Office for
National Statistics

Chapter 4: Mortality, 2010-based NPP Reference Volume

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Geographical Area: **Country**
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Past trends in life expectancy

During the 20th century, the UK witnessed a continuation of the pattern of falling mortality rates that began around the 19th century. Over these two centuries there has been a change in the pattern of mortality, from high infant and child mortality driven by the prevalence of acute and infectious diseases, to a new pattern in which adult mortality dominates, and chronic and degenerative diseases are now the most common causes of death.[1] The pattern has been broadly similar in England, Scotland, Wales and Northern Ireland. [2,3,4]

One measure of the mortality rates in a particular year is the period expectation of life at birth, which is the average number of years a new-born baby would live for, based on the mortality rates for the given year. **Figure 4.1** shows that there was a fairly steady increase in this measure throughout the 20th century and continuing into the 21st century. However, progress was slower between 1950 and 1965, particularly for males, and until 1950, epidemics and severe winters caused significantly higher mortality rates in some years.

Figure 4.1: Period expectation of life at birth according to mortality rates experienced in given years, 1911 - 2010, United Kingdom
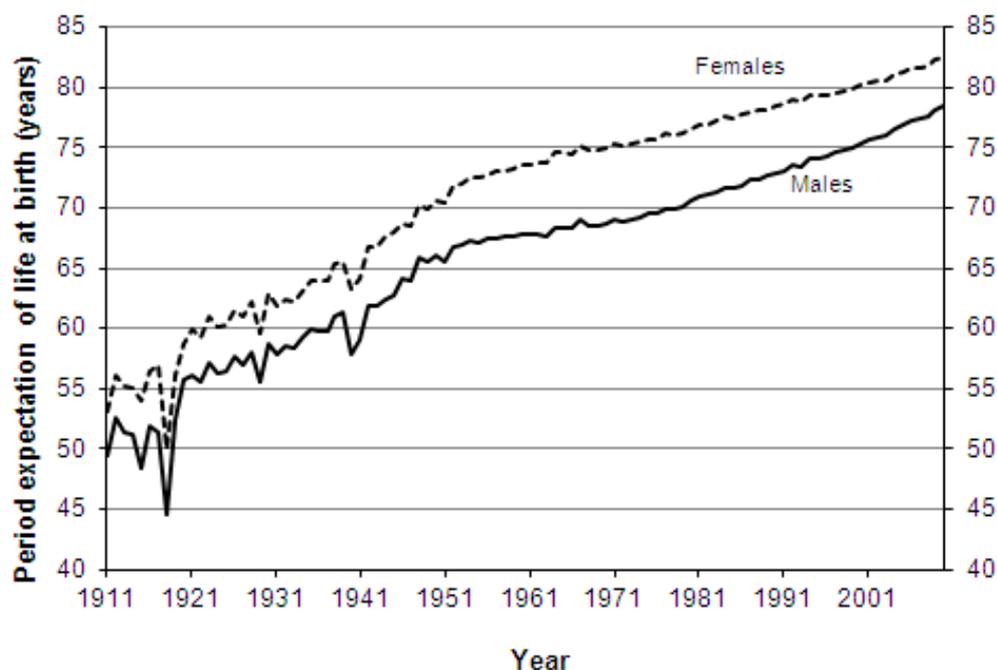
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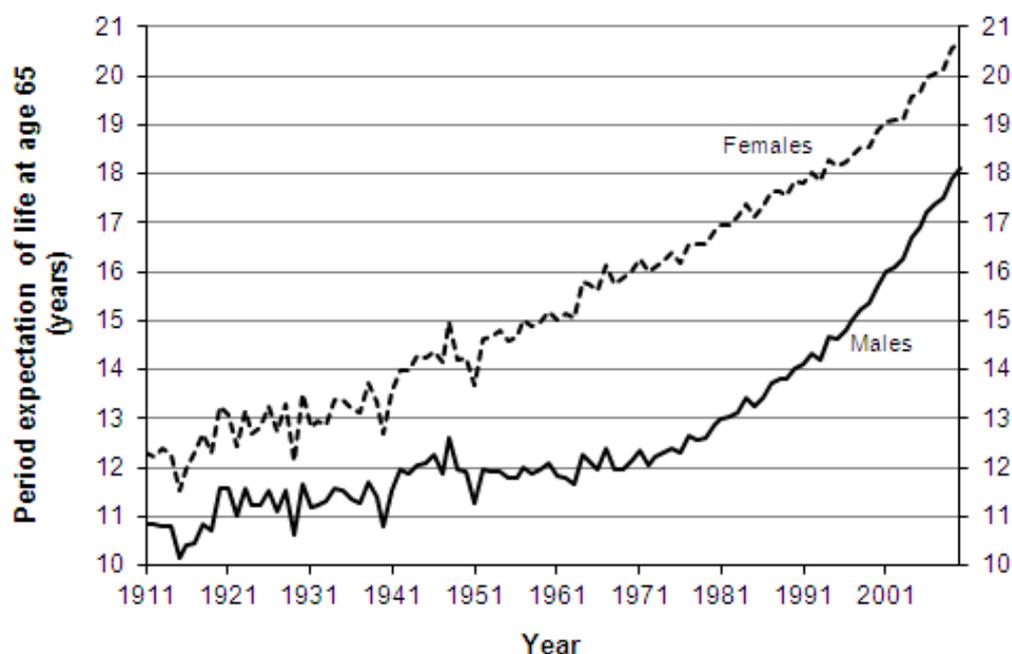PNG **PNG**
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Much of the increase in the period expectation of life at birth in the first half of the 20th century can be attributed to the reduction of infant and child mortality to very low levels by about 1950. Infant and child mortality rates have now fallen to such low levels that further reductions can have little effect on the expectation of life at birth, which has thus come closer to being a measure of the normal life span. Since about 1940, the increasing control of infectious diseases has considerably reduced the number of early adult deaths, and there has recently been a reduction in the number of those dying early from circulatory diseases.[2,3,4] The greatest decline in mortality rates at advanced ages has occurred since the 1970s. However, in general, mortality rates at the oldest ages declined less over the 20th century in relative terms than those at younger ages.

Figure 4.2 shows that period life expectancy at age 65 has also risen during the 20th century and continues to rise in the 21st century. For females, the annual increase was relatively constant over this period whereas for males, after an initial period of increasing longevity, period life expectancy at 65 remained almost constant between 1940 and 1970. Since 1970 there has been a rapid decline in mortality rates at advanced ages, particularly for males for whom mortality is currently improving

more rapidly than female mortality. As a result, the age differential in period life expectancy at age 65 between males and females has reduced from around 4.0 years during the 1970s and early 1980s to 2.6 years in 2010. A partial explanation for this may be the different historical patterns in cigarette smoking between men and women, with a higher proportion of males smoking in the past than females and the peak consumption for males being earlier (1940–1960) than for females (around 1960). [5,6] This might suggest that the rate of increase in female expectation of life at 65 will continue to be slower than for males over the next few years.

Figure 4.2: Period expectation of life at age 65 according to mortality rates experienced in given years, 1911 - 2010, United Kingdom

Source: Office for National Statistics

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In many contexts it is more meaningful to calculate the expected average lifetime taking into account known or assumed improvements in mortality rates in the future (such expectations of life are often referred to as 'cohort' expectations of life). Cohort life expectancies are discussed in greater detail later in this chapter.

A number of publications provide reviews of long-term mortality trends in the UK.[1,2,3,4,7,8,9]

Future prospects for life expectancy

Since the 1980s the period expectation of life at birth in the UK for females has increased by about 1.9 years per decade, while male life expectancy has increased by around 2.6 years per decade. However, there are diverse opinions amongst demographers as to the level of longevity that might reasonably be expected in the future.[9,10,11,12] One can point to Japan, where the period expectation of life at birth in 2010 was about 86.4 years for females and 79.6 years for males,[13] and to other countries in Europe, such as Italy, Norway, Sweden and Switzerland, which also currently have higher period expectations of life at birth than the UK for both males and females.[14] There is also the possibility of lower incidences of cancer, heart disease and strokes through changes in lifestyle and, through medical advances, greater control of these when they do occur. In particular, mortality rates for heart disease and strokes have fallen quite rapidly and steadily over the 1990s for males and females aged 40 to 64 and to a lesser extent for older men and women.[15] Since 2000, the falls in mortality rates from these causes have continued at around the same pace for the 40–64 age-group and have accelerated for older men and women (aged 65 and over). Mortality rates from circulatory diseases had fallen to similar levels as the all cancers mortality rate by 2008. In the future, changes in mortality rates from causes other than circulatory diseases will have an increasingly greater effect on the rates of future mortality improvements.

On the other hand some demographers believe that, despite the possibility of advances in medical practices and of encouraging healthy lifestyles, a law of diminishing returns will apply to mortality rate reductions at advanced ages, partly because no more than a minority of the population will adopt truly healthy lifestyles. It is also possible that new diseases, or the re-emergence of existing diseases such as tuberculosis, may serve to temper future improvements in mortality.

Methodology and derivation of UK base mortality rates

Rather than focusing directly on expectations of life in formulating the mortality assumptions for population projections, the prospects for mortality rates at different ages, and for different generations, have been considered separately. In this chapter, the assumptions for the projections are given in the form of central mortality rates (m_x). The difference between these and the probabilities of dying (q_x) used to carry out the actual projections is described under methodology in chapter 1. The latter figures can be accessed via the NPP interactive table download tool by selecting assumed age specific mortality rates.

Mortality rates for the UK in each calendar year in the period 1961 to 2009 have been smoothed to remove fluctuations from age to age and year to year, using a new methodology. Crude mortality rates were calculated using deaths data and mid-year population estimates for 1961 to 2009 (deaths data for 2010 did not become available until after the mortality assumptions for these projections were finalised). Population estimates by age for those aged 90 and over from 1979 onwards (and retrospective estimates for earlier years, back to when these persons were aged 80) were calculated using the Kannisto-Thatcher survivor ratio method which is a modified form of the method of extinct generations.[16] The retrospective estimates to age 80 have been found to give more reliable results than using the official population estimates made at the time.

A [p-spline model](#) was then applied to the resulting crude mortality rates to produce a fitted, smoothed mortality surface to the historical data for each gender.[17] The addition of an extra year's data or extending the age range can result in quite different rates of improvement at some ages for the most recent years'- in the data used (often termed 'edge effects'). This was the case for the methodology previously used to smooth historical data. Comparisons of the results using different ranges of calendar years and ages were made to assess how sensitive improvement rates calculated from the smoothed mortality rates for a given year were to these edge effects.

It was found that adding an extra year's data often altered the improvement rates derived for previous years for some ages. In particular, when an extra year's data are added improvements calculated for the final and penultimate years of the data range tend to be altered more than those for earlier years, which were usually not altered to a significant degree. The results suggest that improvements for the second last and earlier years should not alter very much when data for an additional year are added.

As a result of these analyses, smoothed mortality rates were calculated using data for years 1961 to 2009 and age ranges 0 to 100 for males and 0 to 105 for females. Age-specific rates of mortality improvement were then calculated for the year 2007 using the smoothed mortality rates calculated for 2006 and 2007. These mortality improvement rates for 2007 were then projected forward to 2010 by assuming that the same rates of improvement applied in 2008, 2009 and 2010. This projection was carried out by year of age for those born in 1960 and later and by cohort for those born before 1960. Improvement rates in 2010 for ages where this methodology did not give an assumed rate were obtained by interpolation from ages where rates were thus derived.

Assumed age specific base mortality rates for 2010 were obtained by applying the resulting assumed rates of improvement to the smoothed age-specific mortality rates produced for 2007.

Base mortality rates for individual countries

Base mortality rates for the calendar year 2010 were initially calculated for the UK, as described above. Base mortality rates for the four individual countries of the UK were obtained by adjusting the UK figure at each age in proportion to the particular country's experience relative to the UK in the three years 2007 to 2009. These rates for individual countries are shown for selected ages in **Table 4.1**. The mortality improvement factors described later in this chapter were then applied to the projected base mortality rates for 2010 for each country to obtain the projected mortality rates for future years.

Table 4.1: Assumed base mortality rates (mx) per 100,000 by selected ages, 2010

	Males					Females			
	England	Wales	Scotland	Northern Ireland		England	Wales	Scotland	Northern Ireland
0	500	498	458	500		415	371	392	445
2	16	13	15	16		14	14	14	13
12	12	13	13	18		9	12	10	9
22	60	73	95	97		25	23	36	30
32	95	130	171	107		46	56	65	47
42	179	209	267	220		107	123	142	115
52	398	435	538	439		267	287	344	298
62	968	1,012	1,293	1,113		630	725	829	643
72	2,546	2,777	3,206	2,724		1,640	1,853	2,119	1,724
82	7,699	7,987	8,821	8,477		5,511	5,690	6,529	5,621
92	20,019	21,539	21,089	22,556		17,844	18,414	19,085	19,582
102	48,468	46,378	48,468	54,639		44,745	44,827	46,484	45,929

Table source: Office for National Statistics

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National Statistics quality review

A review of the methodology for projecting mortality rates in the national population projections for the UK and constituent countries, carried out under the National Statistics Quality Assurance programme, was published in December 2001.[18] The main object of the review was to assess whether the methodology used for projecting mortality rates in the national population projections met the needs of the wide range of users of the projections, met best practices and was founded on good basic data. The review concluded that none of the alternative methodologies assessed would be likely to outperform the methodology used for projections during the 1990s and that the existing methodology should be retained. However, the assumed values for the key parameters used would be reviewed for each new projection round. A number of recommendations for improving the methodology were made in the review and these have been incorporated in recent projections.

Trends in mortality by age

The smoothed mortality rates for the UK fluctuate between increases and reductions at older ages for men up to the mid-1970s, as well as temporary increases at middle ages in the 1960s

and amongst young men in the 1960s and the early 1970s. Mortality rates for men aged 21 to 40 generally rose during the mid-1980s to the mid-1990s. These increases were partly attributable to deaths caused by HIV infection and AIDS.[19] Suicide rates and alcohol-related mortality also increased for men at young ages until the late 1990s.[20] Since the late 1990s mortality rates for men in this age-group have generally been declining, although there has been little improvement in mortality rates for males in their late-thirties and early-forties in recent years. Apart from increasing mortality rates for women aged between 45 and 60 during the 1960s and early 1970s, mortality rates are generally falling for women of all ages. Mortality rates for women aged 15 to 30 generally showed little improvement, or even worsened, during the 1990s but since then this trend has reversed.

It was assumed that the trends apparent during the period 1961 to 2009 (mostly of falling mortality rates) would initially continue at similar rates with improvements for 2009 to 2010 being those derived as described earlier.

Comparisons of the rates of improvement experienced in each individual country with those experienced in the UK as a whole suggested that the assumed initial rates of improvement by age and sex for the UK could be adopted for each individual country, except for Scotland. Mortality for Scottish males and females at some ages has been improving more slowly or worsening at a faster rate than elsewhere in the UK in recent years. As a result, separate initial rates of mortality improvement were assumed for Scottish males and females at several ages with lower rates of improvement for Scottish males aged 27 to 50 and 66 to 95 and for Scottish females aged 27 to 41 and 65 to 92 than for the rest of the United Kingdom. Conversely, higher rates of improvement were assumed for Scottish males aged 50 to 57. The improvement rates for the other countries were then adjusted so that the weighted improvements by age were the same as those initially derived for the United Kingdom as a whole. The resulting assumed smoothed changes in mortality rates between 2009 and 2010 for each country are shown in **Figure 4.3**.

Figure 4.3: Assumed smoothed percentage changes in mortality rates between 2009 and 2010 by age, United Kingdom
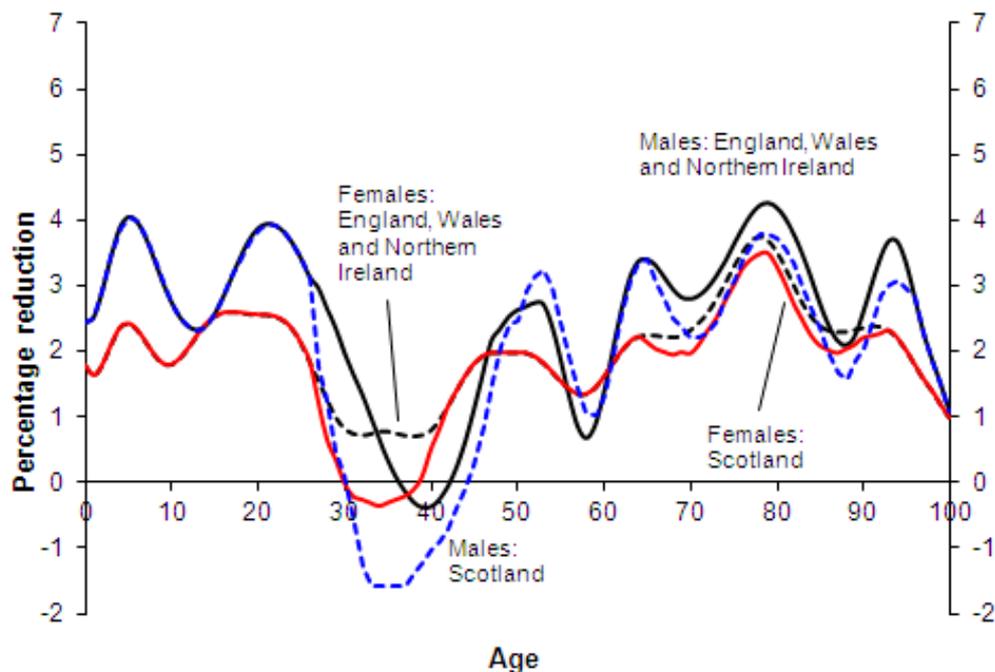
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The peak levels of reduction in mortality rates (of around 4 per cent a year) for both males and females noted in previous projections for the cohorts born around 1931 (aged around 79 in 2010) have continued. It is not understood precisely why the members of the generation born around the early 1930s have been enjoying higher rates of mortality improvement throughout their adult life than preceding generations, or why the rate of improvement slowed down for following generations. It may, however, be relevant that this generation was the first to benefit from a combination of better childhood health, the conquest of infectious diseases affecting young and middle-aged adults and, in later middle-age, improvements in the treatment of circulatory diseases. Additionally, the men, in particular, have smoked fewer cigarettes than those in preceding generations.

Future improvements in age-specific mortality rates

Consideration was then given to how the trends might change in the future. The methodology used for mortality projections in the UK, assumes 'target' rates of mortality improvement for a specific

future year. Following the recommendations of the National Statistics Quality Review,[18] the target year was taken to be 25 years ahead of the base year for the projections.

Over the 40-year period 1969–2009, the average annualised rate of improvement in aggregate standardised mortality rates in the UK has been around 1.8 per cent for males and 1.4 per cent for females. (These rates of improvement are derived from aggregate mortality rates for ages 0 to 99 calculated using the 2001 population estimates for the UK as the standard population.) The rate of improvement over the latter half of this period was higher for both males and females than over the first half, and particularly so for males. This appears to be partly due to differential trends in smoking behaviour between males and females. Relatively higher numbers of men have now given up smoking and mortality rates for males at older ages have shown large rates of improvement in recent years.[5,6]

The average annual rate of improvement over the last hundred years was around 1.2 per cent for both males and females although the improvement rates vary by age. There is considerable debate as to whether the impact of future technical, medical and environmental changes will have a greater or lesser effect on improvements in mortality in the future than they had over the 20th century. Taking these various factors into consideration, the rate of improvement for 2035 (the 25th year of the 2010-based projections) has been assumed to be 1.2 per cent for most ages (that is, broadly equivalent to the average rate of improvement over the period 1911 to 2008).

However, those born after 1924 and before 1939 have exhibited greater rates of improvement over the last 25 years than those born on either side. [21] There is currently no evidence that these differentials are declining. Similar cohort effects seen in other countries suggest that these differentials may persist well into the oldest ages. As a result, it is now assumed that these cohorts will continue to experience higher rates of improvement with the assumed rate of improvement in 2035 rising from 1.2 per cent a year for those born before 1925 to a peak of 2.5 per cent a year for those born in 1931 and 1932 and then declining back to 1.2 per cent a year for those born in 1939 and later. However, there is little evidence of past mortality improvements at the very oldest ages in the UK. As a result, and in order to avoid implausible numbers surviving to extreme ages, the notional assumed rates of improvement in the 25th year of the projections are assumed to reduce to 1.0 per cent for those born between 1911 and 1922 and to reduce further from 1.0 per cent for those born in 1911 to 0.1 per cent for those born in 1902 and earlier. These are the same assumptions for the rates of future mortality improvement in the target year as those assumed for the 2008-based projections (where the target year was 2033) for those born before 1940; for those born in 1940 and later the proposed improvement rates in the target year are higher than assumed in the 2008-based projections.

Table 4.2 shows the reductions in mortality rates assumed for selected years in the future and the total reduction over the next 25 years for each country of the UK. The transition from current rates of mortality improvement by age and sex, derived from recent trends, to the assumed rates of 1.2 per cent to 2.5 per cent in 2035, is not assumed to take place linearly, but more rapidly at first for males and less rapidly for females.

Table 4.2: Assumed percentage reduction in mortality rates, mx, between consecutive calendar years in the projection period and the total reduction over 25 years

percentages

	Age	2010 to 2011		2014 to 2015		2024 to 2025		2034 to 2035		Reduction over 25 years	
		Males	Females	Males	Females	Males	Females	Males	Females	*Males*	*Females*
England, Wales and Northern Ireland	0	2.35	1.78	2.08	1.71	1.51	1.51	1.20	1.20	*34.3*	*32.1*
	2	2.82	1.79	2.43	1.72	1.64	1.52	1.20	1.20	*37.4*	*32.2*
	12	2.29	2.04	2.03	1.94	1.49	1.66	1.20	1.20	*33.9*	*34.7*
	22	3.75	2.50	3.14	2.34	1.89	1.90	1.20	1.20	*43.2*	*39.0*
	32	1.35	0.75	1.31	0.80	1.24	0.95	1.20	1.20	*27.2*	*20.9*
	42	0.01	1.17	0.30	1.18	0.88	1.19	1.20	1.20	*16.5*	*25.8*
	52	**2.58**	**1.96**	2.25	1.87	1.57	1.61	1.20	1.20	*35.9*	*33.9*
	62	**1.91**	**1.79**	**0.95**	**1.33**	1.57	1.61	1.20	1.20	*30.6*	*31.7*
	72	**2.74**	**2.40**	**2.58**	**2.08**	**1.11**	**1.28**	1.20	1.20	*35.5*	*34.0*
	82	**3.92**	**3.26**	**3.59**	**3.49**	**1.69**	**1.74**	**1.20**	**1.20**	*42.8*	*42.5*
	92	**2.87**	**2.35**	**1.86**	**2.13**	**2.82**	**3.07**	**1.20**	**1.20**	*42.4*	*43.7*
Scotland	0	2.35	1.78	2.08	1.71	1.51	1.51	1.20	1.20	*34.3*	*32.1*
	2	2.82	1.79	2.43	1.72	1.64	1.52	1.20	1.20	*37.4*	*32.2*
	12	2.29	2.04	2.03	1.94	1.49	1.66	1.20	1.20	*33.9*	*34.7*
	22	3.75	2.50	3.14	2.34	1.89	1.90	1.20	1.20	*43.2*	*39.0*
	32	-1.14	-0.21	-0.58	-0.04	0.57	0.44	1.20	1.20	*6.2*	*9.0*
	42	-0.59	1.17	-0.16	1.18	0.72	1.19	1.20	1.20	*11.3*	*25.8*
	52	**2.81**	**1.96**	2.43	1.87	1.63	1.61	1.20	1.20	*37.3*	*33.9*
	62	**1.91**	**1.79**	**1.38**	**1.33**	1.63	1.61	1.20	1.20	*32.7*	*31.7*
	72	**2.14**	**2.07**	**2.33**	**1.88**	**1.26**	**1.28**	1.20	1.20	*34.5*	*32.9*
	82	**3.49**	**3.01**	**3.27**	**3.25**	**1.60**	**1.62**	**1.20**	**1.20**	*40.2*	*40.6*
	92	**2.34**	**2.20**	**1.51**	**1.85**	**2.71**	**2.92**	**1.20**	**1.20**	*39.7*	*41.6*

Table source: Office for National Statistics

Table notes:

1. Projections in bold are made by cohort (see text for further details), otherwise projections are made by calendar year.
2. The first column shows the reductions not from the actual death rates from 2010, but the base death rates for 2010, projected from trends in preceding years.

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There is also growing evidence of generational effects after the 1940 cohort. Thus, in these projections, convergence to the assumed rate of improvement in 2035 has been done by cohort for all those born before 1960 (figures in bold in **Table 4.2**). For those born in 1960 and later (figures not in bold in **Table 4.2**), for whom there is little evidence of generational effects, the changes in the rates of improvement to the target rate are projected by calendar year. Of course, at young ages mortality rates are already at low levels and the precise assumptions made for future mortality have a relatively minor impact on the projections.

The rates of improvement after 2035 are assumed to remain constant (by cohort or by age, as described above) at the rate assumed in 2035 for each year thereafter. So, for those born during the period 1925 to 1938, who are assumed to have higher rates of improvement than 1.2% in 2035, it is assumed that they will continue to experience these higher rates of improvement after 2035.

The same future improvements are assumed for all countries of the UK except for some differences (generally, slightly smaller improvements) in the period to 2035 at some ages for males and for females in Scotland, as has been done in recent past projections.

Taking account of the generally higher rates of improvement assumed prior to 2035 this produces an average annualised rate of mortality improvement of around 1.4 per cent for males and around 1.5 per cent for females over the next 77 years for England and Wales and slightly lower rates for Scotland, which, in all cases, are slightly higher than those experienced over the past 77 years. As **Table 4.3** shows, the new projections generally assume broadly similar, for males, or higher annualised rates of improvement, for females, for the future than experienced over corresponding periods in the past.

Table 4.3: Actual and assumed overall average annual rates of mortality improvement for England, Wales and Scotland

Percentages

	Males		Females	
	Past (actual)	**Future (assumed)**	**Past (actual)**	**Future (assumed)**
England & Wales				
Last/next 27 years	2.19	1.80	1.54	1.93
Last/next 47 years	1.62	1.55	1.38	1.62
Last/next 77 years	1.29	1.41	1.30	1.46
Scotland				
Last/next 27 years	1.91	1.72	1.34	1.75
Last/next 47 years	1.39	1.50	1.31	1.51
Last/next 77 years	1.10	1.38	1.21	1.39

Table source: Office for National Statistics

Table notes:

1. Historic estimates are based on comparison of latest (2007-09) interim life tables with English and Scottish Life Tables for 1930–32, 1960–62 and 1980–82. In all cases the rates of improvement shown are derived from aggregate mortality rates for ages 0 to 99 calculated using the 2001 population estimates for the UK as the standard population.

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Making projections of mortality rates is speculative, so it is important when using projected numbers of the elderly to understand that the range of possibilities is wide. Variant projections using alternative assumptions for the future reduction in mortality are considered in chapter 6.

Effect of assumptions

The implications of these assumptions in terms of the period expectation of life at birth are shown in **Figure 4.4** and **Table 4.4**. **Figure 4.5** shows the implications for period expectations of life at age 65. As can be seen from **Table 4.4**, the actual period expectations of life at birth in the UK in 2010 for males was higher (and for females the same as) than the underlying trend figures.

Figure 4.4: Actual and projected period expectation of life at birth according to mortality rates for given year, 1981-2085, United Kingdom
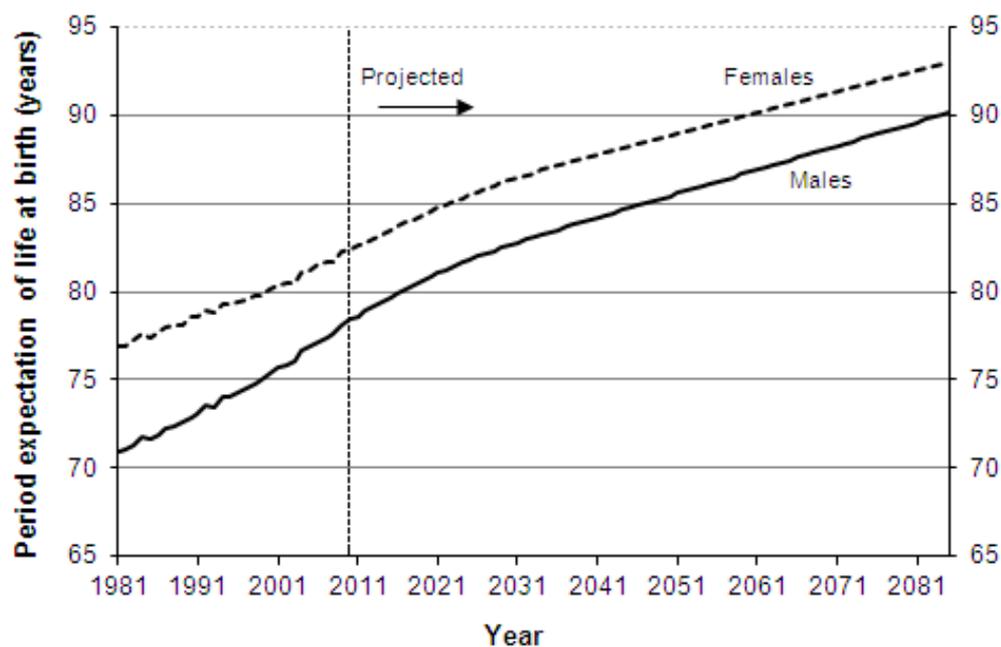
Source: Office for National Statistics

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Figure 4.5: Actual and projected period expectation of life at age 65 according to mortality rates for given year, 1981-2085, United Kingdom
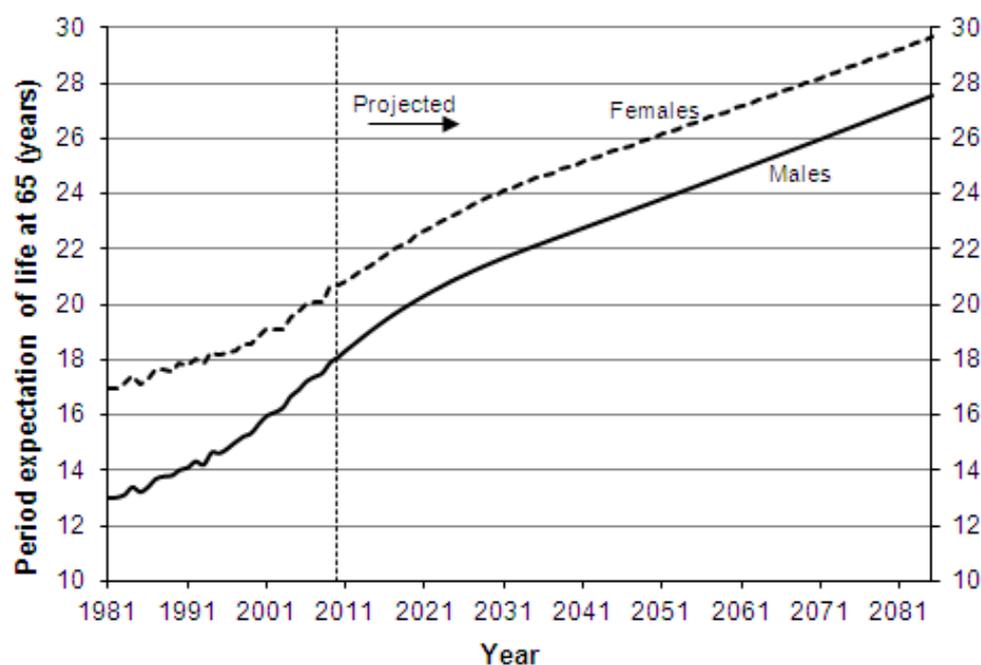

Source: Office for National Statistics

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In 2035, period expectation of life at birth for the UK is around 0.1 years lower than in the previous projections for males and 0.2 years lower for females compared to the previous projections. These differences are mainly due to the age-specific mortality rates for 2010 being assumed to be higher and the rates of mortality improvement between 2010 and 2011 assumed to be lower at many ages below 90 compared to those projected for the same period in the 2008-based projections. Over the early years of the projections these counterbalance the assumption of higher rates of mortality improvement at most ages in 2035.

Table 4.4 also gives ratios of standardised mortality rates for selected future years, together with comparable figures for some past years. The *standardised mortality rate* is the overall mortality rate (that is, total number of deaths divided by total population) resulting from applying the age-specific mortality rates for a particular year to the population numbers for a standard year, taken here as the year 2001. The ratio of these overall mortality rates for selected years to that for a standard year (the average of three years, 2000–2002, in this case) is given in the table. This measure is sometimes

called the *comparative mortality figure* and details of this index decomposed into age-group indices have been published for the UK.[22]

Table 4.4: Actual and projected period expectation of life at birth according to mortality rates for the given year, and ratios of standardised mortality rates, 1981–2071, United Kingdom

	Period expectation of life at birth (years)		Ratios of standardised mortality rates (2000–2002 = 1.00)	
	Males	**Females**	**Males**	**Females**
Actual				
1981	70.9	76.9	1.47	1.30
1986	71.9	77.7	1.38	1.23
1991	73.1	78.6	1.25	1.14
1996	74.2	79.4	1.14	1.09
2001	75.7	80.4	0.99	0.99
2006	77.2	81.5	0.86	0.89
2010 (actual rates)	78.5	82.4	0.77	0.82
2010 (trend rates)	78.3	82.4	0.77	0.82
Projected				
2011	78.6	82.6	0.75	0.80
2021	81.0	84.7	0.59	0.63
2031	82.8	86.5	0.51	0.53
2035	83.4	87.0	0.48	0.50
Longer-term projections				
2041	84.2	87.8	0.45	0.46
2051	85.6	89.0	0.40	0.41
2061	86.9	90.2	0.35	0.36
2071	88.3	91.4	0.31	0.32

Table source: Office for National Statistics

Table notes:
1. Standardised on 2001 population estimates

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Expectation of life for generations

So far in this report, expectations of life have mainly been calculated on the basis of the mortality rates *for a particular calendar year* (period life expectancies). However, for some purposes, cohort life expectancies, which allow for future known or assumed changes in mortality, are more appropriate measures. Further information on the difference between period and cohort life expectancies is available on the [ONS website](.).[23]**Table 4.5** shows projected period and cohort expectations of life at selected ages for four different years.

Table 4.5 shows that the projected period expectation of life at birth for a male in the UK was 78.5 years on the basis of the mortality rates for 2010. However, taking into account assumed mortality improvements in later years, a male born in that year would be expected to live for 90.2 years. Similarly, the average man aged 65 in 2010 would live for a further 18.1 years based on the mortality rates for 2010. However, taking account of the assumed further mortality improvement after 2010, he would actually be expected to live for a further 21.0 years.

Table 4.5: Period and cohort expectation of life by selected ages for the years 2010, 2011, 2021, 2031 and 2035

United Kingdom

	Males						**Females**				
	2010	**2011**	**2021**	**2031**	**2035**		**2010**	**2011**	**2021**	**2031**	**2035**
Period expectation of life											
0	78.5	78.6	81.0	82.8	83.4		82.4	82.6	84.7	86.5	87.0
15	63.9	64.1	66.5	68.2	68.7		67.9	68.1	70.1	71.8	72.3
60	22.1	22.3	24.4	25.8	26.3		24.9	25.1	27.0	28.5	29.0
65	18.1	18.3	20.3	21.7	22.1		20.7	20.9	22.7	24.1	24.6
75	11.1	11.3	13.1	14.3	14.6		12.9	13.1	14.7	16.0	16.4
85	6.0	6.1	7.3	8.4	8.7		6.9	6.9	8.1	9.2	9.5
Cohort expectation of life											
0	90.2	90.3	92.0	93.5	94.2		93.7	93.8	95.2	96.6	97.2
15	73.4	73.6	75.2	76.7	77.3		77.1	77.3	78.6	80.0	80.6
60	25.5	25.6	26.9	28.2	28.7		28.5	28.6	29.8	31.0	31.5
65	21.0	21.1	22.4	23.5	24.0		23.7	23.8	25.0	26.1	26.6
75	12.8	13.0	14.3	15.3	15.6		14.7	14.9	16.2	17.1	17.5
85	6.5	6.6	8.0	8.8	9.1		7.3	7.4	8.9	9.8	10.1

Table source: Office for National Statistics

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Figure 4.6 shows the cohort expectation of life at birth for England and Wales for generations born from 1850 to 2050, and **Figure 4.7** shows the cohort expectation of life at age 65 for those reaching age 65 in 1850 to 2050 based on the actual mortality rates experienced in the past or assumed for the future.

Figure 4.6: Cohort expectation of life at birth according to historic and projected mortality rates, persons born 1850–2050,England and Wales
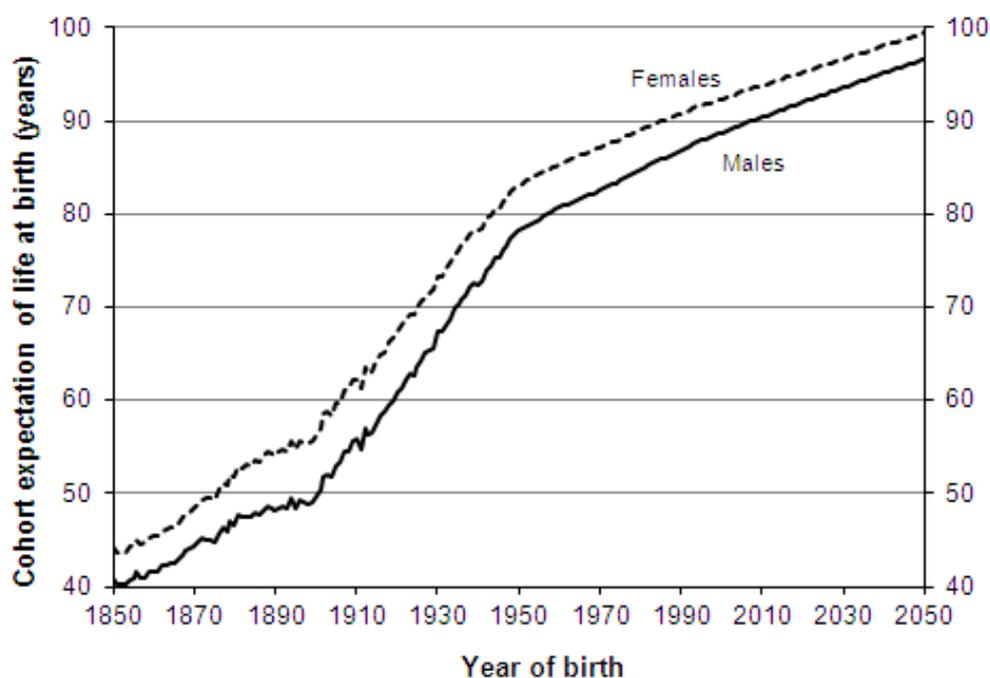
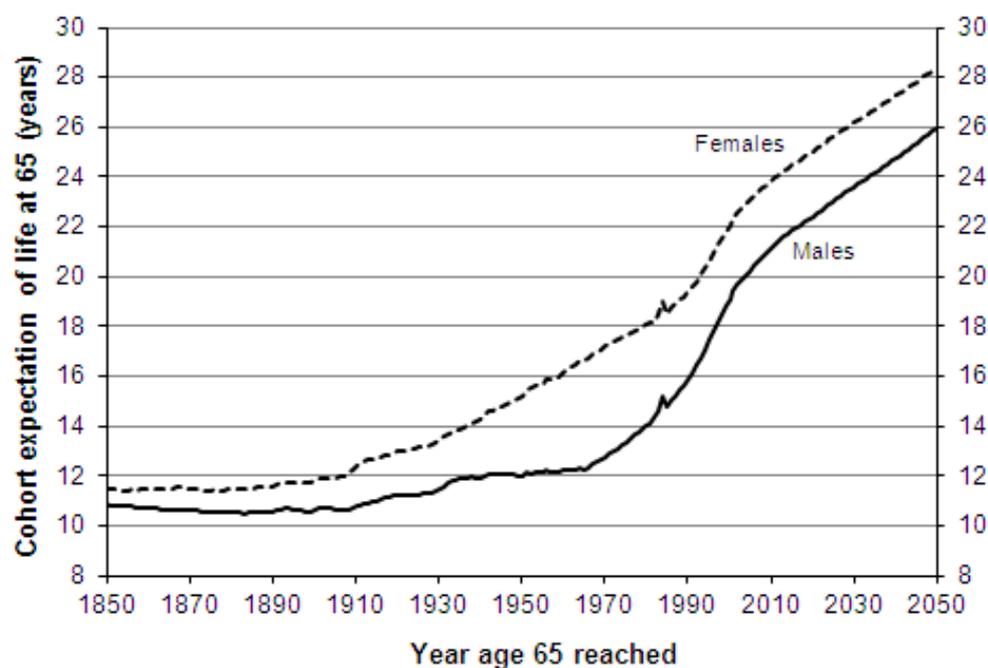Source: Office for National Statistics

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Figure 4.7: Cohort expectation of life at age 65 according to historic and projected mortality rates, persons who reached age 65 1850–2050, England and Wales

Source: Office for National Statistics

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About half of the increase in cohort life expectancies at birth between generations born in 1850 and 1945 was due to the reduction in infant and child mortality to very low levels. Subsequent generations have benefited particularly from the almost complete elimination of deaths from acute and infectious diseases. **Figure 4.6** illustrates the point that, while current reductions in mortality rates at the older ages will continue to extend the average lifetime, once this reaches around 78 years for males and 83 years for females (that is, for men and women born in 1950), further progress is likely to be much slower. The great majority of deaths will then be attributable to chronic and degenerative diseases.

While the cohort expectation of life at age 65 for females has been increasing at a fairly steady rate since the 1930s, the cohort expectation of life at age 65 for males showed relatively little increase between 1930 and 1970 after which it began to increase more rapidly than for females. As discussed earlier, a partial explanation for this may be the different historical patterns in cigarette smoking between men and women. This is likely to have delayed mortality rates for older males falling to the levels they would have reached had they followed the reductions in female mortality

rates experienced during the 1950s and 1960s, rather than indicating a continuing convergence of male mortality rates to those for females.

Constituent countries of the UK

In principle, a different rate of mortality improvement could have been employed for each country of the UK, perhaps showing a convergence later in the 21st century. However, as discussed earlier, a comparison of mortality improvements for each country with those experienced in the UK suggested that the same rates of mortality improvement by age and sex could be assumed for each country of the UK, except for Scotland, where different rates of improvement were assumed to 2035 for males and females at certain ages. The resulting projected mortality rates and expectations of life do vary between countries, of course, as shown in **Table 4.6**, because of the different starting mortality rates. Of the four countries, England shows the highest life expectancy and Scotland the lowest.

As can be seen from **Table 4.6**, compared with the 2008-based projections, period expectations of life at birth for males and females are lower in the early years of the projection period but are generally broadly similar by 2035. In 2035, period expectations of life at birth for males are projected to be broadly similar for England, 0.1 years lower for Wales, 0.2 years lower for Scotland and 0.1 years lower for Northern Ireland. The differences are slightly greater for females, with period life expectancies at birth around 0.1 years lower for England, 0.2 years lower for Wales, 0.3 years lower for Scotland and 0.2 years lower for Northern Ireland in 2035 compared to those previously projected.

Cohort life expectancies at birth for both males and females are projected to be higher than in the previous projections for each country of the UK for all years. For those born in 2035 the differences are around 2.2 years higher for England, Wales and Scotland and 2.0 years higher for Northern Ireland. For females the differentials are slightly smaller; 2.0 years higher for England, 1.9 years higher for Wales, 1.7 years higher for Scotland and 1.9 years higher for Northern Ireland.

Table 4.6: Period and cohort expectation of life at birth for the years 2010, 2011, 2021, 2031 and 2035

Corresponding results from the 2008-based projections are shown in italics

	2010		2011		2021		2031		2035	
Period expectation of life at birth										
Males										
England	78.8	*78.9*	78.9	*79.2*	81.4	*81.7*	83.1	*83.2*	83.7	*83.7*
Wales	77.9	*78.1*	78.0	*78.4*	80.5	*81.0*	82.3	*82.5*	82.9	*83.0*
Scotland	76.2	*76.2*	76.2	*76.5*	78.5	*78.9*	80.3	*80.5*	80.9	*81.0*
Northern Ireland	77.1	*77.6*	77.6	*77.9*	80.1	*80.5*	81.8	*82.1*	82.4	*82.5*
United Kingdom	78.5	*78.5*	78.6	*78.9*	81.0	*81.4*	82.8	*82.9*	83.4	*83.4*
Females										
England	82.7	*82.7*	82.9	*82.9*	85.0	*85.2*	86.7	*86.9*	87.2	*87.3*
Wales	81.9	*82.1*	82.2	*82.4*	84.3	*84.7*	86.1	*86.4*	86.6	*86.8*
Scotland	80.6	*80.7*	80.8	*81.0*	82.9	*83.3*	84.6	*85.0*	85.2	*85.5*
Northern Ireland	81.7	*82.2*	82.1	*82.4*	84.4	*84.7*	86.1	*86.4*	86.6	*86.8*
United Kingdom	82.4	*82.4*	82.6	*82.7*	84.7	*85.0*	86.5	*86.7*	87.0	*87.1*
Cohort expectation of life at birth										
Males										
England	90.5	*89.1*	90.6	*89.2*	92.2	*90.4*	93.8	*91.7*	94.4	*92.2*
Wales	89.8	*88.4*	89.9	*88.6*	91.5	*89.8*	93.1	*91.1*	93.8	*91.6*
Scotland	87.8	*86.5*	87.9	*86.6*	89.6	*88.0*	91.3	*89.3*	92.0	*89.8*
Northern Ireland	88.9	*87.9*	89.2	*88.0*	90.8	*89.3*	92.4	*90.6*	93.1	*91.1*
United Kingdom	90.2	*88.8*	90.3	*89.0*	92.0	*90.2*	93.5	*91.5*	94.2	*92.0*
Females										
England	93.9	*92.6*	94.0	*92.7*	95.4	*93.8*	96.8	*94.9*	97.4	*95.4*

	2010		2011		2021		2031		2035	
Wales	93.3	*92.2*	93.5	*92.3*	94.9	*93.4*	96.4	*94.5*	96.9	*95.0*
Scotland	92.0	*90.9*	92.1	*91.0*	93.6	*92.2*	95.1	*93.4*	95.6	*93.9*
Northern Ireland	93.1	*92.1*	93.4	*92.2*	94.8	*93.3*	96.2	*94.5*	96.8	*94.9*
United Kingdom	93.7	*92.4*	93.8	*92.6*	95.2	*93.7*	96.6	*94.8*	97.2	*95.2*

Table source: Office for National Statistics

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Mortality differences between males and females

In common with other Northern European countries,[1] the excess of period life expectancy at birth for females over males rose in the UK during the period 1900 to 1970, before declining in more recent years. In the UK the differential has fallen from 6.0 years in 1980 to 3.9 years in 2010; it is projected to fall to about 3.6 years by 2035. This decline has been driven mainly as a result of changing differentials in mortality at older ages. These are often driven in turn by changes in behavioural factors such as smoking. For example, in recent years there has been an increasing incidence for women of lung cancer deaths, as compared with falling rates for men. In general, women took up smoking later than men and for them the peak of lung cancer deaths and other deaths related to smoking is still to come.[5, 6]

The changing life table

Figures 4.8 and 4.9 illustrate how the survival curve, which shows the proportion of those born in a given year who survive to each age, is progressively moving to the right of the chart, as more and more deaths occur at advanced ages. The charts are based on the average of male and female mortality in England and Wales. In **Figure 4.8**, the survival curves are calculated on a period basis and show the percentages who would survive to successive ages if they experienced the mortality rates of the year shown with no allowance for known or projected changes in mortality rates for the years thereafter. The first, least rectangular, curve represents the life table according to the mortality rates of the year 1851 and successive curves are given at 20 year intervals, with the uppermost being the projected life table for the year 2031. From this chart it can be seen that the median age at death, that is, the age to which half of those born survive, was about 45 on the basis of the mortality rates of 1851; this is projected to increase to about age 88 by the year 2031.

Figure 4.9 shows the survival curves calculated on a cohort basis, that is, allowing for known and projected future changes in mortality after the cohort's year of birth. Since mortality rates have, in general, been improving over past years and are projected to continue to improve, the survival curve for a given year in **Figure 4.9** lies to the right of that for the corresponding year in **Figure 4.8**. From

this chart it can be seen that, on a cohort basis, the median age at death for those born in 1851 was actually about 48, this is projected to be about 95 for those born now and to increase further to about age 98 for those born in 2031.

It is clear from **Figure 4.8** that recent improvements in period expectation of life at birth have been due primarily to increases in survival to elderly ages. In contrast, increases in maximum lifespans have been comparatively small. There is limited scope for further reduction in mortality rates at young and middle ages. Any continuation of recent increases in expectation of life will only be achieved through major falls in mortality at older ages.

Further details

Projected numbers of deaths and comparisons with the previous (2008-based) projections are discussed in Chapter 2. While Chapter 6 presents the results of variant projections based on alternative assumptions about future mortality. The detailed age specific rates assumed in the principal and variant projections for each country can be accessed via the NPP interactive table download tool.[30]

Figure 4.8: Proportion of persons surviving (on a period basis) to successive ages, according to mortality rates experienced or projected, persons born 1851-2031, England and Wales
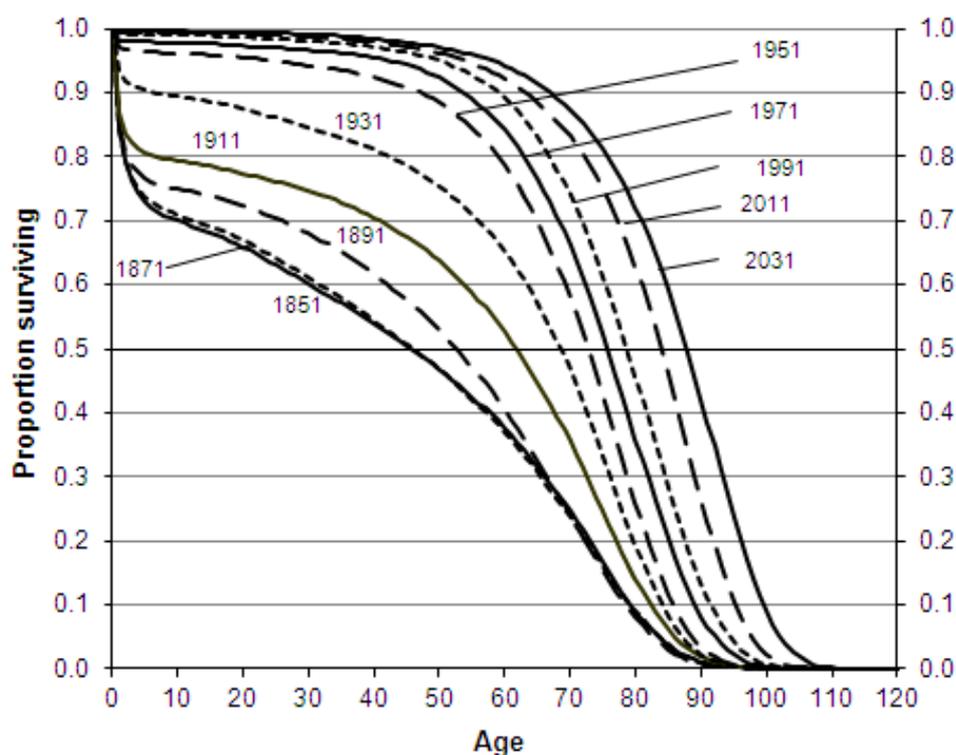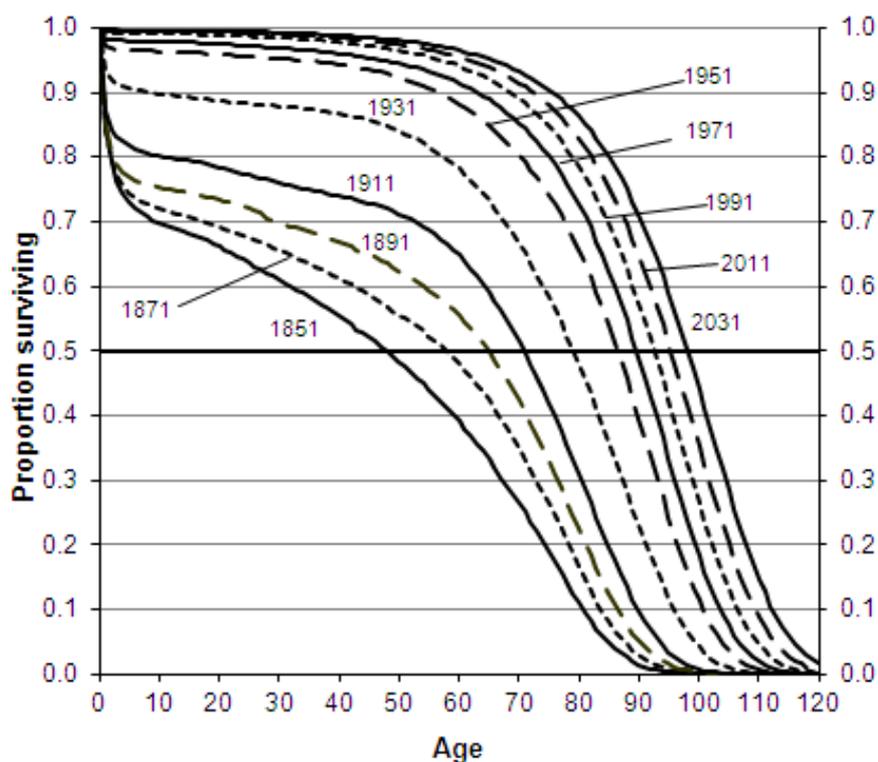

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Figure 4.9: Proportion of persons surviving (on a cohort basis) to successive ages, according to mortality rates experienced or projected, persons born 1851-2031, England and Wales

Source: Office for National Statistics

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Views on future levels of mortality improvements and expectations of life

Mortality projections prepared in other countries and by other agencies tend to be based largely on extrapolation of past trends either in rates of mortality improvement or in expectations of life. Expert opinion is often used to inform the assumptions made. It is therefore perhaps helpful to summarise some of the current arguments put forward by experts regarding future levels of mortality improvements and life expectancy, for the UK and for other developed countries.

For the UK, several factors have been identified amongst the likely drivers of future mortality change including the 'cohort effect', the 'ageing of mortality improvement' (where the ages at which the highest rates of improvement have occurred have been increasing over time), increased uncertainty at younger ages, changes in prevalence of cigarette smoking, the effects of other lifestyle changes and medical advances. These are all discussed elsewhere in this chapter.

Appendix A of the Background and methodology report published on 26th October 2011 provides a note on the meeting of the National Population Projections Expert Advisory Group at which members were asked their views on the validity of a large range of arguments which might be thought likely to influence future mortality trends. In general the UK experts felt that the current high rates of mortality improvement were likely to continue into the future. Many events were occurring which would increase the chances of longevity increasing such as continuing medical and bio-technological advances, more effective health care systems and better health information and changes in lifestyle behaviour. Society would be able and willing to afford new treatments. However, there were factors which would work in the opposite direction and not all sectors of the population may choose to adopt lifestyle behaviours leading to increasing longevity. The likely impact of obesity was discussed. It was agreed that there would be an increase in obesity levels and that this would have an effect on morbidity but there was less agreement as to the subsequent impact of this on mortality and whether any increase might be reversible in the medium-term. Some believed rising levels of obesity would lead to large downward influence on life expectancy but others believed the effect would be relatively small.

It was acknowledged that there are elements influencing mortality improvement in both directions and that these need to be considered together to determine if the overall effect will be positive or negative. However, it was felt that those factors tending to increase longevity would outweigh negative influences and that the increase in life expectancy over the next 25 years would be similar to that experienced over the preceding 25 years.

There is currently a wide range of opinion amongst demographers, gerontologists, epidemiologists, academics and others as to the likely future pattern of longevity. Proponents of a biological maximal length to life refer to the 'Hayflick' limit – in the 1960s, Hayflick found that certain mammal cells could only divide up to a specific limited number of times, which were roughly linked with the typical lifespans of the organisms involved.[24] Others have argued that lifespan can be viewed as a kind of biological warranty period linked to the reproductive period with physiological decline in the post-reproductive period producing restraints on the duration of life.[25]

Oeppen and Vaupel have observed that past predictions of limits to life expectancy have nearly all been broken afterwards.[12] They have noted that record life expectancy (the highest life expectancy observed in any country of the world at any particular time) has increased at a steady pace over the last 160 years or so and suggest that this is likely to continue into the future. However, Olshansky[11] and others have argued that there will be countervailing trends to the high rates of mortality improvements seen in recent years, driven by increasing levels of obesity, sedentary behaviours and other adverse lifestyle factors.

Some scientists have suggested that medical advances could lead to engineered negligible senescence with radical consequences for future life expectancy. For instance, de Grey[26] believes

that there are only seven mechanisms for accumulating damage to the human body and that therapies for reducing or reversing all of these types of damage are currently foreseeable. Given sufficient commitment and resources, the possibility of life expectancy of 150 years, or even longer, may be with us in the next 20 to 30 years.

Given this wide disparity of views as to the likely future course of longevity, users of the projections can gain some insight into the sensitivity of their results to the various views on future mortality by considering the high and low life expectancy variants (see variants chapter 6). However, these are intended to represent plausible alternative assumptions and are far from reflecting the extremes of thinking on future mortality.

Latest Eurostat and UN projections

In their latest (2010-based, convergence scenario) projections,[27] Eurostat assume an increasing period life expectancy at birth for the UK, though the rate of increase declines over time. Eurostat's assumptions were derived by estimating life expectancy and the corresponding mortality rates for a future year (the convergence year) using a version of the Lee Carter method applied to historical combined data for several EU countries. Life expectancies and mortality rates for intermediate years for a given country were then obtained by exponential interpolation from current fitted data for that country to the assumed rates in the convergence year, with improvements occurring at a slowing pace over time. The Eurostat projections of period expectations of life at birth for males and females for the UK are lower than those in the 2010-based national population projections produced by ONS.   The differentials for males continue to increase throughout the projection period; for females the differentials increase until around 2033 after which the differentials decline over time.

Both the national UK projections and the Eurostat projections assume higher projected period expectations of life at birth for the UK than the current United Nations 2010 Revision.[28]

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Background notes

1. Details of the policy governing the release of new data are available by visiting www.statisticsauthority.gov.uk/assessment/code-of-practice/index.html or from the Media Relations Office email: media.relations@ons.gsi.gov.uk

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