Quantifying the contribution of leading causes of death to mortality decline among older people in England, 1991–2005

Charlotte Ashton, Madhavi Bajekal and Rosalind Raine *University College London*

Abstract

Background

This paper quantifies the contribution of leading causes of death to mortality change between 1991 and 2005 for people aged 50 years and over in England.

Between 1971 and 2005 the life expectancy of men aged 50 years increased by more than in the whole of the rest of the 20th century. The ageing population has not only had an important impact on health and social services, but was responsible for sparking the pensions crisis affecting both the public and commercial sector.

Methods

A cross-sectional analysis was used to quantify trends in cause-specific mortality in terms of absolute and relative change between 1991 and 2005 in the population aged 50 and over. Absolute change is quantified in terms of the numbers of deaths prevented or postponed (or conversely, increased or brought-forward) in a year compared to deaths in the baseline year. The percentage change in age-standardised rates was used to identify relative change in causes of death.

Results

Between 1991 and 2005 there was a continuous decline in overall all-cause death rates for people aged 50 and over. Age-standardised mortality declined by 30 per cent for men, from 3,216 per 100,000 men to 2,267 per 100,000. This resulted in 86,477 fewer male deaths in 2005 than would have occurred had 1991 rates persisted. For women the age-standardised mortality rate declined by 20 per cent from 2,032 per 100,000 to 1,626 per 100,000, resulting in 48,406 deaths postponed (or fewer deaths) in 2005.

Of the total numbers of deaths postponed in 2005, ischaemic heart disease contributed the largest share for both men (45,244 deaths – 52.3 per cent) and women (33,601 – 69.4 per cent).

The greatest decline in the mortality rate was observed for influenza, for which age-standardised rates fell by 89 per cent for men and 93 per cent for women. However the proportion of deaths in which influenza was the underlying cause was extremely small and so did not contribute a large proportion in terms of the total fall in numbers of deaths.

Mortality rates from some conditions increased. Liver disease rates demonstrated some of the largest increases for both men and women aged 50 and over. For men the age-standardised mortality rate from liver disease increased by 104 per cent, resulting in 1,434 more deaths in 2005 than in 1991.

Conclusion

The trends of decreasing mortality rates from ischaemic heart disease and stroke have continued into the 21st century, however both causes continue to be the biggest killers in England. They are projected to remain so, and consequently, to contribute significantly to the burden of disease in the population.

The steady increase in liver disease mortality identified highlights the importance of tackling alcohol misuse as a public health priority.

Contents

Abstract.....	100
Introduction	102
Methods	103
Results	108
Discussion.....	121
Conclusions and implications.....	124
Acknowledgements.....	125
References.....	125

List of Tables

Table 1	Top five causes of mortality in men and women, 1991 and 2005.....	109
Table 2	Causes of mortality showing the greatest absolute mortality decline in 2005 compared to 1991 (deaths postponed), by age group and sex.....	112
Table 3	Causes of mortality with the highest relative decline in mortality rates in 2005 compared to 1991	113
Table 4	Causes of mortality with the highest relative decline in age-standardised mortality rates in each year compared to 1991, by sex.....	114
Table 5	The five causes of mortality showing the greatest increases in absolute mortality and in relative mortality (mortality rates) in 2005 compared to 1991, by age and sex....	118

List of Figures

Figure 1A	Trends in ischaemic heart disease mortality in men, 1991–2005	110
Figure 1B	Trends in ischaemic heart disease mortality in women, 1991–2005	111
Figure 2A	Men: Comparison of relative and absolute change in mortality between 1991 and 2005.....	116
Figure 2B	Women: Comparison of relative and absolute change in mortality between 1991 and 2005.....	117
Figure 3A	Men: Trends in liver disease mortality, 1991–2005	119
Figure 3B	Women: Trends in liver disease mortality, 1991–2005	120

Introduction

During most of the 20th century, period life expectancy* increased due to falling mortality at younger ages, whereas life expectancy at middle age changed little. Between 1971 and 2005 period life expectancy in men aged 50 years increased by more than in the rest of the century combined (an increase of 6.2 years, compared to an increase of 4.8 years between 1900 and 1970). The equivalent findings for women were 4.3 years and 8.3 years. Over the period of this study, life expectancy at age 50 in England increased by 3.5 years among men and 2.3 years among women.¹ The ageing of the population, resulting from the unprecedented increase in life expectancy at older ages from the 1970s, had important impacts not only for health and social services but also sparked the pensions' crisis affecting both the public and commercial sector.^{2,3}

* the average number of years a person would live, if they experienced the age-specific mortality rates for that time period throughout their life

Previous investigations of cause-specific mortality trends were limited to analyses up to the end of the 20th century when the ninth revision of the International Classification of Disease (ICD) coding system was in use. The latest revision, ICD10, was introduced in 2001. This revision represents the biggest change in coding of mortality for more than 50 years and fundamentally affects the way that cause of death and trends in mortality for specific causes of death are analysed.^{4,5} Failure to adjust for this coding change can result in artefactual changes in mortality patterns, secondary to coding changes rather than to real changes in underlying patterns of mortality. Consequently this study used bridging codes which allowed analysis of mortality trends using the more recent data from 1991 up to 2005.

Due to the absence of comparability ratios allowing consistent back coding between ICD8 (used in the 1970s) and ICD10, it was not possible to analyse cause-specific change in mortality from the 1970s onwards.

This study identified the diseases that contributed most to the absolute and relative decline in overall mortality between 1991 and 2005 in men and women aged 50 and over in England. It is important to consider both absolute and relative measures of change to obtain a comprehensive understanding of the underlying patterns of mortality decline.⁶ Absolute declines in mortality are important when assessing changing patterns of the burden of disease at the population level. Analyses of absolute changes in total numbers of deaths tend to be dominated by the 'big killers' such as ischaemic heart disease (IHD), because even a small fall in rates results in large reductions in numbers of IHD deaths. Relative changes in mortality are of value in the identification of rarer causes of death that may have fallen (or risen) more rapidly than more common causes of mortality. Such findings may be important early indicators of future changes in patterns of cause-specific mortality.

Methods

Sources

Deaths

This study was based on an extract of ONS mortality data for all deaths occurring in England in those aged 50 and over between 1991 and 2005. Data were provided for each calendar year and included all deaths occurring in this year, aggregated by five-year age group (50–54 to 85 and over years), sex and underlying cause of death, coded to four-digit ICD9 or ICD10 codes.

Coding of mortality saw two major changes over the period of the study. Firstly, there was a change in the ICD volume used – from 9 to 10. Within this analysis this change was overcome by ensuring any specific causes of mortality included in the study had comparable codes in both ICD9 and ICD10. Secondly, the approach used to code deaths to give the underlying cause of mortality changed (Rule 3).

To quantify the effect of both coding changes, the Office for National Statistics (ONS) carried out a bridge coding exercise with all deaths in 1999 independently coded to both ICD9 and ICD10. The changes found were expressed as comparability ratios, defined as the number of deaths coded to a particular cause by ICD10 divided by the number coded to that cause in ICD9.⁵ ONS produces confidence intervals for each of the calculated comparability ratios. When the confidence intervals

contain 1, this indicates the difference between ICD9 and ICD10 coding was not significant and no comparability ratio adjustments were necessary. These ratios are only applicable for the period 1993–2000, during the period when ONS used automated cause coding.

For this analysis comparability ratios were applied to raw counts of deaths between 1993 and 2000, for causes where the bridge code ratio was significantly different from 1 to produce adjusted counts consistently coded to ICD10 throughout the study period. For the years 1991–1992 mortality was not coded using the automated coding system and the change in Rule 3 in ICD10 is considered to be similar to the use of coding during the period 1984–1992. Consequently minimal changes occurred in the way deaths were coded when compared to coding using ICD10 and so it was not necessary to apply the adjustment. There is a slight limitation to this approach as it is not possible to quantify exactly how similar data in 1991–1992 are to the data coded to ICD10.⁵

The selection of causes of death to include in the study was based on those identified as leading causes of mortality in the UK over the period 1991–2005.^{7,8} The causes included also had to have ICD9 to ICD10 comparability ratios. Twenty-nine specific causes of mortality were included within the analysis (Box 1). In 1991, 85 per cent of deaths in men and 79 per cent of deaths in women were classified under one of these specific causes. The corresponding figures in 2005 were 77 per cent and 71 per cent respectively. Causes of death not included in these 29 groups have been coded to 'other' in this analysis.

Populations

The populations used were provided by the ONS Population Estimates Unit in November 2006 and were mid-year estimates for each year, based on decennial censuses.

Analysis

Age-specific and age-standardised rates

For each of the years 1991–2005, cause-specific death rates by sex in each five-year age band from 50–54 onwards were calculated. Age-standardised mortality rates were calculated using the European standard population as the reference population, with rates calculated per 100,000 population aged over 50 years (Box 2).

Calculation of relative and absolute change in cause-specific mortality

Relative change in mortality was defined as the percentage change in the age-standardised rate between 1991 and subsequent years (Box 2).

Absolute change was quantified by estimating the number of additional deaths that would have occurred in each year if the population had been subject to the death rates observed in 1991. This is equivalent to the difference between the observed and expected number of deaths based on 1991 mortality rates. Four steps were taken to quantify this:

1. Calculation of age-specific mortality rates by cause for each of the five-year age bands for the base line year (1991)
2. Calculation of expected rates of mortality: The age-specific death rates for the baseline year were applied to the population (by five-year age band) in each of the subsequent years. For

example the age-specific rate for each specific cause of mortality in 1991 was multiplied by the population of the corresponding age group in each of the subsequent years, 1992–2005. This gave the number of deaths, by cause and sex, that would have been expected to have occurred in each year had the mortality experience of baseline year remained constant

3. Calculation of difference between observed and expected mortality: The observed number of deaths occurring within each of the five-year age bands after applying the comparability ratios, where necessary, was then subtracted from the expected numbers. This gave the potential number of deaths postponed within each five-year age band, by each specific cause of death and for all-cause mortality

4. Deaths postponed attributable to specific causes of mortality: The numbers of deaths postponed in each five-year age band were added together to give a total number of lives saved in the index year compared to baseline year

‘Deaths postponed’ and ‘deaths brought forward’

In the last three decades of the 20th century, because of significant year-on-year mortality rate improvements, more people survived longer. In this cross-sectional analysis the term ‘deaths postponed’ has been used to summarise the total decline in the burden of disease resulting from lower death rates from age 50 onwards in any specific year, compared to baseline year (1991). The equivalent estimate for causes, where rates have increased compared with the baseline year, has been termed ‘deaths brought forward’. It must be emphasised that the count of deaths postponed (or brought forward) in any one year, for example 2005, provides a measure of deaths postponed in that year alone had the baseline year persisted. It is not a cumulative measure of the deaths postponed in every year since 1991. It represents the summation of the fewer (or more) deaths that would have occurred in each age and sex sub-population in that year had the corresponding 1991 age and sex-specific mortality rates remained unchanged (for example expected deaths applying 1991 rates minus observed deaths in 2005). A similar method had been used previously.^{9,10,11}

In this analysis deaths postponed are presented as a positive number in the tables – indicating fewer deaths than expected. Conversely, deaths brought forward are presented as a negative number in the tables (indicating more deaths than expected).

Box 1 Causes of death analysed, 1991–2005

Cause of death	ICD9	ICD10	Comparability ratios	
			Male	Female
Accidents	E800–E928 Excl. E870–E879	V01–X59	1	1.011
Aortic aneurysm and dissection	441	I71	1	1
Bronchitis, emphysema and other chronic obstructive pulmonary disease	490–492, 496	J40–J44	1.04	1.035
Cerebrovascular diseases	430–438	I60–69	1.13	1.09
Diseases of the kidney and ureter	580–594	N00–N28	1.03	1
Diseases of the liver	570–573	K70–K76	1.06	1.078
Influenza	487	J10–J111	1	1
Ischaemic heart diseases	410–414	I20–I25	1.01	1.007
Malignant neoplasm of colon	153	C18	1.02	1.015
Malignant neoplasm of pancreas	157	C25	1	1
Malignant neoplasm of rectosigmoid junction, rectum, anus and anal canal	154	C19–C21	1	1.017
Malignant neoplasms of lymphoid, haematopoietic and related tissue	200–208	C81–C96	1.05	1.047
Malignant neoplasms: Bladder	188	C67	1	1.016
Malignant neoplasms: Breast	174–175	C50	1.11	1.027
Malignant neoplasms: Malignant melanoma of skin	172	C43	0.97	0.955
Malignant neoplasms: Oesophagus	150	C15	1.01	1
Malignant neoplasms: Other malignant neoplasm of skin	173	C44	1	1.14
Malignant neoplasms: Prostate	185	C61	1.04	N/A
Malignant neoplasms: Stomach	151	C16	1.02	1
Malignant neoplasms: Trachea, bronchus and lung	162	C33–C34	1	0.996
Other causes: Asthma	493	J45–J46	1	1.056
Other causes: Diabetes mellitus	250	E10–E14	1.04	1.042
Other causes: Suicide and undetermined deaths	E950–E959, E980– E989 exc. E988.8	X60–X84, Y10–Y34 exc. Y33.9	1	1
Other causes: Ulcers	531–533	K25–K28	1	1
Other heart disease	415–429	I26–I51	1	1
Parkinsons disease	332	G20	1.49	1.489
Pneumonia	480–486	J12–J18	0.58	0.644
Malignant neoplasms: Cervix uteri	180	C53	N/A	1
Malignant neoplasms: Ovary and other uterine adnexa	183	C56	N/A	0.992

Box 2 Worked example of calculations used in the analysis

Age	Population in 1991	Population in 2005	Number of deaths 1991	Death rate per 100,000 population 1991 ¹	Number of deaths 2005	Death rate per 100,000 population 2005 ¹	Expected death 2005 ³	Absolute change: Deaths postponed /brought forward ⁴	Relative change: Percentage change death rates 2001 vs 1991 ⁵
Cause X (mortality rates falling)									
50–54	1,356,300	1,775,900	2,770	204.2	2,060	116.0	3,627	1,567	43.2
55–59	1,279,700	1,428,700	4,620	361.0	3,040	212.8	5,158	2,118	41.1
60–64	1,233,800	1,259,200	7,890	639.5	4,540	360.5	8,052	3,512	43.6
65–69	1,148,900	1,099,700	12,060	1,049.7	6,760	614.7	11,544	4,784	41.4
70–74	878,500	940,500	13,930	1,585.7	9,680	1,029.2	14,913	5,233	35.1
75–79	652,800	740,900	15,470	2,369.8	11,960	1,614.3	17,558	5,598	31.9
80–84	376,600	407,600	12,670	3,364.3	9,760	2,394.5	13,713	3,953	28.8
85 and over	191,300	277,000	9,370	4,898.1	10,400	3,754.5	13,568	3,168	23.3
Total	7,117,900	7,929,500	78,780	991.41²	58,200	648.81²	87,763	29,563	34.6
Cause Y (mortality rates increasing)									
50–54	1,356,300	1,775,900	180	13.3	480	27.0	236	-244	-103.7
55–59	1,279,700	1,428,700	210	16.4	410	28.7	234	-176	-74.9
60–64	1,233,800	1,259,200	230	18.6	370	29.4	235	-135	-57.6
65–69	1,148,900	1,099,700	240	20.9	270	24.6	230	-40	-17.5
70–74	878,500	940,500	190	21.6	220	23.4	203	-17	-8.2
75–79	652,800	740,900	140	21.4	155	20.9	159	4	2.5
80–84	376,600	407,600	60	15.9	70	17.2	65	-5	-7.8
85 and over	191,300	277,000	20	10.5	40	14.4	29	-11	-38.1
Total	7,117,900	7,929,500	1,270	17.31²	2,015	25.91²	1,415	-600	-49.3

Definitions:

1 Age-specific death rate: total number of deaths in age group / total population in age group

2 Age-standardised rate: standardised to the EU standard population

3 Expected number of deaths: age-specific death rate in 1991 * population in age group in 2005

4 Absolute change in mortality: expected deaths - observed deaths

5 Relative change in mortality: (age-specific death rate in 1991 - age-specific death rate in 2005) / age-specific death rate 1991) * 100

Results

All-cause mortality

Men

Between 1991 and 2005, all-cause mortality rates declined by 30 per cent in men aged 50 and over, from 3,216 deaths per 100,000 men in 1991 to 2,267 deaths per 100,000 in 2005. This fall resulted in 86,447 fewer deaths (deaths postponed) in 2005 than would have been expected had 1991 rates persisted (Table 1).

Declines in mortality were seen in all five-year age bands. The greatest relative decline in 2005 compared to 1991 was in the 65–69 age group where the age-specific death rate declined by 40 per cent, from 3,034 deaths per 100,000 in 1991 to 1,816 deaths per 100,000 in 2005. In absolute terms, the 75–79 age band had the biggest decline: in 2005 there were 17,235 deaths postponed in this age group.

The five most important causes of mortality in 1991 were ischemic heart disease (IHD); cerebrovascular diseases (CVD); cancers of the trachea, bronchus and lung; chronic obstructive airways disease (COPD); and pneumonia respectively, accounting for 60 per cent of all deaths in the age group studied. These remained the most common causes of mortality in 2005 when they accounted for 47 per cent of deaths (Table 1).

Women

There were substantial declines in the mortality rate in women aged 50 and over between 1991 and 2005. There were 48,406 deaths postponed in 2005, compared to deaths expected based on 1991 mortality. The directly age-standardised mortality rate declined from 2,032 deaths per 100,000 women in 1991 to 1,626 per 100,000 in 2005, a relative decline of 20 per cent (Table 1).

The greatest relative decline, 32 per cent fall in the mortality rate, was seen in the 65–69 age group within which 6,379 deaths were postponed. In absolute terms the age group in which most deaths were postponed was the 80–84 year cohort: 10,635 more deaths would have been expected in 2005 had the age-specific death rate in 1991 persisted.

For women the top five causes of mortality in 1991 were IHD; CVD; breast cancer; pneumonia; and cancers of the trachea, bronchus and lung respectively, accounting for 53 per cent of all deaths. IHD remained the most common cause of mortality in 2005 and the five most common causes of death accounted for 42 per cent of all deaths (Table 1).

Table 1 **Top five causes of mortality in men and women, 1991 and 2005**

		Age standardised rates per 100,000 population		Relative change (%)	Absolute change (numbers of deaths postponed)
		1991	2005		
Men	Ischaemic heart diseases (IHD)	980.9	475.6	51.5	45,243.7
	Cerebrovascular diseases (CVD)	315.9	182.7	42.2	12,815.2
	Malignant neoplasms: Trachea, bronchus and lung	281.6	171.0	39.3	9,619.7
	Bronchitis, emphysema and other chronic obstructive pulmonary disease (COPD)	208.1	124.6	40.1	8,049.6
	Pneumonia	130.8	117.2	10.4	1,366.5
	All deaths (all causes)	3,215.7	2,266.9	29.5	86,447.4
Women	Ischaemic heart diseases (IHD)	479.4	228.6	52.3	33,601.0
	Cerebrovascular diseases (CVD)	275.3	172.4	37.4	15,349.4
	Malignant neoplasms: Breast	116.7	82.8	29.1	3,330.7
	Pneumonia	112.0	99.7	11.0	2,652.9
	Malignant neoplasms: Trachea, bronchus and lung	98.4	95.4	3.1	-556.7
	All deaths (all causes)	2,031.7	1,625.8	20.0	48,405.8

Causes are listed in rank order of descending deaths rates in 1991

Absolute decreases in mortality

Men

In 2005 86,447 deaths were postponed. The five conditions with the greatest absolute declines were IHD (45,244 deaths postponed); CVD (12,815 deaths postponed); cancers of the trachea, bronchus and lung (9,620 deaths postponed); COPD (8,050 deaths postponed); and stomach cancer (2,756 deaths postponed). Together these accounted for 91 per cent of the total number of deaths postponed and resulted in 78,485 fewer deaths in 2005 than if 1991 rates had persisted. Other than these five, no cause of death contributed more than 2 per cent to the total deaths postponed (Table 2).

The five causes of mortality resulting in the greatest absolute declines in 2005 also contributed most to the declines in mortality throughout the period 1991–2005. IHD accounted for the largest number of deaths postponed in every year from 1991 to 2005. In 1992 and 1993 the number of observed deaths and the number expected were relatively similar. A line of best fit for the trend in IHD mortality suggests on average there were around 3,249 fewer deaths per year than expected, based on mortality rates in 1991 (Figure 1A).

Figure 1A **Trends in ischaemic heart disease mortality in men, 1991–2005**

IHD was the biggest contributor to absolute decline in all age groups in 2005 compared to 1991. Those aged 70–74 and 75–79 contributed the largest number of deaths postponed from IHD – contributing, respectively, 7,988 fewer deaths than expected, (18 per cent of all IHD deaths postponed) and 8,536 fewer IHD deaths than expected (19 per cent of all IHD deaths postponed). In 2005 CVD and cancer of the trachea, bronchus and lung were major contributors to absolute mortality decline in all age groups.

Women

In 2005 48,406 deaths were postponed (Table 2). The five causes with the greatest absolute declines were IHD (33,601 deaths postponed), CVD (15,349 deaths postponed), breast cancer (3,331 deaths postponed), pneumonia (2,653 deaths postponed) and colon cancer (1,894 deaths postponed). Together these causes resulted in 56,828 deaths being postponed. The number of deaths postponed from these five causes is greater than the total number of deaths postponed, because some causes of mortality saw an increase in the number of deaths and the total figure balances out the increases and decreases.

As in men, IHD accounted for the largest absolute decline in mortality in all years compared to 1991. The gradient of the line of best fit indicated for every year there were 2,405 deaths postponed, compared to deaths expected based on 1991 IHD mortality rates (Figure 1B).

The other four main contributors to absolute declines in mortality in women showed fluctuation over time in their contribution to absolute falls in mortality, although CVD and breast cancer were consistently among the top causes of absolute mortality decline in each year.

Analysis by age group found IHD was one of the biggest contributors to decline in all ages. The 80–84 and 85 and over age groups attributed the greatest numbers of deaths postponed from IHD. There were 7,474 postponed deaths in the 80–84 group (22 per cent of the IHD death reduction) and 8,780 postponed deaths in the 85 and over group (26 per cent of the IHD death reduction).

Figure 1B **Trends in ischaemic heart disease mortality in women, 1991–2005**

Table 2 Causes of mortality showing the greatest absolute mortality declines in 2005 compared to 1991 (deaths postponed), by age group and sex

SEX	Cause	Observed deaths										Expected deaths										Expected - Observed										Deaths post- poned
		50-54	55-59	60-64	65-69	70-74	75-79	80-84	85 plus	50-54	55-59	60-64	65-69	70-74	75-79	80-84	85 plus	50-54	55-59	60-64	65-69	70-74	75-79	80-84	85 plus	Total						
Males	Ischaemic heart diseases (IHD)	1378	2376	3260	4439	6177	8015	8967	9443	3033	5675	7963	11279	14165	16551	15957	14676	1655	3299	4703	6840	7988	8536	6990	5233	45244						
	Cerebrovascular diseases (CVD)	266	457	647	1057	1850	3158	4256	5880	442	843	1309	2267	3842	6005	7362	8318	178	386	662	1210	1992	2847	3106	2438	12815						
	Malignant neoplasms: Trachea, bronchus and lung	527	1046	1718	2207	2721	3078	2465	1622	933	1833	2850	4218	4716	4700	3578	2176	406	787	1132	2011	1995	1622	1113	554	9620						
	Bronchitis, emphysema and other chronic obstructive pulmonary disease (COPD)	125	311	687	1111	1676	2531	2801	2696	167	476	981	1933	2999	4189	4693	4550	42	165	284	822	1323	1658	1892	1854	8050						
	Malignant neoplasms: Stomach	72	134	225	365	490	575	512	391	142	363	555	773	931	1053	958	746	2254	5088	7835	13246	15304	17235	15084	10400	2756						
	Total ¹	8657	10628	14492	19753	27750	36834	42461	51425	8911	16017	22327	32999	43054	54069	57545	61825	2254	5088	7835	13246	15304	17235	15084	10400	86447						
Females	Ischaemic heart diseases (IHD)	290	568	971	1716	2930	5212	8209	15922	595	1600	2819	4929	7672	11419	15683	24702	305	1032	1848	3213	4742	6207	7474	8780	33601						
	Cerebrovascular diseases (CVD)	232	339	464	811	1646	3518	6457	15561	328	578	957	1750	3243	6459	10613	20449	96	239	493	939	1597	2841	4156	4888	15349						
	Malignant neoplasms: Breast	667	1049	935	938	1045	1300	1346	1956	1079	1437	1389	1487	1458	1588	1800	2328	412	388	454	549	413	288	454	372	3331						
	Pneumonia	87	124	200	326	639	1471	3105	11912	47	102	172	309	672	1535	3579	14102	-40	-22	-28	-17	33	64	474	2190	2653						
	Malignant neoplasm of colon	90	212	262	377	518	669	856	1095	191	321	459	607	758	922	1154	1562	101	109	197	230	240	253	298	467	1694						
	Total ¹	4529	7345	9185	13519	19975	32393	48243	106287	5519	9758	13594	19898	28053	41606	58878	112576	990	2413	4409	6379	8078	9213	10635	6289	48406						

Causes of death are ranked in descending order of deaths postponed

Counts of observed numbers of deaths are adjusted using ONS comparability ratios

1 total includes deaths from all causes, not just the five listed here

Table 3 **Causes of mortality with the highest relative decline in mortality rates in 2005 compared to 1991**

Sex	Cause	Age standardised rates per 100,000 population		Relative change (%)	Deaths postponed*	Percentage of all deaths postponed in 2005
		1991	2005			
Men	Influenza	0.8	0.1	88.8	69.3	0.1
	Asthma	8.3	3.0	63.7	447.0	0.5
	Ischaemic heart diseases	980.9	475.6	51.5	45,243.7	52.3
	Malignant neoplasms: Stomach	60.7	30.0	50.6	2,756.4	3.2
	Diabetes mellitus	43.2	24.8	42.6	1,724.3	2.0
	Total	3,215.7	2,266.9	29.5	86,447.0	100.0
Women	Influenza	1.1	0.1	92.8	169.2	0.3
	Ischaemic heart diseases	479.4	228.6	52.3	33,601.0	69.4
	Malignant neoplasms: Cervix uteri	12.0	5.8	51.2	561.5	1.2
	Malignant neoplasms: Stomach	24.1	12.4	48.5	1,579.3	3.3
	Diabetes mellitus	31.8	18.1	43.2	1,869.9	3.9
	Total	2,031.7	1,625.8	20.0	48,406.0	100.0

* Number of deaths that would have occurred had the population experienced the same death rates as in 1991
Causes of death are ordered in descending order of magnitude of relative decline in mortality rates

Men

The total relative decline in the age-standardised mortality rate in men in 2005 compared to 1991 was 30 per cent (Table 3). Of the causes of death contributing to the decline, influenza showed the biggest relative decline (88.8 per cent), although it was a rare cause of mortality (the age-standardised mortality rate fell from 0.8 to 0.1 per 100,000 men over the period studied).

The other conditions with the largest relative declines in mortality rates were asthma (63.7 per cent decline), IHD (51.5 per cent), stomach cancer (50.6 per cent) and diabetes (42.6 per cent). Other major causes of death in 1991 showed relative declines in 2005 ranging from 10 per cent for pneumonia to 42 per cent for CVD.

There were yearly fluctuations in the causes showing the greatest relative decline in mortality rates, although asthma and influenza consistently remained among the causes with the biggest relative declines (Table 4).

Table 4 Causes of mortality with the highest relative decline in age-standardised mortality rates in each year compared to 1991, by sex

Sex	Year	Cause	Age standardised rate 1991	Age standardised rate in year	Relative change (%)	Deaths postponed
Men	1992	Diseases of the kidney and ureter	23.6	16.0	32.1	596.6
	1993	Other malignant neoplasm of skin	3.3	2.3	30.7	66.5
	1994	Influenza	0.8	0.2	72.7	42.9
	1995	Asthma	8.3	5.6	32.8	201.2
	1996	Asthma	8.3	4.7	42.9	268.8
	1997	Asthma	8.3	5.3	36.5	226.4
	1998	Asthma	8.3	4.9	41.2	260.7
	1999	Asthma	8.3	4.6	44.2	284.0
	2000	Asthma	8.3	4.2	49.6	323.5
	2001	Influenza	0.8	0.1	85.4	61.2
	2002	Influenza	0.8	0.1	86.2	62.4
	2003	Influenza	0.8	0.2	77.8	58.1
	2004	Influenza	0.8	0.1	89.5	67.6
	2005	Influenza	0.8	0.1	88.8	69.3
Women	1992	Diseases of the kidney and ureter	15.7	12.2	22.2	519.9
	1993	Diabetes mellitus	31.8	25.5	19.8	967.0
	1994	Influenza	1.1	0.2	77.1	131.7
	1995	Diabetes mellitus	31.8	24.3	23.4	1174.5
	1996	Diabetes mellitus	31.8	22.6	29.0	1380.2
	1997	Malignant neoplasms: Cervix uteri	12.0	8.3	30.7	308.4
	1998	Influenza	1.1	0.4	61.5	108.3
	1999	Malignant neoplasms: Cervix uteri	12.0	7.5	37.8	390.1
	2000	Malignant neoplasms: Stomach	24.1	15.1	37.1	1190.0
	2001	Influenza	1.1	0.1	89.7	163.2
	2002	Influenza	1.1	0.1	90.5	162.2
	2003	Influenza	1.1	0.2	80.6	144.4
	2004	Influenza	1.1	0.1	93.1	163.7
	2005	Influenza	1.1	0.1	92.8	169.2

Women

The total relative decline in age-standardised mortality rate in women in 2005 compared to 1991 was 20 per cent. In common with men, influenza showed the biggest relative decline (92.75 per cent decrease in the age-standardised rate) although it was (as in men) a rare cause of death (the age-standardised rate of mortality fell from 1.1 to 0.1 per 100,000 women in 2005) (Table 3). In most age groups, influenza and IHD were causes showing some of the biggest relative declines.

The other conditions with the largest relative declines in mortality rates were IHD (52.3 per cent decline), cervical cancer (51.22 per cent), stomach cancer (48.5 per cent) and diabetes (43.2 per cent). As with men, other than IHD, causes that had the largest relative declines were not leading causes of mortality. Among the five most common causes of death in 1991, the relative decline in age-standardised rates ranged from 3 per cent for lung cancer to 52 per cent for IHD.

The rank position in the causes of death showing the greatest relative decline in rates varied annually, with influenza showing the greatest relative decline in age-standardised rates in most years (Table 4).

Combining relative and absolute declines in mortality

Men

The distribution of causes of relative and absolute decline in 2005 was examined graphically by plotting the number of deaths postponed (absolute change) against the percentage change in the age-standardised rate (relative change) (Figure 2A). The causes of mortality showing the biggest decreases in absolute and relative mortality are located in the top right-hand quadrant of the graph. Analysis found the causes with the largest absolute and relative declines were IHD; CVD; cancer of trachea, bronchus and lung and COPD. Figure 2A is heavily dominated by the large declines in both absolute and relative mortality in IHD. Influenza and asthma are found on the top central part of Figure 2A indicating a large relative decline, but only a very small absolute change, that is the total number of deaths postponed was low.

Women

In women, using a scatter plot to compare absolute and relative declines showed IHD, CVD and breast cancer had the largest decline in mortality (Figure 2B).

Figure 2A **Men: Comparison of relative and absolute change in mortality between 1991 and 2005**

% change in age standardised rate

Figure 2B Women: Comparison of relative and absolute change in mortality between 1991 and 2005

Absolute increases in mortality

Men

Five causes of mortality saw absolute increases in mortality in men in 2005 compared to 1991 (Table 5). The greatest absolute increase was in liver disease; where there were 1,434 deaths brought forward compared to the number expected based on 1991 mortality rates. Other causes with absolute increases were 'other heart disease'; oesophagus cancer; skin cancer; and accidents.

In the period 1992–2002 'other heart disease' showed the greatest increase in deaths compared to 1991. Since 2003, however, the biggest absolute increases were in liver disease mortality.

Table 5 The five causes of mortality showing the greatest increases in absolute mortality and in relative mortality (mortality rates) in 2005 compared to 1991, by age and sex

SEX	Cause	Expected deaths - observed deaths										Deaths brought forward	Age standardised rate per 100,000		Relative change (%)
		50-54	55-59	60-64	65-69	70-74	75-79	80-84	85plus		1991	2005			
Male	Diseases of the liver	-422.4	-355.7	-281.1	-146.4	-100.8	-39.8	-52.4	-35.1	-1433.8	18.5	37.9	-104.4		
	Malignant neoplasms:														
	Malignant melanoma of skin	-14.5	-11.7	-10.3	-25.3	-52.9	-37.5	-30.0	-28.8	-211.0	5.7	8.0	-41.7		
	Malignant neoplasms:														
	Oesophagus	23.3	-101.0	-104.7	56.8	-6.8	-105.5	-127.8	-80.6	-446.2	38.7	43.3	-11.9		
	Other heart disease	-1.5	17.6	-34.9	61.7	55.3	47.3	-189.7	-428.2	-472.4	86.7	91.4	-5.4		
	Accidents	34.8	24.4	48.8	72.1	-7.7	26.8	-61.6	-211.5	-73.8	35.0	35.2	-0.7		
	Total¹	2254.2	5088.1	7835.3	13246.4	15303.8	17235.0	15084.1	10400.3	86447.4	3215.7	2266.9	29.5		
Female	Diseases of the liver	-176.3	-141.5	-85.4	-29.6	-34.9	-21.9	-77.2	-14.6	-581.4	12.3	19.2	-56.4		
	Malignant neoplasms:	0.3	8.1	-8.5	-10.1	-20.1	-21.5	-23.2	-31.9	-106.9	4.5	5.3	-16.5		
	Malignant melanoma of skin														
	Other heart disease	-36.1	-10.2	-2.3	-65.5	-88.9	-9.9	-84.0	-474.8	-771.6	73.2	78.4	-7.1		
	Malignant neoplasm of pancreas	3.6	-20.2	-6.5	-26.5	-44.7	-21.8	-10.0	5.0	-121.2	24.8	26.0	-4.9		
	Bronchitis, emphysema and other chronic obstructive pulmonary disease (COPD)	-3.4	77.5	140.9	295.7	-35.0	-534.0	-879.5	-276.4	-1214.2	72.5	75.9	-4.7		
	Total¹	989.8	2413.1	4408.8	6379.0	8077.8	9212.9	10635.4	6288.9	48405.8	2031.7	1625.8	20.0		

¹ total includes deaths from all causes, not just the five listed here

Women

In 2005, eight causes of mortality showed absolute increases compared to 1991. COPD had the biggest absolute increase in mortality (1,214 more deaths than expected based on 1991) (Table 5).

'Other heart disease' showed the biggest absolute increases in mortality in all but two years between 1991 and 2005. The increase in liver disease deaths brought forward was, however, continuous. In 1993 93 deaths were brought forward; by 2005 the number of deaths brought forward had increased to 581 (Figure 3B).

Figure 3A **Men: Trends in liver disease mortality, 1991–2005**

Figure 3B Women: Trends in liver disease mortality, 1991–2005

Relative increases in mortality

Men

Some diseases saw an increase in mortality rates in 2005 compared to 1991 (Table 5). The biggest relative increase in the age-standardised rate, 104 per cent, was in liver disease (Table 5). The rate for liver disease rose from 19 per 100,000 men in 1991 to 38 per 100,000 in 2005 that is from the 22nd most common cause of mortality to the 13th most common (out of 28 causes analysed). The other causes which saw a relative increase in age-standardised rates were skin cancer, oesophagus cancer, 'other heart disease' and accidents.

There was some annual fluctuation in the cause of death showing the biggest increase in rates between 1991 and 2005. However, rate increases in liver disease were consistently the highest from 2001 onwards (Figure 3A).

In 2005, disease of the liver was one of the biggest (either the biggest or second biggest) cause of relative increase in rates in all age groups.

Women

Among women in 2005, six causes of mortality showed a relative increase in rates compared to 1991. As in men, the biggest relative increase was in liver disease (56 per cent increase in the age-standardised rate) (Table 5). The age-standardised rate of mortality for liver disease increased from 12.3 per 100,000 women in 1991 to 19.2 per 100,000 in 2005 – from the 21st most common cause of mortality in 1991 to 15th in 2005 (out of 29 causes included within this analysis) (Figure 3). The other causes showing an increase in mortality rates were skin cancer, other heart disease, pancreatic cancer, COPD and accidents.

As in men there was annual fluctuation in the rank position of the cause showing the highest relative increase. Liver disease showed highest relative increases in all of the last five years (2000–2005). ‘Other heart disease’ was the most common cause of death showing a relative increase in rates in four of the 14 years studied.

Analysis of the relative changes in age-specific mortality rates in women in 2005 found liver disease to be the cause of the biggest relative increase in all age groups other than the 85 and over group, where it was accidents.

Combining relative and absolute increases in mortality

Men

Graphical comparison of absolute and relative mortality increases showed the greatest combined increases were in liver disease, skin cancer, oesophagus cancer, other heart disease and accidents (Figure 2A).

Women

As in men, combining absolute and relative mortality showed liver disease as the cause resulting in the biggest combined increases in mortality, followed by other heart disease; COPD; skin cancer and pancreas cancer (Figure 2B).

Discussion

Key findings

Mortality rates in men and women aged 50 and over declined substantially (30 per cent and 20 per cent respectively) between 1991 and 2005. Analysis by cause of death showed in absolute terms the greatest number of deaths postponed were due to falls in IHD and CVD mortality in men (58,059 deaths) and women (48,950 deaths). The greatest decline in relative mortality was in influenza, where age-standardised rates declined by 89 per cent in men and 93 per cent in women in 2005 compared to 1991. However the proportion of all deaths due to influenza was extremely small throughout this period so these causes did not have a major impact on the decline in the total burden of disease. Over the same period, there were increases in mortality rates for some conditions, liver disease in particular.

The analysis demonstrates the value of assessing both absolute and relative mortality change. For example, for pneumonia in women, a large absolute decline had a great impact on overall mortality, even though the relative decline was small. In contrast, for influenza, a large relative decline in mortality had little impact on the overall decline in mortality because influenza is a rare cause of death.

Explanation of findings

This study found a substantial decline in IHD, both in absolute and relative terms. The evidence on the drivers of decline in cardiovascular mortality suggest the majority of the decline in IHD mortality is related to corresponding declines in modifiable lifestyle and dietary risk factors such as high cholesterol levels, smoking and high blood pressure.^{9,12,13} In England there has been a considerable policy drive to reduce IHD, backed by targets aimed at reducing premature IHD

mortality. A target of reducing circulatory disease mortality by 40 per cent in those under 75 and reducing the absolute gap between the fifth of areas with the worse health and deprivation by 40 per cent compared to the population as a whole by 2010 were published in *Saving Lives: Our healthier nation*.¹⁴ Although there has been success in meeting the target for reduction in IHD mortality rates in the population as a whole, the inequalities target has not been met. The fact that the gap between the most deprived fifth of areas and England as a whole has increased emphasises that although there may have been improvements in overall IHD mortality overall, there are substantial differences in the scale and pace of improvements across socio-economic groups.¹⁵

While this study found there were substantial falls in the expected number of deaths from lung cancer and COPD among men, deaths from COPD increased among women. Gender differences in diseases strongly related to smoking may reflect historical differences between men and women in take-up and quit rates and life time exposure. Men started smoking early in the 20th century, whereas smoking prevalence increased among women later in the century and the peak in their consumption occurred later than in men.⁴ In addition women tended to start smoking at an older age, to smoke less and may be slower to give up.^{16,17} These factors are likely to result in a peak in smoking-related mortality occurring later in women than in men.

At the population level, the lag times between a change in smoking prevalence and a change in mortality are still unknown and are likely to differ between diseases. For instance, for lung cancer the lag time between peak smoking in the population and the peak in lung cancer mortality is thought to be around 40 years. However the evidence suggests a shorter lag time between peak prevalence in smoking and vascular disease, that is the peak in vascular disease attributable to smoking occurs earlier in the smoking epidemic.^{18,19} The evidence quantifying the lag time between smoking prevalence and attributable cause-specific mortality is sparse and inconclusive and would benefit from further research.

This study found stomach cancer was one of the causes showing a large absolute decline in men. These improvements are not thought to be related to either better diet or improved survival among those with diagnosed stomach cancer. One of the factors suggested in adult mortality from stomach cancer is early life influences. For instance there is a link between stomach cancer in adulthood and infection with *Helicobacter pylori* in childhood. There have been declines in this infection in each cohort since the 1920s and this may be associated with subsequent declines in stomach cancer mortality. Recent improvements could also reflect improvements in cancer care, such as earlier diagnosis and better compliance with treatment guidelines.^{4,20}

Colon cancer was also found to have large declines in absolute mortality; in total absolute declines in 2005 were equivalent to 3,498 deaths being postponed. It is possible that earlier diagnosis, improvements in treatment and reduction in post-operative mortality have contributed in part to the decline.^{21,22}

Absolute and relative mortality from liver disease in men and women increased over time. A predominant factor in the increase seen is likely to be due to the increase in alcohol consumption.²³ Changing patterns of consumption, for example binge drinking, the type of alcohol consumed and the change in drinking habits at younger age may all play a role in the increased mortality seen.²⁴ This is supported by the fact that in 1991 around 37 per cent of all liver disease

mortality in those aged 50 and above was from alcoholic liver disease, while in 2005 this accounted for 55 per cent of all liver disease.

In women breast cancer mortality saw one of the largest absolute declines after IHD. The reasons for this decline are multifaceted but the evidence suggests the reduced mortality is the result of improvements in both diagnosis and treatment, such as the use of tamoxifen. Breast screening has also played a role in the declines seen, although to a lesser extent.^{4,25}

In most years influenza was found to have the largest relative decline in mortality. However during the period under study there were no serious influenza epidemics.^{4,26} Influenza is also thought to be frequently under diagnosed, and often, although not the underlying cause of mortality, will be a contributing factor in other causes of mortality. Changing diagnostic fashion could also have an effect on influenza mortality trends.⁴ Of those who die as a result of influenza, microbiological confirmation will only be available in a very small proportion. An influenza epidemic could result in increases in mortality from associated causes, for example pneumonia; the implication of this could be both absolute and relative increases in a range of causes of mortality.

Limitations

Analysis of mortality change in this study used a single baseline year (1991); all subsequent years were then compared against this baseline. This assumes that point estimates of mortality by cause of death in 1991 were not unusually high or low compared to what would be expected given long-term underlying trends. One approach to overcoming this could have been to use three-year rolling averages – for instance using the baseline of 1991–1993, as this could have smoothed out any random annual fluctuations. As analysis was conducted at the national level, there were a large number of observed deaths for each cause and this reduced the potential of random fluctuations from year-to-year. Comparison with the mortality rates in successive years did not seem to suggest 1991 was anomalous. Subsequent analysis will look at temporal trends in cause-specific mortality and the annual contribution to overall mortality declines.

The analysis covered the period from 1991 to 2005 although the accelerated declines in mortality in those aged 50 and over began in the 1970s. We limited our analysis to the more recent period to ensure consistency in analysis (communication with ONS). If the analysis had begun in 1970 it is possible that the trends identified could be the result of coding changes (that is purely artefactual) as opposed to real changes.

Two of the major causes of mortality identified in our study were IHD and stroke. A previous study examining mortality throughout the 20th century found declines in mortality from stroke and IHD occurred since the 1970s. Therefore there is an ongoing trend in mortality decline, which started in the 1970s and has continued into the period covered in our analysis.⁴

When assessing changes in causes of mortality over time it is important to recognise that the changes observed can be the result of a range of factors. For instance variation in the incidence of the disease, detection or description of diseases, case-fatality of cause-specific disease, statistical and classification artefacts can all effect temporal trends in mortality. As a consequence any analysis over time should consider the impact of the changing understanding of diseases and coding of causes of death.⁴

The start and end point of any trend analysis will influence the causes of mortality that are identified as major contributors to the declines found within the period. For instance had analysis started at the beginning of the 20th century, the major contributors to overall decline would have been infectious diseases. If the period of analysis had started in the middle of the 20th century and ended in 2000, it is possible that the peak in lung cancer deaths in men that occurred within this period (1970s) may have been overlooked.⁴

This analysis used 1991 as the baseline year. However as there is not a method of adjusting 1991 data to be entirely comparable to either later deaths coded to ICD10 or those coded to ICD9 using the automated system, it is possible that changes identified are not fully reflective of actual changes in cause-specific mortality, that is they could be artefact as a result of coding changes. To examine this, analysis was rerun using 1993 as a baseline year. Although some differences were identified, the key findings remained consistent. Using both baseline years IHD and CVD remained the biggest causes of absolute decline and influenza and IHD the biggest causes of relative decline in both men and women. Liver disease also remained an important cause of mortality increase. Assessment of the changes using different baselines showed there was greater variation in the absolute rankings, while the relative rankings remained more constant.

‘Other heart disease’, pneumonia and diabetes were areas where differences were identified. Mortality from ‘other heart disease’ went from one of the causes showing an increase to one showing a decrease. In men, pneumonia went from the fifth biggest cause of absolute decline to the tenth biggest, however in women it remained one of the top five causes of absolute decline. In relative terms the importance of diabetes as a cause of relative mortality decline reduced. This is likely to reflect coding changes, with deaths coded to diabetes in 1991 and 1992 coded to an alternative cause in subsequent years.

The analysis performed was cross-sectional. When assessing trends in mortality decline it is important to consider the impact of cohort effects, as the trends found may differ from those found using a cross sectional approach to analysis. For instance there is evidence of a cohort effect, with those born in or around 1930 having experienced consistently higher amounts of improvements in mortality when compared to earlier or later cohorts.^{2,4}

Conclusions and implications

This study analysed cause-specific mortality to 2005 and updates previous work examining mortality trends up to the end of the 20th century.⁴ Trends of declining rates in IHD and CVD mortality have continued into the 21st century, however both diseases continue to remain the biggest killers in England and are projected to remain so. Recently published analysis of future mortality by the World Health Organisation suggest the three major causes of mortality in 2030 will be IHD, CVD and cancer of the trachea, bronchus and lung – accounting for around 30 per cent of mortality in high income countries.²⁷ Consequently, although there have been substantial declines in mortality from these causes, they will continue to place a large burden on the population of England. With an ageing population and a rapid decline in premature mortality, it is likely that mortality from IHD will be postponed to later life.^{12,13} This will have implications for health and social care service provision.

The increases in liver disease mortality highlight the importance of tackling alcohol misuse as a public health priority, as acknowledged in recent national policy.^{28,29} Much emphasis in current policy has been put on antisocial behaviour and the impact of drinking on children and young adults. However, as this study shows, liver disease is a problem also affecting those aged 50 and over and this group should not be forgotten.

Acknowledgements

The authors would like to thank the Longevity Steering Group, UCL, for their advice and comments on the approach to analysis.

References

- 1 Office for National Statistics. (2006) Life expectancy at birth and 50 years – 2006 based national populations. Available on the Office for National Statistics website at:
www.statistics.gov.uk/downloads/theme_population/Interim_Life
- 2 Willets R, Gallop A, Leandro P *et al.* (2004): Longevity in the 21st century, Institute of Actuaries and Faculty of Actuaries. Available on The Actuarial Profession website at:
www.actuaries.org.uk/data/assets/pdf_file/0015/31623/sm20040426_longevity.pdf
- 3 Tinker A. (2002) 'The social implications of an ageing population', *Mechanisms for ageing and development* **123**, 729–735. Available on the Office for National Statistics website at:
www.statistics.gov.uk/cci/article.asp?ID=1535&Pos=1&ColRank=1&Rank=1
- 4 Griffiths C and Brock A. (2003) 'Twentieth century mortality trends in England and Wales', *Health Statistics Quarterly* **18**, 5–17. Available on the Office for National Statistics website at:
www.statistics.gov.uk/cci/article.asp?ID=1535&Pos=1&ColRank=1&Rank=1
- 5 Office for National Statistics. (2002) 'Results of the ICD-10 bridge coding study, England and Wales, 1999,' *Health Statistics Quarterly* **14**, 75–83. Available on the Office for National Statistics website at:
www.statistics.gov.uk/downloads/theme_health/HSQ14_v4.pdf
- 6 Department of Health. (2005) *Tackling health inequalities: status report on the programme for action*, Crown, London. Available on the Department of Health website at:
www.dh.gov.uk/en/Publicationsandstatistics/index.htm
- 7 Griffiths C, Rooney C and Brook A. (2005): 'Leading causes of death in England and Wales – how should we group cause?' *Health Statistics Quarterly* **28**, 6–17. Available on the Office for National Statistics website at:
www.statistics.gov.uk/cci/article.asp?ID=1301&Pos=8&ColRank=1&Rank=1
- 8 Office for National Statistics. (2005) 'Mortality statistics – review of the Registrar General on deaths by cause, sex and age in England and Wales, 2005' *DH2* **32**. Available on the Office for National Statistics website at:
www.statistics.gov.uk/downloads/theme_health/Dh2_32/DH2_No32_2005.pdf

- 9 Unal B, Critchley J and Capewell S. (2004) 'Explaining the decline in coronary heart disease mortality in England and Wales between 1981–2000', *Circulation* **109**, 1101–1107.
- 10 Ford E, Ajani U, Croft J *et al.* (2007) 'Explaining the decreases in US death from coronary heart disease, 1980–2000', *New England Journal of Medicine* **356**, 2388–2398.
- 11 Capewell S, Beaglehole R, Seddon M *et al.* (2000) 'Explanation for the Decline in Coronary Heart Disease Mortality Rates in Auckland, New Zealand, Between 1982 and 1993', *Circulation* **102**, 1511–1516.
- 12 Capewell S. (2006) 'Commentary: predicting future coronary heart disease deaths in Finland and elsewhere', *International Journal of Epidemiology* **35**, 1253–1254.
- 13 Capewell S and O'Flaherty. (2008) 'What explains declining coronary mortality? Lessons and warnings', *Heart*, **94**, 1105–1108.
- 14 Department of Health. (1999) *Saving Lives: Our healthier nation*, Crown. Available on The Stationery Office website at:
www.archive.official-documents.co.uk/document/cm43/4386/4386.htm
- 15 Department of Health. (2008) *Mortality Target Monitoring: Update to include data for 2007*. Available on the Department of Health website at:
www.dh.gov.uk/prod_consum_dh/groups/dh_digitalassets/@dh/@en/documents/digitalasset/dh_088873.pdf
- 16 Davy M. (2006) 'Time and generational trends in smoking among men and women in Great Britain, 1972–2004–05', *Health Statistics Quarterly* **32**, 35–43. Available on the Office for National Statistics website at:
www.statistics.gov.uk/cci/article.asp?ID=1681&Pos=2&ColRank=1&Rank=1
- 17 Evandrou M and Falkingham J. (2002) 'Smoking behaviours and socio-economic status: a cohort analysis, 1974 to 1998', *Health Statistics Quarterly* **14**, 30–38. Available on the Office for National Statistics website at:
www.statistics.gov.uk/cci/article.asp?ID=1522&Pos=3&ColRank=1&Rank=1
- 18 Lopez A, Collishaw N and Piha T. (1994) 'A descriptive model of the cigarettes epidemic in developed countries', *Tobacco Control*, **3**, 242–247.
- 19 Brunnhuber K, Cummings M, Feit *et al.* (2007) 'Putting evidence into practice: Smoking Cessation', *British Medical Journal Clinical Evidence*, Summer 2007.
- 20 Rachet B, Maringe C, Nur U *et al.* (2009) 'Population based cancer survival trends in England and Wales up to 2007: an assessment of the NHS cancer plan for England', *Lancet Oncology*, **10**, 351–369.
- 21 Fernández E, La Vecchia C, González J *et al.* (2005) 'Converging patterns of colorectal cancer mortality in Europe', *European Journal of Cancer*, **41**, 431–437.

- 22 Coleman M, Rachet B, Woods L *et al.* (2004) 'Trends and socioeconomic inequalities in cancer survival in England and Wales up to 2001', *British Journal of Cancer*, **90**, 1367–1373.
- 23 Academy of Medical Sciences. (2004) *Calling time*, Academy of Medical Sciences, London.
- 24 Breakwell C, Baker A and Griffiths C. (2007) Trends in geographical variations in alcohol related deaths in the United Kingdom, 1991-2004, *Health Statistics Quarterly* **33**, 6–24. Available on the Office for National Statistics website at:
www.statistics.gov.uk/cci/article.asp?ID=493&Pos=1&ColRank=1&Rank=1
- 25 Peto R, Boreham J, Clarke M *et al.* (2000) UK and USA breast cancer deaths down 25 per cent in year 2000 at ages 20-69 years, *Lancet*, **355**, 1822.
- 26 Fleming D and Elliot A. (2008) 'Lessons from 40 years' surveillance in England and Wales', *Epidemiology and Infection* **136**, 866–875.
- 27 Mathers C and Loncar D. (2006) Projections of global mortality and burden of disease from 2002 to 2030, *PLoS Medicine* **3**, e442
www.plosmedicine.org/article/info%3Adoi%2F10.1371%2Fjournal.pmed.0030442
- 28 Department for Health, Home Office, Department for Educational and Skills and Department for Culture, Media and Sport. (2007) *Safe. Sensible. Social. The next steps in the National Alcohol Strategy*, HM Government. Available on the Department of Health website at:
www.dh.gov.uk/en/Publicationsandstatistics/Publications/PublicationsPolicyandGuidance/DH_075218
- 29 Department of Health. (2004) *Choosing health: making healthy choices easier*, Department of Health, Crown. Available on the Department of Health website at:
www.dh.gov.uk/en/Publicationsandstatistics/Publications/PublicationsPolicyAndGuidance/DH_4094550