Public Health England

Protecting and improving the nation's health

A review of recent trends in mortality in England

About Public Health England

Public Health England exists to protect and improve the nation's health and wellbeing, and reduce health inequalities. We do this through world-leading science, research, knowledge and intelligence, advocacy, partnerships and the delivery of specialist public health services. We are an executive agency of the Department of Health and Social Care, and a distinct delivery organisation with operational autonomy. We provide government, local government, the NHS, Parliament, industry and the public with evidence-based professional, scientific and delivery expertise and support.

Public Health England
Wellington House
133-155 Waterloo Road
London SE1 8UG
Tel: 020 7654 8000
www.gov.uk/phe
Twitter: @PHE_uk
Facebook: www.facebook.com/PublicHealthEngland

Published December 2018
PHE publications
gateway number: GW-686

PHE supports the UN
Sustainable Development Goals

Contents

Corrections

A revision was made to this report in August 2019 to correct a statement on p56 regarding the number of people aged 75+ who died in 2014 and 2015, and were admitted to hospital as an emergency in the week before death, or died in hospital from an emergency admission.

This represents 45% of all deaths among people aged 75 and over in England and not just over 75% as reported in the original version of the report.

The titles of Figures 5H and 5I have also been amended to clarify that they are based on deaths in hospital following an emergency admission.

The title of Figure 5I has also been corrected as the analysis presented is solely for 2015, rather than 2014-15 as originally stated.

Executive summary

Introduction

Public Health England (PHE) was commissioned by the Department of Health and Social Care (DHSC) to review trends in life expectancy and mortality in England. This report summarises the findings from the commission and makes suggestions for further work that could be undertaken, by PHE or others.

The aims were to review official data to develop understanding of the trends in life expectancy and mortality in England, to provide further detail on specific population groups and causes of death, and to determine whether this provides insight into possible explanations for the trends seen. The terms of reference are provided in Appendix 1.

Main findings

After decades of progress, since 2011 improvement in age-standardised mortality rates and life expectancy has slowed down considerably, for both males and females. For some age groups, and for some parts of England, improvement has stopped altogether.

Inequality in life expectancy has widened, and since 2010-12 improvement in life expectancy has been slower in the more deprived areas than the less deprived areas of England. In addition, female life expectancy in the most deprived decile areas has actually decreased. Therefore, the causes of the slowdown in improvement are having the greatest impact in the more deprived areas.

This slowdown in improvement has been seen in the other countries of the UK, and in other large European Union (EU) countries. However, among the large EU countries, the UK has had the slowest rate of improvement since 2011.

There was a large increase in the number of deaths in the winters of 2014/15, 2016/17 and 2017/18. These increases were also seen across many other European countries and coincided, over these three seasons, with circulation of influenza A(H3N2) subtype, known to predominantly affect older people. Analysis of 2015 data also shows that hospital admissions for influenza (or ‘flu’) increased at the time of the mortality increase.

There has been a substantial shift in the age structure of the population in recent decades: the number and proportion of people at older ages has increased. This indicates that there are likely to be more people living with dementia and other long-term conditions that may make them particularly vulnerable to the effects of flu and other winter risk factors, and who may be particularly reliant on health and social care services.

The size and frequency of recent winter peaks in mortality, determined by the intensity and dominant type of influenza circulating, flu vaccine uptake and effectiveness, and which is sometimes exacerbated by cold weather, has contributed to the fluctuations in the annual age-standardised rates and the slowdown in improvement . However, improvement in mortality rates for the non-winter months has also slowed in recent years.

Reductions in mortality from heart disease and stroke, which are leading causes of death, have historically driven improvements in life expectancy. A slowdown in improvement in mortality rates from these causes has therefore had a large impact on the trend in life expectancy. This slowdown has also been seen across many other countries.

While influenza, heart disease and stroke have determined the trend in mortality rates in older adults, other causes of death have influenced the trend in younger people. Mortality rates among younger adults made almost no positive contribution to trends in life expectancy between 2011 and 2016. The cause of death that had the biggest negative impact was accidental poisoning, with a large proportion due to drug misuse.

Conclusions and further work

The main findings suggest that the overall slowdown in improvement is due to factors operating across a wide range of age groups, geographies and causes of death. It has also been seen, to some extent, in many other countries. This slowdown is unlikely to be caused by problems with the data or methods of analysis used to monitor the trend. It is not possible, however, to attribute the recent slowdown in improvement to any single cause and it is likely that a number of factors, operating simultaneously, need to be addressed.

The analysis by cause of death shows the importance of stepping up efforts to reduce the risk of heart disease and stroke by addressing the underlying wider determinants of health and by reducing risk factors such as smoking, high blood pressure and obesity. Addressing the increase in deaths due to accidental poisoning in younger age groups is also important. Further research focused on these specific causes of death, including further examination of potential cohort factors, could aid understanding of the trends seen.

Other authors have reported an association between trends in mortality and changes in public spending, and health and social care provision. Further work would be required to understand any potential causal mechanisms which may be operating between changes in health and social care provision and trends in mortality within England and across different countries.

The increase in numbers of deaths in some winters, and the analysis by deprivation, highlight the need to support the most vulnerable in society, particularly older people, to minimise the impact of poverty and extremes of temperature, and diseases such as dementia and influenza. Recent evidence of reduced flu vaccine effectiveness in older people has led to changes in the type of vaccine offered to this group. Additional research could focus on understanding the interactions between these factors and suggest actions to address widening health inequality.

Key facts

Trends in the number of deaths

The number of deaths in England per year has generally increased since 2011. This reverses the previous downward trend, but the increase was expected as the population has also increased and aged. The number of deaths is not, however, a useful measure of long term trends in the health status of the population as it does not take into account population size or age structure.

Between the 1970s and 2011 the trend in the number of deaths was downwards, but fluctuations from year to year did occur. Between 1971 and 2017, the biggest year on year increase in the number of deaths was between 2014 and 2015.

There was a large increase in the number of deaths in early 2015. This led to the overall annual increase that year and a large number of excess winter deaths. The winters of 2016/17 and 2017/18 also had a high number of deaths; excess winter deaths in 2017/18 were the highest since 1975/76.

The number of deaths in January to March 2018 was higher than the number in each of the previous five years (including 2015). The peak in deaths in January 2018 was not quite as high as the peak in January 2015. However, in 2018 there were a series of additional peaks in late February / early March, a period of particularly cold weather.

Trends in age-standardised mortality rates and life expectancy

Trends in age-standardised mortality rates and age-specific death rates take account of changes in population size and age structure and are therefore a better measure of mortality than the number of deaths. Period life expectancy at birth is an alternative summary indicator of mortality.

The overall age-standardised mortality rate in England has generally been declining (improving) in recent decades for both males and females. However, the rate of improvement was much smaller between 2011 and 2017 than in earlier periods, particularly the first decade of the 2000s which had the greatest rate of improvement in the period examined (1970s onwards).

The provisional age-standardised mortality rate for January to March 2018 was the highest since the first quarter of 2009. The rate for April to June 2018 was higher than the same quarter in 2017. Therefore an overall increase in the annual rate between 2017 and 2018 is possible.

Life expectancy at birth in England has generally been increasing (improving) in recent decades for both males and females. In 2017, life expectancy in England had reached 79.6 years for males and 83.2 years for females. However, as with mortality rates, improvement in life expectancy, in both males and females, has slowed since 2011. Between 2006 and 2011, life expectancy increased by 1.6 years in males and 1.3 years in females, but between 2011 and 2016 this reduced to 0.4 and 0.1 years for males and females respectively.

Trends by age group

Between 2011 and 2016, mortality rates for the five year age groups between 10-34 and 40-49 years, and people aged 90+, increased. Mortality rates decreased in all other age groups, but, with the exception of those aged 5-9 years, there has been a slowdown in improvement since 2011.

These trends in mortality rates at different ages determine the trend in life expectancy. As a result of the increase in their mortality rates, most age groups between 10 and 49 years made no positive contribution to changes in life expectancy between 2011 and 2016, in contrast to making small positive contributions in earlier periods.

Between 2006 and 2011, mortality improvements in those aged 90+ years made a small positive contribution of 0.06 years to changes in male life expectancy and 0.12 years to female life expectancy. However, between 2011 and 2016, as mortality rates in this age group increased, they made a negative contribution to changes in life expectancy of -0.02 years in males and -0.06 years in females.

Between 2006 and 2011, mortality improvements in those aged 50-89 years made a positive contribution of 1.2 years to changes in male life expectancy and 0.9 years in females. However, although mortality rates in these ages continued to decline, between

2011 and 2016 this contribution reduced to 0.4 in males and 0.2 in females. Therefore, the positive contribution to life expectancy was much reduced in this later period and this has had a big effect on the slowdown in improvement in life expectancy.

Geographical variations

All regions of England, the majority of local authorities and all deprivation decile areas in England (based on small area deprivation scores) had either a slowdown in improvement or a decrease in life expectancy since 2011 (or 2010-12).

Between 2006-08 and 2010-12, only 4 local authorities had a fall in male life expectancy and 7 had a fall for females. Between 2010-12 and 2014-16, 72 local authorities had a fall in male life expectancy and 87 had a fall for females.

Between 2010-12 and 2014-16, life expectancy in the more deprived areas in England increased more slowly than in the least deprived areas. In addition, female life expectancy in the most deprived decile areas has actually decreased since 2010-12. Inequality in female life expectancy has been increasing since 2001-03, while inequality for males has fluctuated over time, but increased since 2011-13.

International comparisons

The large increase in deaths in the winters of 2014/15, 2016/17 and 2017/18 was also seen in a number of other European countries.

All other countries of the UK have also experienced a slowdown in improvement in life expectancy between 2011 and 2016. In addition, most of the largest EU countries also had a slowdown in this time period, however, improvement in life expectancy in the UK between 2011 and 2016 was smaller than in the other largest EU countries for both sexes.

In 2006, the UK had the joint 6th highest male life expectancy out of the 28 EU countries. Its relative position reduced in 2016 to 10th highest. The picture is worse for UK female life expectancy, however, the UK rank position was the same in 2006 and 2016, 17th out of the 28 EU states.

Contribution of the leading causes of death

Mortality rates from many of the leading causes of death, such as heart disease and stroke, have continued to improve but there has been a slowdown in improvement between 2011 and 2016. Alongside this, there has been a small increase in the mortality rates from chronic lower respiratory disease in males and females, and ‘other’ causes in males. In addition, largely due to changes in diagnostic and death certification practices, there has also been an increase in the mortality rates from dementia and Alzheimer's disease since around 2006.

Between 2006 and 2011, the decrease in mortality rates from heart disease and stroke made a positive contribution to changes in life expectancy of 0.7 years in males and females. However, between 2011 and 2016 this reduced to a positive contribution of only 0.4 years in males and 0.3 years in females. The increase in mortality rates from dementia made a negative contribution to changes in life expectancy of -0.2 years in males and -0.3 years in females between 2011 and 2016.

Among people aged 20-44, mortality rates from accidental poisoning have increased since 2011 which has made a negative contribution to changes in life expectancy of -0.06 years in males and -0.11 years in females.

Introduction

Until recently the trend in mortality over the last 100 years in England had been relatively clear: since World War 1 every decade has seen people living longer than before.[1]

Earlier this decade, however, concern was raised about an increase in mortality in older people.[2] Following this, Public Health England (PHE) reported on the fall in life expectancy at older ages in England in 2012, a phenomenon which also occurred in many other European countries.[3]

More recently, some authors have drawn attention to the fact that the number of deaths in some winters has been exceptionally high.[4, 5] The Office for National Statistics (ONS), with support from PHE, examined a spike in deaths at the start of 2015, which led to a fall in life expectancy at birth that year.[6]

ONS is now issuing quarterly mortality reports providing more up to date information on trends in mortality.[7] In June this year, for example, ONS reported that in the first three months of 2018 the number of deaths and the provisional age-standardised mortality rate was higher than in the first three months in each of the last five years.[8]

In addition to this, it has been highlighted that life expectancy and age-standardised mortality rates may no longer be improving at the same rate as in earlier years, and may even be worsening in some population groups.[9-13] PHE reported in 2017 that there was a slowdown in improvement in mortality rates since 2011.[14] Further evidence has recently been provided by ONS, who reported a statistically significant slowdown in the long-term improvement in age-standardised mortality rates from around the early 2010s.[15]

To further understand what is happening, the Department of Health and Social Care (DHSC) commissioned PHE to undertake a review of trends in mortality in England, with a particular focus on the number of deaths in some recent winters and the slowdown in mortality improvement. This report summarises the findings from the commission and makes suggestions for further work that could be undertaken.

The aims of this report

The aims of this work are to provide a review of official data to advance understanding of the trends, to provide further detail on specific population groups and specific causes of death, and to determine whether this provides insight into possible explanations for the trends seen. The terms of reference are provided in Appendix 1.

In particular, 2 important concerns are examined:

- a recent increase in the number of deaths in England, particularly in some winter periods from 2014/15 through to 2017/18
- a reduction in the rate of improvement (slowdown in improvement) in life expectancy and age-standardised mortality rates in recent years, particularly since 2011

Section 1 of this report examines the trend in the number of deaths.

Section 2 sets out recent trends in age-standardised mortality rates and life expectancy in England, to provide evidence of change in trend.

Section 3 breaks down trends in mortality and life expectancy by sex, age group, geography, level of deprivation and leading causes of death, to determine whether the findings are confined to particular population groups or causes of death.

Section 4 compares mortality trends in England with the other countries of the UK, and makes international comparisons, to see if other countries have had similar trends in recent years.

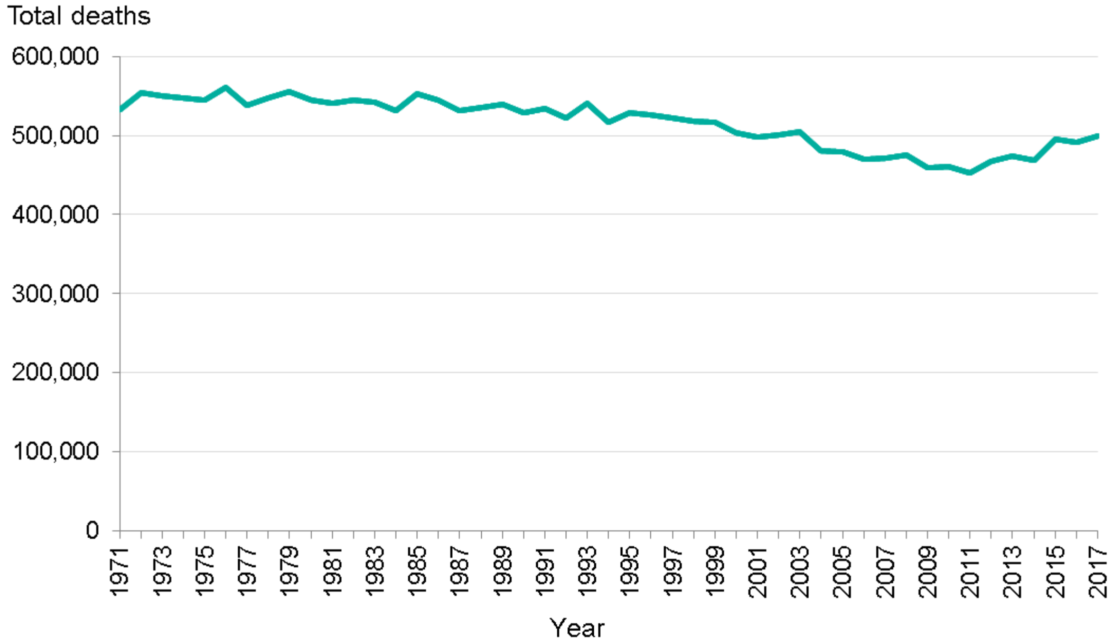
Section 5 considers some possible explanations for the findings that can be investigated using routine data, including a review of available literature.

Section 1: Trends in the number of deaths

Long-term trends

Since 2011 the number of deaths in England has been generally increasing. This follows a general downward trend in the annual number of deaths since the 1970s, although the number of deaths fluctuates from year to year (Figure 1A).

Figure 1A: numbers of deaths in England, 1971 to 2017



Source: PHE analysis of ONS mortality data, 1971-2016 and 2017

The number of deaths reached its lowest point since 1971 in 2011 (453,000 deaths) but numbers have increased since then and in 2017 there were 499,000 deaths (Figure 1A).

This reduction in the number of deaths up to 2011 happened despite a population which was both growing in size and ageing.[16] However, given this, it was inevitable that the downward trend in the number of deaths could not continue indefinitely.

As the number of people aged 85 and over has increased over recent decades, there has also been a continued increase in the percentage of deaths that are among people in this age group. In 1971, deaths among those aged 85 and over made up just 15% of all deaths in England and Wales, but by 2016 they accounted for 39% of the total.[16]

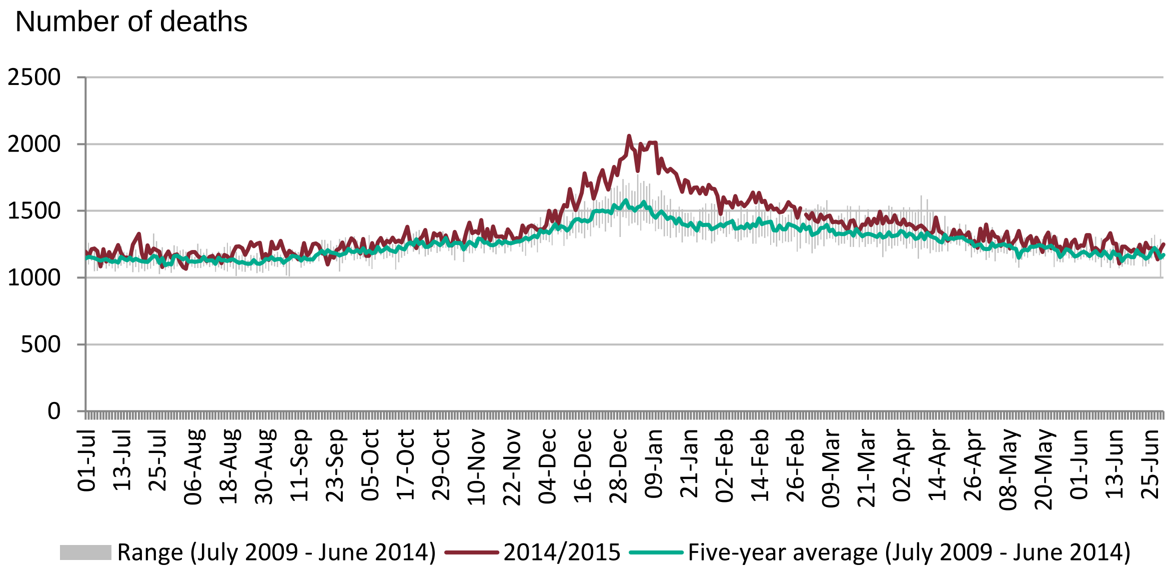
Short-term fluctuations

Despite this clear long-term trend in the number of deaths, over the last 50 years there has been some fluctuation in the number of deaths from year to year. Between 1971 and 2017, the biggest year on year increase in number of deaths in England was between 2014 and 2015.[1]

The number of deaths fell between 2015 and 2016, and increased again in 2017, which had the highest number since 2003.

The increase in deaths in 2015 largely resulted from a spike at the start of the year which has been well documented (Figure 1B).[6] Most of the increase in deaths in 2015 were of people aged 75 and over, with an underlying cause of respiratory illness or dementia.[6]

Figure 1B: number of deaths occurring each day in England from 1 July 2014 to 30 June 2015, with five-year average and daily range[2]



Source: PHE analysis of mortality data from ONS

In some years the number of winter deaths is much higher than in other years, and this can often determine the large variation in annual number of deaths. Trends in winter deaths, and their influence on recent annual mortality trends, are considered further in Section 5.

---

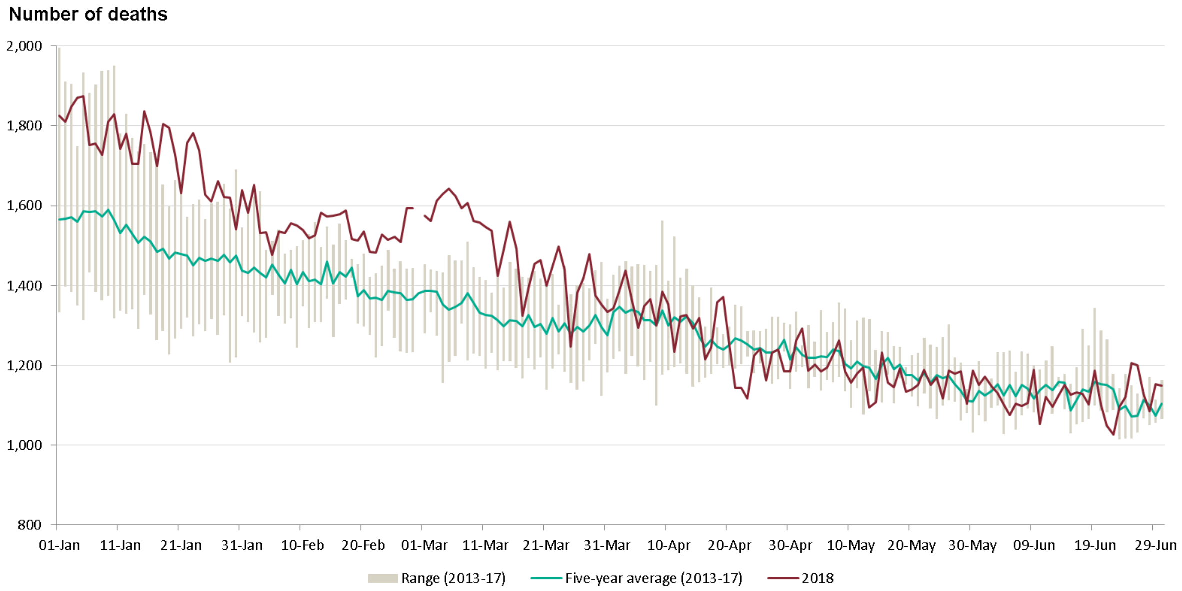
[1] Annual number of deaths for England are available from ONS back to 1940. There were three years before 1971 which had a bigger year on year increase in the number of deaths than that between 2014 and 2015: 1949, 1951 and 1968. Trend in Figure 1A is only shown from 1971 onwards for consistency with age-standardised mortality rates in Section 2, which are only available from ONS from 1971 onwards for England.
[2] The vertical grey bars show the maximum and minimum number of deaths occurring on each day in the 5 year period July 2009 to June 2014. The break in the red line for 2015 is for 29 February.

Latest data for 2018

Almost 154,000 deaths were registered in England in the first three months of this year. This was higher than the number registered in this period in each of the previous five years (including 2015, which itself had a high number of deaths) and 18,000 more than the average of the previous five years.[8]

The peak in deaths in January 2018 was not quite as high as the spike in January 2015, but in 2018 there was a series of additional peaks in late February / early March, a period of particularly cold weather (Figure 1C).

Figure 1C: number of deaths occurring in England on each day from 1 January to 30 June 2018, with five-year average and daily range[3]



Source: PHE analysis of ONS data

The number of deaths in England in the three months from April to June 2018 was much closer to the five-year average than in the first three months of the year. There was however a peak in mid-April during a period of unseasonably hot weather (Figure 1C).

A high number of deaths also occurred at the end of June, a period when high temperatures triggered a heatwave alert from 25 June. ONS will report in December 2018 on deaths from July to September, in which they will consider the effect of the 2018 heatwave.

---

[3] The vertical bars show the maximum and minimum number of deaths occurring on each day in the years 2013 to 2017. The break in the red line for 2018 is for 29 February.

Section 2: Trends in mortality rates and life expectancy

Introduction

Section 1 demonstrated that the number of deaths in England has generally increased since 2011, however an increase in the number of deaths was expected as the population has also increased and aged. Although this trend in the number of deaths is important to understand potential demand for health and social care services, it is not useful as a measure of long term trends in the health status of the population.

To account for changes in the size and age structure of the population, and to establish whether the increase in deaths is more than expected, this section examines trends in age-standardised mortality rates and life expectancy. These are alternative measures of mortality that both adjust for population size and ageing. They generally show consistent trends, but a decrease in mortality rates is an improvement, while an increase in life expectancy is an improvement.

Trends in age-standardised mortality rates

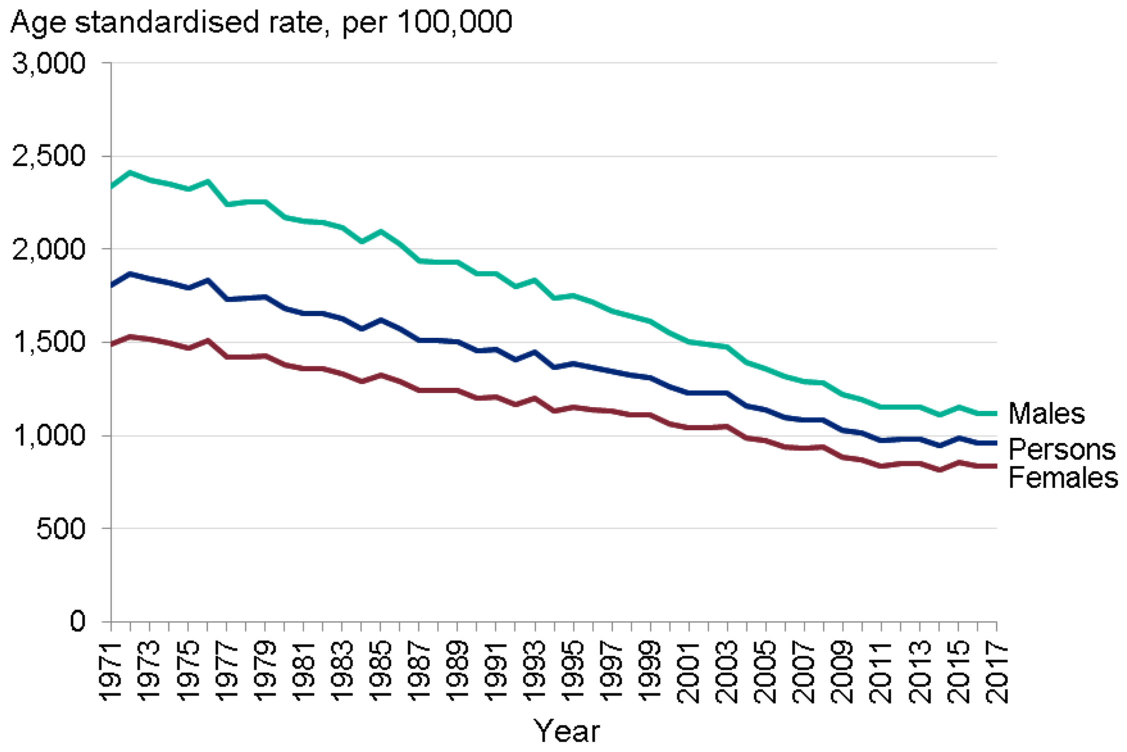
The overall age-standardised mortality rates (for all causes of death combined) in England have generally declined for both sexes since 1971 (Figure 2A). In 2017, the rates for both sexes were at the second lowest recorded levels (they were lowest in 2014).

In 2015, the increase in the number of deaths resulted in a significant increase in the age-standardised rate for both sexes and all persons.[4]

Between 2014 and 2015, the rate increased by 3.1% in males and 5.1% in females. This was the biggest year-on-year percentage increase for females (since 1971) and the second biggest for males. In 2016 there was a fall in the rate for both sexes. Between 2016 and 2017, although the number of deaths increased, the age-standardised rate was stable.

[4] There was also a significant year-on-year increase in the directly age-standardised mortality rate for both sexes in 1993, 1985, 1976 and 1972, and a significant increase for females only in 2012, 2003 and 1995.

Figure 2A: trends in age-standardised mortality rates from all causes of death, by sex, England, 1971 up to 2017



Source: PHE analysis of ONS mortality data, 1971-2016 and 2017

The provisional age-standardised mortality rate for January to March 2018 was the highest since the first quarter of 2009 (although not statistically significantly higher than the first quarter of 2015).[8] The provisional age-standardised mortality rate for April to June 2018 was higher than the same quarter in 2017 [17], therefore an overall increase in the annual rate between 2017 and 2018 is possible.

Methods for measuring trends in mortality rates

The rate of improvement in mortality rates can be measured in a number of ways. In 2017, PHE published a blog which considered what's happening with mortality rates in England.[14]

The blog reported the results of a model which estimated the mortality rates which would have been expected in 2012 to 2016, had the downward trend from 2002 to 2011 continued.[5] The model indicated that for both sexes, mortality rates in England between 2012 and 2014 were slightly higher than would have been expected if the

---

[5] Using 2011 as a 'breakpoint' for the change in trend has been confirmed as an appropriate approach following analysis by ONS of changing mortality trends between 1990 and 2017.

earlier downward trend had continued unchanged. In 2015 and 2016, mortality rates were around 10% higher than expected.

Change over time can also be measured by estimating the gradients in mortality rates for different periods. These take account of the mortality rate in every year in the period (not just the first and last years) and can be used to provide the average annual absolute change in rates. This method was used to assess change for each decade of the mortality rates shown in Figure 2A.

The results reported in Table 2A are all negative, showing that mortality rates fell (improved) in each decade, but the average annual fall varied over time. The largest falls were in the 2000s for both sexes. Between 2011 and 2017, the average annual improvement was smaller than in each of the previous four decades.

Table 2A: average annual absolute change in directly age-standardised rates per 100,000 population, England*

Decade	Males	Females
1971 to 1980	-20.9	-14.3
1981 to 1990	-32.3	-17.3
1991 to 2000	-32.6	-12.9
2001 to 2010	-36.1	-20.5
2011 to 2017	-6.1	-1.6

*A negative value indicates an improvement in mortality rates within the period

Source: PHE analysis of ONS mortality data, 1971-2016 and 2017

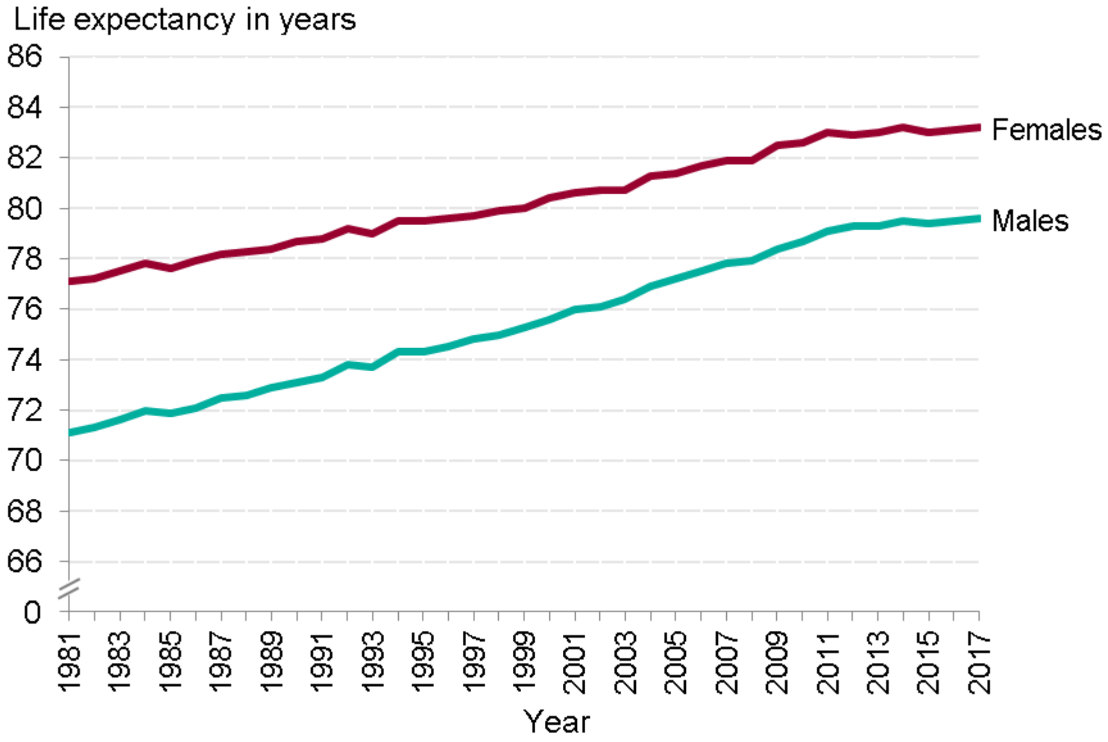
As the results for average annual improvement may be sensitive to the years chosen to start and end each period, a sensitivity analysis was undertaken to test the impact of changing periods slightly. This resulted in small changes to the figures but did not change the overall picture.

Further confirmation of the change in trend for mortality rates has been provided in a recent ONS report which reported a statistically significant slowdown in the long-term improvement in age-standardised mortality rates from around the early 2010s.[15] ONS found this to be true for both England and Wales, for both sexes, and for age groups both above and below age 75, with some variations in the timing and extent of the change in trend.

Trends in life expectancy

Life expectancy at birth in England has generally increased in recent decades and it reached 79.6 years for males and 83.2 years for females in 2017 (Figure 2B).6 However, as with mortality rates, there has been a slowdown in improvement in life expectancy since 2011.[7]

Figure 2B: trends in life expectancy at birth, by sex, England, 1981 up to 2017



Source: PHE analysis of ONS mortality data, 1971-2016 and 2017

Between 2014 and 2015, life expectancy at birth fell for both sexes (reflecting the increase in the age-standardised mortality rate in 2015). This was the first time since 1993 that it fell for both sexes.[8]

As with age-standardised mortality rates, change over time was measured by estimating the gradients in life expectancies for different decades. Results for average annual change in life expectancy are shown in Table 2B.

---

[6] The national life expectancy figures included in this report are for single calendar years. ONS also produces National Life Tables based on 3 years of data. Further detail on the different life expectancy estimates released by ONS are included in the Definitions section.
[7] Directly age-standardised mortality rates and life expectancy estimates are both based on age-specific mortality rates, and so generally do have very similar trends. Life expectancy estimates for England for single calendar years are only available from 1981 onwards.
[8] There was a fall for both sexes in 1985 and there was a fall for females only in 2012.

Similar to the results for age-standardised mortality rates, absolute improvement in the current decade was considerably lower than in the preceding three decades. The 2000s was the decade with the greatest improvement.

Table 2B: average annual absolute change in life expectancy at birth (in years and weeks), England*

Decade	Years		Weeks	
	Males	Females	Males	Females
1981 to 1990	0.22	0.17	11.4	8.8
1991 to 2000	0.24	0.15	12.5	7.8
2001 to 2010	0.31	0.23	16.1	12.0
2011 to 2017	0.07	0.04	3.6	2.1

*A positive value indicates an improvement in life expectancy within the period

Source: PHE analysis of ONS life expectancy data

Section 3: Detailed breakdowns of mortality rates and life expectancy

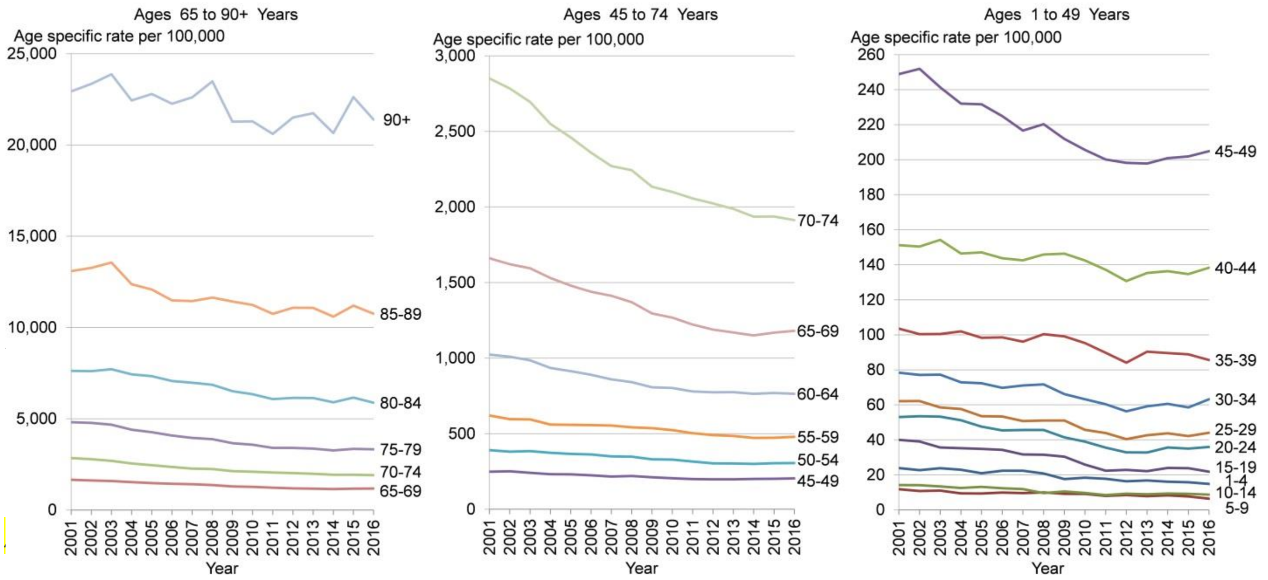
Introduction

This section presents trends in mortality rates and/or life expectancy by sex, age group, geography, level of deprivation and cause of death, to determine whether the slowdown in improvement has occurred across all population groups, and leading causes of death.

Trends in mortality rates by age group

All-cause age-specific mortality rates declined in all age groups between 2001 and 2016, as shown in Figure 3A.

Figure 3A: trends in age-specific mortality rates, persons, 2001 up to 2016, England[9]



Source: PHE analysis of ONS mortality data

Average annual absolute change in the mortality rate for each age group is shown in Table 3A for three time periods: 2001 up to 2006, 2006 up to 2011, and 2011 up to

---

[9] Note that each of the three charts is on a different scale to make change over time more clearly visible for younger age groups.

2016. Table 3A also shows the relative percentage change in the age-specific mortality rate within each period.

Mortality rates fell (improved) for each age group between 2001 and 2006, and between 2006 and 2011. In the most recent period between 2011 and 2016, mortality rates increased (worsened) for those aged 10-34, 40-49 and 90+. For these age groups the downward trend seen in earlier periods has therefore not continued.

For all other age groups, mortality rates fell in the most recent period, but apart from those aged 5-9, there was a slowdown in improvement between 2011 and 2016.

Table 3A: average annual absolute change in age-specific rates per 100,000 population, England, 2001 up to 2006, 2006 up to 2011, and 2011 up to 2016*

Age group	Average annual absolute change in mortality rates within each period			Average annual percentage change in mortality rates within each period		
	2001 to 2006	2006 to 2011	2011 to 2016	2001 to 2006	2006 to 2011	2011 to 2016
1-4	-0.4	-1.1	-0.5	-1.7	-5.3	-3.0
5-9	-0.4	-0.3	-0.3	-4.1	-3.7	-3.7
10-14	-0.4	-0.7	0.0	-2.6	-6.7	0.5
15-19	-1.2	-2.2	0.1	-3.1	-7.7	0.2
20-24	-1.7	-2.1	0.3	-3.3	-5.0	0.9
25-29	-2.0	-1.8	0.2	-3.4	-3.6	0.5
30-34	-1.8	-2.2	0.7	-2.4	-3.2	1.1
35-39	-0.8	-1.4	-0.2	-0.8	-1.4	-0.2
40-44	-1.6	-0.9	0.6	-1.1	-0.7	0.4
45-49	-5.4	-4.7	1.1	-2.3	-2.2	0.5
50-54	-5.6	-9.1	-1.4	-1.5	-2.6	-0.5
55-59	-13.3	-10.5	-5.1	-2.2	-1.9	-1.0
60-64	-28.7	-21.6	-2.9	-3.0	-2.6	-0.4
65-69	-45.7	-45.5	-8.2	-2.9	-3.4	-0.7
70-74	-102.1	-61.0	-29.5	-3.8	-2.7	-1.5
75-79	-156.0	-134.5	-18.4	-3.4	-3.5	-0.5
80-84	-111.4	-205.8	-34.4	-1.5	-3.1	-0.6
85-89	-364.6	-130.6	-2.5	-2.9	-1.2	-0.0
90+	-185.1	-412.3	177.8	-0.8	-1.9	0.8

*A negative value indicates an improvement in mortality rates within the period

Source: PHE analysis of ONS mortality data

ONS have also looked at changes in the trend in mortality rates for broad age groups in the UK.[18] Although they have therefore used a slightly different method, the findings from both analyses are broadly consistent.

The infant mortality rate is not included in Figure 3A or Table 3A. In England, the number of infant deaths (under one year) is relatively small and subject to variation from year to year. As a result, the data are often considered on a three-year rolling average basis. The infant mortality rate fell from 5.4 per 1,000 live births in 2001-03 to 3.9 in 2013-15. However, there was then no further decline in 2014-16. [16]

Contribution of age groups to trends in life expectancy

The contribution of trends in mortality rates in different age groups to the change in life expectancy over time can be examined using a method for 'decomposing' life expectancy (see Definitions for more information).[19, 20][10] The impact of any change in the age-specific rate is determined by how high the rate is to start with and also the number of potential years of life lost past that age group. A single death at a young age has more of an impact on life expectancy than the death of an older person, as more potential years of life have been lost.

In Figure 3B, age groups where the mortality rate has reduced over time made a positive contribution to changes in life expectancy and have a positive value, while age groups where the mortality rate has increased over time made a negative contribution to changes in life expectancy and have a negative value. In Figure 3B, the sum of the values for all the bars for each sex, will add up to the total change in life expectancy for that sex in the period presented.

All age groups made a positive contribution to changes in life expectancy between 2001 and 2006, and between 2006 and 2011. The age groups which made the biggest positive contribution were at older ages, 60 to 89 years (Figure 3B).

The contribution from almost all age groups was smaller between 2011 and 2016. Age groups between 10 and 49 years made almost no contribution between 2011 and 2016, either positive or negative.

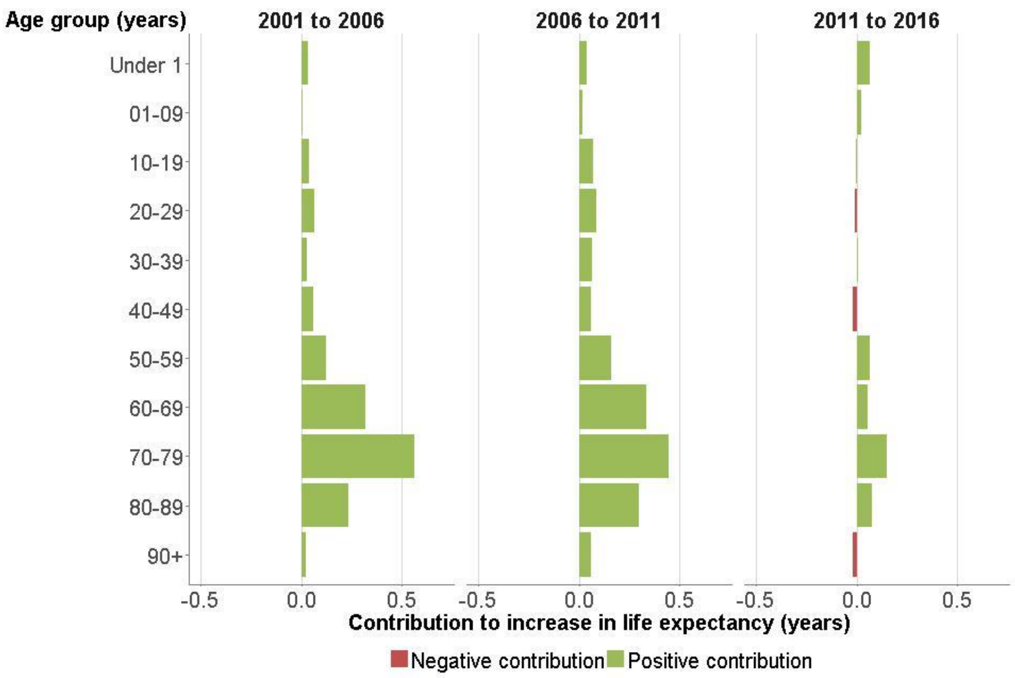
Between 2006 and 2011, the age group 90+ made a positive contribution to changes in life expectancy of 0.06 years in males and 0.12 years in females. Between 2011 and 2016 the increase in the mortality rate in this age had a negative effect on life expectancy of -0.02 years in males and -0.06 years in females. Therefore, although mortality rates in people aged 90+ years increased, the effect on overall life expectancy was small.

---

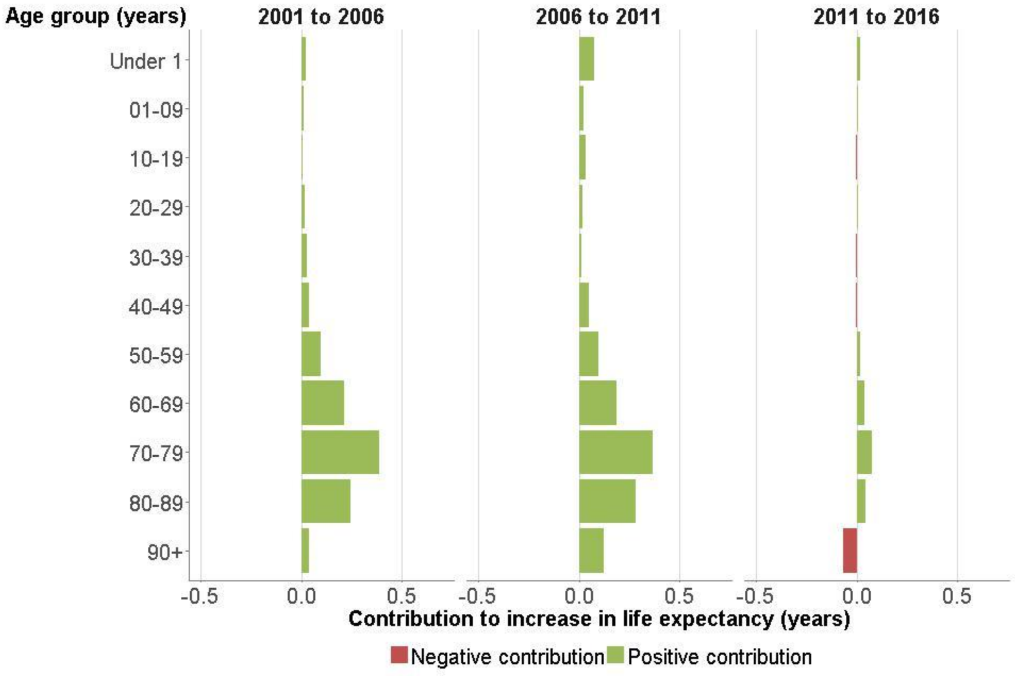
[10] This analysis follows a 2017 report which decomposed life expectancy estimates in Northern Ireland: https://www.health-ni.gov.uk/publications/health-inequalities-life-expectancy-decomposition-2017

Figure 3B: contribution of age groups to changes in life expectancy at birth, by sex, England, 2001 up to 2006, 2006 up to 2011 and 2011 up to 2016

Males



Females



Source: PHE analysis of ONS mortality data and population estimates

Between 2006 and 2011, the age groups 50-89 years made a positive contribution of 1.2 years to male life expectancy and 0.9 years to female life expectancy. However, between 2011 and 2016 this contribution reduced to 0.4 years in males and 0.2 years in females. Therefore, it is the change in mortality rates at ages 50-89 that has had the biggest effect on the slowdown in life expectancy improvement between 2011 and 2016.

Trends in age-standardised mortality rates from leading causes of death

Figures 3C and 3D show trends in the age-standardised mortality rates for the 10 leading causes of death, plus 'Other', between 2001 and 2016.[11] Table 3B shows average annual absolute change in 3 periods (2001 up to 2006, 2006 up to 2011, and 2011 up to 2016). Unfortunately, it is not possible to analyse trends in mortality rates by cause before 2001 on a comparable basis.[12]

Since 2001, for both sexes, there has been a decline in mortality rates from heart disease and stroke. For both sexes, the level of improvement decreased in each consecutive period.

Mortality rates from dementia and Alzheimer's disease (referred to as dementia from now on) have been steadily increasing in males and females since 2006. This is now the leading cause of death for females, accounting for 16% of all deaths, and is the second leading cause of death for males (8% of all deaths).[16] The reasons for this are not clear, but increased awareness of dementia, making it more likely to be diagnosed and recorded, is a factor. A more detailed discussion on this can be found in Section 5.

The mortality rate from influenza and pneumonia has declined for both sexes since 2001, but annual improvement between 2011 and 2016 slowed down.

For both sexes, chronic respiratory disease mortality declined between 2001 and 2011, but there was an increase between 2011 and 2016. For lung cancer there was a steady decline for males throughout, and for females there was a small decline between 2011 and 2016, following an increase between 2001 and 2011.

For the other leading cancer sites, there was a clear reduction in mortality rates throughout 2001 to 2016. However, the reduction in the rate for female breast cancer was not as great between 2011 and 2016 than in earlier periods.

---

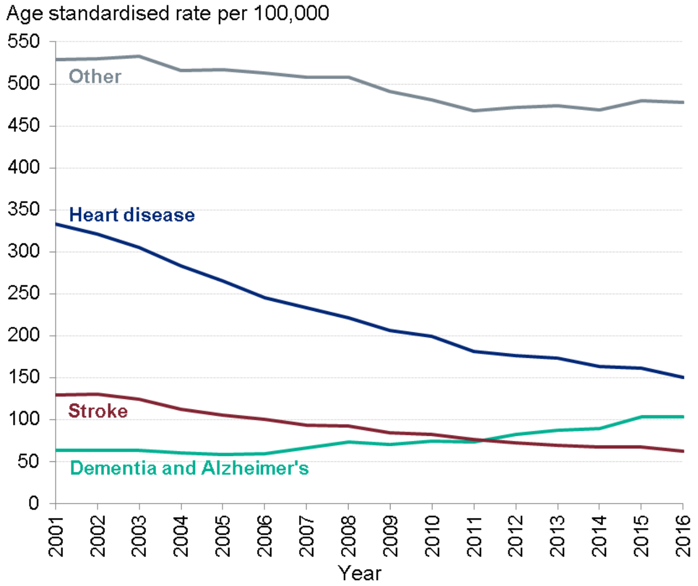
[11] Mortality rates in this section are all based on the underlying cause of death. See Definitions section for further details. Cause groups are based on the ONS definition of leading causes of death
[12] This is due to coding changes in 2001. There were further coding changes in 2011 and 2014, which this analysis takes into account. See Definitions section for further details.

The ‘Other’ group represents diseases which are not in the top 10 leading causes for each sex. In 2016 ‘Other’ represented 43% of deaths for males, and 42% for females.

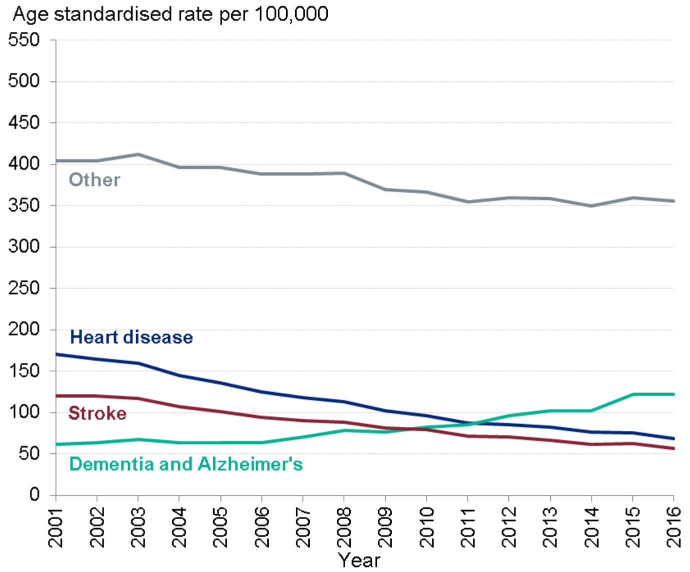
For ‘Other’ causes of death, there was improvement for both sexes between 2001 and 2011. Rates have fluctuated since 2011, but there was no overall annual change for females between 2011 and 2016, and for males there was actually an increase.

Figure 3C: trends in age standardised mortality rates for three leading causes of death and ‘other’ diseases outside of the top 10 leading causes, England, 2001 up to 2016

Males



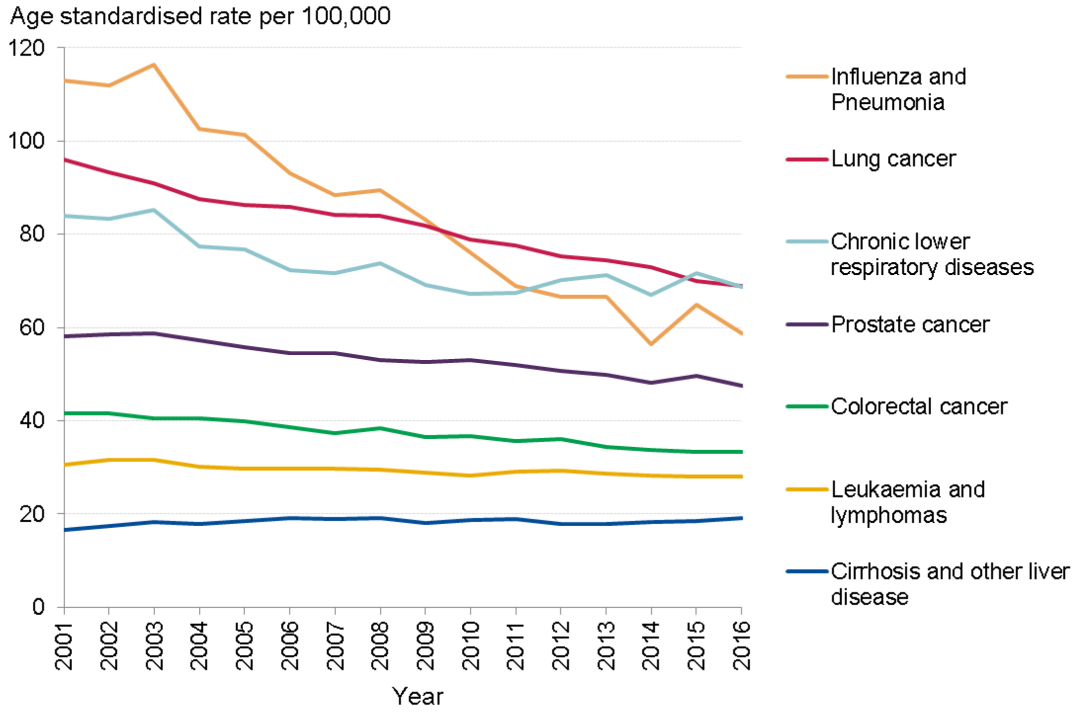
Females



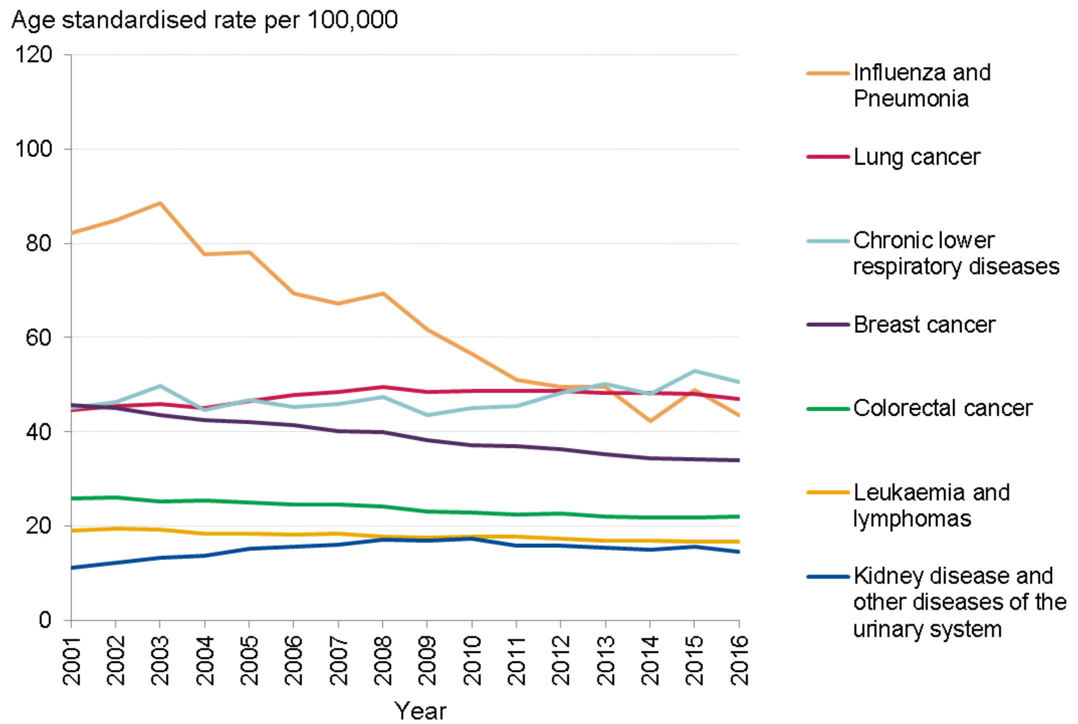
Source: PHE analysis of ONS mortality data and population estimates

Figure 3D: trends in age standardised mortality rates from selected causes of death, England, 2001 up to 2016

Males



Females



Source: PHE analysis of ONS data and population estimates

Table 3B: average annual absolute change in directly age-standardised mortality rates per 100,000 population, for leading causes of death, England, 2001 up to 2006, 2006 up to 2011 and 2011 up to 2016*

Cause of death	2001 to 2006	2006 to 2011	2011 to 2016
Males			
Heart disease	-17.9	-12.5	-5.9
Dementia and Alzheimer's disease	-1.1	2.5	6.2
Stroke	-6.7	-4.6	-2.4
Prostate cancer	-0.8	-0.5	-0.8
Lung cancer	-2.2	-1.7	-1.7
Influenza and pneumonia	-4.1	-4.7	-1.9
Colorectal cancer	-0.6	-0.5	-0.6
Chronic lower respiratory diseases	-2.4	-1.2	0.2
Leukaemia and lymphomas	-0.3	-0.2	-0.3
Cirrhosis and other liver disease	0.4	-0.1	0.1
Other	-4.0	-9.3	1.9
Females			
Heart disease	-9.4	-7.6	-3.7
Dementia and Alzheimer's disease	0.1	4.1	7.4
Stroke	-5.6	-4.4	-2.9
Breast cancer	-0.9	-0.9	-0.6
Lung cancer	0.5	0.1	-0.3
Influenza and pneumonia	-2.7	-3.7	-1.3
Colorectal cancer	-0.3	-0.5	-0.2
Chronic lower respiratory diseases	-0.1	-0.1	1.1
Leukaemia and lymphomas	-0.3	-0.1	-0.2
Kidney disease / other diseases of urinary system	0.9	0.2	-0.2
Other	-3.5	-7.2	0.0

*A negative value indicates an improvement in mortality rates within the period

Source: PHE analysis of ONS mortality data and population estimates

ONS have also reported that mortality rates for cancer, circulatory and respiratory diseases have generally been decreasing since 2001 across the UK, while mortality rates for mental and behavioural disorders, such as dementia, have increased sharply in recent years. [18] This is consistent with the analysis presented here.

Contribution of leading causes to trends in life expectancy

The contribution of the 10 leading causes of death to changes in life expectancy over three periods between 2001 and 2016 are shown in Figure 3E. The impact of any change in the rate for a particular cause is determined by how high the rate is to start with and also the age distribution of the deaths for that cause.

Since 2001, reductions in mortality from heart disease have made the largest positive contribution to changes in life expectancy, but these contributions were smaller between 2011 and 2016, as were the contributions due to reductions in mortality from stroke.

Rising mortality from dementia had a negative effect on life expectancy between 2006 and 2016. Trends in mortality from chronic respiratory disease also had a small negative effect between 2011 and 2016.

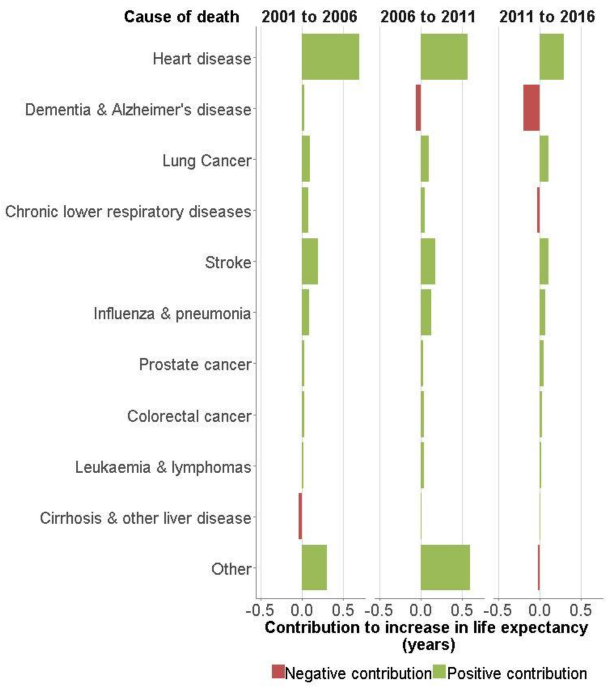
The ‘Other’ group made a substantial positive contribution to changes in life expectancy in the earlier time periods, but not between 2011 and 2016.

Figure 3F shows the impact of changes in mortality rates by cause and age group.

Much of the impact of the 10 leading causes was focused on people aged 65 and over, which is expected as the leading causes reflect the most common causes of death at older ages. To further understand the contribution of the ‘Other’ group it is necessary to examine deaths at younger ages.

Figure 3E: contribution of 10 leading causes of death to changes in life expectancy, England, 2001 up to 2006, 2006 up to 2011, and 2011 up to 2016

Male



Female

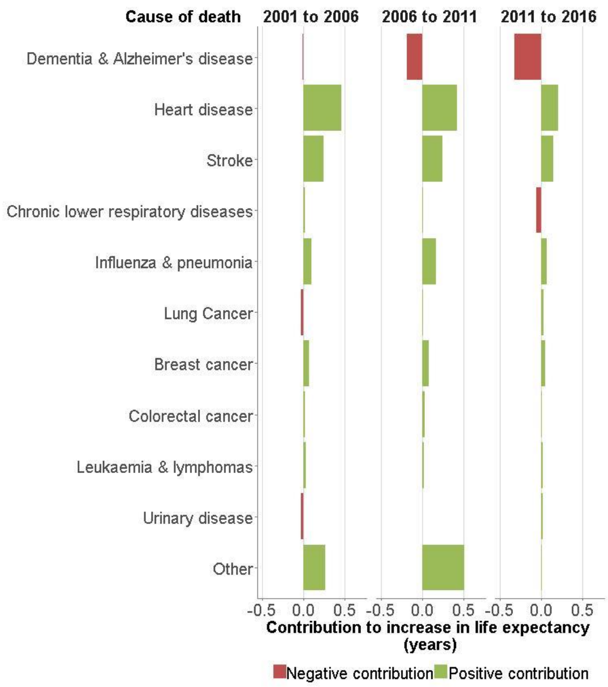
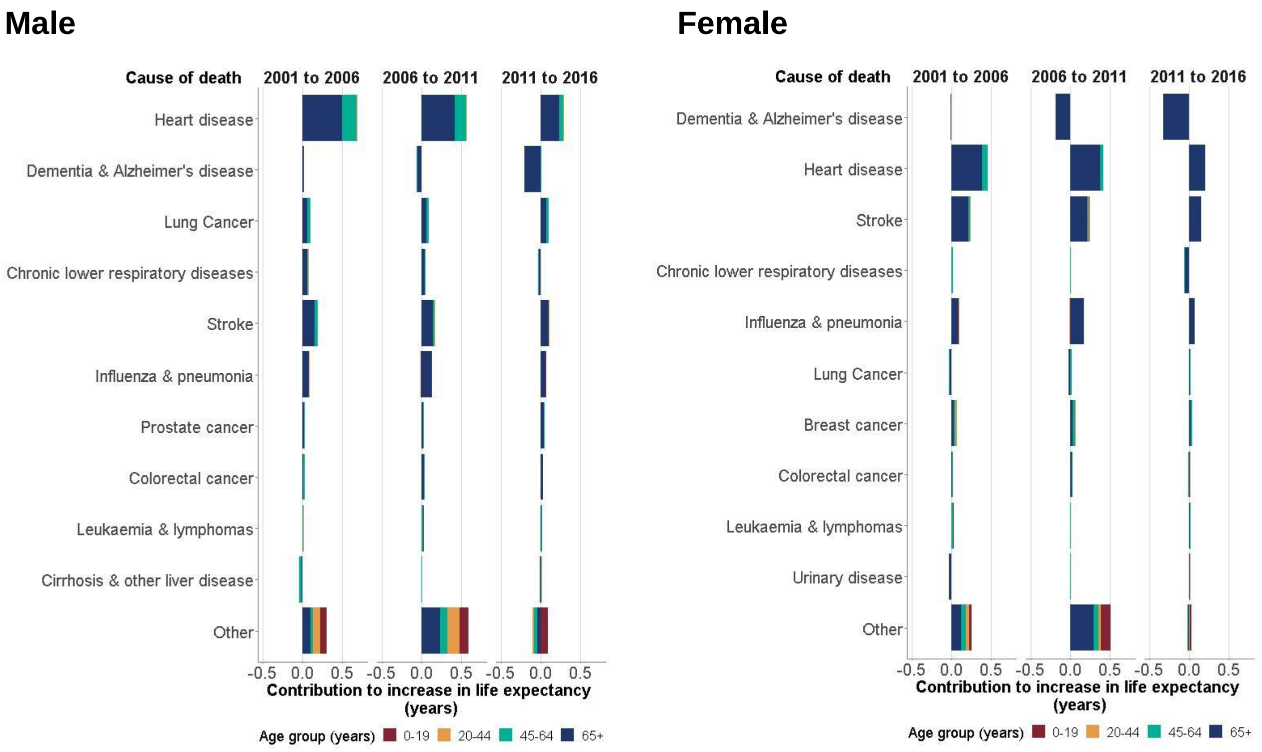


Figure 3F: contribution of 10 leading causes of death to changes in life expectancy, by broad age group, England, 2001 up to 2006, 2006 up to 2011, and 2011 up to 2016



Source: PHE analysis of ONS mortality data and population estimates

Analysis of the impact of trends in the five leading causes of death for each broad age group is shown in Figures 3G to 3I. Note that the leading causes are different in each age group, and the overall contribution in each of these age groups is different so each chart is shown on a different scale. All the charts show the contribution made by each age group to life expectancy at birth, not the life expectancy for the age group in the chart.

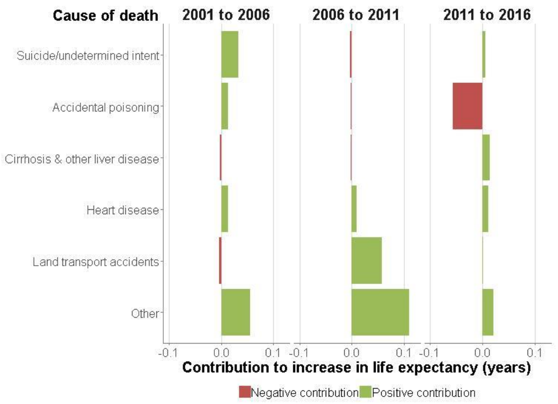
Among people aged 20-44, an increase in mortality rates from accidental poisoning had a negative effect on life expectancy between 2011 and 2016 of -0.06 years in males and -0.11 years in females. Data from ONS indicate that in this age group, over the whole period from 2011 to 2016, 70% of accidental poisonings were due to drug misuse and 10% were to alcohol. An increase in the female suicide rate in this age group also had a small negative effect on life expectancy between 2011 and 2016 (-0.02 years).

Improvement in mortality from heart disease among females aged 45-64 made a positive contribution to changes in life expectancy between 2001 and 2011, but between 2011 and 2016 the contribution was zero (Figure 3H). Among males, heart disease made a positive contribution in all 3 periods, but between 2011 and 2016 it was much reduced. For both sexes in this age group, 'Other' causes made a small negative contribution to changes in life expectancy between 2011 and 2016, after having made positive contributions in the earlier two periods.

ONS also observe that "The slowdown of the decline in mortality rates for diseases of the circulatory system…from 2011 has also been a large contributor to the changing trend in mortality for those aged 55 years and over." For those aged 15-55, ONS found that increases in external causes of death (which include accidents and suicide) have influenced the trend at these ages.[18] This is consistent with the analysis presented here.

Figure 3G: contribution of 5 leading causes of death to changes in life expectancy, aged 20-44, England, 2001 up to 2006, 2006 up to 2011 and 2011 up to 2016

Male



Female

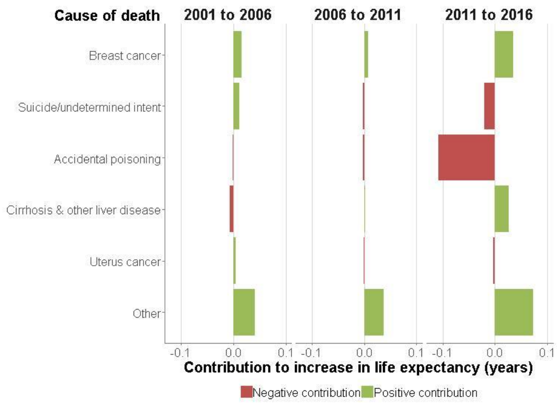
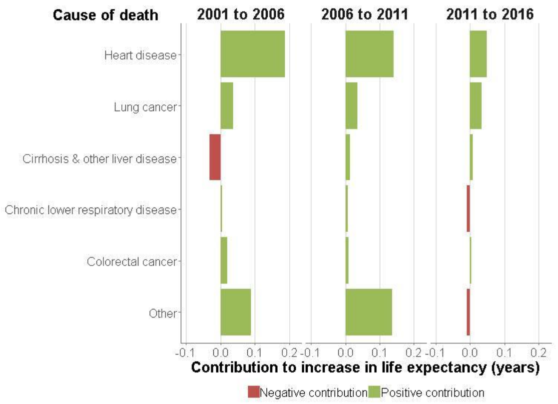


Figure 3H: contribution of 5 leading causes of death to changes in life expectancy, aged 45-64, England, 2001 up to 2006, 2006 up to 2011 and 2011 up to 2016

Male



Female

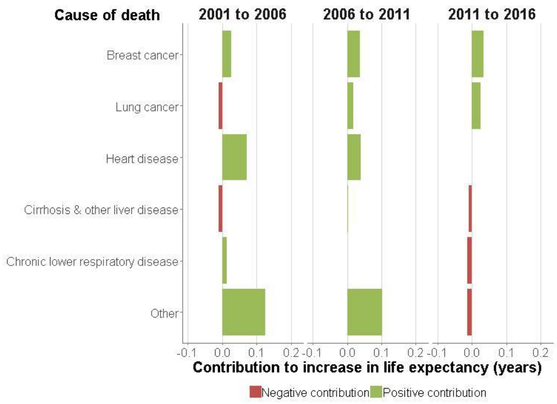
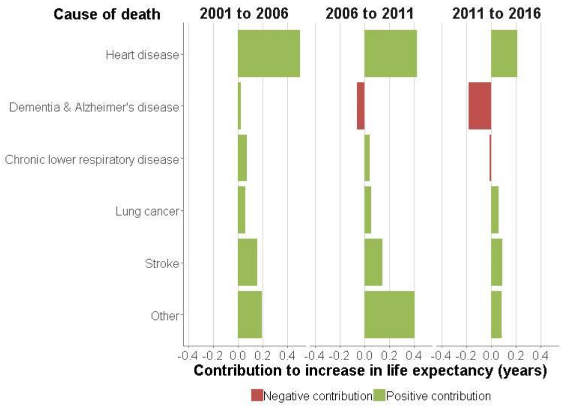
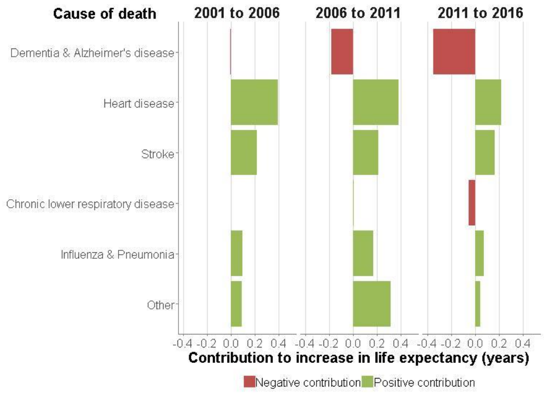


Figure 3I: contribution of 5 leading causes of death to changes in life expectancy, aged 65+, England, 2001 up to 2006, 2006 up to 2011 and 2011 up to 2016

Male



Female



Source: PHE analysis of ONS mortality data and population estimates

Trends by geography

Regions

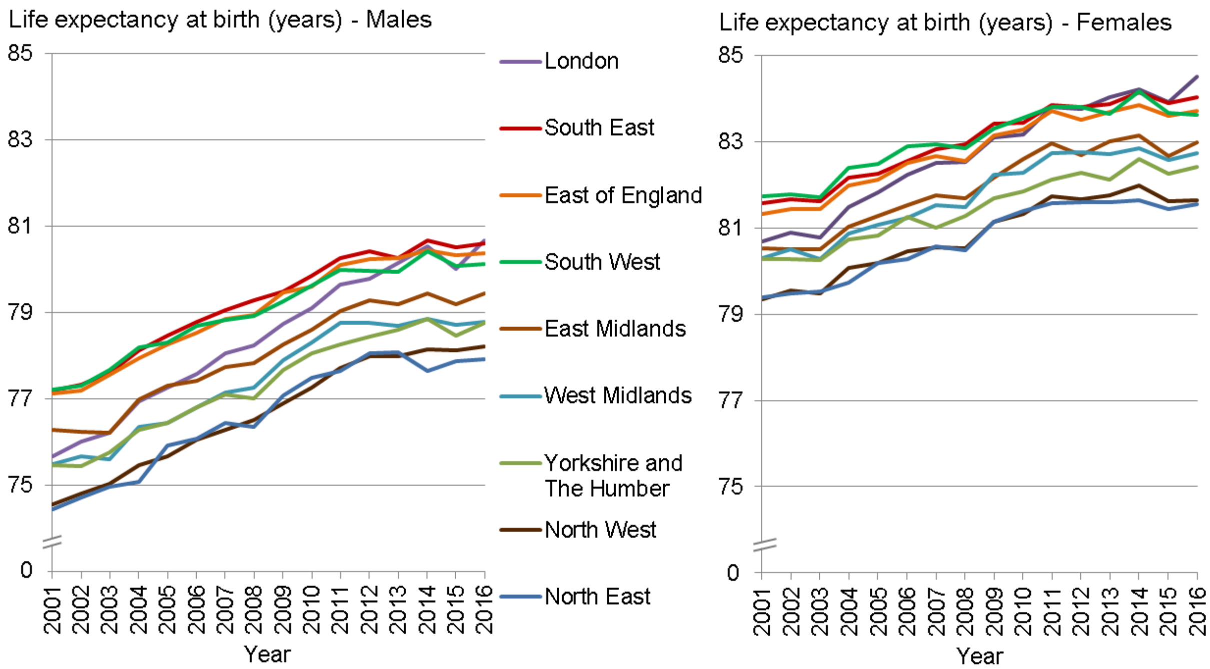
Life expectancy in all English regions increased between 2001 and 2016 for both sexes, but the biggest increases were in London. Of the 9 English regions, London had the fifth highest male life expectancy in 2001. In 2016, following an increase of 5 years, male life expectancy in London was higher than all other regions. Similarly for females, its rank order changed from fourth highest to highest (Figure 3J).[13]

The South West had the smallest increase over this period, 2.9 years for males, 1.9 years for females. All regions had a fall in life expectancy in 2015 (apart from males in the North East) but the extent of these decreases varied.

All regions had a slowdown in improvement between 2011 and 2016 (Table 3C). In four regions (North East, North West, West Midlands, South West) female life expectancy fluctuated between 2011 and 2016, but they had a negative average annual change.

[13] ONS publishes annual estimates of life expectancy for the English regions based on three years of data. The estimates in Figure 3J have been calculated by PHE for single calendar years so that recent trends can be more easily examined.

Figure 3J: life expectancy at birth by English region, 2001 up to 2016



Source: PHE analysis of ONS mortality data and population estimates

Local authorities

Due to their smaller populations, life expectancy at local authority level is subject to more fluctuation between years, than for regions or England as a whole. Analysis is therefore based on rolling three-year averages of data.

Changes in life expectancy by local authority in England are illustrated in Maps 1 and 2 for the periods between 2006-08 to 2010-12, and 2010-12 to 2014-16. It is evident that improvement in life expectancy has slowed across many local authorities.

Between 2006-08 and 2010-12, 318 local authorities had an increase in male life expectancy, 2 had no change and 4 had a fall. For females, 314 had an increase in life expectancy, 3 had no change and 7 had a fall.

The picture is different between 2010-12 and 2014-16: for males, 237 local authorities had an increase in male life expectancy, 15 had no change and 72 had a fall. For females, 207 had an increase in life expectancy, 30 had no change and 87 had a fall.

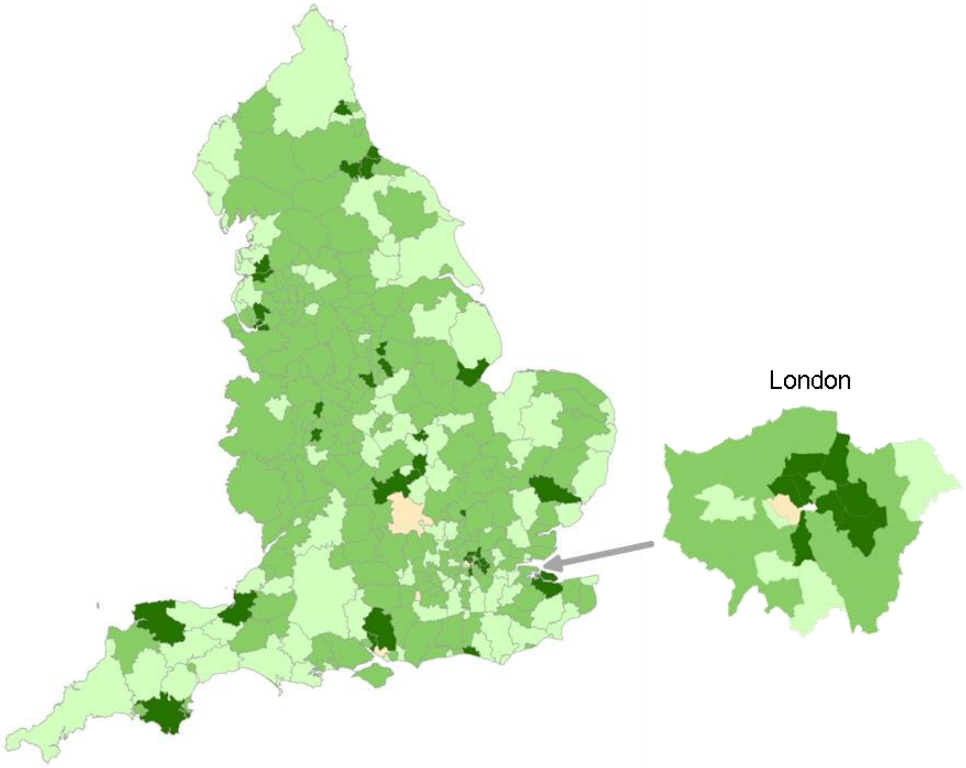
Of the 231 local authorities which had an increase in male life expectancy in both time periods, 177 areas had a greater increase between 2006-08 and 2010-12, than between 2010-12 and 2014-16. Of the 197 local authorities which had an increase in female life expectancy in both time periods, 146 areas had a greater increase in the earlier time period.

Table 3C: average annual absolute change in life expectancy at birth (years), English regions, 2001 up to 2006, 2006 up to 2011 and 2011 up to 2016*

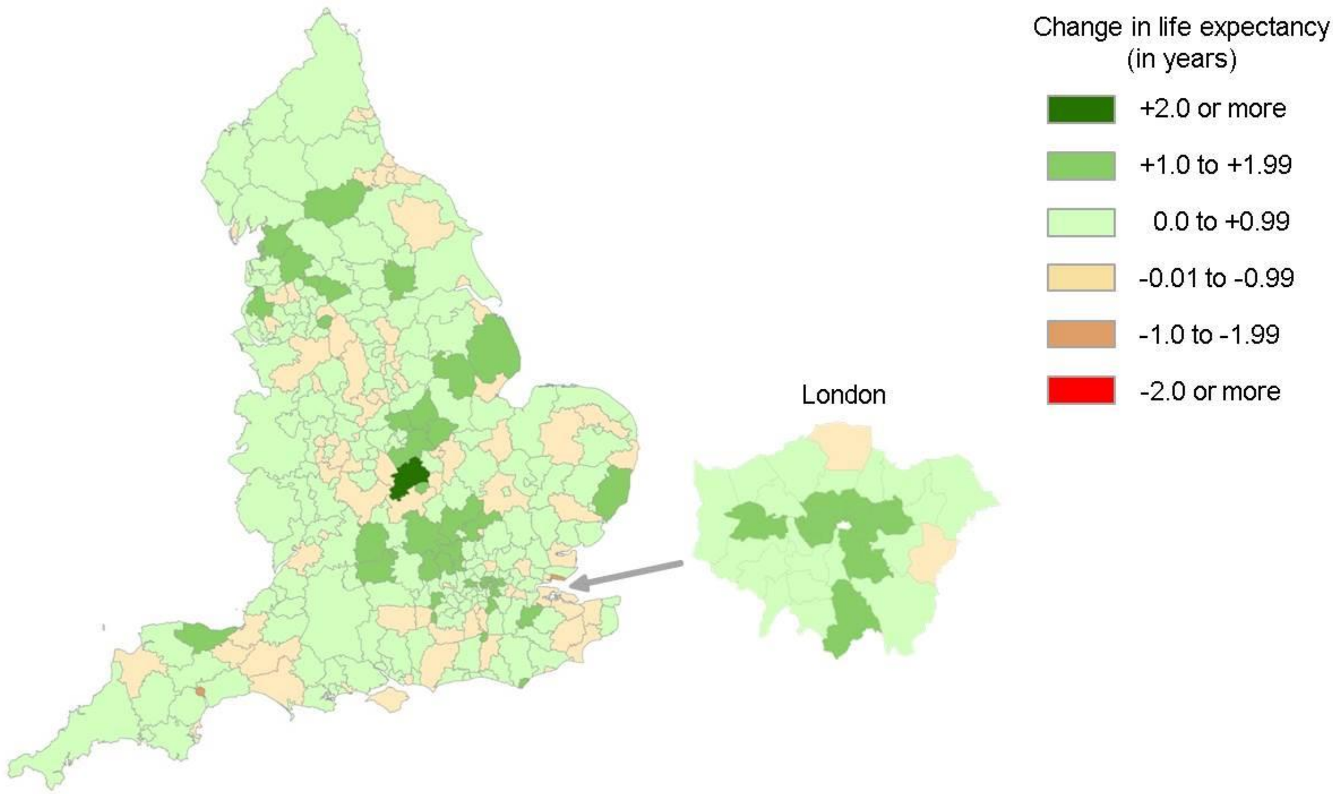
Males			
Region	**2001 to 2006**	**2006 to 2011**	**2011 to 2016**
North East	0.34	0.34	0.01
North West	0.30	0.33	0.09
Yorkshire and The Humber	0.29	0.31	0.08
East Midlands	0.28	0.32	0.06
West Midlands	0.27	0.40	0.00
East of England	0.30	0.30	0.05
London	0.40	0.40	0.17
South East	0.34	0.28	0.07
South West	0.31	0.26	0.04
Females			
Region	**2001 to 2006**	**2006 to 2011**	**2011 to 2016**
North East	0.19	0.28	-0.02
North West	0.23	0.26	-0.01
Yorkshire and The Humber	0.20	0.21	0.06
East Midlands	0.22	0.29	0.00
West Midlands	0.20	0.30	-0.01
East of England	0.25	0.24	0.01
London	0.32	0.30	0.12
South East	0.21	0.25	0.04
South West	0.25	0.20	-0.02

*A positive value indicates an improvement in life expectancy within the period
Source: PHE analysis of ONS mortality data and population estimates

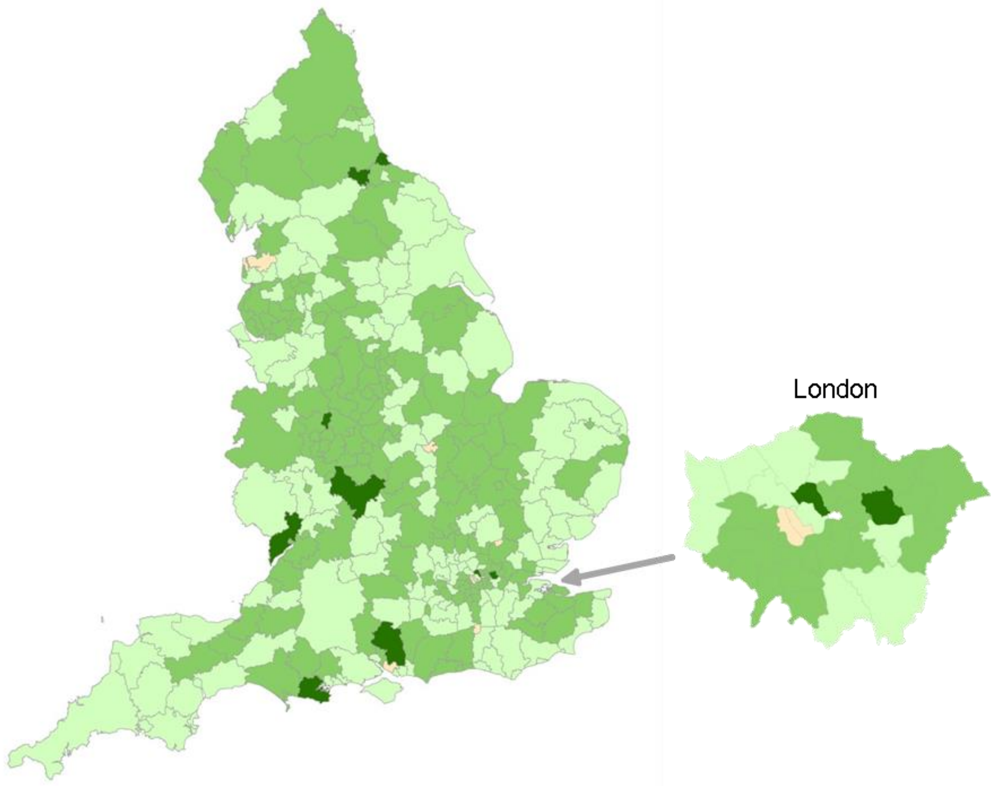
Map 1a: change in male life expectancy at birth, English local authorities, 2006-08 up to 2010-12



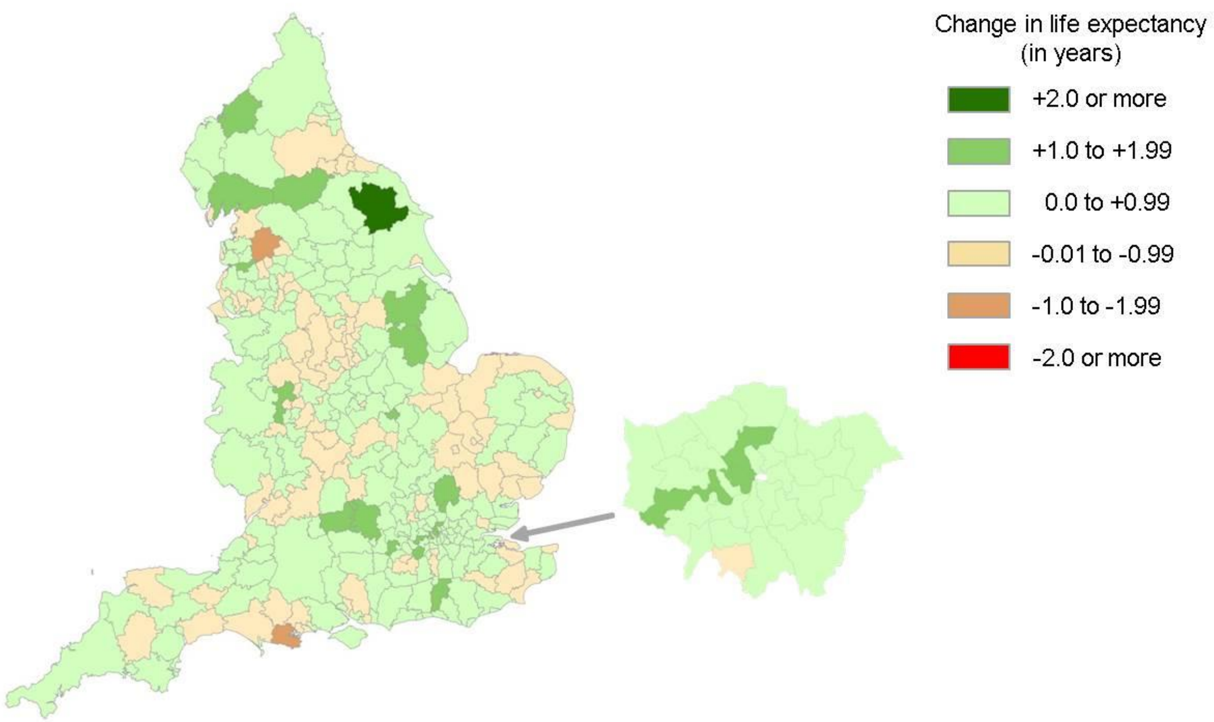
Map 1b: change in male life expectancy at birth, English local authorities, 2010-12 up to 2014-16



Map 2a: change in female life expectancy at birth, English local authorities, 2006-08 up to 2010-12



Map 2b: change in female life expectancy at birth, English local authorities, 2010-12 up to 2014-16



Source: PHE analysis of ONS life expectancy data

Trends by level of deprivation

Life expectancy trends by deprivation decile areas are shown in Figure 3K and Table 3D. For males and females all deciles had a slowdown in improvement in the most recent period.

Between the most and least deprived areas of England, the level of inequality, or gap, in life expectancy was 9.3 years for males and 7.3 years for females in 2014-16.[14] These figures are a summary measure of inequality between deprivation decile areas.

Inequality in life expectancy between the most and least deprived in England has fluctuated over recent years for males, but there was a significant widening between 2011-13 and 2014-16, indicating that improvement in the most deprived deciles was lower than for those in the least deprived deciles.

For females, there has been a statistically significant widening of inequality between 2001-03 and 2014-16, indicating that improvement in the most deprived deciles was lower than for those in the least deprived deciles throughout the period. In addition female life expectancy in the most deprived decile actually decreased between 2010-12 and 2014-16.

These findings are consistent with a recent report which examined trends in life expectancy in England by level of deprivation between 2001 and 2016.[91] This reported widening inequality in life expectancy for both sexes, and a decline in female life expectancy in the most deprived two deciles since 2011.

---

[14] Figures for 2014-16, as measured by the slope index of inequality, a summary measure of inequality across the social gradient from most to least deprived. See Definitions section for further details.

Table 3D: average annual absolute change in life expectancy at birth (years), English deprivation deciles*†

Deprivation decile	Males			Females		
	2001-2003 to 2005-2007	2005-2007 to 2010-2012	2010-2012 to 2014-2016	2001-2003 to 2005-2007	2005-2007 to 2010-2012	2010-2012 to 2014-2016
Most - 1	0.27	0.40	0.06	0.18	0.27	-0.04
2	0.32	0.34	0.07	0.24	0.22	0.00
3	0.35	0.32	0.08	0.25	0.22	0.08
4	0.29	0.33	0.11	0.24	0.22	0.04
5	0.33	0.29	0.11	0.26	0.22	0.06
6	0.31	0.28	0.13	0.24	0.23	0.06
7	0.34	0.26	0.13	0.25	0.23	0.09
8	0.36	0.30	0.10	0.26	0.25	0.08
9	0.33	0.29	0.12	0.28	0.25	0.09
Least - 10	0.37	0.27	0.12	0.29	0.28	0.10

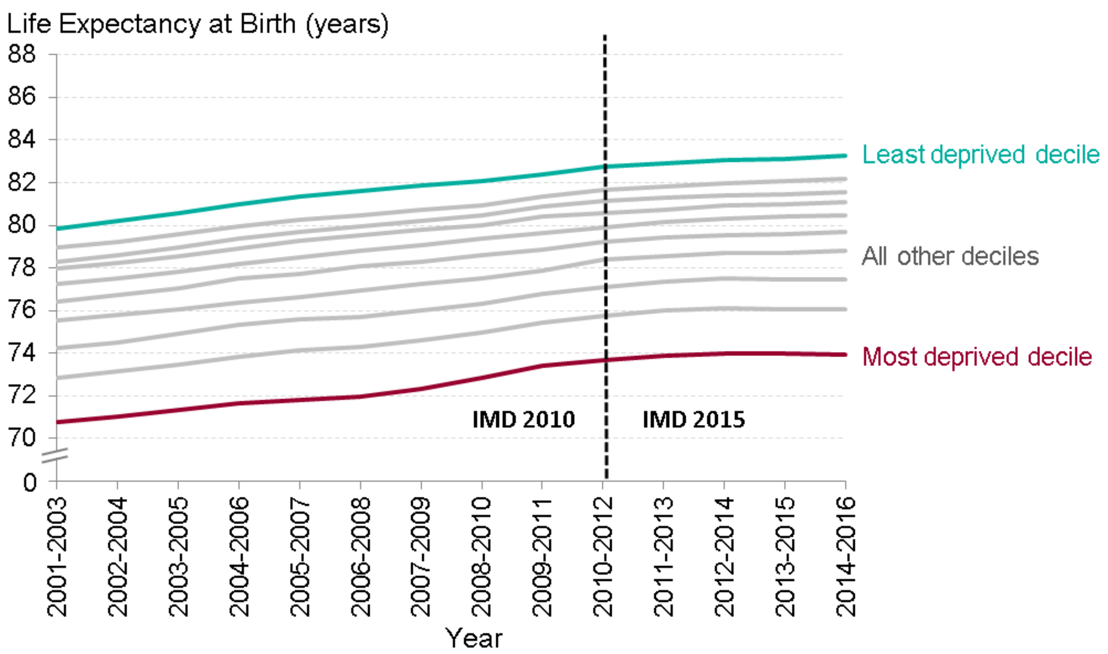
*A positive value indicates an improvement in life expectancy within the period

†Decile 1 = Most deprived, Decile 10 = Least deprived

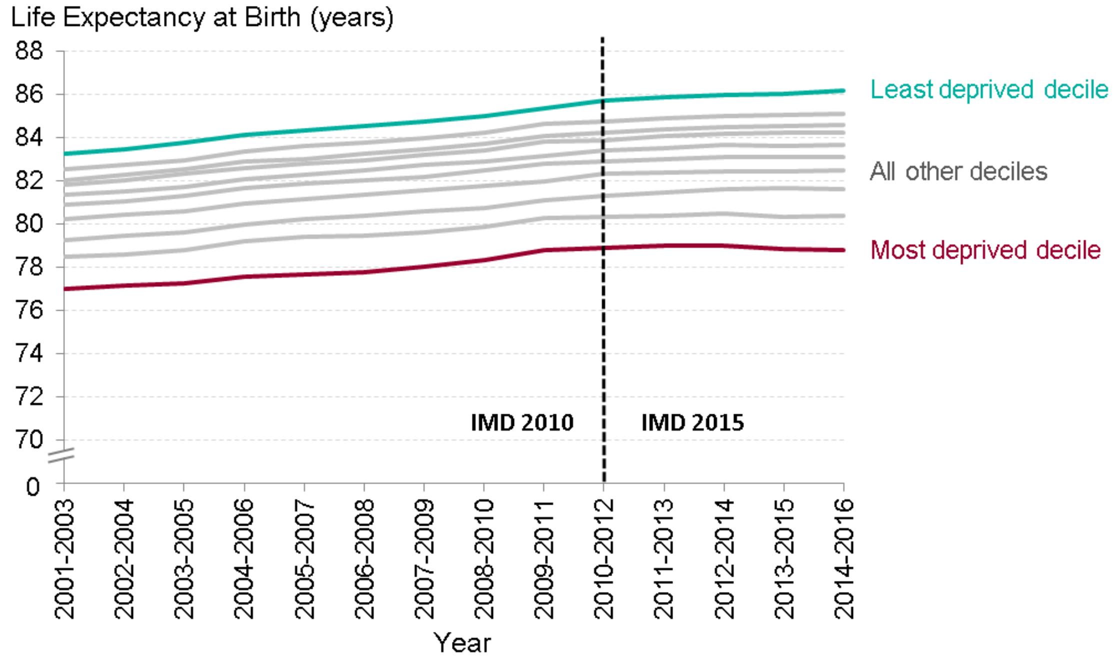
Source: PHE analysis of life expectancy by deprivation deciles in the Public Health Outcomes Framework

Figure 3K: trend in life expectancy at birth, for most and least deprived deciles*, England, 2001-03 to 2014-16

Males



Females



Source: Public Health Outcomes Framework

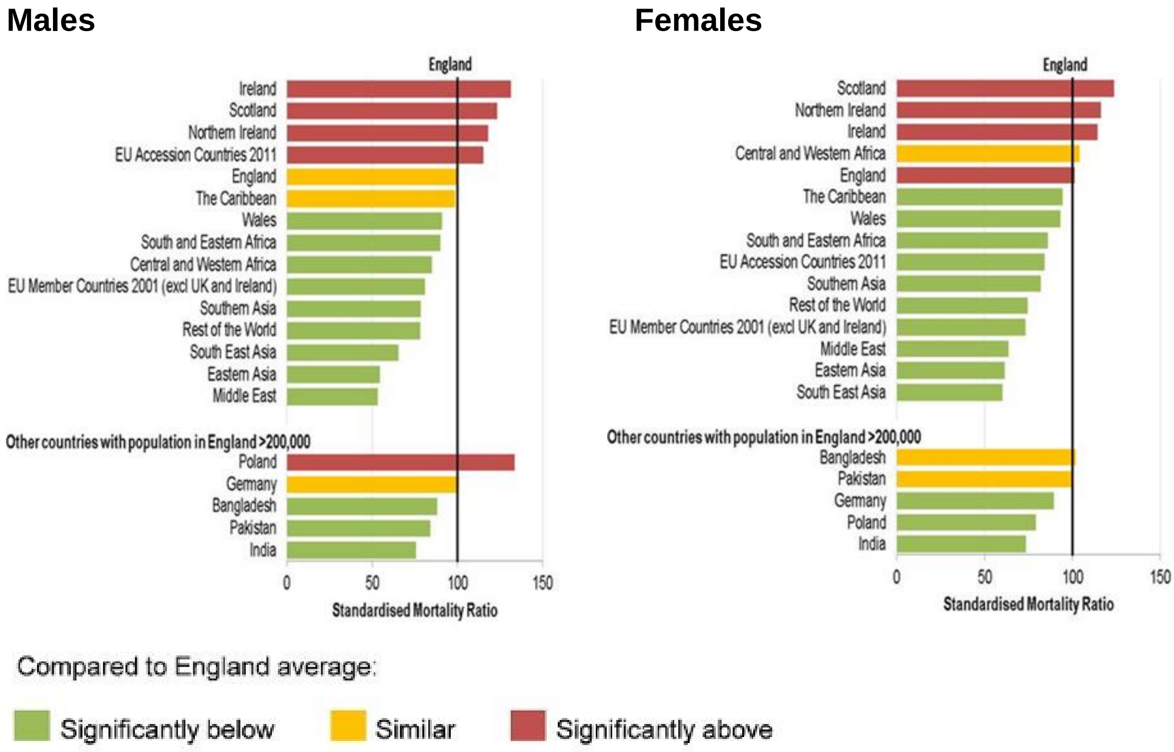
*Deciles based on groups of Lower Super Output Areas. Deprivation defined using Index of Multiple Deprivation 2010 (2001-03 to 2009-11) and Index of Multiple Deprivation 2015 (2010-12 onwards) from Ministry of Housing, Communities and Local Government

Mortality by country of birth

In 2011-13 (the latest years for which we have data), among people resident in England, standardised mortality ratios (SMRs) for men under age 75 born in Ireland, Scotland, Northern Ireland and those born in countries which joined the EU between 2004 and 2011 (EU accession countries[15]) were significantly higher than the England average. The highest SMR was for men born in Poland, their level of premature mortality was 34% higher than the male average for England (Figure 3L).

[15] The EU accession countries are Bulgaria, Cyprus, Czech Republic, Estonia, Hungary, Latvia, Lithuania, Malta, Poland, Romania, Slovakia and Slovenia. In chart 3L, Poland is reported by itself and as part of the group of EU accession countries.

Figure 3L: standardised mortality ratios for all cause deaths under age 75, by country of birth, England, 2011-13



Source: PHE Public Health Outcomes Framework: Health Equity report, focus on ethnicity, Figure 1G

The pattern was not quite the same for females. Women born in Scotland, Northern Ireland and Ireland had significantly high levels of premature mortality, but women born in the EU accession countries, including Poland, had significantly lower mortality than the England average.

Studies looking at mortality rates for earlier time periods also found high adult mortality in people born in Scotland and Ireland for both sexes.[21, 22] Results for 2001-03 for people born in Eastern Europe are also similar to those shown in Figure 3L for people born in the EU accession countries. Men born in Eastern Europe had higher mortality than the average for England and Wales for age groups from 20-69 years. Women born in Eastern Europe had lower than average mortality, except in the 20-44 age group (which was higher but not significantly higher than average).[22]

For both males and females, the SMRs for 2011-13 indicate that people born in groups of countries outside the UK, Ireland and EU accession countries had levels of premature mortality which were lower or similar to the England average (Figure 3L). Earlier studies found this was also the case for many country of birth groups, but there were exceptions with higher mortality found in some cases, including people born in

West Africa[21, 22] and men born in Bangladesh.[22] The results for 2011-13 for people born in these countries suggest relative improvement over time, but direct comparisons are not possible because of differences in the age groups and country groupings used for analysis.

Section 4: International comparisons

Comparison with other countries of the UK

Of the four countries of the UK, England has had the highest life expectancy for both males and females in recent years (Figure 4A). All four countries have experienced a slowdown in life expectancy improvements since 2011 (Table 4A), and all four had a decrease in 2015. However for females in Northern Ireland, life expectancy decreased slightly overall between 2011 and 2016.

The fall in life expectancy in 2015, and the slowdown in improvement, was therefore not confined to England.

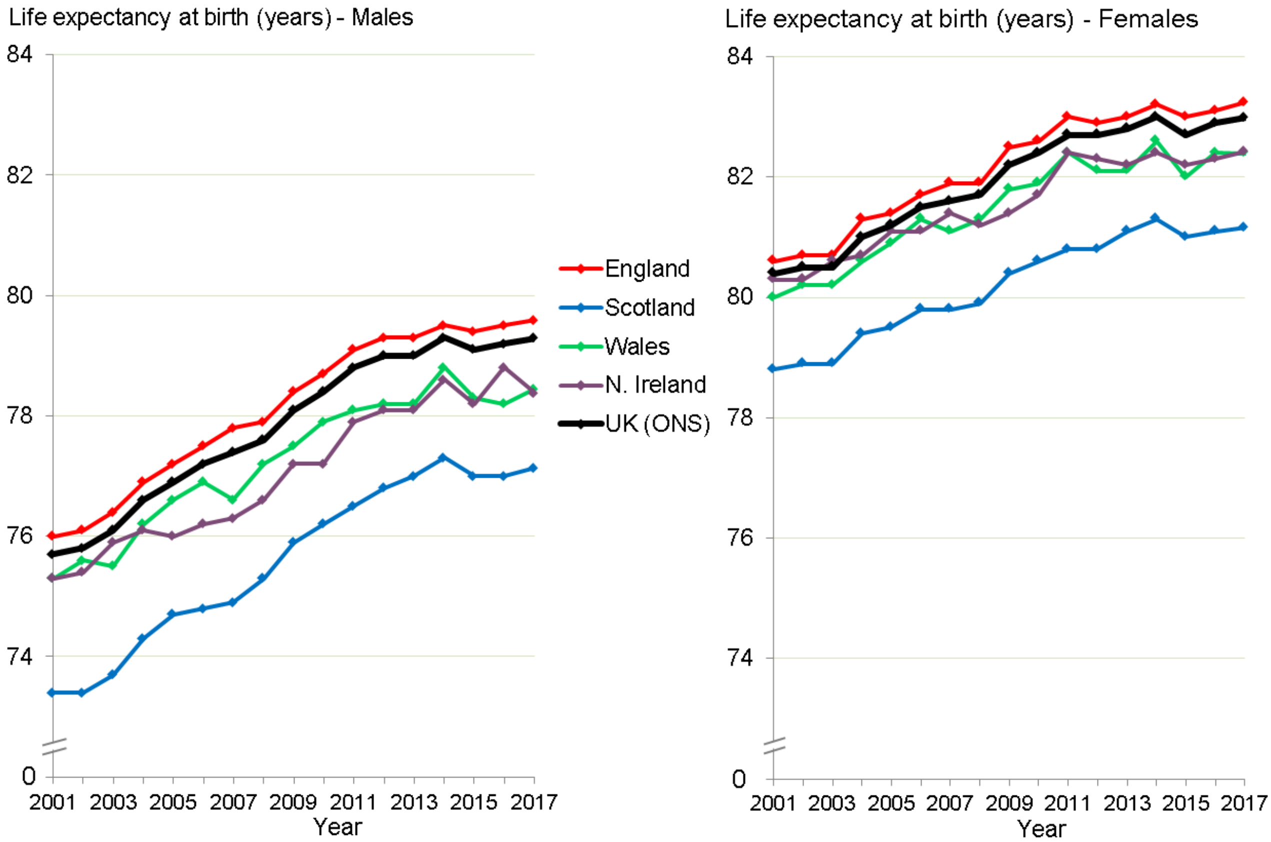
Table 4A: average annual absolute change in life expectancy at birth (years), UK and constituent countries, 2001 up to 2006, 2006 up to 2010, and 2011 up to 2016*

Country	Males			Females		
	2001 to 2006	2006 to 2011	2011 to 2016	2001 to 2006	2006 to 2011	2011 to 2016
England	0.32	0.32	0.07	0.23	0.26	0.03
N. Ireland	0.19	0.34	0.15	0.19	0.22	-0.02
Scotland	0.33	0.37	0.10	0.21	0.23	0.07
Wales	0.33	0.29	0.04	0.26	0.24	0.01
UK	0.32	0.33	0.07	0.23	0.25	0.03

*A positive value indicates an improvement in life expectancy within the period

Source: PHE analysis of data from ONS past & projected data from period life tables, UK, 1981-2066

Figure 4A: trends in life expectancy at birth, by sex, countries of the UK, 2001 up to 2017



Source: PHE analysis of data from ONS past & projected data from period life tables, UK, 1981-2066 (2001-2016) and 2017 single year life tables (2017)

These findings are consistent with ONS who also reported that in all four countries of the UK there was less improvement between 2011 and 2016 than between 2006 to 2011.[18]

Comparison with other countries of the EU and the USA

Considering the trend over the last 11 years, male life expectancy at birth in the UK has been consistently higher than the EU average (Figure 4B).[16] In 2006, it was 1.5 years higher, and the UK had the joint 6th highest male life expectancy out of the 28 EU countries. Its relative position reduced in 2016 to 10th highest, when it was 1.2 years higher than the EU average.[23]

The picture is worse for UK female life expectancy at birth, which has been consistently lower than the EU average. In 2006 it was 0.4 years below the average, and by 2016 it

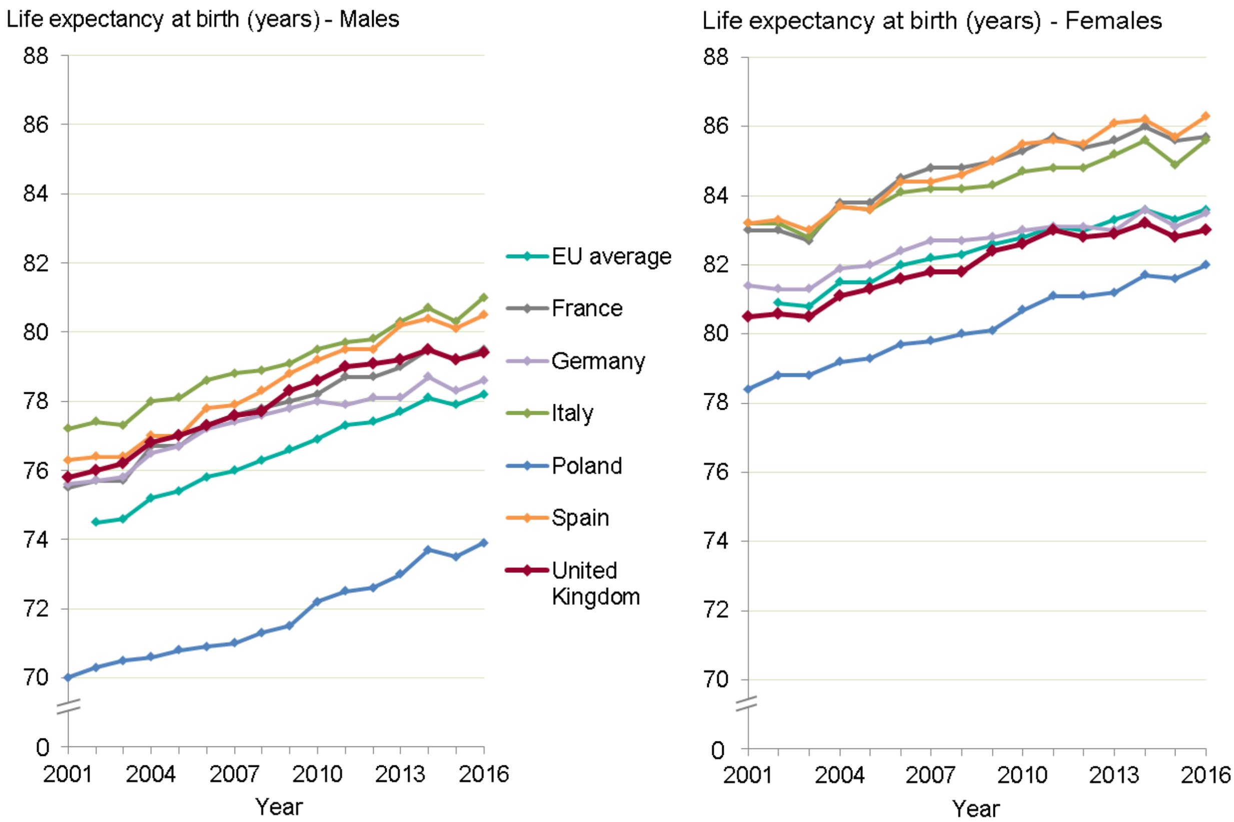
---

[16] ONS life expectancy estimates for England cannot be compared with Eurostat estimates for EU member states because of differences in the methods used.

was 0.6 years lower. The UK rank order was the same in 2006 and 2016, 17th out of the 28 EU countries.

All of the largest EU countries had a fall in life expectancy between 2014 and 2015 (Figure 4B).[17]

Figure 4B: trends in life expectancy at birth, by sex, large EU countries, 2001 up to 2016*



* Data for the EU28 countries are not available for 2001. Source: PHE analysis of data from Eurostat Database

[17] Large EU countries were defined as having a population greater than 35 million.

Table 4B: average annual absolute change in life expectancy at birth (years), EU countries with largest populations and EU as a whole (EU 28)*†

Country	Males			Females		
	2001 to 2006	2006 to 2011	2011 to 2016	2001 to 2006	2006 to 2011	2011 to 2016
France	0.37	0.26	0.17	0.31	0.22	0.03
Germany	0.33	0.16	0.13	0.22	0.13	0.07
Italy	0.28	0.22	0.24	0.19	0.15	0.13
Poland	0.17	0.34	0.30	0.24	0.28	0.19
Spain	0.28	0.37	0.20	0.22	0.28	0.12
UK	0.32	0.35	0.07	0.23	0.29	0.01
EU 28	0.34	0.30	0.18	0.29	0.22	0.11

*Data for the EU28 countries are not available for 2001. Source: PHE analysis of data from Eurostat Database
†A positive value indicates an improvement in life expectancy within the period

As with the UK, for the EU as a whole there was a slowdown in improvement in life expectancy between 2011 and 2016 for both sexes (Table 4B). In addition, with the exception of males in Italy, all of the largest EU countries had a smaller annual improvement in the later period.

It is however clear that improvement in life expectancy in the UK between 2011 and 2016 was lower than in the other largest EU countries, and the EU as a whole, for both sexes. The change in the rate of improvement was greater for the UK than the other large EU countries, although France, Spain and Germany also saw a marked slowdown in improvement, especially for females.

This analysis is supported by an ONS report which compared changing trends in mortality across 20 countries from across Europe, North America, and including Australia and Japan.[24] Most other countries analysed by ONS experienced a slowdown in mortality improvement in the early 2010s. This slowdown was seen across all age groups, but was observed most widely across the analysed countries for the 65 to 79 age group. Females were also more affected than males.

Out of the 20 countries analysed by ONS, the UK and USA experienced the greatest relative slowdowns for both sexes. For the UK, the ONS state that this was in part explained by the UK experiencing large gains in life expectancy between 2001 and 2011. Nordic countries (except for Sweden) have not experienced slowdowns in life expectancy improvements. Japan had the largest increase in improvements after a period of low life expectancy gains, demonstrating that a country can return to faster improvements after a period of slow growth.

The experience of the USA is different from the UK, however. Life expectancy fell in the United States in 2015, as in many countries in Europe, but unlike most European countries, it fell again in 2016.[25] In comparisons by ONS of life expectancy across 20 countries, the USA ranked lowest for females and third lowest for males in 2015.[24]

The USA also ranks lowest in another study comparing life expectancy across 18 high income countries.[26] That study found declines in life expectancy were widespread between 2014 and 2015, but the decline in the USA was largely concentrated at younger ages, unlike other countries where it was concentrated at ages 65 and over. The decline was attributed to external causes, such as drug overdoses, and the US ‘opioid epidemic’ and its impact on numbers of deaths has been well documented.[27][28]

The comparison of the UK to other countries shows that the slowdown in mortality improvements has been experienced elsewhere. It may be that some similar factors affecting the mortality experience in England/UK are also affecting other countries. However, the UK, along with the USA, has had one of the most substantial slowdowns in life expectancy for both sexes.

Section 5: Potential explanatory factors

Introduction

This section considers some possible explanations for the findings demonstrated that can be investigated using routine data, including a review of available literature, and makes suggestions for further research.

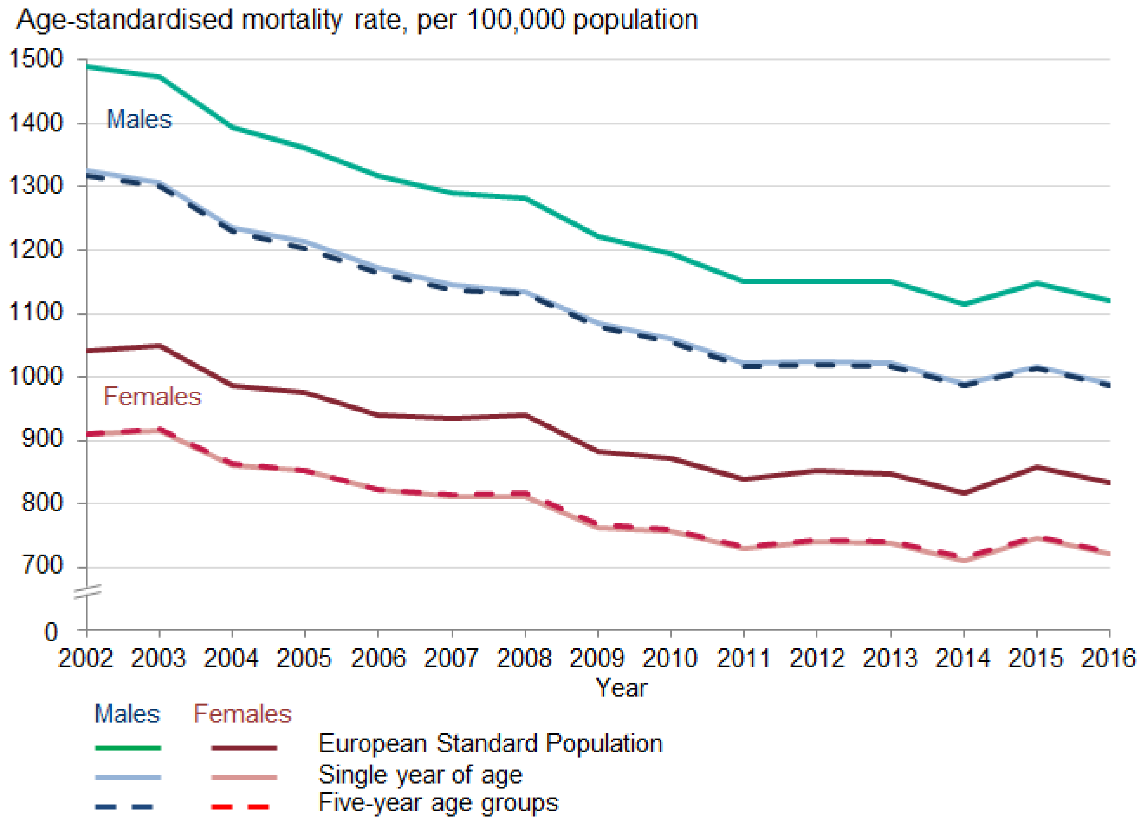
Measurement artefact

Standardisation methods

The all-age mortality rates presented in Section 2 and 3 are age-standardised, which adjusts for changes in the age structure of the population, meaning valid comparisons can be made between rates in different years (see Definitions section for further details). They were calculated using a standard method in which the age specific rates, in five-year age bands up to a final age band of 90+, were weighted according to the age structure of the European Standard Population. It is possible, however, that this may not adequately standardise for changes in the population. For example, if the population aged over 90 is getting older over time, this will not be taken into account by the standard method of standardisation.

To examine this, age-standardised mortality rates were calculated using the population of England in 2011 as the standard population, by single year of age up to a final age band of 100+, and by five-year age groups up to a final age band of 90+. It is clear that there is almost no difference between the trend in these rates and rates calculated using the standard method (Figure 5A). It is therefore unlikely that recent trends in mortality rates in England are influenced by an artefact related to the method of age-standardisation being used.

Figure 5A: mortality rates standardised by single year of age to 100+ and by five-year age group to 90+, England, 2002 to 2016



Source: PHE analysis of ONS data[18]

Population estimates

The mortality rates and life expectancy estimates presented in this report are calculated with annual mortality data and population estimates from ONS. Therefore recent mortality trends would be influenced by changes or inaccuracies in the estimated size and age structure of the population.

The slowdown in improvement in mortality started around 2011, which is also the year of the last census. Population estimates for 2011, and every year since, are based on data collected in that census, and the results were also used to adjust estimates back to 2002. If the process for creating estimates since 2011 resulted in an underestimate of England's population, this would raise mortality rates. Conversely, if the population was

[18] The rates by single year of age and five-year age groups were both calculated using the population of England in 2011 as the standard population, but one set used age-specific rates by single year of age up to 100+, while the other was based on the five-year age groups used elsewhere in this report, up to 90+, ie.: 0-4, 5-9, 10-14….80-84, 85-89, 90+. Those five-year age groups were also used to calculate the third set of rates which were standardised using the European Standard Population.

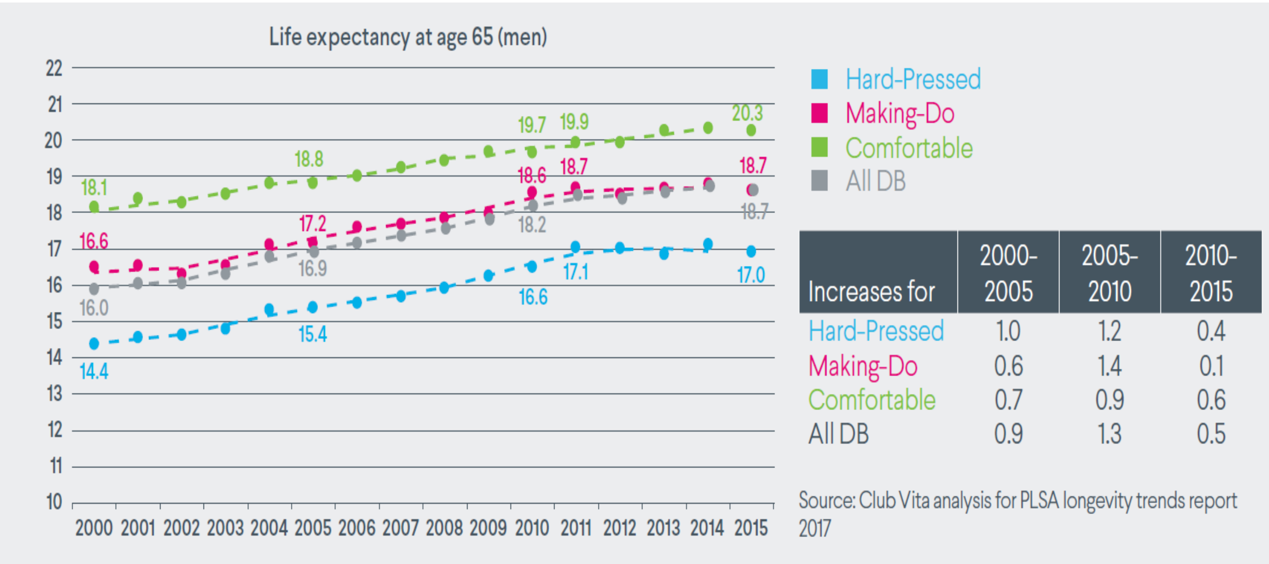
an overestimate prior to 2011, but has been more accurate since, this would mean that mortality rates in the past were too low.

The life expectancy estimates for other UK and EU countries, and the USA, also show a general pattern of a slowdown in improvement since 2011, however, many other countries also conducted a decennial census around that year. The estimates for Scotland and Northern Ireland are based on population estimates derived from the 2011 Censuses conducted independently in those countries (but using an aligned methodology).[19]

The Pensions and Lifetime Savings Association and Club Vita LLP have also published life expectancies based on a database of around 2.5 million members of defined benefit pension schemes.[29] Life expectancy for men aged 65 is shown in Figure 5B from 2000 up to 2015, with men divided into three socio-economic groups.

For all three groups, improvement in life expectancy was lower in the later period (between 2010 and 2015) than between 2000 and 2010. In the later period there was less improvement in the 'Hard-Pressed' and 'Making-Do' groups than in the 'Comfortable' group. This is consistent with the trends in life expectancy by deprivation reported earlier in Table 3D.

Figure 5B: male life expectancy at age 65 - estimates from pension company models by socio-economic group, 2000 to 2015



Increases for	2000-2005	2005-2010	2010-2015
Hard-Pressed	1.0	1.2	0.4
Making-Do	0.6	1.4	0.1
Comfortable	0.7	0.9	0.6
All DB	0.9	1.3	0.5

Source: reproduced with permission from the Pensions and Lifetime Savings Association (PLSA) and Club Vita LLP (CV LLP). You must not rely on this material and neither PLSA nor CV LLP accept any liability for it.

[19] ONS is responsible for the census in England and Wales. National Records of Scotland is responsible for the census in Scotland, and the Northern Ireland Statistics and Research Agency is responsible for the census in Northern Ireland.

These figures are based purely on analysis of the database of pension scheme members, rather than being based on ONS population estimates, which are not used in the calculations. Despite that, the trend for these estimates broadly reflects those based on ONS populations. It is therefore unlikely that the slowdown in improvement is due to inaccuracies in the population estimates, or change in the methods of estimating the size of the population.

Ambient temperature

Estimates of excess winter deaths, produced by ONS,[20] measure the excess in winter compared with the average of non-winter months.[30] This is a different method to the EuroMOMO model presented later, which compares numbers of deaths seen each week with expected numbers for that week based on data from previous years. EuroMOMO therefore takes account of underlying seasonal variation in deaths.[31] The ONS approach does not allow for seasonality and therefore a much larger apparent excess is reported than with the EuroMOMO method.

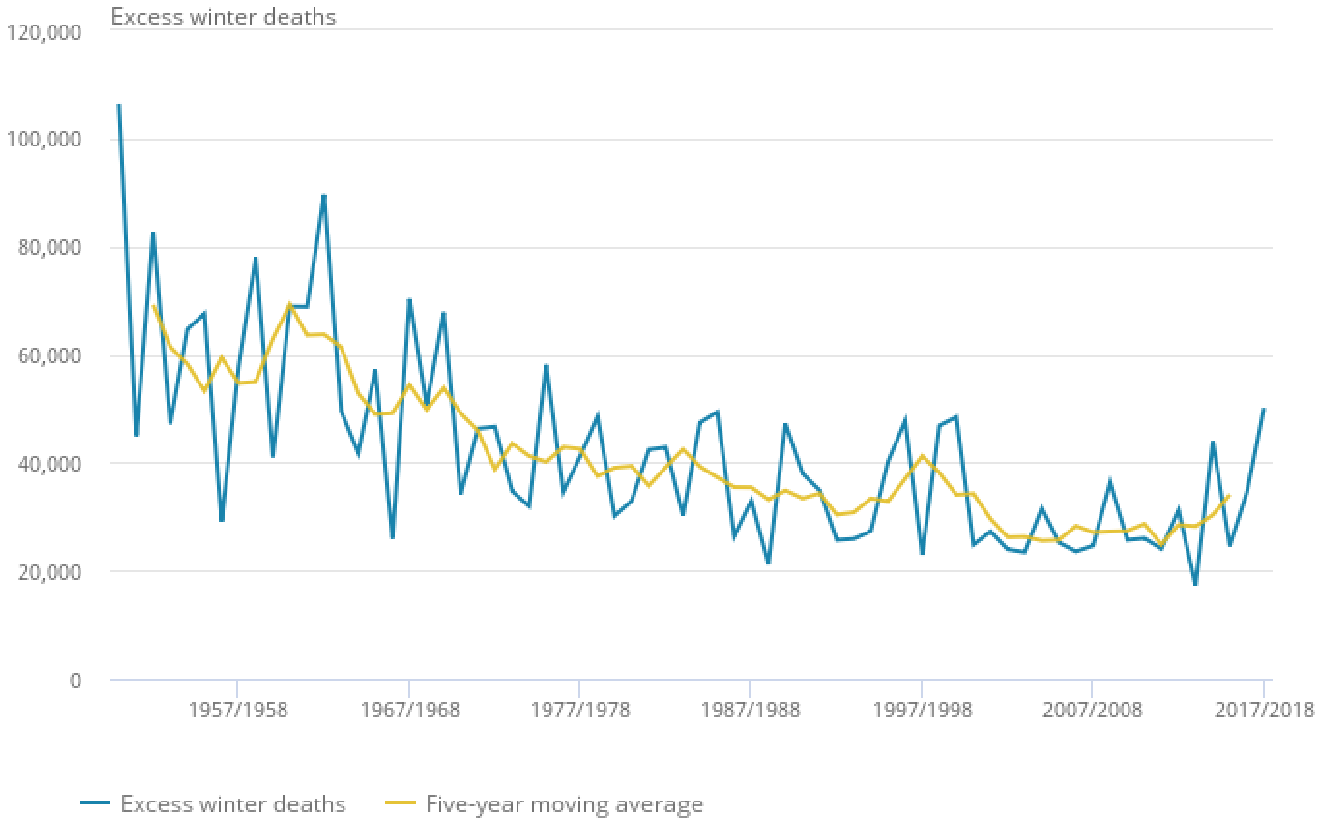
Although there are large fluctuations in the annual number of excess winter deaths using the ONS method, the rolling five-year average, which smooths out short term fluctuations, has generally declined since the early 1950s, though there was an increase in the late 1990s (Figure 5C).[30] However, there has been little improvement in the five-year average since the winter of 2002/03, and it has increased in the last two time periods.

Respiratory diseases, including influenza, are one of the leading contributors to excess winter deaths, but there are also more deaths from cardiovascular disease and dementia in the winter months.[30]

Low temperature can pose a risk to all age groups, but risks are greatest in older people. Extreme cold can lead to death through hypothermia, but this is relatively rare. Exposure to cold can also cause deaths from heart disease, stroke and respiratory disease, as well as from falls and injuries.[32] The onset of cold weather can lead to an almost immediate increase in deaths from heart disease, reaching their highest levels after two days. Increased incidence of stroke takes place approximately five days after onset of cold periods and deaths from respiratory illnesses peak at 12 days. [32] Therefore, the effect of low temperatures on increased mortality can have a lag of three to four weeks.[33, 34]

[20] This measure makes no adjustment for the age structure of the population and so the ageing population is not taken into account in these estimates. See Definitions section for further details.

Figure 5C: ONS excess winter deaths and five-year moving average, England and Wales, 1950/51 to 2017/18



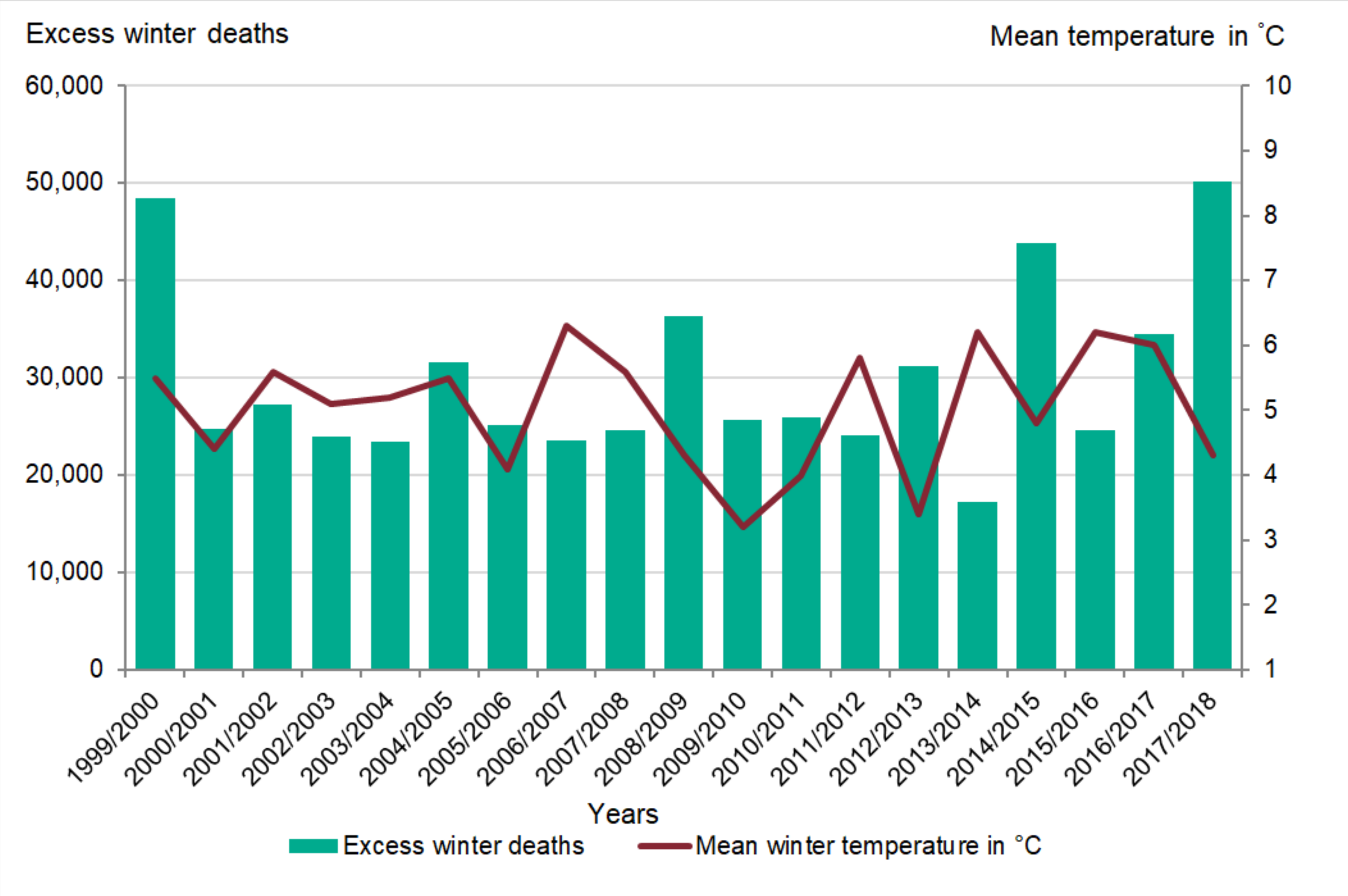
Source: ONS excess winter mortality data

Housing and fuel poverty are key to cold weather vulnerability: it has been reported that the 25% of homes which are coldest have almost three times as many excess deaths in winter than the warmest 25%. [35]

Figure 5D shows how trends in ONS excess winter deaths compare with trends in the average winter temperature since winter 1999/2000. The mean winter temperature masks considerable variation in temperatures within the season and between geographies, and does not necessarily reflect the temperature in the location at which people became ill or died.

Although not shown in the chart, since 1980 the mean winter temperature for England has increased.[36] However, there was a considerable drop in the temperature in winter 2009/10, which had the coldest December in the last 100 years,[37] and there was a similarly cold winter in 2012/13. The excess winter deaths were not particularly high in winter 2009/10, but were relatively high in 2012/13.

Figure 5D: ONS excess winter deaths in England and Wales and average winter temperature, between winter 1999/2000 and winter 2017/18



Source: ONS excess winter mortality data

Figure 5D shows that there were 50,100 excess winter deaths in England and Wales in 2017/18. This was higher than in any year since 1975/76. January 2018, when numbers of deaths were particularly high (Figure 1C), was warmer than average in England and Wales, but February and March were colder than average and early March was exceptionally cold. [92.93]

There were 43,850 excess winter deaths in England and Wales in 2014/15, higher than in any year since 1999/2000. The winter of 2014/15 was colder than neighbouring winters, however the number of excess deaths resulted largely from a peak in the first half of January 2015. That period was described as very mild by the Met Office however,[38] and while the second half of the month was considerably colder, the daily number of deaths was falling by then (Figure 1B). The winter of 2016/17 also had relatively high excess winter deaths, but the mean winter temperature was relatively mild.

Extreme high temperatures can also impact on the number of deaths. Notable heatwaves occurred in England in 1976, 1995, and 2003.[39-41] In 1976 there was a significant increase in the annual age-standardised mortality rate for both sexes, and in

1995 and 2003 there was a significant increase for females. These increases were not necessarily related to excess deaths during the heatwaves, however. In 1976, for example, there was also an intense flu season and some very cold spells.[94,95] During the 2003 heatwave, there was a 17% increase in deaths, resulting in 2,091 additional deaths in England.[41] Despite this increase in deaths over the heatwave period, it had little effect on the total number of deaths that year.

ONS released a blog on this summer's heatwave but concluded that it was too early to draw conclusions about the impact on deaths from the provisional data available at that point.[42] ONS will report further on deaths during the summer of 2018 in the next of their quarterly mortality reports,[7] due for release in December 2018, but they did note some peaks in the number of deaths on a few days coinciding with an increase in temperature in June.[17] PHE is also planning to report on the impact of the 2018 heatwave.

In summary, both low and high temperatures can have an impact on numbers of deaths. Mean winter temperatures in England have been generally increasing but, as the next section confirms, cold has exacerbated the burden of winter deaths in some recent years. The relationship between cold and excess winter deaths is not straightforward however, as other factors, such as influenza, will also influence the level of winter mortality.

Influenza

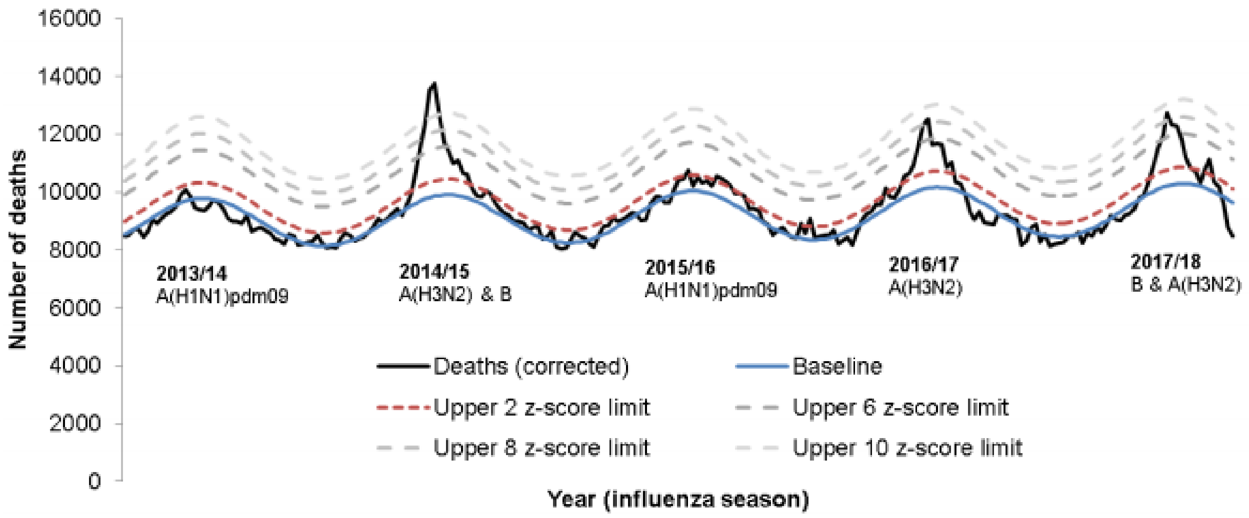
It is not straightforward to estimate the number of people who die each year from flu.[43] For many people who die from flu-related complications, flu is not mentioned on the death certificate or it is not selected as the underlying cause of death. For example, many older people, who are particularly vulnerable to flu, are not tested to confirm a flu infection. Some people with flu go on to develop pneumonia (which is more frequently recorded on the death certificate) but flu can also aggravate an existing chronic condition, such as heart disease, which is then selected as the underlying cause of death instead. Reporting the number of deaths where flu is recorded as the underlying cause of death would therefore greatly underestimate the burden of flu infections on mortality.

PHE monitors the association of flu activity with estimates of excess deaths in winter using a model developed by the European Mortality Monitoring Network (EuroMOMO).[31] EuroMOMO monitors real-time mortality data for all participating European countries, using a standardised approach, and therefore allows comparison of the mortality experience in England with other countries.[31] [21]

[21] The EuroMOMO model is endorsed by the European Centre for Disease Prevention and Control, an EU agency for the control of infectious disease.

The EuroMOMO model compares numbers of deaths seen each week with the expected baseline for that week based on data from previous years. Therefore, the baseline takes account of underlying seasonal variation in deaths. Estimates from EuroMOMO show the peak in excess deaths in the winter of 2014/15 in England and the subsequent winters of 2016/17 and 2017/18 (Figure 5E).The number of deaths in these winters (black line) were far above the expected baseline (blue line).

Figure 5E: weekly observed and expected number of all-age all-cause deaths, with the dominant circulating strain type(s), England, 2013/14 to 2017/18



Source: PHE flu annual report: 2017 to 2018 (Figure 33)

The dominant subtype of circulating flu in 2014/15, 2016/17 and 2017/18 was A(H3N2), which is widely recognised to have a more severe impact in older people compared with other seasonal influenza viruses.[44, 45] In contrast, in the winter of 2013/14 the dominant circulating subtype was A(H1N1)pdm09 and the numbers of deaths in that winter was generally below the expected baseline estimate (Figure 5E).[22] This was also the dominant strain in 2015/16, when deaths were above the baseline at times, but did not peak as they did in the winters either side.

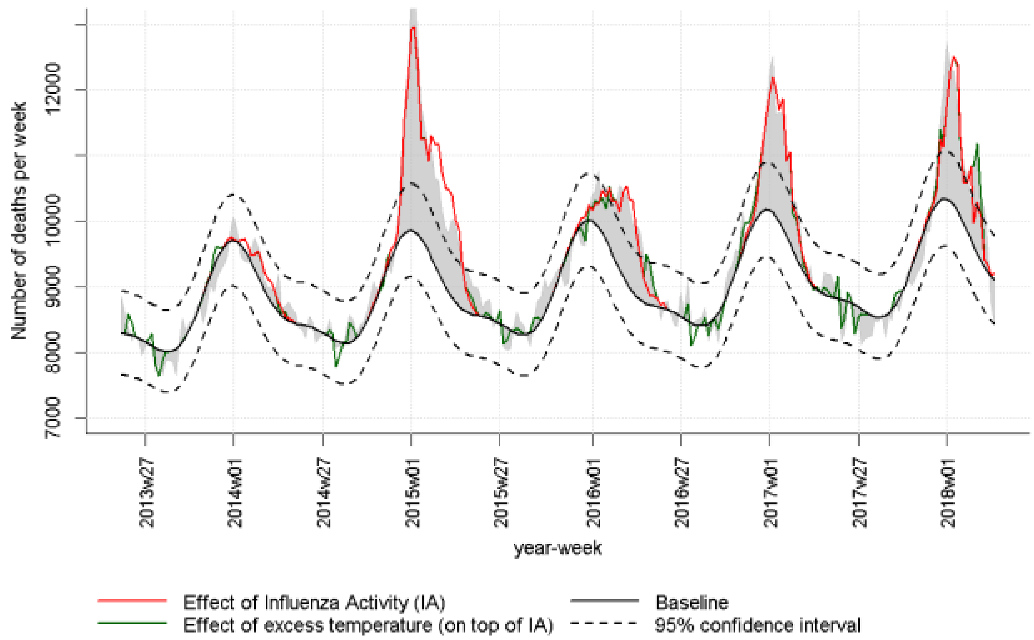
EuroMOMO also reported pronounced increases in the number of deaths in the winters of 2014/15, 2016/17 and 2017/18 in most other participating countries.[31] Therefore, excess mortality was not confined to England. EuroMOMO report that excess mortality among older people was the main contributor to the overall increase in mortality during these winters, though the 15–64 age group also made a contribution.

[22] Using the ONS definition, 2013/14 had the lowest level of excess winter deaths (17,300) since ONS records began in 1950/51.

As cold weather and acute respiratory infections often occur at the same time, the FluMOMO model has been created as an extension of the EuroMOMO model. It aims to quantify the excess number of deaths associated with influenza activity, adjusting for extreme temperatures.[46]

Estimates from the FluMOMO model suggest that the excess deaths seen in winters of 2014/15, 2016/17 and 2017/18 were primarily associated with flu rather than temperature (Figure 5F – red line). In 2018, cold weather was associated with a second peak in March, as shown by the green line in the chart.

Figure 5F: weekly number of all-age deaths and attribution to influenza (red line) and extreme temperature (green line), England, 2013 to 2018 (up to week 15)



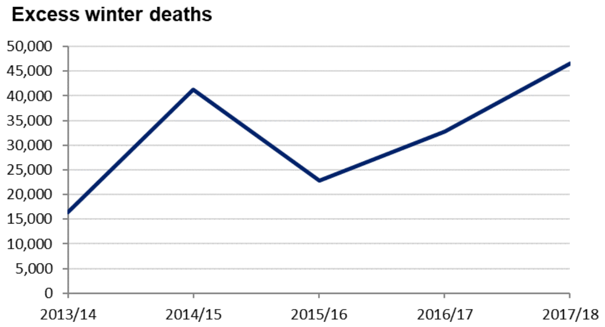
Source: PHE flu annual report: 2017 to 2018 (Figure 34)

To enable further comparisons between recent winters, available data are shown for 5 key indicators in Figure 5G. These are ONS excess winter deaths, FluMOMO deaths from flu, flu vaccine effectiveness, flu vaccine uptake and mean winter temperature.

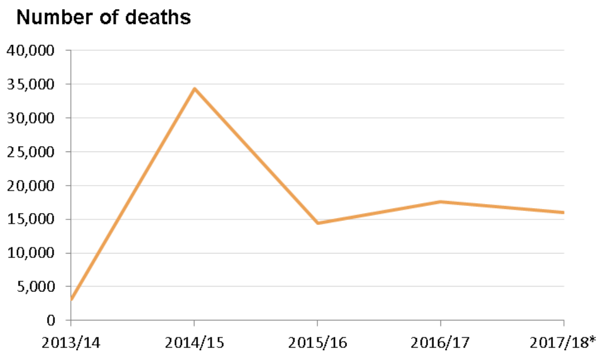
In recent years flu vaccine effectiveness has varied in the UK. The 2014/15 vaccine was only 34% effective for all ages,[47] and the 2016/17 vaccine 40% effective.[48] Vaccine effectiveness is typically less at older ages as was the case in these two winters. Estimates for the 2017/18 vaccine show it was only 15% effective for all age groups (10% effective for those aged 65 and over).[48] In contrast during the 2015/16 winter when the A(H1N1) subtype dominated, vaccine effectiveness was higher at 52% for all age groups.[48]

Figure 5G: Recent trends in winter deaths, winter temperatures, flu vaccine uptake and effectiveness.

Excess winter deaths in England (ONS method)

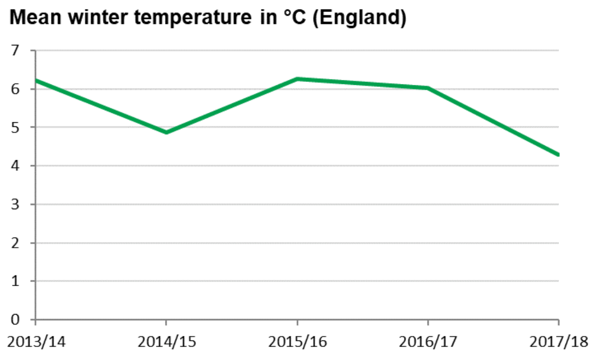


Deaths associated with influenza in England (FluMOMO model)

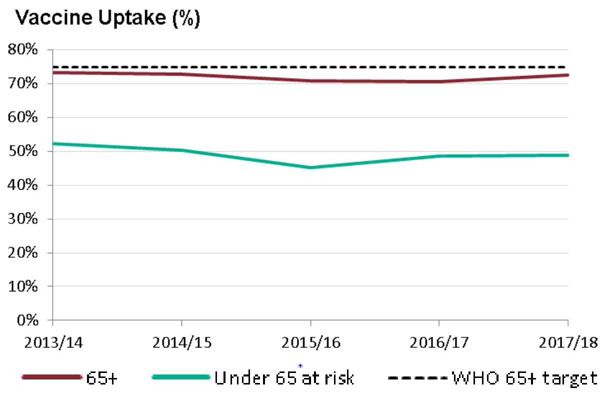


*Includes data to week 15 in 2018

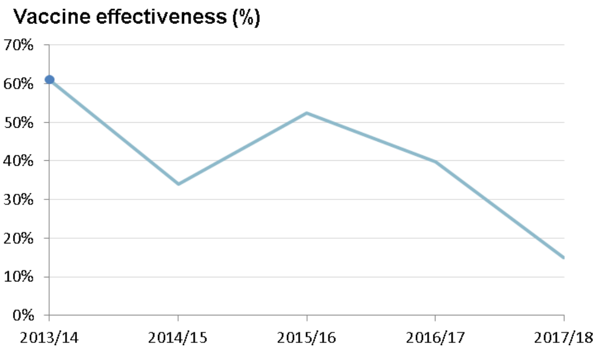
Average winter temperature in England



Flu vaccine uptake in England



Flu vaccine effectiveness in the UK



*2013/14 value is a mid year estimate

The percentage uptake of flu vaccination in adults aged 65 and over was 73% in 2017/18.[49] Vaccine uptake in this group has not changed very much in recent years, varying between 70 and 74%. The percentage uptake in ‘at risk’ individuals (aged six months to under 65 years, excluding pregnant women) has also been relatively stable and was 49% in 2017/18.[50]

The mean winter temperatures in 2013/14, 2015/16 and 2016/17 were similar (Figure 5G). The winter of 2014/15 was colder than adjacent winters, and 2017/18 was colder still.

The relationship between indicators is clear for the winter of 2014/15: there was a high number of deaths associated with flu, a high number of excess winter deaths (ONS method), a low average winter temperature and flu vaccine effectiveness was lower than in the following two winters. Flu vaccine effectiveness and the mean winter temperature were even lower in 2017/18, and this had the highest number of excess winter deaths, although the FluMoMo model estimates that there were far fewer deaths associated with flu in 2017/18 than in 2014/15 (Figure 5G). This may partly be explained by the fact that the baseline for the FluMoMo model is higher in 2017/18 than in 2014/15 and the number of deaths associated with cold weather was higher in 2017/18 than 2014/15. The 2017/18 FluMoMo estimate is also provisional and will be revised in the next PHE annual flu report.

In contrast, in 2013/14 there were only an estimated 3,100 deaths associated with flu (compared with 34,300 in 2014/15), there were only 16,300 excess winter deaths (ONS method) (compared with 41,300 the following winter) and vaccine effectiveness was the highest of the period examined.

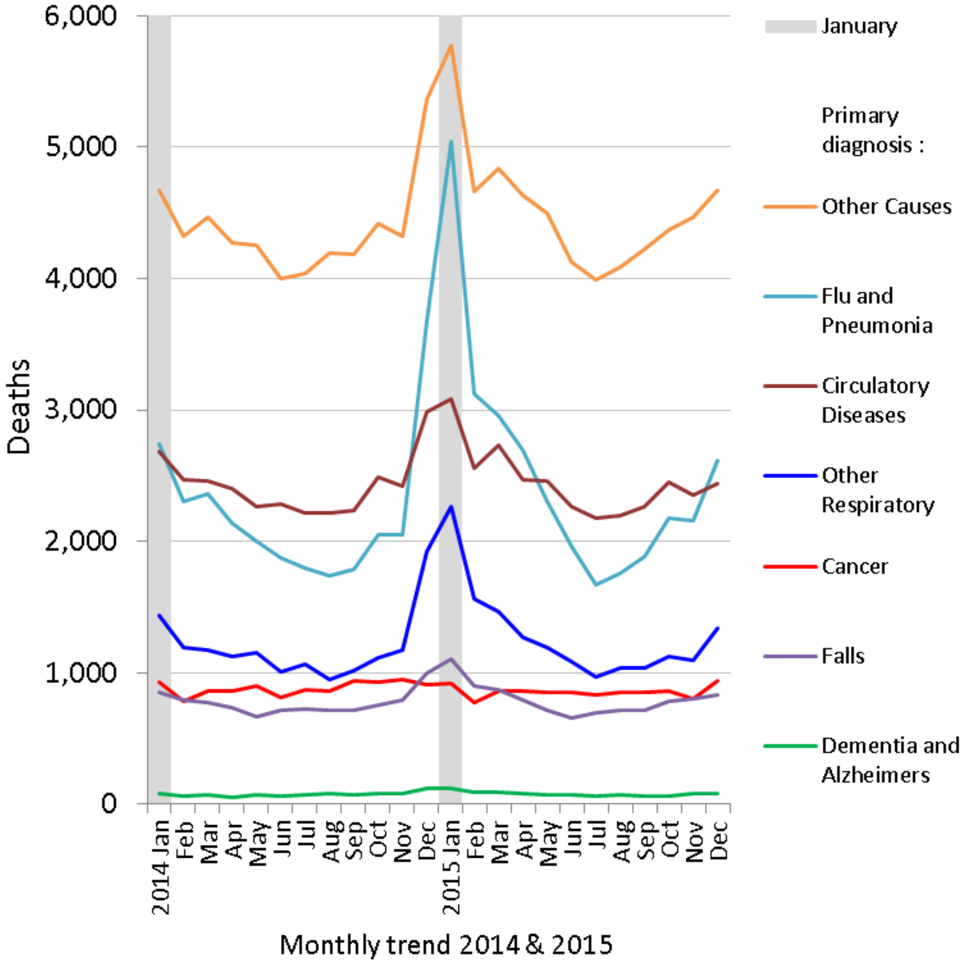
Out of these factors examined, the dominant subtype of circulating flu and the vaccine effectiveness appear to have been the most important factors in determining the number of deaths in recent winters, which are sometimes exacerbated by cold weather. These findings are consistent with, and supported by, analysis of the EuroMOMO model across participating countries. [51] [52]

Further analysis of 2015

To further examine the peak in deaths in winter 2014/15, analysis was undertaken of hospital episode statistics (HES) linked with mortality data. Figure 5H presents data on people aged 75+ who died in 2014 and 2015, and were admitted to hospital as an emergency in the week before death, or died in hospital from an emergency admission. This represents 45% of all deaths among people aged 75 and over in England.

The number of deaths is broken down by primary diagnosis on admission, by month. The number of people admitted for most causes increased in January 2015, although admissions for flu and pneumonia had by far the largest increase. This is further evidence that flu was having an impact during January 2015 when there was a significant peak in deaths. The increase in admissions for other causes, such as circulatory disease and other respiratory, is also likely to reflect the impact of flu, even though that was not the primary reason for admission.

Figure 5H: primary diagnosis of emergency admission by month, persons with last emergency admission within one week of death or died in hospital following an emergency admission, aged 75 +, England, 2014-15

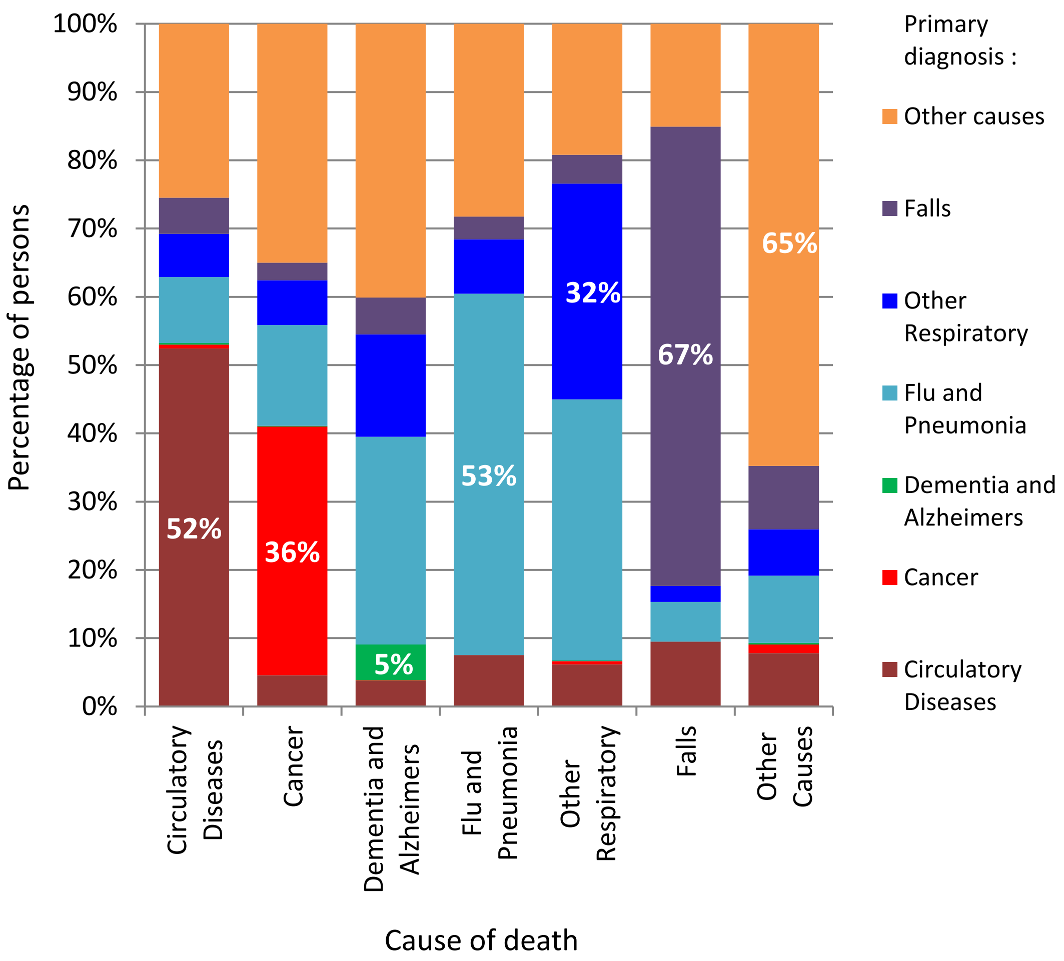


Source: PHE analysis of linked HES and mortality data

Figure 5I shows that for the same group of people analysed, in 2014 and 2015, 53% of people who died from flu and pneumonia were also admitted for flu and pneumonia. However, of those who died from dementia, only 5% were actually admitted for dementia: 45% were admitted for flu, pneumonia and other respiratory diseases and 5% were admitted for falls.

From Figure 5I it is evident that flu, pneumonia and other respiratory diseases make up a sizeable proportion of admissions for people who died from most causes of death. While flu is not frequently mentioned on the death certificate, flu and pneumonia are a common cause of admission, not just for people who are recorded as dying from these illnesses.

Figure 5I: cause of death by primary diagnosis of admission, persons with last emergency admission within one week of death or died in hospital following an emergency admission, aged 75 +, England, 2015



This analysis illustrates that those aged 75 and over may have multiple morbidities, making it difficult to determine a single underlying cause of death. It also indicates that flu can have a considerable impact on vulnerable populations, particularly those with conditions such as dementia, and often results in death from existing medical conditions.

Although some authors have discounted the impact of flu on the spikes in deaths in recent winters,[4,5] there is a considerable body of evidence for both England and across Europe, besides what is reported here, which provides evidence that respiratory diseases, including flu, are leading contributors to levels of excess mortality in recent winters.[51-54]

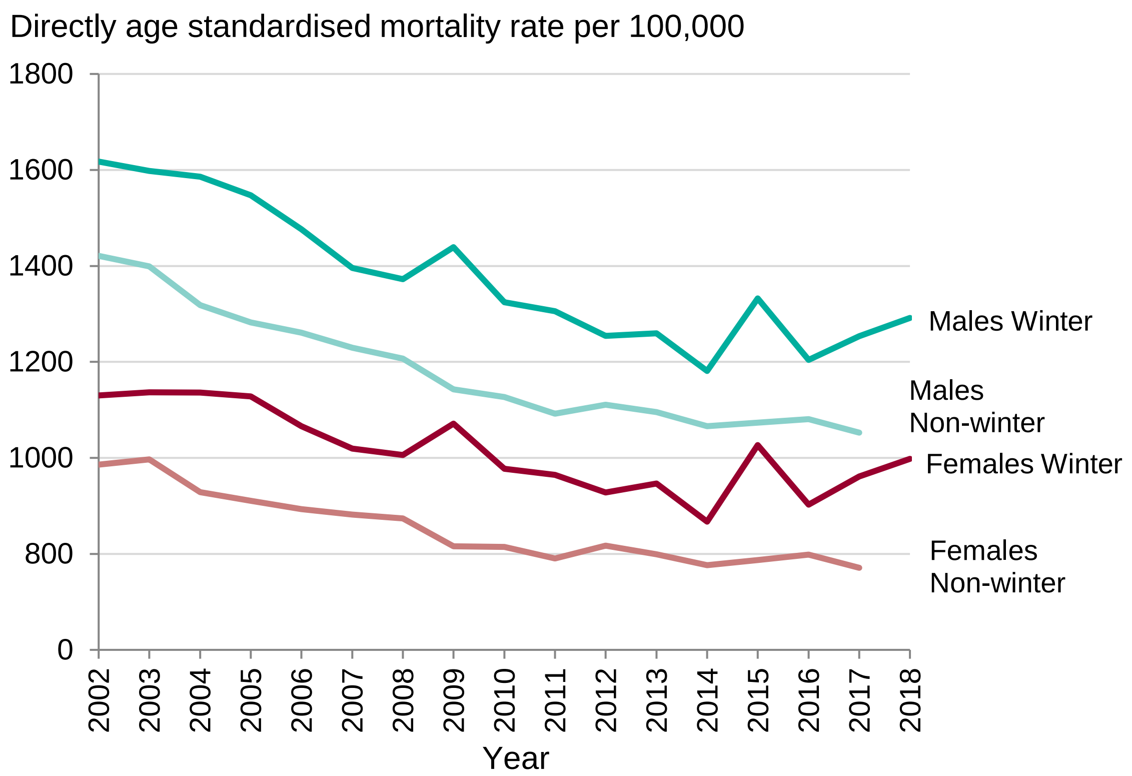
The size and frequency of recent winter peaks in mortality, determined by the intensity and dominant type of influenza circulating, flu vaccine uptake and effectiveness, and which is sometimes exacerbated by cold weather, has also contributed to the fluctuations in the annual age-standardised rates and the slowdown in improvement.

Trends in non-winter mortality

Figure 5J shows trends in the age-standardised mortality rates for winter and non-winter months. The winter and non-winter rates have been decreasing between 2002 and 2017, but there are pronounced fluctuations in the winter rates. However it is clear that for both, the level of improvement seen up to 2011 has not continued since then (Figure 5J).

Therefore, although the winter peaks are influencing the overall trend, as the non-winter months have had a slowdown in improvement, other factors must also be influencing the trend.

Figure 5J: trend in age-standardised mortality rate for winter and non-winter months in England, for males and females, 2002 to 2018*



*The winter months run from December to March (inclusive) and are plotted as the year in which each winter period ended (e.g. December 2014 to March 2015 is plotted as winter 2015). The non-winter months run from April to November. Data are based on month of registration of the death, not month of occurrence.

Source: PHE analysis of ONS mortality data and population estimates

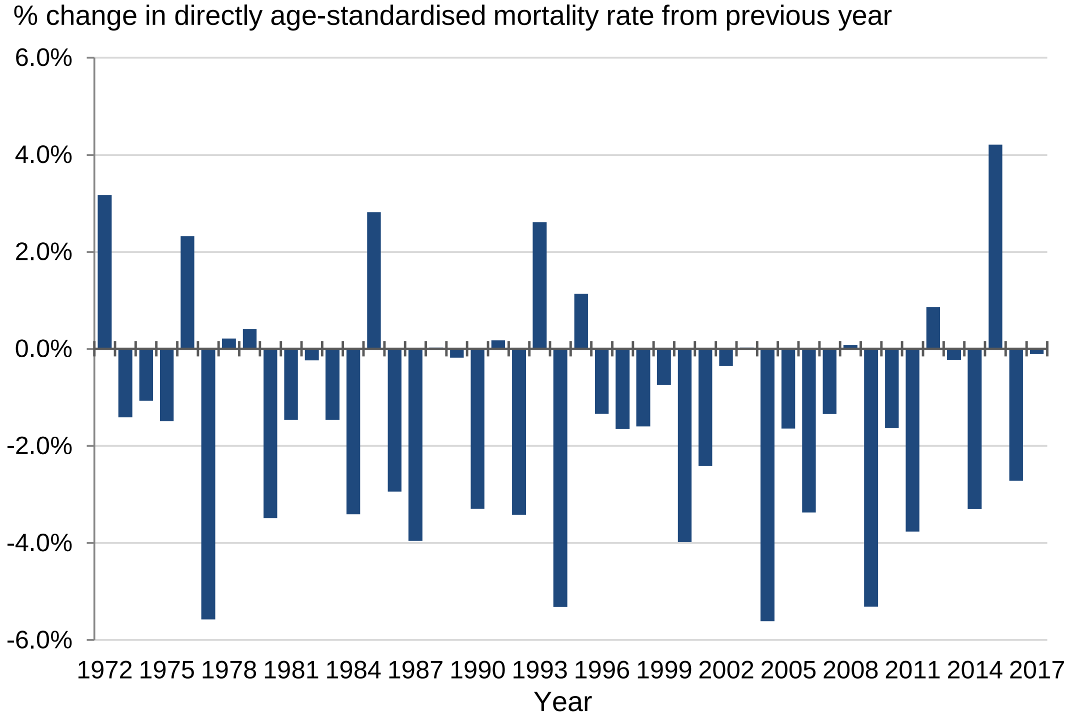
Year on year changes

Age-standardised rates can fluctuate from year to year. A large decrease one year can be followed by a modest decrease or a rise the next. The extent to which this happens is known as autocorrelation. Year-on-year change in the overall age-standardised mortality rate in England is shown in Figure 5K.

The percentage change in the age-standardised rate between years was used to test the extent of autocorrelation in the trend. For this statistical test, a value of 0 would indicate no correlation between years while a value of 1 would indicate perfect correlation. The analysis resulted in a correlation value of -0.447. This negative value means that a large percentage change in one direction is more likely to be followed by a smaller change in the same direction or a change in the opposite direction, ie a large decrease in the rate in one year is statistically more likely to be followed by a smaller decrease or an increase in the next year, and vice versa.

This analysis may help to indicate why a particular factor, such as flu or cold weather, could have more impact one year than the next. For example, the 2015 increase in the age-standardised mortality rate may have been more significant because it followed 2014, a year with the lowest age-standardised mortality rate. It is possible that older vulnerable people survived 2014 and there were therefore a greater number at risk of dying in 2015.

Figure 5K: year on year percentage change in age-standardised mortality rates, persons, England, 1972 up to 2017



Source: PHE analysis of ONS mortality data, 1971-2016 and 2017

Ageing population

As discussed in Section 1, England's population is increasing and ageing, with older people making up an increasingly larger proportion of the population. The proportion of deaths at older ages has also been increasing over time, and in 2016 almost 40% of deaths were at ages 85 and over.[16] Trends in mortality rates among older people are most likely to influence the overall trend for all age groups combined.

The age-specific rates presented in Figure 3A show that the rates for the oldest ages are particularly volatile, with large year-on-year changes in recent years which follow the fluctuations in the overall all-age rate. These changes are more likely than deaths at younger ages to be related to seasonal factors, such as influenza and weather. For example, in 2017/18 there were 36% more deaths in the winter months than non-winter months for males aged 85 and over and 43% more for females. But for those aged under 65, there were 19% more winter deaths for males, and 15% for females.[30]

Age-standardised mortality rates and life expectancy estimates adjust for population ageing, so this in itself should not have affected the slowdown in improvement. As the number and proportion of people at older ages has increased, there are likely to be more people living with dementia and other long-term conditions. This may make them particularly vulnerable to the effects of flu and other winter risk factors and may exacerbate the number of excess winter deaths in some years. The increases in excess winter deaths have affected the fluctuations in the age-standardised mortality rates and the slowdown in the rate of improvement.

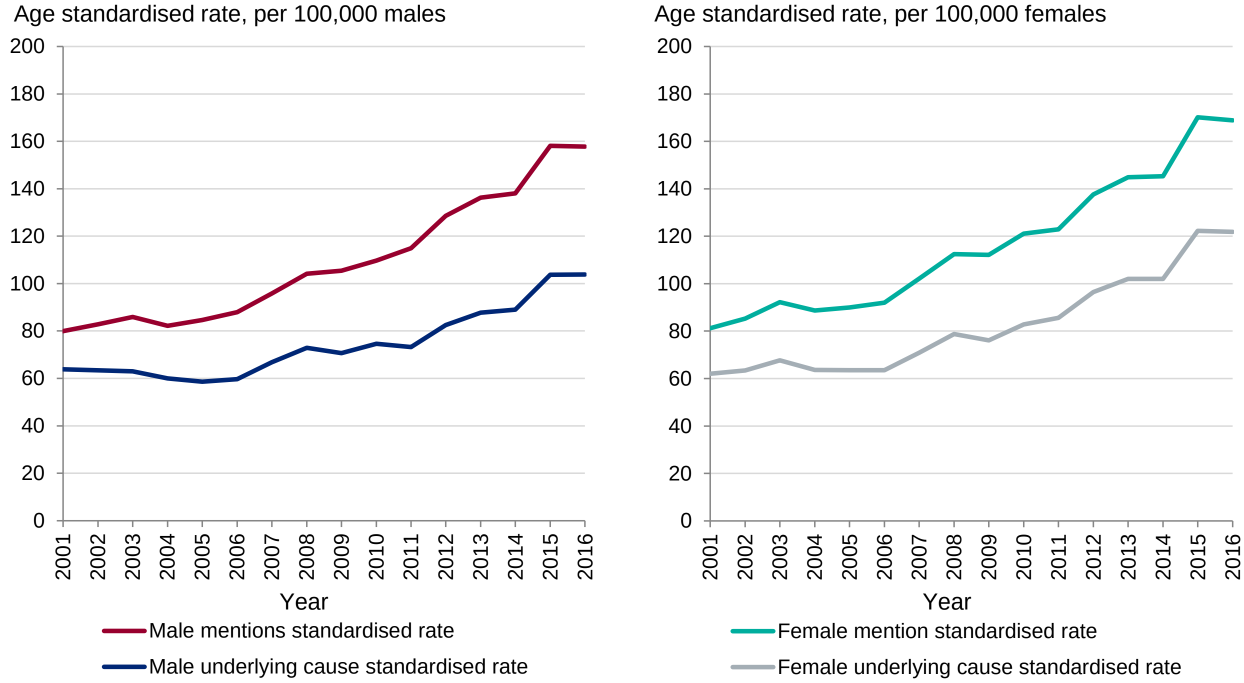
Increasing mortality rates from dementia

Figure 3C in Section 3 shows that for both sexes, the age-standardised mortality rate for dementia has increased over the last decade. With an ageing population, an increase in the number of people living with dementia and the number of deaths from dementia may be expected. However age-standardised rates take into account changes in population size and age structure, and these have also increased.

Further examination of trends in dementia deaths are presented in this section to try to determine whether the increase is real (and therefore could be contributing to the change in the trend in overall mortality rates), or whether the change is largely due to changes in diagnostic, recording and coding practices.

During the period being considered, ONS implemented two coding changes (in 2011 and 2014) which affected the selection of the underlying cause of death. (A death certificate may list many causes which contributed to the death, but only one may be selected as the underlying cause). The coding changes meant that, if recorded on a death certificate, dementia was more likely to be selected as the underlying cause. For example, deaths from vascular dementia, which would once have been coded to circulatory disease, are now coded to dementia as the underlying cause.

Figure 5L: trends in age standardised mortality rates for dementia and Alzheimer's disease, based on any mention of these on the death certificate versus underlying cause, all ages, males and females, England, 2001 up to 2016



Source: PHE analysis of ONS mortality data and population estimates

The trends presented in Section 3 have been adjusted to take the coding changes into account and so rates should be comparable across this period.[55] However to confirm that the coding changes had been adequately accounted for, mortality rates were also calculated based on deaths where dementia was mentioned anywhere on the death certificate (which was not affected by the coding change). The trends for mentions of dementia are very similar to the trends based on underlying cause (Figure 5L). This indicates that mortality rates from dementia are therefore likely to have been correctly adjusted for coding changes.

A number of other factors are likely to have contributed to the increase however, such as improvement in detection and diagnosis practices, and a greater awareness of these conditions among healthcare professionals. In 2012, the Prime Minister issued a challenge on dementia, which included an aim to increase diagnosis rates through regular checks for over-65s.[56] In 2013/14 new regulations were introduced to encourage the identification and diagnosis of dementia among older people who had had an episode of emergency or unplanned hospital care, and in 2014/15, GPs were financially incentivised to diagnose dementia.[57, 58]

The Government's mandate to NHS England in 2015 included an agreed ambition that two-thirds of the estimated number of people with dementia in England should have a diagnosis.[59]

Efforts to increase diagnoses of dementia will have led to dementia being recorded more frequently on the death certificate. Prior to the introduction of these incentives, however, there is evidence that recording of dementia on death certificates was increasing. A study which tracked a group of older people was able to identify those who had a dementia diagnosis and then obtain death certificates when members of the study died.[60] In 2001-04, only 30% of those with a dementia diagnosis had dementia recorded on their death certificates. By 2009-12 this had increased to 47% and in 2013-16 it was 62%.

This increase in the propensity to record dementia on death certificates, has contributed to the increase in the mortality rate from dementia seen in England. This change will have inevitably led to a decrease in the death rates from other underlying causes (Figures 3C and 3D), although it is impossible to quantify this.

For example, while the mortality rate from dementia has been increasing, the rate for deaths from flu and pneumonia has been falling. PHE analysis of death certificates mentioning flu and pneumonia shows that 15.5% of them had flu or pneumonia as the only cause in 2001, compared with 5.6% in 2016. The corresponding figures for dementia are 6.7% in 2001 and 14.0% in 2016. This indicates that there has been a decrease in the likelihood of flu or pneumonia being the only cause mentioned, and a corresponding increase for dementia.

In addition, examination by PHE of death certificates that are coded with dementia as the underlying cause, shows that 21% mentioned flu or pneumonia in the first position of the certificate in 2016. Therefore, it seems likely that there has been a shift in certification practice, meaning that dementia is now more likely to be recorded on the death certificate instead of, or as well as, flu or pneumonia. If dementia is recorded as well as flu or pneumonia, then coding rules determine that dementia is more likely to be selected as the underlying cause of death.

In the winters of 2016/17 and 2017/18, when the dominant flu virus was influenza A(H3N2), known to affect older people in particular, there were 40% and 54% more deaths respectively from dementia compared with non-winter months.[30] The reasons for this may be related to the greater vulnerability of people with these conditions to respiratory diseases, difficulties with self-care, and falls, all of which may have greater impact in winter months.[32, 61, 62]

In summary, the increase in mortality rates from dementia is most likely due to changes in diagnostic and recording practices, but not coding practices. However, as mentioned previously, the ageing population indicates there are likely to be more people living with dementia and other conditions who are therefore vulnerable to the effects of flu and other winter risk factors.

Reduction in improvement in cardiovascular disease mortality rates

Heart disease and stroke (cardiovascular diseases) are leading causes of death for both sexes, and so any change in trend for these is very likely to impact on the trend in overall mortality rates and life expectancy.

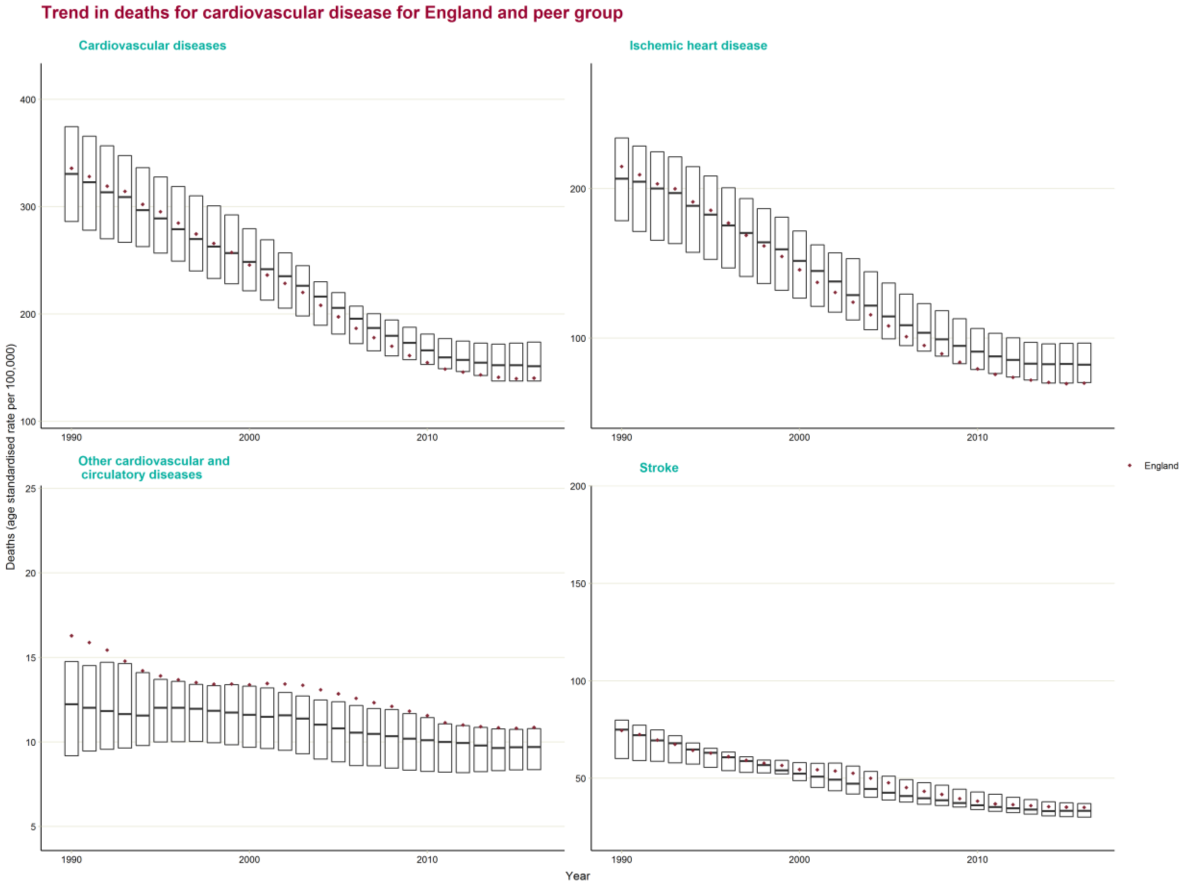
The analysis presented in Section 3 of this report shows that heart disease mortality rates have declined since 2001 for both sexes. But the level of improvement was much lower between 2011 and 2016. Mortality rates for stroke have followed a similar pattern.

These rates are for all ages, but age–specific analysis suggests that the slowing in improvement may have started earlier at younger ages. A study of heart disease deaths in England and Wales between 1984 and 2004 found that falls in mortality rates seemed to be slowing for both sexes aged 45–54.[63]

Evidence from the Global Burden of Disease (GBD) study shows that this slowdown in improvement in cardiovascular diseases is not restricted to England.[64] Figure 5M shows data from the GBD study from 1990 to 2016. England, shown by the red dot, is compared with an international peer group of 22 countries.[23,24] The median value for those countries is shown by the horizontal line in the box plot, with the box presenting the interquartile range for the 22 countries.

[23] Australia, Austria, Belgium, Canada, Denmark, Finland, France, Germany, Greece, Iceland, Ireland, Italy, Luxembourg, Netherlands, Norway, Portugal, Spain, Sweden, United States, plus Northern Ireland, Wales and Scotland.
[24] The mortality rates presented here from the GBD study are not comparable with the cause-specific rates included in Section 3 of this report. For more information on the GBD estimates please see the Definitions section.

Figure 5M: age-standardised mortality rate trends for cardiovascular disease for England and 22 peer countries, 1990 to 2016



Source: Global Burden of Disease, 2016

The slowdown in the rate of decline is similar across the peer group for cardiovascular disease, as well as ischaemic heart disease, the single biggest contributor to cardiovascular mortality.[25] However, for both of these, England was above the median value in the early 1990s but in recent years has been towards the bottom of the interquartile range, indicating that improvement in England has been faster than in the group of peer countries.

It is estimated that more than 58% of the rapid decline in heart disease in England and Wales between 1981 and 2000 was attributed to reductions in major risk factors, and 42% to medical therapies.[65] The biggest impact was from reduced smoking prevalence, but reduced prevalence of high cholesterol and high blood pressure also contributed. The decrease was partially offset by increasing prevalence of diabetes, obesity and physical inactivity.

---

[25] Ischaemic heart disease is also commonly referred to as ‘coronary heart disease’ or just ‘heart disease’. The latter term is used throughout the rest of this report.

A later analysis covered the period 2000 to 2007, a period when a number of population wide initiatives were introduced to improve cardiovascular disease outcomes.[66] During this period, approximately half the fall in cardiovascular disease mortality was found to be attributable to improved treatment uptake. Reductions in risk factors explained a third of the fall, with the biggest contribution from reductions in blood pressure. Although other risk factors, such as smoking and cholesterol, reduced, there was an increase in the prevalence of obesity and diabetes.

In the USA, the rate of decline in mortality rates for cardiovascular disease has been described as slowing down dramatically between 2011 and 2014.[67] This has been linked to rapidly increasing prevalence of obesity and diabetes.[68, 69] Analysis from the United States in 2005 predicted that the effect of increasing obesity would mean that the steady rise in life expectancy could soon come to an end there.[68]

Some risk factors for cardiovascular disease have improved in England in recent years. Smoking prevalence has decreased: in 2017, 14.9% of adults still smoked, a reduction from 19.9% in 2010.[16] Prevalence of high blood pressure has also reduced from 30.2% in 2010 to 28.3% in 2016.[16] There has also been an overall reduction in average total cholesterol in the population between 2003 and 2016, although there have been some fluctuations over time.[16]

However, in 2003, 22.6% of adults were obese and there has been a general upward trend since then, but with some fluctuations. In 2016 in England, 26.2% of adults were obese.[70] The prevalence of diabetes in England has also increased over the last 20 years. The Health Survey for England recorded an increase in the prevalence of self-reported ‘doctor diagnosed’ diabetes between 1994 and 2016, from 2.4% to 6.9%.[70]

It remains challenging, from routine data analysis, to determine the overall effect of changing risk factors on trends in cardiovascular disease mortality. However, it is clear from this analysis that further examination of the causes of the change in the trend in cardiovascular disease mortality will shed further light on the reasons for the slowdown in improvement overall.

Widening health inequalities

In Section 3, analysis of trends in life expectancy by level of deprivation shows that since 2010-12 there has been a slowdown in life expectancy improvement across all deprivation deciles areas. However, between 2010-12 and 2014-16, life expectancy in the more deprived areas in England increased more slowly than in the least deprived areas. In addition, female life expectancy in the most deprived decile areas has decreased since 2010-12 and inequality in life expectancy has increased. Inequality in male life expectancy has fluctuated over time, but increased since 2011-13.

This analysis indicates that whatever is causing the reduction in the rate of improvement, it is affecting the most deprived areas more than the least deprived areas, and that widening health inequalities has exacerbated the slowdown in improvement.

Health and social care funding

Some papers have reported on the relationship between reductions in government funding for health and social care and slowing mortality improvements or recent increases in deaths in winter periods. Much of this observational analysis focuses on providing an association, within England as a whole, between trends in funding and changes in mortality, often by ruling out other factors first.[4, 71] Suggestions for how funding constraints may have influenced mortality rates include through inadequate nursing provision, particularly in care homes,[72] and delayed discharges from hospital.[73]

Responses to these papers have noted that they may not have fully taken other factors into account (such as what has happened in other countries)[74] and have queried the methods used and interpretation of results.[75-78]

Analysis by local authorities has found no geographical pattern to changes in mortality and no association with deprivation.[72, 79] This reflects the analysis presented in Section 3 of this report which showed no obvious geographical pattern in the local authorities which have seen a recent fall in life expectancy. An association between rising mortality in those aged 85 and over with local authority reductions in spending on income support for poor pensioners and social care has been observed, [80] though this analysis could not investigate these relationships at an individual level and did not fully standardise for differences in the age structure of the population of local authorities above age 85.

Data from the Institute of Fiscal Studies indicates that increases in public expenditure on health reduced around the same period as the change in the trend in mortality. The period between 2009–10 and 2014–15 "….saw historically slow increases in UK public spending on health, averaging 1.1% per year." For social care, the IFS has reported real-term public spending "….by English local authorities fell by 1.0% between 2009–10 and 2015–16. Within this, spending on adult social care fell by 6.4%, during a period when the population aged 65 and above grew by 15.6%."[81]

Examination of international evidence may help to further understand the patterns in England and the UK. The results from one study looking at the relationship between change in life expectancy and government spending as a percentage of Gross Domestic Product (GDP) across western European countries between 2011 and 2015 were inconclusive.[82] In addition, this analysis only considered change between 2011 and 2015, and in the latter year life expectancy fell by varying degrees in most

European countries. If different periods were analysed the results would likely be different. Further research is clearly needed to examine relationships between government spending and mortality across different countries.

Data from the Organisation for Economic Co-operation and Development (OECD) shows that growth in health spending slowed markedly in almost all OECD countries following the financial crisis in 2008, but evidence for the impact of economic downturns on mortality is inconclusive on whether or not it leads to poorer outcomes.[83]

The papers which have looked at the relationship between government spending, or health and social care provision, have shown an association with mortality but there is currently limited evidence on any potential causal mechanisms. The analysis that is possible using routine data sources to determine the role of changes in government spending is rather limited, but we have shown in this report that those who have been most affected by the change in trend in mortality are those with the least resources – those living in deprived decile areas – which could indicate a role for government spending.

Recent mortality trends thus need to be seen in the context of increased demand for health and social care services through an ageing population, during a period of changing trends in government expenditure. Having an increasingly ageing population will put greater pressure on health and social care "but issues will only arise if these services are underfunded or operate inefficiently." [73]

Changes in migration patterns

The number of people moving to live in the UK has been greater than the number emigrating since the mid-1990s, but migration patterns have not been consistent over time. It is possible that these changes have had some influence on recent mortality trends.

There was a large increase in migrants from outside the EU in the late 1990s but numbers have fluctuated since 2004. There was a large increase in migration by EU nationals from 2004 onwards (Figure 5O), much of which was from the 8 countries in central and eastern Europe, and the Baltic states, which joined the EU in May 2004. Bulgaria and Romania joined the EU in 2007, but nationals of these countries could not work in the UK without a work permit until 2014, when there was another stepped increase in the number of EU migrants (Figure 5O).

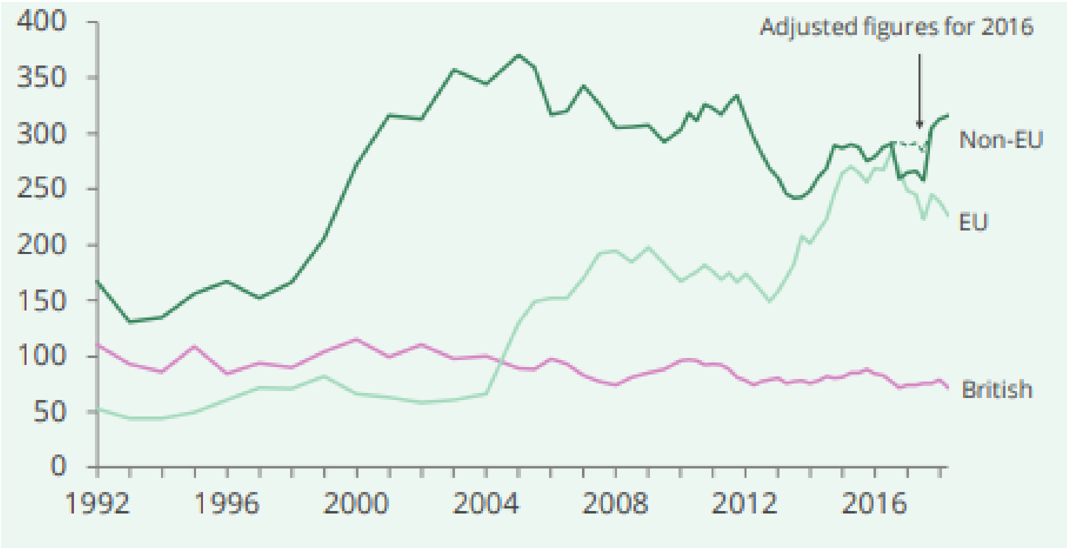
Migration patterns could affect mortality rates in a number of ways, such as through a reduction in the number of 'healthy migrants' moving to England, or an increase in migration from people whose country of origin has higher mortality rates than England.

Such effects have been observed in other countries. An Australian study, for example, found that a substantial increase in life expectancy in the latter part of the 20th Century could be partly attributed to immigration from countries with low mortality in the decades after World War 2, and concluded that ongoing migration would continue to have a beneficial effect upon future Australian life expectancy.[84]

Figure 3L shows that people born in most non-EU countries had lower premature mortality for both sexes than the England average in 2011-13, and migration from non-EU countries has fluctuated since 2004.

Premature mortality for males who died in England but who were born in Poland and the other EU accession countries was significantly higher than the average for England in 2011 to 2013 (Figure 3L). This may reflect lower male life expectancy in these countries, eg male life expectancy in Poland is over 5 years lower than in the UK (Figure 4B).

Figure 5O: immigration to the UK by nationality (thousands)[26]



Source: Migration Statistics: House of Commons Library briefing paper Number SN06077, 23 February 2018

It is possible that the changes in migration patterns have had some influence on recent mortality trends, however, the timing of these changes does not necessarily coincide with changes in mortality. In addition, the mortality patterns in Figure 3L indicate that the mortality rates for males and females born in EU accession countries are quite different.

---

[26] ONS issued adjusted figures for 2016 to account for a possible anomaly resulting from an inconsistency in sampling, relative to previous years. See Section 2.4 of Migration Statistics: House of Commons Library briefing paper Number SN06077, 23 February 2018 for further details.

Further detailed investigation would be required to determine the impact of changes in migration patterns on overall mortality rates. However, it is likely that the impact would be quite small as, for example, deaths of migrants from EU accession countries accounted for only 0.8% of the total number of deaths in England in 2017.

Other factors that should be considered

Other explanations have been suggested in the literature for the increase in deaths in some recent winters, and for the slowdown in improvement in mortality since 2010.

One of these factors is the possibility that, as a population, we are reaching the limit of our lifespan. This suggestion has been rejected by many commentators, [71,85] and this report already demonstrates that there are many countries with higher life expectancy than the UK.

In addition, a recent report by the ONS noted that although life expectancy in Japan is higher than the UK, male life expectancy in Japan increased at a rate of 16.2 weeks per year between 2011 and 2016, compared with 4.2 in the UK.[24] The corresponding figures for females are 13.3 and 1.2 weeks per year respectively. The suggestion that we are reaching the upper limits of longevity therefore seems implausible, but this has not been examined in detail in this report.

Cohort effects (sometimes referred to as “generation effects”) are factors that may affect people born or experiencing a situation at a particular time. These effects can be short-lived or have long-term consequences on the health outcomes of the population within the cohort.

There are theories suggesting that the cohort of people who survived the Spanish flu epidemic of 1918 shared characteristics which influenced mortality in later life.[86, 87] In Scotland, it has been suggested that a rise in suicide in the 1990s was due to cohort effects among those born in the 1960s and 1970s.[88] In addition, it has been suggested that people born in the UK between 1925 and 1945 (centred on the generation born in 1931) have experienced more rapid improvement in mortality than generations born either side of this period.[89]

The greatest percentage improvements in mortality rates in the 1970s were experienced by people then in their 40s and therefore born in the 1930s. The greatest improvement around the year 1980 was by people in their 50s, around 1990 by people in their 60s and around 2000 by people in their late 60s or early 70s - the same birth cohort.[89] This report shows that the greatest average annual percentage improvement in mortality rates between 2011 and 2016 (excluding children under age 10) was in people aged 70-74 – born in the late 1930s and early 1940s (Table 3A).

The historical trend in smoking prevalence by cohort is one factor that could be determining these trends. Cigarette consumption as measured by the average number of cigarettes smoked per day among males in Britain climbed steadily during the period 1900 to 1940, stayed constant from 1940 to 1960 and fell steadily during the 1960s, 1970s and 1980s. Among females the peak of consumption was much later, in the late 1960s, following which it began to fall. At its peak, female cigarette consumption was still less than half that of males, but current smoking prevalence among the sexes is more similar. [89] In addition to this, smoking prevalence varies by birth cohort, and those in the 1931 to 1935 cohort are less likely to have ever smoked than those born in previous cohorts, but are more likely than subsequent cohorts.[90]

In this analysis of routine data sources it has not been possible to examine these and other cohort effects further. A more detailed review of the literature may be beneficial to further determine whether cohort factors have influenced the slowdown in improvement. As the slowdown has affected most age groups to some extent, the role of cohort factors may, however, be limited.

Section 6: Summary, conclusions and further work

Main findings

After decades of progress, since 2011 improvement in age-standardised mortality rates and life expectancy has slowed down considerably, for both males and females. For some age groups, and for some parts of England, improvement has stopped altogether.

Inequality in life expectancy has widened, and since 2010-12 improvement in life expectancy has been slower in the more deprived areas than the less deprived areas of England. In addition, female life expectancy in the most deprived decile areas has actually decreased. Therefore, the causes of the slowdown in improvement are having the greatest impact in the more deprived areas.

This slowdown in improvement has been seen in the other countries of the UK, and in other large European Union (EU) countries. However, among the large EU countries, the UK has had the slowest rate of improvement since 2011.

There was a large increase in the number of deaths in the winters of 2014/15, 2016/17 and 2017/18. These increases were also seen across many other European countries and coincided, over these three seasons, with circulation of influenza A(H3N2) subtype, known to predominantly affect older people. Analysis of 2015 data also shows that hospital admissions for influenza (or 'flu') increased at the time of the mortality increase.

There has been a substantial shift in the age structure of the population in recent decades: the number and proportion of people at older ages has increased. This indicates that there are likely to be more people living with dementia and other long-term conditions that may make them particularly vulnerable to the effects of flu and other winter risk factors, and who may be particularly reliant on health and social care services.

The size and frequency of recent winter peaks in mortality, determined by the intensity and dominant type of influenza circulating, flu vaccine uptake and effectiveness, and which is sometimes exacerbated by cold weather, has contributed to the fluctuations in the annual age-standardised rates and the slowdown in improvement. However, improvement in mortality rates for the non-winter months has also slowed in recent years.

Reductions in mortality from heart disease and stroke, which are leading causes of death, have historically driven improvements in life expectancy. A slowdown in improvement in mortality rates from these causes has therefore had a large impact on the trend in life expectancy. This slowdown has also been seen across many other countries.

While influenza, heart disease and stroke have determined the trend in mortality rates in older adults, other causes of death have influenced the trend in younger people. Mortality rates among younger adults made almost no positive contribution to trends in life expectancy between 2011 and 2016. The cause of death that had the biggest negative impact was accidental poisoning, with a large proportion due to drug misuse.

Conclusions and further work

The main findings suggest that the overall slowdown in improvement is due to factors operating across a wide range of age groups, geographies and causes of death. It has also been seen, to some extent, in many other countries. This slowdown is unlikely to be caused by problems with the data or methods of analysis used to monitor the trend. It is not possible, however, to attribute the recent slowdown in improvement to any single cause and it is likely that a number of factors, operating simultaneously, need to be addressed.

The analysis by cause of death shows the importance of stepping up efforts to reduce the risk of heart disease and stroke by addressing the underlying wider determinants of health and by reducing risk factors such as smoking, high blood pressure and obesity. Addressing the increase in deaths due to accidental poisoning in younger age groups is also important. Further research focused on these specific causes of death, including further examination of potential cohort factors, could aid understanding of the trends seen.

Other authors have reported an association between trends in mortality and changes in public spending, and health and social care provision. Further work would be required to understand any potential causal mechanisms which may be operating between changes in health and social care provision and trends in mortality within England and across different countries.

The increase in numbers of deaths in some winters, and the analysis by deprivation, highlight the need to support the most vulnerable in society, particularly older people, to minimise the impact of poverty and extremes of temperature, and diseases such as dementia and influenza. Recent evidence of reduced flu vaccine effectiveness in older people has led to changes in the type of vaccine offered to this group. Additional research could focus on understanding the interactions between these factors and suggest actions to address widening health inequality.

Section 7: Definitions

Age-standardised mortality rates

Age-standardised rates adjust for differences in the age structure of populations and allow comparisons to be made between geographical areas and through time, allowing identification of any underlying change in mortality rates. The direct method uses the age-standardised rate for a particular condition which would have occurred if the observed age-specific rates for the condition had applied in a given standard population. The standard used throughout this report is the European Standard Population 2013.

Deprivation deciles

Deprivation deciles have been constructed using Index of Multiple Deprivation scores at lower super output area (LSOA) level.

LSOAs are small geographic areas produced by ONS to enable reporting of small area statistics in England and Wales. There are 32,844 LSOAs in England, each having a population of approximately 1,500. LSOAs within England were ranked from most to least deprived and then divided into ten categories (deciles) with approximately equal numbers of LSOAs in each.

From 2010-12 onwards, deciles were defined using Index of Multiple Deprivation 2015 (IMD2015) scores from the English Indices of Deprivation 2015, released by the Ministry of Housing, Communities & Local Government. For periods before 2010-12, the Index of Multiple Deprivation scores were from the English Indices of Deprivation 2010.

Since the total number of LSOAs in England is not exactly divisible by ten, the 'extra' LSOAs were allocated to deprivation deciles using a systematic method outlined in the PHOF overarching indicators technical user guide.

Excess Winter Deaths (EWD) Office for National Statistics

The ONS method defines the winter period as December to March, and compares the number of deaths that occurred in this winter period with the average number of deaths occurring in the preceding August to November and the following April to July.
The calculation for EWD is winter deaths minus average non winter deaths.

This measure makes no adjustment for the age structure of the population and so the ageing population is not taken into account in these estimates, but age-specific figures are released by ONS for the age groups 0-64, 65-74, 75-84 and 85+.

Global Burden of Disease

The Global Burden of Disease study (GBD) collects data from over 80,000 data sources from countries across the world. These are used as inputs for the GBD modelling methodology to produce comparative estimates of death and disability.

The mortality rates for cardiovascular diseases included in Figure 5M of this review are quite different to the rates for heart disease and stroke presented earlier in Figure 3C. The reasons for this are largely due to reclassification of various underlying causes of death by the GBD study. For heart disease, the GBD estimates include some deaths with conditions which were ill-defined at death registration (deaths with an 'R' code in the International Classification of Diseases) and also some deaths where the underlying cause was heart failure.
Deaths from stroke in the GBD similarly also include some redistribution of deaths from causes that were ill-defined, and it also moves some deaths from dementia to stroke.

Gradient analysis

The estimates of average annual absolute change over time were calculated by estimating gradients in mortality rates (or life expectancy) for different periods. These take account of the mortality rate in every year in the period (not just the first and last years).

The gradients were estimated using a linear regression approach to best fit a line to the time points in each period. This was done using the SLOPE function in Excel 2010, with results also replicated in STATA version 2013.

As some mortality rates have decreased relatively rapidly in recent decades, this could have led to differences between relative and absolute changes over time. To test the validity of the gradient results, they were first calculated using actual mortality rates and life expectancy estimates. These were then log transformed and new gradients were calculated using the transformed data, which provided a measure of the relative rate of change. The results for absolute and relative change over time proved generally consistent, ie for both of them the level of improvement was markedly lower in the most recent time period compared with earlier periods. Only the results for absolute change over time have been included in this review.

ICD-10 coding changes

ONS uses software to automate the translation of cause of death information on death certificates from text to International Classification of Diseases Tenth Revision (ICD-10) codes. In January 2011, ONS adopted a new version of the coding software which incorporated updates to ICD-10, including codes for new conditions (such as swine flu) and changes to the rules used to select the underlying cause of death. In January 2014, ONS changed the coding software to a package developed for use across the EU.

Both of these changes had an impact on cause of death information, but this impact can, in general, be quantified and adjusted for. PHE has provided guidance for both coding changes in technical guides available from the Technical Guidance section of the Public Health Outcomes Framework.

Life expectancy definition

Life expectancy at birth is the average number of years that would be lived by babies born in a given time period if mortality rates at each age remain constant. Similarly, life expectancy at age 65 is the average number of remaining years of life that a man or woman aged 65 will have if mortality rates at each age over 65 remain constant. This 'period' life expectancy doesn't take into account how mortality rates might change in the future.[27]

In practice, life expectancy is used as a summary measure of mortality which takes into account changes in the size and age structure of the population. It is therefore an alternative summary measure to age-standardised mortality rates, and both are looked at in this review. Where one is analysed instead of the other, this is often due to the type of data being available rather than a preference for one measure over the other. The two measures are linked and generally when mortality rates increase then life expectancy will fall, and vice versa.

Life expectancy decomposition method and interpretation for age and cause of death

The contribution of different age bands or causes of death to changes in life expectancy over time (due to changes in age or cause specific death rates) can be calculated using a method of 'life expectancy decomposition'. In this report, the Arriaga III method has been used, as described by Ponnapalli.[19] The method is based on a life table divided into 5-year age groups. The contributions of each age group are then distributed into causes of death using a method described by Preston and others.[20] Contributions are distributed proportionately according to the difference in mortality between time periods by cause of death within each age group.

Contributions to changes in life expectancy over time show the amount that life expectancy has increased in the later time period due to changes in the mortality rate since the earlier time period in a given age group or cause of death, assuming all other rates remained constant. Contributions that increased life expectancy (that is, where mortality rate has reduced over time) have a positive value, while contributions that offset the life expectancy increase (that is, where mortality rate has increased over time) have a negative value.

[27] See the ONS Guide to: Life Expectancy in the United Kingdom for more information.

The same decomposition method can also be used to assess the contribution of different age bands or causes of death to differences (or the gap) between areas with different levels of deprivation.

Contributions to the gap show the amount that life expectancy would increase in the most deprived area if its mortality rate for a given age group or cause of death was changed to that of the least deprived area, assuming all other rates remained constant. Contributions that widen the inequality gap (that is, where mortality rate is higher in the most deprived area) are represented with a positive value, while contributions that offset the gap (that is, where mortality rate is higher in the least deprived area) are represented with a negative value.

Life expectancy - sources of data

Every year ONS produces a set of National Life Tables for the UK and its constituent countries. As these are based on 3-year rolling averages of data, they have not been used within this review, which has looked instead at recent changes for single calendar years.

For years up to and including 2016, these have been sourced from the ONS 2016 based past and projected data from period and cohort life tables. For the UK, and each constituent country, ONS produces a set of life expectancy projections up to 2066 based on different scenarios of what may happen to mortality rates in the future. For this review, however, only results up to 2016 have been used, which are based on historical mortality rates. Only period life expectancies have been used, which make no assumptions about future changes to mortality rates.

For 2017, the national estimates were kindly provided by ONS as an ad-hoc release. The life expectancy estimates for local authorities were taken from the ONS release of estimates for local areas in the UK. This release includes figures for regions, but as these were based on data for 3-years, the regional estimates in this report were calculated by PHE using mortality data supplied by ONS, and published mid-year population estimates. Similarly, estimates for deprivation deciles were calculated by PHE.

Life expectancy estimates for EU countries were taken from the Eurostat database. These different sources do not all use a consistent method and so are not all directly comparable. For example, the estimates for England and other countries of the UK from ONS are based on a ‘complete’ life table calculated with age specific rates by single year of age from 0 to 100+. The results for local authorities are based on an ‘abridged’ life table calculated with death rates in 5-year age groups up to age 90+, while the Eurostat results are also based on an abridged life table but with an upper age band of 85+.

Standardised mortality ratios by country of birth

Information on country of birth is collected when deaths are registered, but robust data on the numbers of people living in England who were born in other countries is only collected by age and sex in the decennial census. PHE has used these data to look at levels of mortality by country of birth in 2011-13. For further details of the method used, and the countries included in each of the groups shown in Figure 3L, see the methodology section in PHE's 2017 report on health equity in England.

Slope index of inequality

The slope index of inequality (SII) is a measure of the social gradient in an indicator and shows how much the indicator varies with deprivation (by deprivation decile). It takes account of inequalities across the whole range of deprivation within England and summarises this into a single number. The SII represents the absolute difference in the indicator across the social gradient from most to least deprived. A detailed description of the methodology used to calculate the SII can be found in the PHOF overarching indicators technical user guide.

Sources of mortality data

Where possible in this review, links to published sources of mortality rates have been included. However, some analysis has been undertaken by PHE using mortality data supplied by ONS. These results are included in the accompanying data pack.

Underlying cause of death

The World Health Organization defines the underlying cause of death as "the disease or injury which initiated the train of morbid events leading directly to death, or the circumstances of the accident or violence which produced the fatal injury", in accordance with the rules of the International Classification of Diseases.

References

1. Office for National Statistics, Past and projected data from the period and cohort life tables 2014-based, England and Wales, 1841 to 2064 (2017): https://www.ons.gov.uk/peoplepopulationandcommunity/birthsdeathsandmarriages/lifeexpectancies/adhocs/006833pastandprojecteddatafromtheperiodandcohortlifetables2014basedenglandandwales1841to2064

2. Dorling, D., Why are old people in Britain dying before their time? New Statesman (2014): https://www.newstatesman.com/politics/2014/02/why-are-old-people-britain-dying-their-time

3. Public Health England, Recent trends in life expectancy at older ages (2015): https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/403477/Recent_trends_in_life_expectancy_at_older_ages.pdf

4. Hiam, L., et al., What caused the spike in mortality in England and Wales in January 2015? J R Soc Med, 2017. 110(4): p. 131-137.

5. Hiam, L. and D. Dorling, Rise in mortality in England and Wales in first seven weeks of 2018. BMJ, 2018. 360.

6. Office for National Statistics, Provisional analysis of death registrations: 2015 (2016): https://www.ons.gov.uk/peoplepopulationandcommunity/birthsdeathsandmarriages/deaths/articles/provisionalanalysisofdeathregistrations/2015

7. Office for National Statistics, Quarterly mortality reports: https://www.ons.gov.uk/peoplepopulationandcommunity/birthsdeathsandmarriages/deaths/articles/quarterlymortalityreports/previousReleases

8. Office for National Statistics, Quarterly mortality report, England: January to March 2018 (2018): https://www.ons.gov.uk/peoplepopulationandcommunity/birthsdeathsandmarriages/deaths/articles/quarterlymortalityreports/januarytomarch2018

9. Hiam, L., et al., Why has mortality in England and Wales been increasing? An iterative demographic analysis. J R Soc Med, 2017. 110(4): p. 153-162.

10. Marmot, M., The UK's current health problems should be treated with urgency (2017): https://blogs.bmj.com/bmj/2017/09/13/michael-marmot-the-uks-current-health-problems-should-be-treated-with-urgency/

Raleigh, V., Why have improvements in mortality slowed down? (2017): https://www.kingsfund.org.uk/blog/2017/11/improvements-mortality-slowed-down#comments-top

12. Fransham, M. and D. Dorling, Have mortality improvements stalled in England? BMJ, 2017. 357: p. j1946.

13. Raleigh, V.S., Stalling life expectancy in the UK. BMJ, 2018. 362: p. k4050.

14. Newton J, B.A., Fitzpatrick J and Ege F, What's happening with mortality rates in England? Public Health Matters (2017): https://publichealthmatters.blog.gov.uk/2017/07/20/whats-happening-with-mortality-rates-in-england/

15. Office for National Statistics, Changing trends in mortality in England and Wales: 1990 to 2017 (Experimental Statistics) (2018): https://www.ons.gov.uk/peoplepopulationandcommunity/birthsdeathsandmarriages/deaths/articles/changingtrendsinmortalityinenglandandwales1990to2017/experimentalstatistics

16. Public Health England, Health Profile for England: 2018 (2018): https://www.gov.uk/government/publications/health-profile-for-england-2018

17. Office for National Statistics, Quarterly mortality report, England: April to June 2018 (2018): https://www.ons.gov.uk/peoplepopulationandcommunity/birthsdeathsandmarriages/deaths/articles/quarterlymortalityreports/apriltojune2018

18. Office for National Statistics, Changing trends in mortality: a cross-UK comparison, 1981 to 2016 (2018): https://www.ons.gov.uk/peoplepopulationandcommunity/birthsdeathsandmarriages/lifeexpectancies/articles/changingtrendsinmortality/acrossukcomparison1981to2016#how-is-uk-mortality-changing-across-different-ages

19. Ponnapalli, K., A comparison of different methods for decomposition of changes in expectation of life at birth and differentials in life expectancy at birth. Demographic Research 2005. 12: p. 31.

20. Preston, S.H., P; Guillot, M, Demography: Measuring and Modelling Population Processes. 2005: Blackwell Publishing.

21. Wild, S. and P. Mckeigue, Cross sectional analysis of mortality by country of birth in England and Wales, 1970-92. BMJ, 1997. 314(7082): p. 705: https://www.bmj.com/content/314/7082/705

22. Wild, S.H., et al., Mortality from all causes and circulatory disease by country of birth in England and Wales 2001-2003. J Public Health (Oxf), 2007. 29(2): p. 191-8: https://academic.oup.com/jpubhealth/article/29/2/191/1505208

23. Eurostat, Life expectancy by age and sex, Eurostat Database (2018): https://ec.europa.eu/eurostat/web/population-demography-migration-projections/deaths-life-expectancy-data/database

24. Office for National Statistics, Changing trends in mortality: an international comparison: 2000 to 2016 (2018): https://www.ons.gov.uk/peoplepopulationandcommunity/birthsdeathsandmarriages/lifeexpectancies/articles/changingtrendsinmortalityaninternationalcomparison/2000to2016

25. Centers for Disease Control and Protection Mortality in the United States, 2016 (2017): https://www.cdc.gov/nchs/products/databriefs/db293.htm

26. Ho, J.Y. and A.S. Hendi, Recent trends in life expectancy across high income countries: retrospective observational study. BMJ, 2018. 362: p. k2562.

27. US Department of Health and Human Services, What is the U.S. Opioid Epidemic? https://www.hhs.gov/opioids/about-the-epidemic/index.html

28. Woolf, S.H., et al., Changes in midlife death rates across racial and ethnic groups in the United States: systematic analysis of vital statistics. BMJ, 2018. 362.

29. Pensions and Lifetime Savings Association and ClubVIta, Longevity trends, (2017): https://www.clubvita.co.uk/assets/images/general/170623_16_PLSA-Longevity-model.pdf

30. Office for National Statistics, Excess winter mortality in England and Wales: 2017 to 2018 (provisional) and 2016 to 2017 (final) (2018): https://www.ons.gov.uk/peoplepopulationandcommunity/birthsdeathsandmarriages/deaths/bulletins/excesswintermortalityinenglandandwales/2017to2018provisionaland2016to2017final

31. EuroMoMo Mortality monitoring in Europe: http://www.euromomo.eu/

32. Public Health England, Cold Weather Plan For England - Making the case: why long-term strategic planning for cold weather is essential to health and wellbeing (2017): https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/652568/Cold_Weather_Plan_Making_the_Case_2017.pdf

33. Anderson, B.G. and M.L. Bell, Weather-related mortality: how heat, cold, and heat waves affect mortality in the United States. Epidemiology, 2009. 20(2): p. 205-13.

34. Pattenden, S., B. Nikiforov, and B.G. Armstrong, Mortality and temperature in Sofia and London. J Epidemiol Community Health, 2003. 57(8): p. 628-33.

35. Marmot Review Team, The Health Impacts of Cold Homes and Fuel Poverty (2011): https://friendsoftheearth.uk/sites/default/files/downloads/cold_homes_health.pdf

36. Jenkins, G.J., Perry, M.C., and Prior, M.J, The climate of the United Kingdom and recent trends (2008): https://ukcip.ouce.ox.ac.uk/wp-content/PDFs/UKCP09_Trends.pdf

37. Met Office, Snow and low temperatures, December 2010: https://www.metoffice.gov.uk/climate/uk/interesting/dec2010

38. Met Office, January 2015: https://www.metoffice.gov.uk/climate/uk/summaries/2015/january

39. Met Office, Anniversary of record breaking 1976 heatwave: https://www.metoffice.gov.uk/news/releases/2016/heat-wave

40. C Rooney, et al., Excess mortality in England and Wales, and in Greater London, during the 1995 heatwave. Journal of Epidemiology & Community Health, 1998. 52: p. 5. https://jech.bmj.com/content/jech/52/8/482.full.pdf

41. Helen Johnson, et al., The impact of the 2003 heat wave on mortality and hospital admissions in England. Health Statistics Quarterly, 2005. 25: https://webarchive.nationalarchives.gov.uk/20151014023408/http://www.ons.gov.uk/ons/rel/hsq/health-statistics-quarterly/no--25--spring-2005/index.html

42. Office for National Statistics, How deadly is this year's heatwave? (2018): https://blog.ons.gov.uk/2018/08/07/how-deadly-is-this-years-heatwave/

43. Centers for Disease Control and Protection, Estimating Seasonal Influenza-Associated Deaths in the United States (2018): https://www.cdc.gov/flu/about/disease/us_flu-related_deaths.htm

44. Pebody, R.G., et al., Uptake and effectiveness of influenza vaccine in those aged 65 years and older in the United Kingdom, influenza seasons 2010/11 to 2016/17. Eurosurveillance, 2018. 23(39): p. 1800092: https://www.eurosurveillance.org/content/10.2807/1560-7917.ES.2018.23.39.1800092

45. Matias, G., et al., Estimates of mortality attributable to influenza and RSV in the United States during 1997–2009 by influenza type or subtype, age, cause of death, and risk status. Influenza and Other Respiratory Viruses, 2014. 8(5): p. 507-515: https://onlinelibrary.wiley.com/doi/full/10.1111/irv.12258

46. Nielsen, J., T.G. Krause, and K. Molbak, Influenza-associated mortality determined from all-cause mortality, Denmark 2010/11-2016/17: The FluMOMO model. Influenza Other Respir Viruses, 2018

47. Public Health England, Final flu vaccine effectiveness data published (2015): https://www.gov.uk/government/news/final-flu-vaccine-effectiveness-data-published

48. Public Health England, Influenza vaccine effectiveness: seasonal estimates: https://www.gov.uk/government/publications/influenza-vaccine-effectiveness-seasonal-estimates

49. Public Health England, Public Health Outcomes Framework: population vaccination coverage, flu, ages 65+ (2018): https://fingertips.phe.org.uk/profile/public-health-outcomes-framework/data#page/4/gid/1000043/pat/6/par/E12000005/ati/102/are/E06000021/iid/30314/age/27/sex/4

50. Public Health England, Public Health Outcomes Framework: population vaccination coverage, flu (at risk individuals) (2018): https://fingertips.phe.org.uk/profile/public-health-outcomes-framework/data#page/4/gid/1000043/pat/6/par/E12000004/ati/102/are/E06000015/iid/30315/age/226/sex/4

51. Mølbak, K., et al., Excess mortality among the elderly in European countries, December 2014 to February 2015. Eurosurveillance, 2015. 20(11): p. 21065: https://www.eurosurveillance.org/content/10.2807/1560-7917.ES2015.20.11.21065

52. Vestergaard, L.S., et al., Excess all-cause and influenza-attributable mortality in Europe, December 2016 to February 2017. Euro Surveill, 2017. 22(14): https://www.ncbi.nlm.nih.gov/pmc/articles/PMC5388126/

53. Public Health England, PHE Annual flu reports: https://www.gov.uk/government/statistics/annual-flu-reports

54. Pebody RG, G.H., S.M. Warburton F, Ellis J, Mølbak, and N.J. K, de Lusignan S, Andrews N, Significant spike in excess mortality in England, in winter 2014/15 – influenza the likely culprit. Epidemiology and Infection, 2018.

55. Public Health England, PHE Technical Guides: Using ONS mortality data – taking account of changes to cause of death coding: https://fingertips.phe.org.uk/profile/guidance

56. Department of Health and Social Care, Prime Minister's challenge on dementia (2012): https://www.gov.uk/government/publications/prime-ministers-challenge-on-dementia

57. NHS England, Dementia Assessment and Referral: https://www.england.nhs.uk/statistics/statistical-work-areas/dementia/

58. NHS England, Enhanced Service Specification: Dementia Identification Scheme (2014): https://www.england.nhs.uk/wp-content/uploads/2014/10/dementia-ident-schm-fin.pdf

59. Department of Health and Social Care, The Mandate: a mandate from the Government to NHS England: April 2015 to March 2016 (2015): https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/486818/mndate-NHSE-15_16.pdf

60. Gao, L., et al., Accuracy of death certification of dementia in population-based samples of older people: analysis over time. Age Ageing, 2018: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC6014308/

61. Helmer, C., et al., Mortality with Dementia: Results from a French Prospective Community-based Cohort. American Journal of Epidemiology, 2001. 154(7): p. 642-648: https://academic.oup.com/aje/article/154/7/642/107444

62. Shaw, F.E., Falls in cognitive impairment and dementia. Clin Geriatr Med, 2002. 18(2): p. 159-73.

63. O'Flaherty, M., et al., Coronary heart disease trends in England and Wales from 1984 to 2004: concealed levelling of mortality rates among young adults. Heart, 2008. 94(2): p. 178-81.

64. Institute for Health Metrics and Evaluation, GBD Results Tool: http://ghdx.healthdata.org/gbd-results-tool

65. Unal, B., J.A. Critchley, and S. Capewell, Explaining the decline in coronary heart disease mortality in England and Wales between 1981 and 2000. Circulation, 2004. 109(9): p. 1101-7: https://www.ahajournals.org/doi/full/10.1161/01.CIR.0000118498.35499.B2?url_ver=Z39.88-2003&rfr_id=ori%3Arid%3Acrossref.org&rfr_dat=cr_pub%3Dpubmed

66. Bajekal, M., et al., Analysing recent socioeconomic trends in coronary heart disease mortality in England, 2000-2007: a population modelling study. PLoS Med, 2012. 9(6): p. e1001237.

67. Sidney, S., et al., Recent Trends in Cardiovascular Mortality in the United States and Public Health Goals. JAMA Cardiol, 2016. 1(5): p. 594-9: https://jamanetwork.com/journals/jamacardiology/fullarticle/2530559

68. Olshansky, S.J., et al., A potential decline in life expectancy in the United States in the 21st century. N Engl J Med, 2005. 352(11): p. 1138-45.

69. Mensah, G.A., et al., Decline in Cardiovascular Mortality: Possible Causes and Implications. Circ Res, 2017. 120(2): p. 366-380: https://www.ahajournals.org/doi/full/10.1161/CIRCRESAHA.116.309115?url_ver=Z39.88-2003&rfr_id=ori:rid:crossref.org&rfr_dat=cr_pub%3dpubmed

70. NHS Digital, Health Survey for England, 2016 (2017): https://digital.nhs.uk/data-and-information/publications/statistical/health-survey-for-england/health-survey-for-england-2016

71. Hiam, L., et al., Why is life expectancy in England and Wales 'stalling'? J Epidemiol Community Health, 2018. 72(5): p. 404-408.

72. Watkins, J., et al., Effects of health and social care spending constraints on mortality in England: a time trend analysis. BMJ Open, 2017. 7(11).

73. Green, M.A., et al., Could the rise in mortality rates since 2015 be explained by changes in the number of delayed discharges of NHS patients? J Epidemiol Community Health, 2017. 71(11): p. 1068-1071: https://jech.bmj.com/content/71/11/1068.long

74. Baker, A., et al., Response to articles on mortality in England and Wales. Journal of the Royal Society of Medicine, 2018. 111(2): p. 40-41: https://journals.sagepub.com/doi/pdf/10.1177/0141076817743075

75. Steventon, A., Can you really link mortality to delayed discharge? The evidence is far from clear. The Health Foundation (2017): https://www.health.org.uk/blog/can-you-really-link-delayed-discharge-mortality-evidence-far-clear

76. Fordham R and Roland M, Expert reaction to paper on health and social care spending and excess deaths in England, Science Media Centre (2017): http://www.sciencemediacentre.org/expert-reaction-to-paper-on-health-and-social-care-spending-and-excess-deaths-in-england/

77. Janke, K. Response to Effects of health and social care spending constraints on mortality in England: a time trend analysis. BMJ Open (2017): https://bmjopen.bmj.com/content/7/11/e017722.responses#strong-claims-based-on-questionable-methods

78. Milne, E., 120,000 deaths revisited…. (2017): https://eugenemilne.com/2017/11/24/120000-deaths-revisited/

79. Green, M., D. Dorling, and J. Minton, The Geography of a rapid rise in elderly mortality in England and Wales, 2014-15. Health Place, 2017. 44: p. 77-85: https://www.sciencedirect.com/science/article/pii/S1353829216303367?via%3Dihub

80. Loopstra, R., et al., Austerity and old-age mortality in England: a longitudinal cross-local area analysis, 2007-2013. J R Soc Med, 2016. 109(3): p. 109-16: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4794969/

81. Daria Luchinskaya, et al, Institute for Fiscal Studies, UK health and social care spending (2017): https://www.ifs.org.uk/publications/8879

82. Green, M.A., Austerity and the new age of population health? Scandinavian Journal of Public Health, 2018. 46(1): p. 38-41: https://journals.sagepub.com/doi/abs/10.1177/1403494817726616

83. Gool, K.v. and M. Pearson, Health, Austerity and Economic Crisis (2014): https://www.oecd-ilibrary.org/content/paper/5jxx71lt1zg6-en

84. Andrew Page, S.B., Richard Taylor, Alan D Lopez, Global comparative assessments of life expectancy: the impact of migration with reference to Australia (2007): http://www.who.int/bulletin/volumes/85/6/06-036202/en/

85. Marmot, M., Social causes of the slowdown in health improvement. J Epidemiol Community Health 2018(72): https://jech.bmj.com/content/72/5/359.info

86. Mamelund, S.E., Effects of the Spanish influenza pandemic of 1918 - 19 on later life mortality of Norwegian cohorts born about 1900, University of Oslo, Department of Economics (2003): https://www.econstor.eu/bitstream/10419/63083/1/369885325.pdf

87. Minton J, et al, Visualizing Europe's demographic scars with coplots and contour plots International Journal of Epidemiology, 2013. 42(4): p. 12: https://academic.oup.com/ije/article/42/4/1164/658892

88. Parkinson, J., et al., Recent cohort effects in suicide in Scotland: a legacy of the 1980s? J Epidemiol Community Health, 2017. 71(2): p. 194-200.

89. Willets, R.C., The Cohort Effect: Insights and explanations (2004): https://www.actuaries.org.uk/documents/cohort-effect-insights-and-explanations

90. Evandrou M and Falkingham J, Smoking behaviour and socio-economic status: a cohort analysis, 1974 to 1998. Health Statistics Quarterly, 2002. 14: p.30: https://webarchive.nationalarchives.gov.uk/20151014023257/http://www.ons.gov.uk/ons/rel/hsq/health-statistics-quarterly/no--14--summer-2002/index.html

91. Bennett JE, Pearson-Stuttard J, Kontis V, Capewell S, Wolfe I and Ezzati M, Contributions of diseases and injuries to widening life expectancy inequalities in England from 2001 to 2016: a population-based analysis of vital registration data. The Lancet, 2018, 18 30214-7: https://www.thelancet.com/journals/lanpub/article/PIIS2468-2667(18)30214-7/fulltext

92. Met Office, February 2018: https://www.metoffice.gov.uk/climate/uk/summaries/2018/february

93. Met Office, March 2018: https://www.metoffice.gov.uk/climate/uk/summaries/2018/march

94. Fleming, DM and Elliot J, Lessons from 40 years' surveillance of influenza in England and Wales. Epidemiol Infect 2008, 136(7) 866-875: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC2870877/

95. Met Office, Monthly weather reports, 1970s: https://www.metoffice.gov.uk/learning/library/archive-hidden-treasures/monthly-weather-report-1970s

Acknowledgements

We are grateful for the detailed peer review comments from the following:

Prof Carol Brayne, University of Cambridge
Prof Simon Capewell, University of Liverpool
Pamela Cobb, Office for National Statistics
Prof Majid Ezzati, Imperial College London
Dr Colin Fischbacher, Information Services Division Scotland
Prof Peter Goldblatt, University College London
Adele Graham, Public Health Agency , Northern Ireland
Dr Ciarán Humphreys, Public Health Wales
Dr Gerry McCartney, NHS Health Scotland
Prof Eugene Milne, Newcastle City Council
Prof Mike Murphy, London School of Economics
Prof Martin O'Flaherty, University of Liverpool
Dr Veena Raleigh, The King’s Fund
Julie Ramsay, National Records Scotland
Chris White, Office for National Statistics