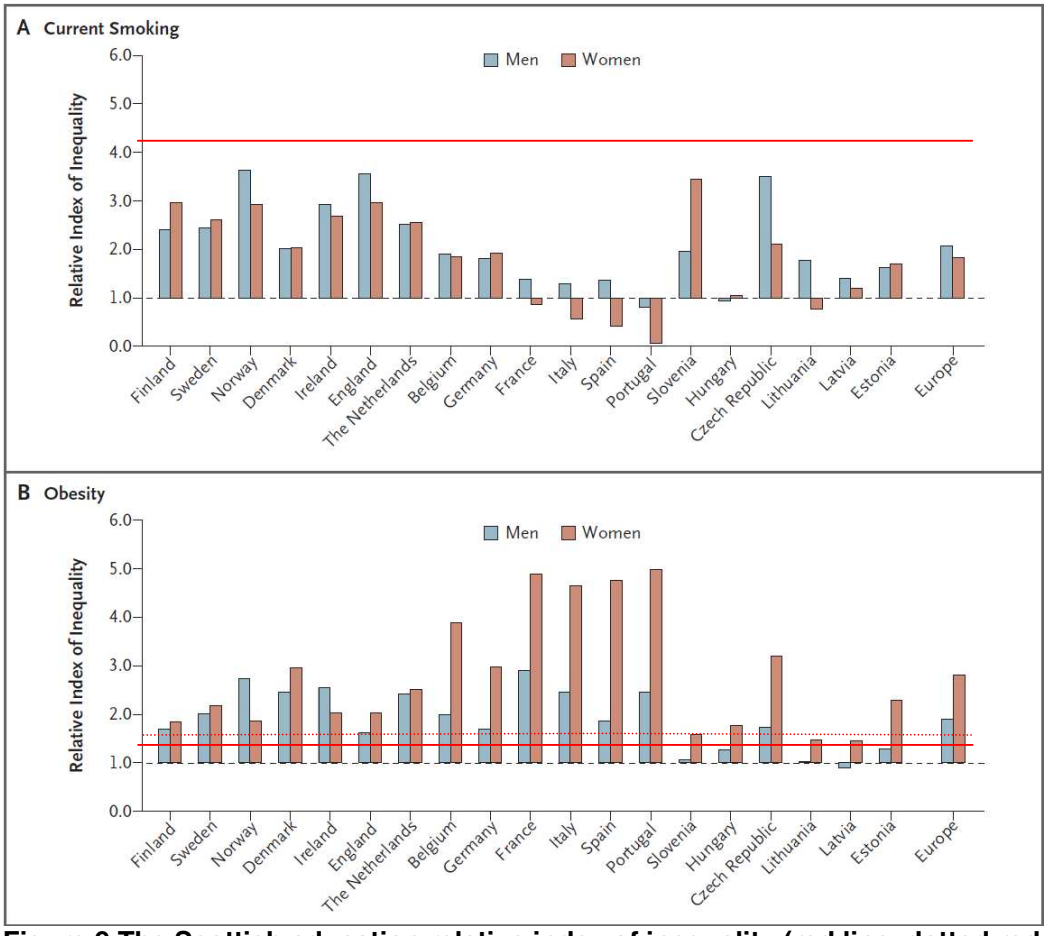

Figure 9 The Scottish education relative index of inequality (red line, dotted red line is for women in the obesity chart) for current smoking and obesity plotted against results for Europe from Mackenbach *et al.* 2008

Source: Mackenbach et al., 2008 and the Scottish result from the Scottish Health Survey

Inequalities in mortality for Scotland from the Human Mortality Database

Figure 10 shows the position of Scotland in terms of average lost life expectancy per death (averaged across each decade) relative to the other high income countries listed in the methods section. For both men and women, Scotland in 2000-06 ranked second most unequal (only the USA has greater inequality in this period) losing 11.7 and 10.5 years of life expectancy per death, respectively.

Men's relative position in the distribution has worsened in the 1990s and 2000s; in the early decades Scottish men fell in the middle of the distribution. The position of Scottish women had historically been slightly worse than average but there is also a relative worsening in the 1990s and 2000s.

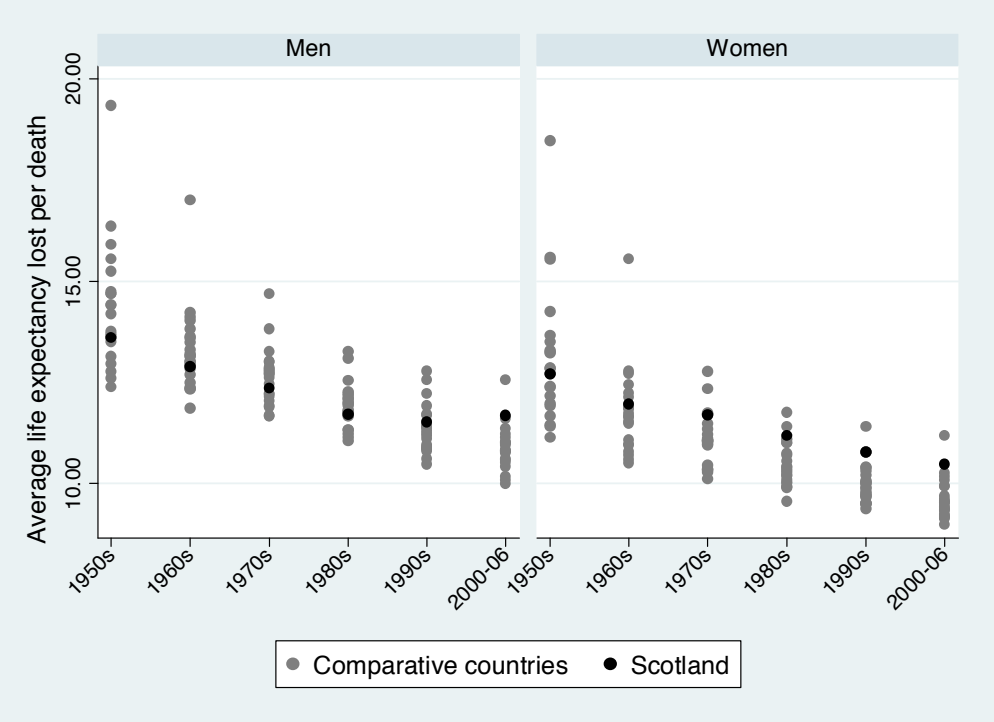

Figure 10 Average length of life lost per death in Scotland compared to other countries (see methods section) since the 1950s
Source: Human Mortality Database

Figures 11 and 12 show the more detailed trends for Scotland relative to England and Wales and Sweden for men and women respectively. Throughout the period both men and women had higher life expectancy lost per death than either England and Wales or Sweden. For women, the Scottish difference compared to the other two countries has remained quite consistent over time (although with some evidence of very slight increases recently) after initially declining through the 1950s. The pattern for men is more dramatic with increasing differences in inequality recently brought about by a slight rise in Scottish inequality in the 1990s and a fairly steady rate thereafter compared to the downward trends in the other two countries (although in England and Wales the decline has also slowed).

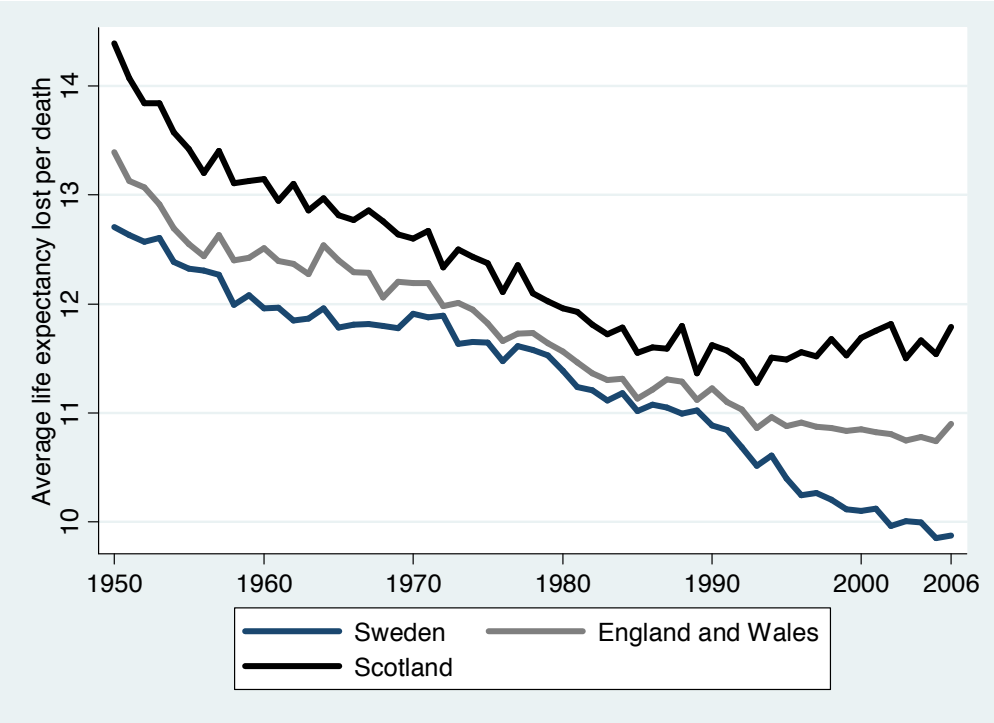

Figure 11 Average length of life lost per death in Scotland for men compared to England and Wales and Sweden since the 1950s
Source: Human Mortality Database

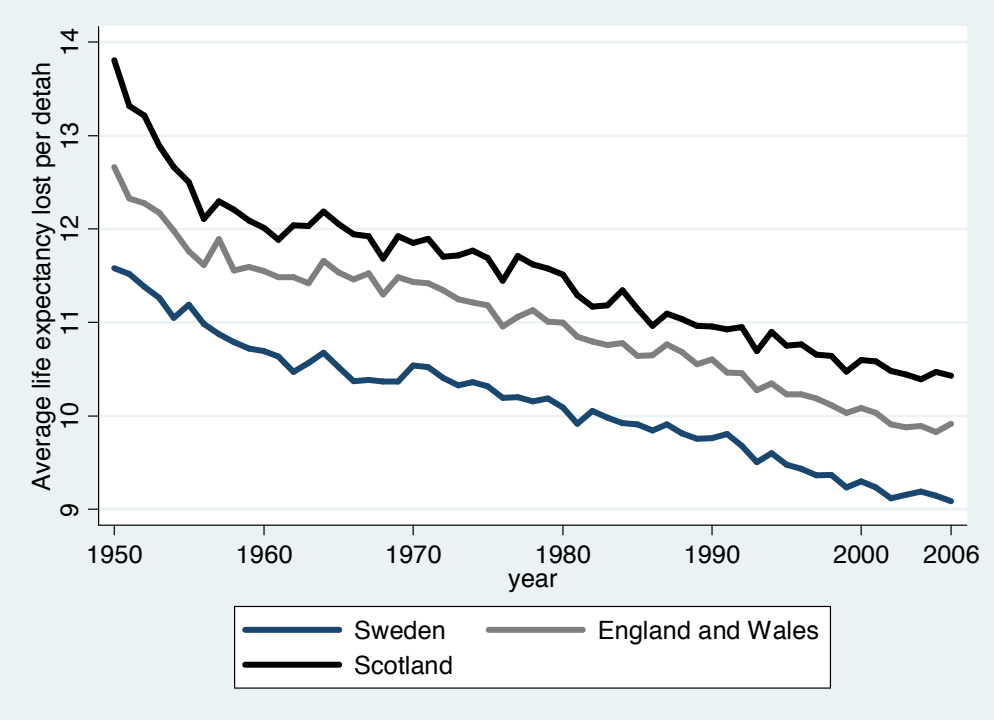

Figure 12 Average length of life lost per death in Scotland for women compared to England and Wales and Sweden since the 1950s
Source: Human Mortality Database

Discussion and conclusion

Although Scotland's overall health as measured by life expectancy is improving year on year, the rate of improvement is not as fast as in other European countries leading to Scotland having very low life expectancy for a high income Western European country[1]. Within Scotland relative inequalities in the risk of death are large and widening[2], however to date Scotland has not been included in international comparisons of the extent of inequalities. The current project aimed to fill this gap. It indicates that inequalities in Scotland may also be comparatively large (whether judged by social group differences or judged using the variation in mortality approach) and there is also some indication that inequalities are widening (based on social group differences) in line with other Scottish research [2], and that Scotland's relative international position is becoming worse over time with particular worrying trends for men in the last decade and so. Smoking related diseases seem to play an important role in Scotland's inequalities as is the case in some other northern European countries [3] and there appeared to be particularly wide inequalities in smoking prevalence in Scotland.

Recent mortality work for younger ages in Scotland shows worrying trends[2 15] that can be attributed to rises in negative and self destructive causes of death (alcohol and drug related and suicide) amongst those living in deprived circumstances [2]. The reasons for these worrying trends are not clear and require further research but it is clear that they are associated with deprivation [2].

Limitations

There are of course limitations to this analysis. Firstly, although we have endeavoured to replicate as closely as possible the methods used in the Mackenbach *et al.* paper [3], it needs to be recognised that our analysis is separate from the Mackenbach *et al.* project and so this may affect comparability. However, there is a new Mackenbach led European comparative project using data from the 2000s and the hope is to include Scotland using the Scottish Longitudinal Study (http://www.euro-gbd-se.eu/). Moreover, Eurostat are planning to monitor on an annual basis educational inequalities in mortality across Europe post 2011 census using death record linkage to 2011 census data. So information on Scotland's relative European position will improve in the future and be timelier. Indeed, as we have shown mortality inequalities can also be monitored using a standard life table allowing timely monitoring of trends now as well as historical analysis.

As part of the on-going improvements to the Scottish Longitudinal Study, a small number of additional deaths have been identified recently (they were not originally recorded due to non linkage related to date of birth discrepancies – a common problem in data linkage studies). Causes of death were not available at the time of analysis for these additional deaths and so they have not been included in the inequalities analysis which thus underestimates the absolute rate of death very slightly. The inequalities analysis is not affected as the reason for the missing deaths was not related to socio-economic circumstances and so these were distributed randomly across socio-economic groups. Although levels of missing data were very low and unlikely to greatly affect the results of this study, there was some evidence that people missing data on any of the socio-economic variables (because of non completion of the census question) had higher death rates because the highest age adjusted death rates were seen when analysis was done for socio-economic variables with virtually no missing data (such as the Carstairs score).

Finally, comparing social inequalities over time and across countries is a complex task and there are continuing concerns about the comparability of seemingly similar social groupings in different European countries [3]. Comparing trends in both relative and absolute differences in mortality and health over time and between countries is also difficult as the level of differences is related to the underlying rate of mortality / health in the population. So as health improves over time and the level of health varies across countries, there is a need to be cautious in using difference measures to assess trends and differences [16]. An advantage of using average lost life expectancy per death as a comparative measure is that it is not a difference measure but an absolute one that is intrinsically linked to the level of health. As life expectancy improves mortality inequality will reduce by this measure unless life expectancy gains are coming mainly from the older ages rather than from also tackling premature mortality[13].

Conclusion

The level of mortality inequality in Scotland appears high for a high income European country, with some evidence of increasing inequality over time. Smoking related mortality seems to play a large part in Scotland's mortality inequalities with high inequalities in current smoking.

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Ethical approval

The project was approved by the Geography and Geosciences School Ethics Committee of the University Teaching and Research Ethics Committee of the University of St Andrews.

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The Scottish Health Survey 2003 was made available through the UK Data Archive. Neither the original collectors of the data nor the Archive bear any responsibility for the analyses or interpretations presented here.

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Appendix: Additional tables

Table A1 Relative (RII) and Slope (SII) indices of inequality for men and women 1991 to 1999 by the various measures of socio-economic position

	Education			
	Men		**Women**	
Cause of death	*RII*	*SII*	*RII*	*SII*
All	3.19 (2.67 to 3.81)	1545	2.21 (1.79 to 2.73)	691
All cancer	2.39 (1.78 to 3.22)	391	1.32 (0.97 to 1.79)	94
Lung	7.77 (4.06 to 14.86)	263	5.49 (2.29 to 13.17)	115
Breast			0.71 (0.38 to 1.31)	-22
All cardio	3.18 (2.43 to 4.16)	683	2.89 (1.99 to 4.22)	340
IHD	3.87 (2.77 to 5.42)	535	3.5 (2.08 to 5.87)	223
Stroke	2.71 (1.44 to 5.08)	105	2.38 (1.18 to 4.8)	75
All external	4.79 (2 to 11.49)	70	1.31 (0.49 to 3.54)	7
All other	4.95 (3.2 to 7.64)	388	5.01 (2.91 to 8.63)	265
Alcohol	5.72 (1.77 to 18.49)	47	2.03 (0.56 to 7.38)	12
Smoke	6.07 (3.78 to 9.74)	413	4.84 (2.56 to 9.15)	198
Amenable	4.11 (1.96 to 8.6)	117	1.7 (1 to 2.91)	67
	Tenure			
Cause of death	*RII*	*SII*	*RII*	*SII*
All	2.97 (2.72 to 3.24)	1485	2.68 (2.42 to 1.44)	846
All cancer	2.25 (1.93 to 2.63)	368	1.7 (1.44 to 2.7)	180
Lung	3.73 (2.86 to 4.85)	197	3.82 (2.7 to 0.61)	97
Breast			0.91 (0.61 to 2.55)	-6
All cardio	2.69 (2.36 to 3.06)	611	3 (2.55 to 2.88)	353
IHD	2.81 (2.39 to 3.29)	437	3.58 (2.88 to 1.6)	228
Stroke	2.79 (2.03 to 3.82)	109	2.19 (1.6 to 1.92)	68
All external	3.53 (2.24 to 5.56)	61	3.56 (1.92 to 3.75)	29
All other	5.78 (4.71 to 7.09)	417	4.69 (3.75 to 3.26)	260
Alcohol	11.81 (6.39 to 21.86)	57	7.16 (3.26 to 3.27)	27
Smoke	4.26 (3.47 to 5.22)	358	4.23 (3.27 to 1.66)	187
Amenable	5.85 (4.04 to 8.49)	141	2.04 (1.51 to 2.76)	90
	Car			
Cause of death	*RII*	*SII*	*RII*	*SII*
All	3.3 (3.01 to 3.61)	1599	2.41 (2.17 to 1.43)	766
All cancer	2.33 (1.98 to 2.74)	382	1.7 (1.43 to 3.05)	180
Lung	3.29 (2.52 to 4.3)	183	4.42 (3.05 to 0.69)	105
Breast			1.06 (0.69 to 2.12)	4
All cardio	2.89 (2.52 to 3.31)	648	2.52 (2.12 to 2.2)	304
IHD	2.72 (2.3 to 3.2)	425	2.77 (2.2 to 1.2)	190
Stroke	4.48 (3.24 to 6.21)	147	1.68 (1.2 to 1.81)	46
All external	4.58 (2.86 to 7.31)	70	3.47 (1.81 to 3.09)	29
All other	7.32 (5.96 to 9)	449	3.91 (3.09 to 4.13)	238
Alcohol	31.24 (16.62 to 58.72)	63	9.22 (4.13 to 3.22)	29
Smoke	3.98 (3.24 to 4.89)	346	4.23 (3.22 to 1.52)	187
Amenable	7.47 (5.14 to 10.86)	152	1.93 (1.41 to 2.65)	83
	Carstairs			
Cause of death	*RII*	*SII*	*RII*	*SII*
All	2.07 (1.91 to 2.25)	1045	1.96 (1.79 to 1.26)	600
All cancer	1.73 (1.5 to 2)	257	1.46 (1.26 to 1.82)	130
Lung	2.52 (1.98 to 3.21)	148	2.48 (1.82 to 0.71)	70
Breast			1.01 (0.71 to 1.74)	1
All cardio	2.12 (1.88 to 2.39)	478	2.01 (1.74 to 1.76)	237

IHD	2.1 (1.81 to 2.43)	326	2.13 (1.76 to 1.4)	146
Stroke	2.75 (2.05 to 3.68)	108	1.86 (1.4 to 1.55)	55
All external	1.97 (1.31 to 2.98)	35	2.71 (1.55 to 2.44)	24
All other	2.69 (2.24 to 3.23)	271	2.97 (2.44 to 2.04)	199
Alcohol	5.11 (2.94 to 8.91)	45	4.16 (2.04 to 2.18)	22
Smoke	2.41 (2.01 to 2.9)	239	2.74 (2.18 to 1.47)	141
Amenable	3.89 (2.75 to 5.5)	118	1.54 (1.17 to 2.03)	56
		Social class		
	RII	***SII***		
All	2.25 (1.86 to 2.72)	414		
All cancer	2.18 (1.56 to 3.03)	134		
Lung	4.79 (2.46 to 9.34)	71		
All cardio	2.44 (1.81 to 3.3)	186		
IHD	2.73 (1.92 to 3.89)	154		
Stroke	2.32 (1.02 to 5.26)	23		
All external	2.11 (1.1 to 4.06)	28		
All other	2.03 (1.3 to 3.17)	65		
Alcohol	2.78 (1.09 to 7.08)	20		
Smoke	5.63 (3.28 to 9.65)	121		
Amenable	1.43 (0.8 to 2.54)	19		

Source: Scottish Longitudinal Study

Table A2 Relative (RII) and Slope (SII) indices of inequality for men and women 2001 to 2007 by the various measures of socio-economic position

	Education			
	Men		**Women**	
Cause of death	*RII*	*SII*	*RII*	*SII*
All	2.59 (2.28 to 2.93)	884	2.85 (2.44 to 3.32)	641
All cancer	2.14 (1.75 to 2.62)	270	1.74 (1.4 to 2.17)	156
Lung	5.71 (3.7 to 8.81)	151	5.73 (3.42 to 9.6)	109
Breast			0.83 (0.5 to 1.37)	-9
All cardio	2.81 (2.26 to 3.51)	317	4.15 (3.01 to 5.74)	222
IHD	2.93 (2.23 to 3.86)	212	4.35 (2.78 to 6.8)	121
Stroke	2.64 (1.54 to 4.54)	50	5.13 (2.58 to 10.2)	58
All external	2.76 (1.53 to 5.01)	39	1.86 (0.79 to 4.36)	11
All other	3.05 (2.37 to 3.92)	256	5.14 (3.72 to 7.1)	243
Alcohol	2.16 (1.3 to 3.59)	39	5.29 (2.24 to 12.46)	28
Smoke	5.34 (3.84 to 7.42)	252	5.62 (3.81 to 8.3)	190
Amenable	2.78 (1.58 to 4.92)	48	2.06 (1.33 to 3.2)	55
	Tenure			
Cause of death	*RII*	*SII*	*RII*	*SII*
All	3.97 (3.53 to 4.46)	1222	3.86 (3.39 to 4.4)	805
All cancer	2.44 (1.99 to 2.97)	310	2.55 (2.08 to 3.14)	253
Lung	4.86 (3.42 to 6.92)	146	6 (4.09 to 8.8)	114
Breast			1.2 (0.68 to 2.13)	8
All cardio	3.78 (3.09 to 4.61)	402	4.74 (3.72 to 6.05)	247
IHD	3.58 (2.79 to 4.6)	252	5.63 (4.05 to 7.84)	144
Stroke	4.94 (3.04 to 8.03)	76	3.83 (2.3 to 6.39)	52
All external	5.79 (3.26 to 10.29)	59	3.37 (1.48 to 7.64)	20
All other	7.67 (6.12 to 9.61)	406	5.82 (4.54 to 7.47)	263
Alcohol	14.58 (8.78 to 24.21)	94	13.26 (6.11 to 28.77)	37
Smoke	5.31 (4.06 to 6.95)	259	6.45 (4.83 to 8.61)	205
Amenable	8.54 (4.94 to 14.76)	85	4.53 (2.92 to 7.01)	102
	Car			
Cause of death	*RII*	*SII*	*RII*	*SII*
All	5.16 (4.57 to 5.83)	1388	3.19 (2.78 to 3.67)	722
All cancer	2.44 (1.97 to 3.02)	314	2.09 (1.68 to 2.6)	205
Lung	4.42 (3.04 to 6.42)	140	3.15 (2.1 to 4.73)	83
Breast			1.23 (0.69 to 2.2)	10
All cardio	4.92 (4 to 6.07)	460	3.57 (2.76 to 4.62)	214
IHD	4.71 (3.63 to 6.11)	292	4.71 (3.32 to 6.68)	135
Stroke	6.58 (3.97 to 10.9)	84	3.06 (1.79 to 5.25)	44
All external	11.27 (6.27 to 20.27)	71	7.49 (3.22 to 17.43)	29
All other	12.94 (10.24 to 16.35)	451	4.93 (3.8 to 6.42)	252
Alcohol	48.36 (28.52 to 82)	104	40.48 (18.18 to 90.14)	43
Smoke	4.91 (3.7 to 6.51)	252	3.81 (2.81 to 5.17)	165
Amenable	25.1 (14.29 to 44.09)	99	3.26 (2.05 to 5.19)	86
	Carstairs			
Cause of death	*RII*	*SII*	*RII*	*SII*
All	2.46 (2.22 to 2.73)	879	2.17 (1.93 to 2.44)	516
All cancer	2.13 (1.79 to 2.53)	271	1.41 (1.18 to 1.69)	99
Lung	3.83 (2.76 to 5.31)	131	2.55 (1.8 to 3.61)	71
Breast			1.09 (0.69 to 1.72)	4
All cardio	2.19 (1.83 to 2.62)	262	2.73 (2.19 to 3.41)	181
IHD	2.17 (1.74 to 2.72)	167	3.05 (2.25 to 4.12)	107
Stroke	2.58 (1.66 to 4)	52	2.99 (1.87 to 4.77)	44

All external	3.28 (1.96 to 5.49)	47	2.15 (1.05 to 4.42)	14
All other	3.38 (2.74 to 4.16)	293	3.35 (2.67 to 4.21)	208
Alcohol	5.37 (3.36 to 8.59)	78	6.06 (2.94 to 12.51)	32
Smoke	3.39 (2.65 to 4.34)	210	3.33 (2.56 to 4.35)	153
Amenable	5.78 (3.42 to 9.77)	77	3.26 (2.05 to 5.19)	86
		Social class		
	RII	***SII***		
All	3.67 (2.9 to 4.65)	474		
All cancer	2.05 (1.39 to 3.01)	99		
Lung	3.57 (1.68 to 7.59)	47		
All cardio	4.07 (2.63 to 6.31)	150		
IHD	5.98 (3.45 to 10.4)	121		
Stroke	1.8 (0.59 to 5.52)	10		
All external	7.8 (3.27 to 18.6)	53		
All other	5.77 (3.61 to 9.24)	158		
Alcohol	7.63 (3.56 to 16.37)	69		
Smoke	4.35 (2.37 to 8)	83		
Amenable	1.7 (0.78 to 3.71)	18		

Source: Scottish Longitudinal Study