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# Continuous Mortality Investigation

## Mortality Projections Committee

## WORKING PAPER 83

# Recent mortality in England & Wales

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## Executive Summary

Mortality improvements in 2015 are expected to be unusually low. Based on deaths to 31 July 2015 and an estimate for the rest of the year, we expect mortality improvements in 2015 of around −2.3% for the 18-102 age range and −3.2% for ages 65-102, for males and females combined. These are both lower than any other improvement for the same age range in the period 1975-2015, used to calibrate the latest version of the CMI Mortality Projections Model (the CMI Model), CMI_2015.

The main difference in mortality between 2015 to date and 2014 occurred during the first quarter of the year, particularly in January.

While the relatively high level of mortality in 2015 is partly due to a large number of deaths in January, mortality improvements in other recent years have also been low. Although the mortality improvement in 2014 was slightly higher than the average improvement in the recent past, improvements in 2012 and 2013 were close to zero. This means that the average annual improvement from 2011 to 2015 is just 0.3% p.a. for the 18-102 age group and 0.1% p.a. for ages 65-102. As for the single-year improvements, these are both the lowest for decades; lower than any other equivalent period in the data used to calibrate CMI_2015.

The low improvements for 2011-2015 contrast starkly with average improvements of 2.4% p.a. between 2000 and 2011.

At this stage it is difficult to say whether mortality improvements may return to levels more in line with prior years' experience, or whether we are at the start of a period of prolonged lower improvements. This poses a challenge for the CMI Model – and other projections of mortality – to respond promptly to potential changes in mortality trends without introducing unwarranted volatility.

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## 1 Introduction

This Working Paper analyses and discusses mortality in England & Wales in recent years. After more than a decade of fairly steady mortality improvements, the last few years have had low and sometimes negative mortality improvements. Mortality in 2015 to date has been particularly heavy.

The Working Paper is designed to complement the Mortality Projections Committee's work. It provides additional analysis of the data that has been used to calibrate the latest version of the CMI Mortality Projections Model, CMI_2015, which is being released at the same time as this paper. It also gives context to the Committee's deliberations on future versions of the Model, which will be discussed at public meetings in October 2015[1].

However, the analysis in this Working Paper is "model free" and is not tied to the CMI Mortality Projections Model (the CMI Model). As such the Committee hopes that that it will be of wide interest and relevance. The unusual experience of the last few years poses a number of challenges to anyone who needs to project mortality:

- Does recent experience suggest that we might be at the start of an era of prolonged lower mortality improvements, or should we expect to return to more typical levels of improvements?
- How quickly should mortality models react to new data, to reflect genuine trends promptly without being unnecessarily volatile?

Section 2 looks at mortality data on an annual basis, putting the mortality experience of recent years into context. Section 3 takes a closer look at mortality within years, drawing on weekly data. Section 4 focusses on the experience of 2015 to date, and section 5 summarises results from earlier sections. Details of the calculations are contained in an Appendix.

Please note that while this Working Paper is being made publically available, it makes reference to the CMI Model and other outputs which are restricted to those organisations and individuals who register as CMI users. Information on how to register is available on the CMI's website[2].

[1] http://www.actuaries.org.uk/research-and-resources/pages/future-cmi-mortality-projections-model

[2] http://www.actuaries.org.uk/research-and-resources/pages/how-access-cmi-outputs

## 2 Mortality for complete calendar years

The analysis in this section is based on the annual data that is used to calibrate the CMI_2015 Model, which is derived from data published by the Office for National Statistics (ONS) for deaths and mid-year populations.

We have estimated the number of deaths for 2015, which is not yet complete, so that we can include it in the analysis of annual data. To do so we have combined data on weekly deaths to 31 July 2015 with an estimate for the rest of the year. The methods used are described in Appendix C of [CMI Working Paper 84](CMI Working Paper 84).

To avoid repetition, in the rest of this paper we will refer to data for 2015 without explicitly stating that this is estimated. However it should be borne in mind that actual experience could be higher or lower than the estimate. We discuss this uncertainty later in this section. Estimated values in Figures are shown using unfilled markers as a visual reminder of their uncertainty.

Figure 1 shows the total number of deaths over time, for ages 18-102, the ages used to calibrate the Model. It shows a steady fall from 1975 to 1995, albeit with considerable year-to-year volatility; a faster fall, with lower volatility, from 1995 to 2011; and then a sharp rise in the number of deaths from 2011 to 2015.

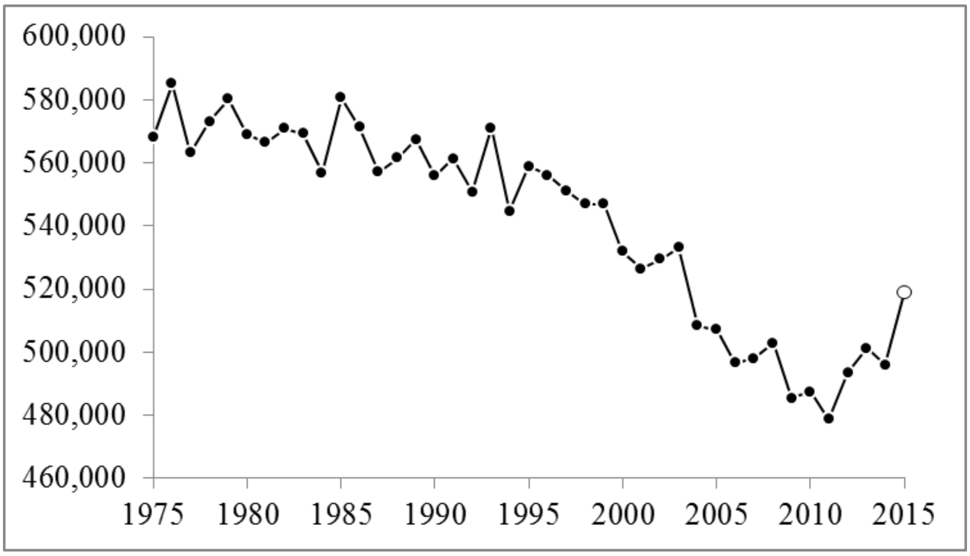


**Figure 1: Total deaths for ages 18-102 in England & Wales, 1975-2015, Males & Females combined**

The numbers of deaths shown in Figure 1 are affected by the growth and ageing of the population over the period. For the rest of this section we would like to remove the impact of changes in the population, so that we can focus on underlying mortality rates and improvements.

To do so, we first calculate the hypothetical number of deaths in a given year using the crude mortality rates for that year but the population of a standard year, 2011. We then express that hypothetical number of deaths as a multiple of those in 2011. We describe this as a standardised mortality ratio (SMR). Details of the calculation are in the Appendix.

We could choose to make any year our standard year. 2011 is a convenient reference point, partly as it is the year of the most recent census in England & Wales, and partly as the mortality experience in Figure 1 before and after 2011 appears to be quite different.

Figure 2 plots the SMR for each year, together with a trend line fitted to 2000-2011. The choice of 2000 is arbitrary, but provides a recent period with fairly consistent experience. The trend line is exponential, to correspond to a constant level of mortality improvement. Over the period from 2000-2011 the trend line fits the SMRs well, and represents a mortality improvement of 2.4% p.a.

The experience from 2011 to 2015 has been almost flat, with an average improvement of just 0.3% pa. As a result the SMR for 2015 is over 8% higher than what might have been expected in 2011, based on the trend line.

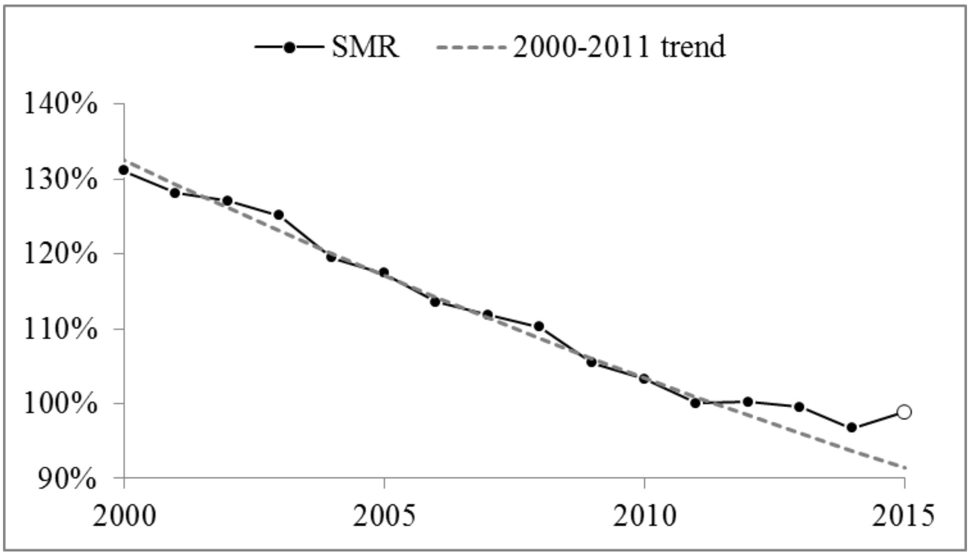


**Figure 2: Standardised mortality ratio for ages 18-102 in England & Wales, 2000-2015, and trend line fitted to 2000-2011**

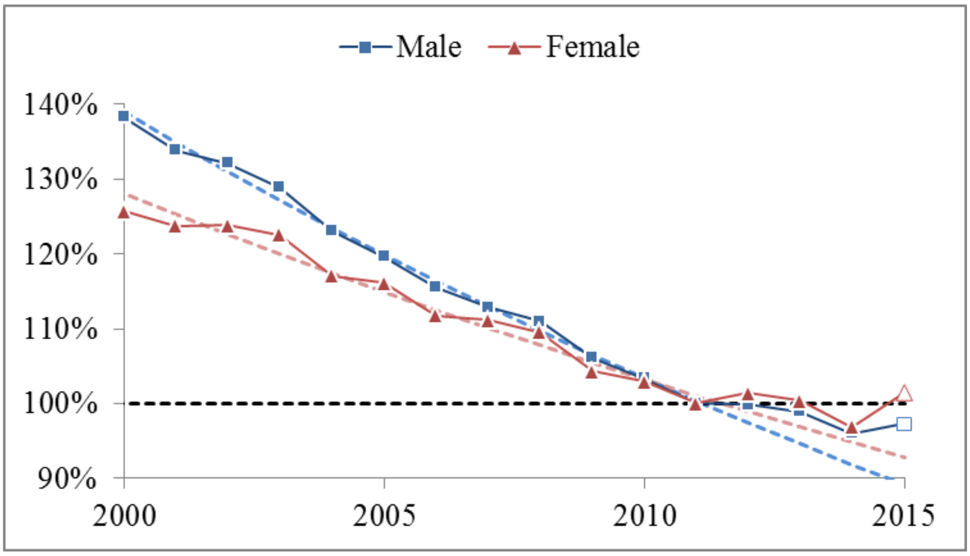


**Figure 3: Standardised mortality ratios for ages 18-102 in England & Wales, 2000-2015, with trend lines fitted to 2000-2011**

Figure 3 shows SMRs for males and females. The SMR for females in 2015 is 100.8%, so mortality has worsened compared to 2011. Although the SMR in 2015 for females is higher than for males, the experience of 2011-2015 relative to the 2000-2011 trend is similar, being 9% higher than the trend for females and 8% higher for males. The higher female SMR in 2015 reflects lower rates of mortality improvement throughout the period from 2000.

The change in SMR provides a measure of mortality improvement, averaged over the ages used for the SMR. Figure 4 shows the annual mortality improvements from 2000 to 2015. The improvement for 2015 stands out, being negative for both males and females. The improvement of −2.3% is the lowest in the period 1975-2015 used to calibrate CMI_2015.

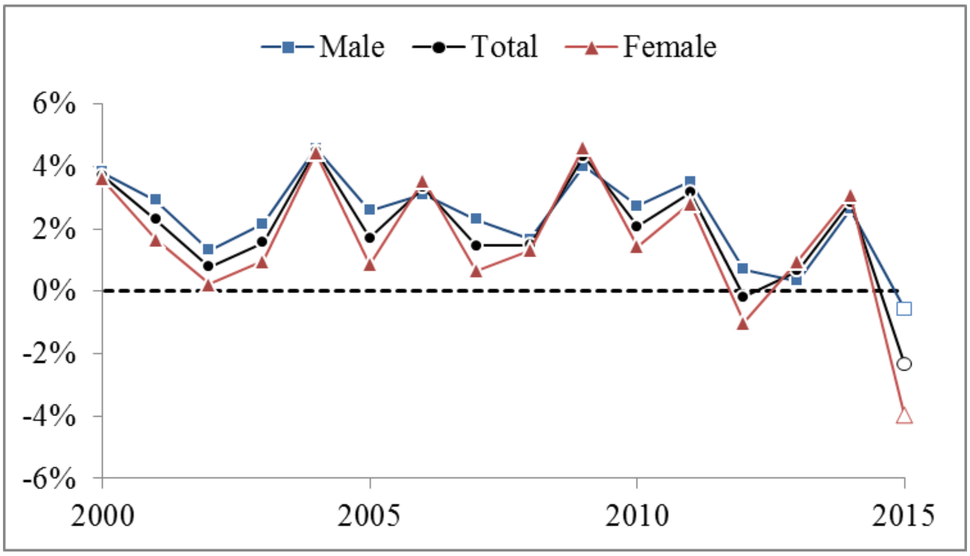


**Figure 4: Annual mortality improvements in England & Wales, 2000-2015, weighted average of ages 18-102**

Figure 4 shows that while males have had higher mortality improvements than females on average, the difference between them tends to be small in years with high mortality improvements (e.g. 2000, 2004, 2006, 2009, 2014) and larger in years with low or negative improvements (e.g. 2002, 2012, 2015). This might be because females are more susceptible to the negative effects of cold winters and influenza, perhaps because they are on average older.

Figure 5 is similar to Figure 4 but shows mortality improvements averaged over the previous four years (e.g. the improvement for 2000 is the average annual reduction in SMR from 1996 to 2000).

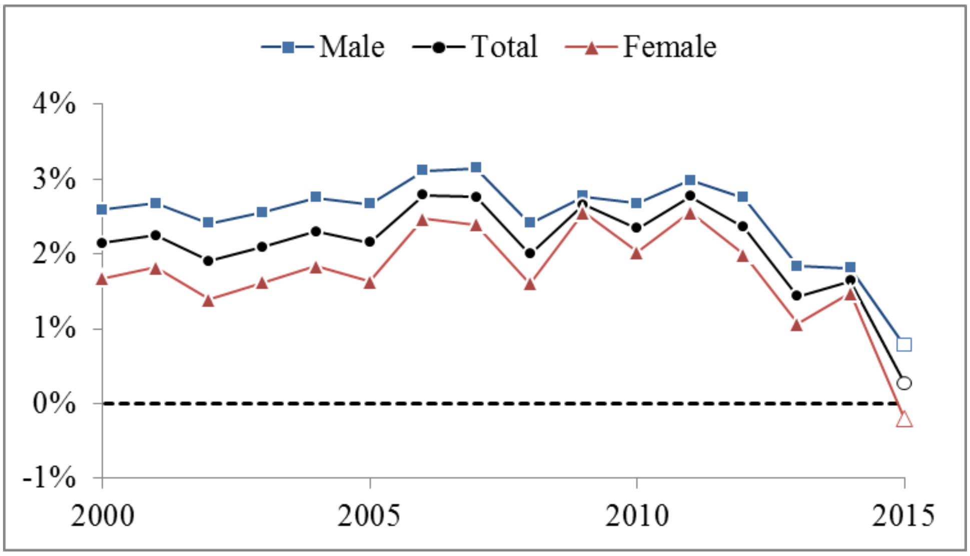


**Figure 5: Annualised four-year mortality improvements in England & Wales, 2000-2015, weighted average of ages 18-102**

Figure 5 shows that males have had higher mortality improvements than females, particularly in the earlier years. The period from 2011-2015 stands out as having an exceptionally low improvement, of just 0.3% p.a. This is the lowest four-year mortality improvement in the period 1975-2015 used to calibrate CMI_2015.

So far the analysis has considered the age range 18-102. Figures 6 and 7 also show the one-year and annualised four-year mortality improvements for ages 18-64, 65-84, and 85-102. They show that the oldest age group has been most strongly affected by the high mortality in 2015.

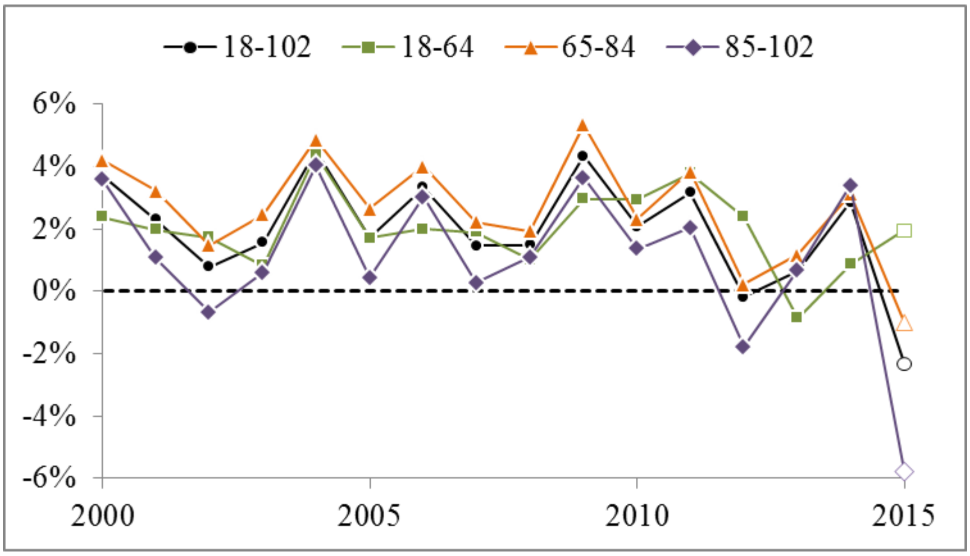


**Figure 6: Annual mortality improvements in England & Wales, 2000-2015, weighted average for various age ranges**

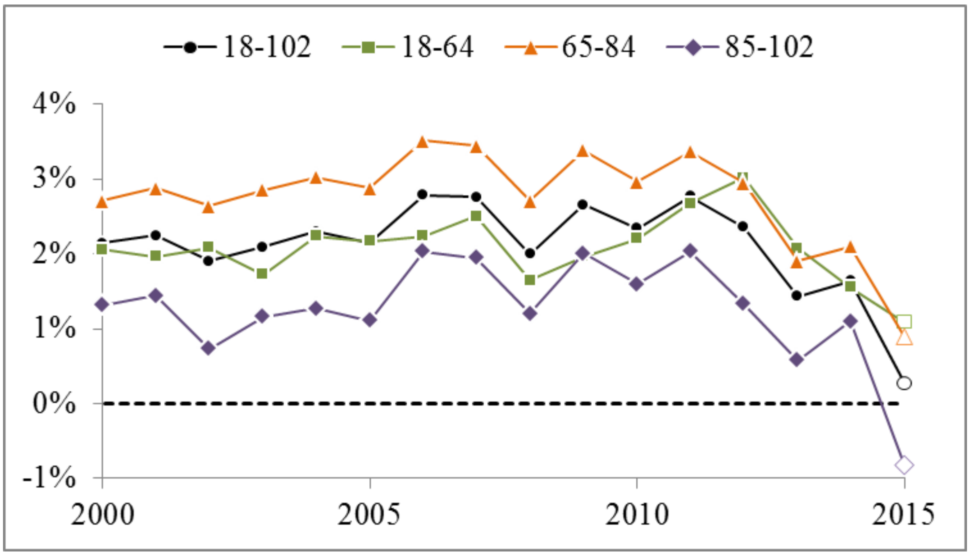


**Figure 7: Annualised four-year mortality improvements in England & Wales, 2000-2015, weighted averages for various age ranges**

Table 1 shows the one-year and four-year mortality improvements in 2015 for these age ranges, and the "pensioner" age range 65-102, and how they rank among the improvements within the 1975-2015 data used to calibrate the Model. For example the mortality improvement in 2015 for the 65-84 age group is ranked 37$^{th}$ of 40 as only three years between 1976 and 2014 had an improvement lower than −1.0%.

**Table 1: One-year and four-year mortality improvements for 2015 for different age ranges, and their rankings within the period 1975-2015**

| Age range | One-year improvement | | Four-year improvement (p.a.) | |
|---|---|---|---|---|
| | 2015 value | 2015 rank | 2015 value | 2015 rank |
| 18-102 | −2.3% | 40$^{th}$ of 40 | +0.3% | 37$^{th}$ of 37 |
| 18-64 | +2.0% | 24$^{th}$ of 40 | +1.1% | 36$^{th}$ of 37 |
| 65-84 | −1.0% | 37$^{th}$ of 40 | +0.9% | 36$^{th}$ of 37 |
| 85-102 | −5.8% | 40$^{th}$ of 40 | −0.8% | 37$^{th}$ of 37 |
| 65-102 | −3.2% | 40$^{th}$ of 40 | +0.1% | 37$^{th}$ of 37 |

Table 1 shows that the one-year improvements have been unusually low for the pensioner age groups, although not for younger ages. However the four-year improvements have been unusually low for all age groups.

**Uncertainty of expected deaths in 2015**

In estimating the expected number of deaths from 1 August to 31 December 2015 we have projected the life table NLT2011-13 using the CMI_2014 Model. This gives a "neutral" estimate which does not take a view on whether the latter part of 2015 is likely to have more or fewer deaths than in a typical year.

For ages 18-102, the ages used to calibrate the Model, in 2015 we have 319,807 deaths in the 212 days to 31 July and a neutral estimate of 199,200 deaths for the remaining 153 days of the year, giving a total of 519,007. So we expect deaths in the second part of the year to be 62% of those in the first part. We will describe this as the "153/212 ratio" referring to the number of days in each part.

We can test the reasonableness and sensitivity of this method by comparing the 153/212 ratio for 2015 to that in previous years. To avoid potential inconsistencies caused by leap years we always use the first 212 days and the following 153 days of each year; ignoring the 366th day of a leap year.

Calculating the 153/212 ratio for deaths registered in earlier years from 2005 to 2014 inclusive gives a range from 64% (in 2013) to 71% (in 2014). The fact that the extremes for this ratio are in the last two years emphasises the volatility of mortality in recent years. Our neutral estimate for 2015 lies outside this range, due to the exceptional number of deaths seen in the early part of 2015.

If we were to estimate deaths for 2015 using a historical average 153/212 ratio, rather than our neutral estimate, this would lead to a higher estimate and hence a larger fall in mortality improvements than the −2.3% improvement from 2014 to 2015 quoted above.

# 3 Weekly mortality

Section 2 considered mortality over annual time periods. We now look at patterns of mortality within years, using weekly deaths data from the ONS.

The ONS groups deaths in one of two ways:

- by date of "occurrence" – when the death actually happened; or
- by date of "registration" – when the death was registered.

There are advantages and disadvantages of each approach:

- Registrations can only occur when register offices are open; so public holidays can lead to artefacts in data by date of registration. This consequently shows more week-to-week volatility than data by date of occurrence.
- There can be significant delays between occurrence and registration. A 2011 ONS report[3] indicates a delay of over three months in nearly 5% of cases. Because of this, data by occurrence is typically published significantly later than data by registration.
- Deaths by occurrence tend to understate the total number of deaths. Some deaths are not registered until after the date of publication of occurrence statistics and the statistics are not subsequently revised.
- Deaths by occurrence are available from August 1999 to July 2014, so we do not have data on this basis for the most recent months. Deaths by registration are available from January 2005 to July 2015, so we do not have data on this basis for earlier years.

Figure 8 shows the raw data on each basis. The two series are broadly similar, with the registrations data showing more spikes, particularly in the first week of the year after the Christmas and Boxing Day public holidays.

Although some of the registrations data is split by sex and age group, we only consider total deaths in this section to provide as long a data series as possible.

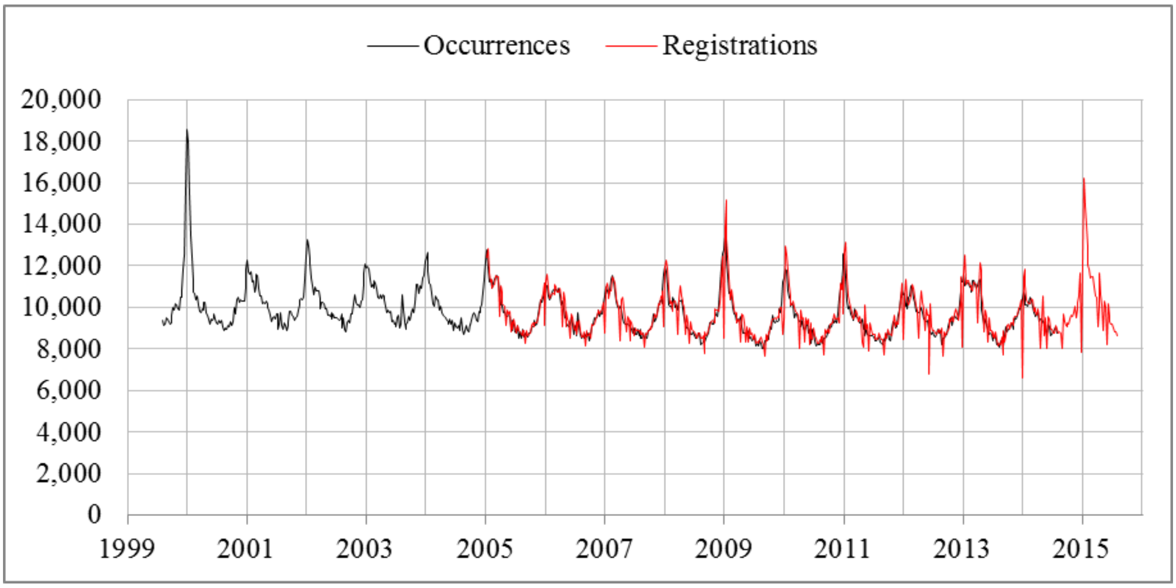


**Figure 8: Weekly deaths, England & Wales**

[3] http://www.ons.gov.uk/ons/guide-method/user-guidance/health-and-life-events/impact-of-registration-delays-on-mortality-statistics/index.html

We then calculate 13-week moving averages for each basis (i.e. the figure for week *w* is the average of data for the 13 weeks from *w*−6 to *w*+6 inclusive) and blend the two averages to produce a single series, covering as long a period as possible. This is shown in Figure 9. The choice of a 13-week average is somewhat arbitrary, but allows us to focus on broad seasonal patterns (e.g. whether a particular winter or summer had light or heavy mortality) without the distraction of very short-term variations.

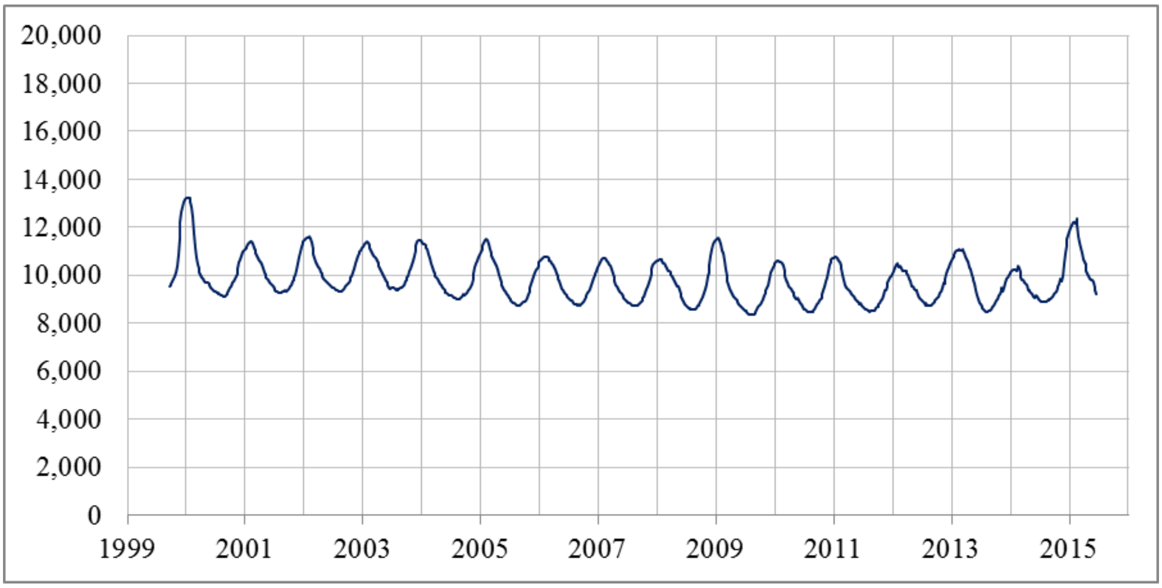


**Figure 9: 13-week central moving average of weekly deaths, England & Wales**

Figure 9 shows that, using the 13-week moving average, early-2015 had the highest number of deaths since 2000. However, as for Figure 1 in the previous section, Figures 8 and 9 do not allow for changes in the population, and it would be helpful to adjust the data in order to understand it better.

The method used here to allow for changes in population is slightly different from that of Section 2 as we do not have weekly deaths data for individual ages; this method is also described in the Appendix.

Figure 10 shows the moving average after allowing for changes in population, together with a trend line fitted to 2000-2011. The trend is exponential, corresponding to a constant mortality improvement of 2.6% p.a, reassuringly similar to the value of 2.4% p.a. calculated from annual data in Section 2.

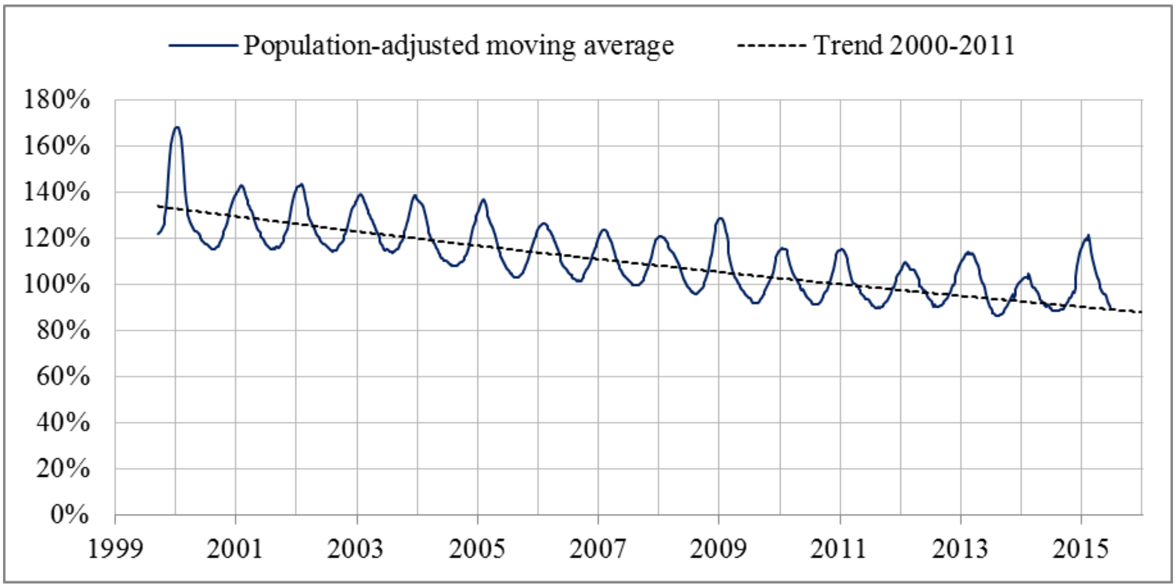


**Figure 10: Population-adjusted moving average of weekly deaths, England & Wales, with exponential trend fitted to 2000-2011**

After adjusting for changes in population, early-2015 still shows a level of mortality that is high compared to recent years, but lower than the 2008/2009 winter.

The difference between the population-adjusted moving average and its trend (i.e. the difference between the two lines in Figure 10) is a combination of regular seasonal variation (more deaths in winter and fewer in summer) and features specific to each year. Figure 11 shows this difference. It also shows the seasonal average – the average of the corresponding weeks of the years from 2000 to 2011 inclusive. The seasonal average line is identical within each year.

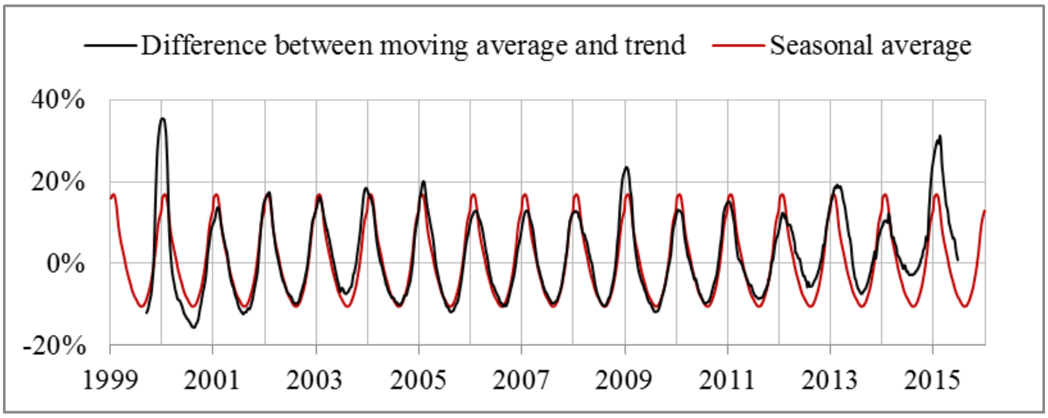


**Figure 11: Population-adjusted moving average of standardised weekly deaths relative to its exponential trend; together with seasonal average**

Figure 12 presents the same information in a different format for the 16 years from 2000 to 2015, to show the patterns for each year more clearly. Each part of Figure 12 represents one year from Figure 11.

Many years from 2001 to 2011 are unexceptional, and close to the seasonal average. The winters of 1999/2000 and 2008/2009 had high mortality, although in each case the periods of high mortality spanned two calendar years, limiting the impact on annual mortality improvements. In contrast, the high mortality of the winter of 2014/2015 fell primarily within 2015 and so contributes to a strongly negative mortality improvement.

Figures 11 and 12 emphasise the message from section 2, i.e. that experience since 2011 has been quite different to that before 2011. The high mortality of 2015 relative to the long-term trend is partly due to high numbers of deaths early in the year, but also reflects several years of low improvements since 2011.

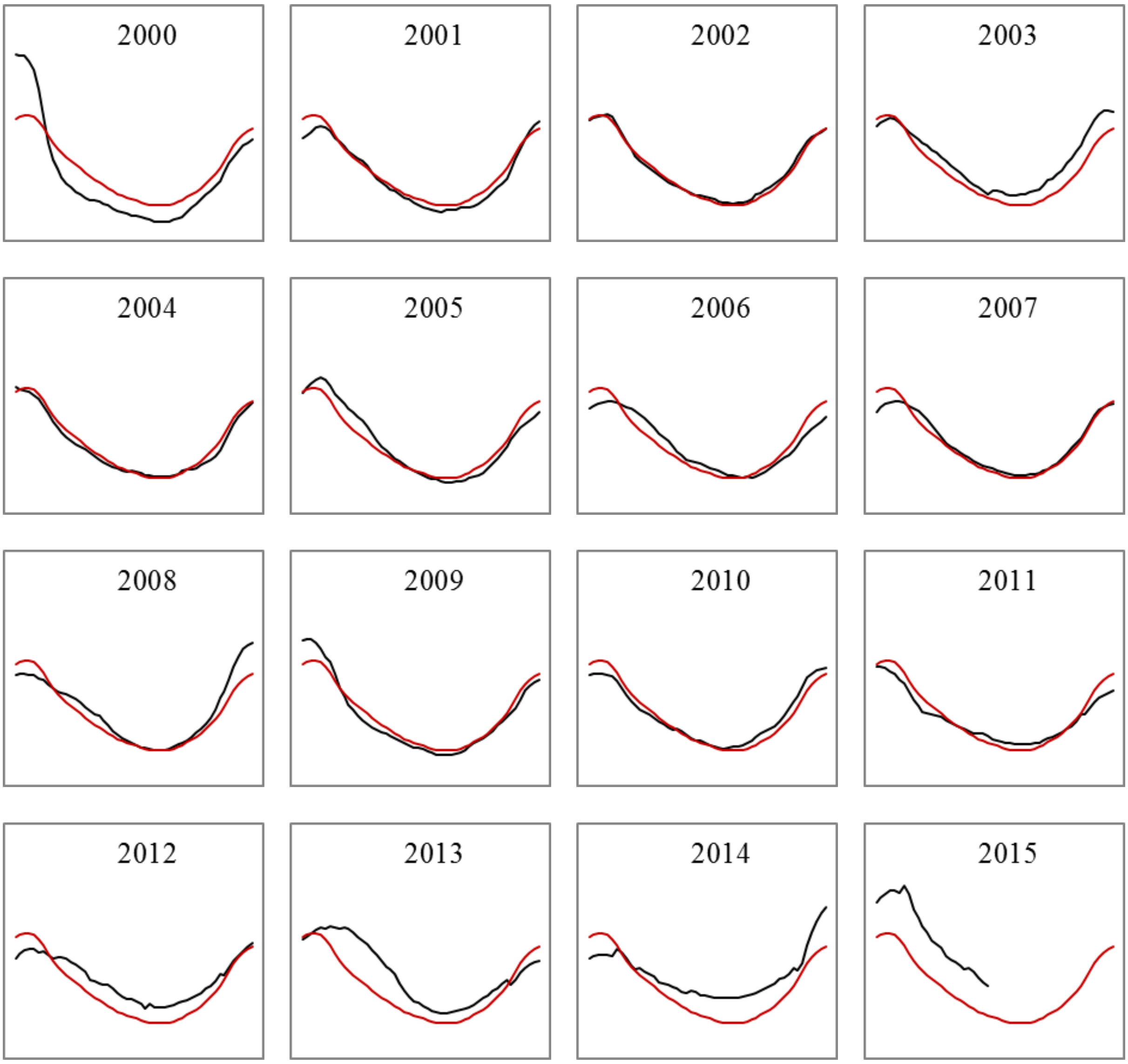


**Figure 12: Population-adjusted moving average of standardised weekly deaths relative to its exponential trend; together with seasonal average**

## 4 2015 in detail

Earlier sections have shown that mortality in 2015 has been unusual. This section looks at the pattern of deaths in 2015 in more detail.

Figure 13 shows the percentage change in the numbers of deaths registered in England & Wales between the periods 4-31 January 2014 and 3-30 January 2015. Each period consists of four weeks with no public holidays, to allow a consistent comparison. Figure 14 is similar, but shows the percentage change between the 30-week periods from 4 January 2014 to 1 August 2014 and from 3 January 2015 to 31 July 2015. Each of these periods has four public holidays, so they also allow a consistent comparison. For simplicity, Figures 13 and 14 are based on actual numbers of deaths without any adjustment for changes in population. (Note the difference in the *y*-axis scale between the two Figures.)

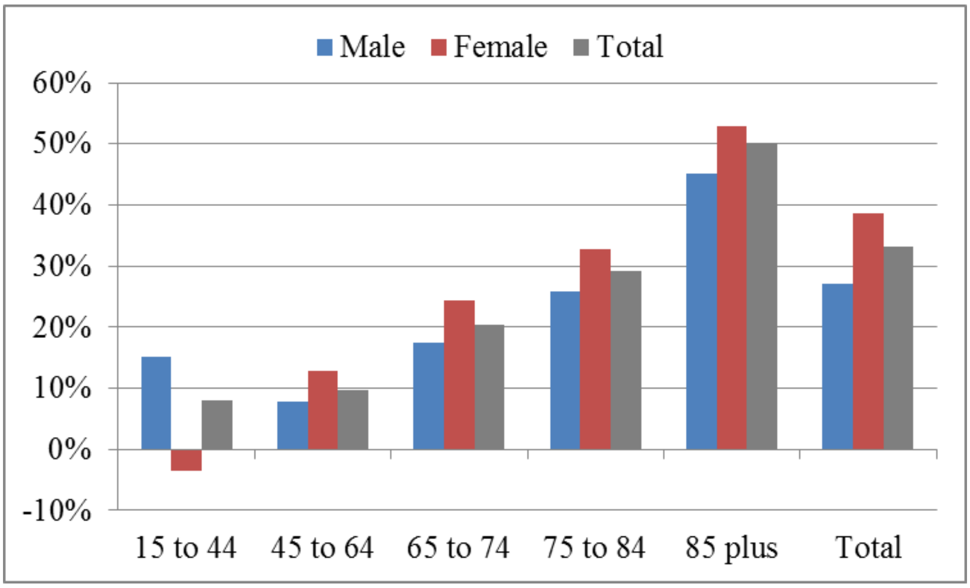


**Figure 13: Percentage change in numbers of deaths between 4-31 January 2014 and 3-30 January 2015**

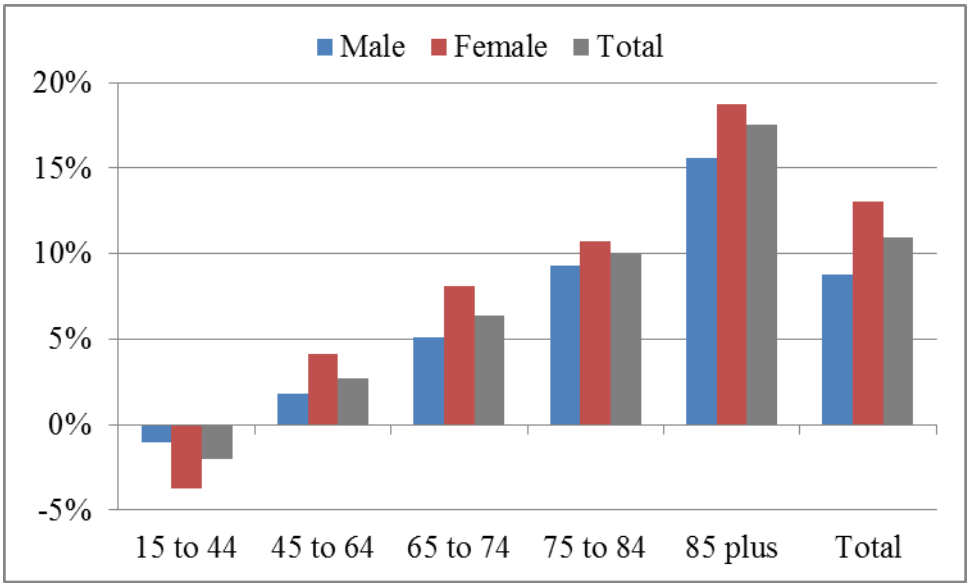


**Figure 14: Percentage change in numbers of deaths between 4 January 2014 to 1 August 2014 and 3 January 2015 to 31 July 2015**

Figure 13 shows that 3-30 January 2015 had 33% more deaths in total than the corresponding period of 2014. The difference is most pronounced for older age groups and for females. Figure 14 has a very similar profile by age and gender to Figure 13 (apart from ages 15 to 44), but with a smaller percentage difference.

Figure 15 shows the numbers of total weekly deaths for corresponding weeks of 2014 and 2015, where "week 1" is 4-10 January for 2014 and 3-9 January for 2015. Again, these do not make any adjustment for changes in population. Public holidays affect the numbers of deaths registered:

- Easter holidays fall in weeks 15 and 16 in 2014 and weeks 13 and 14 in 2015.
- The May bank holidays fall in weeks 18 and 21 in each year.

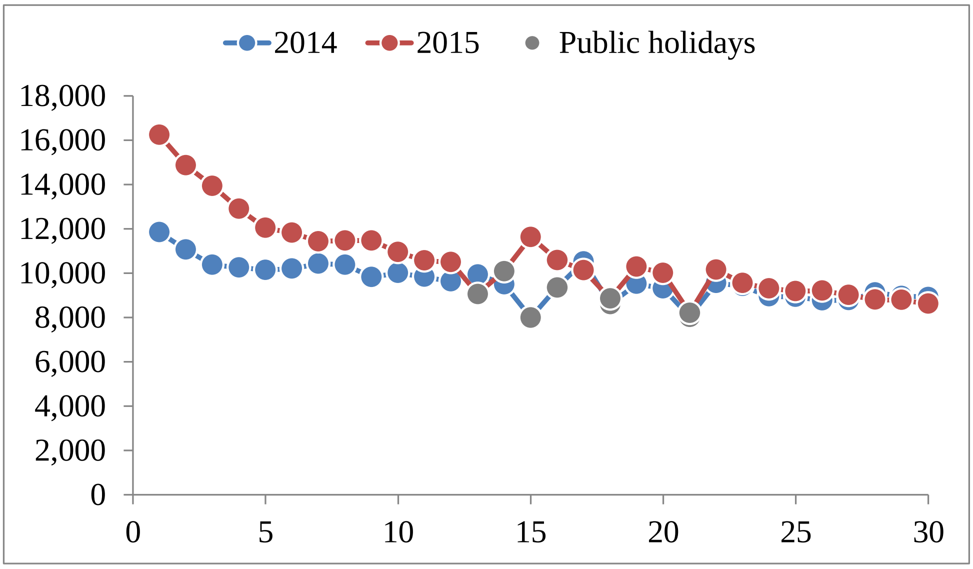


**Figure 15: Numbers of deaths in corresponding weeks of 2014 and 2015**
**"Week 1" is 4-10 January for 2014 and 3-9 January for 2015**

Figure 15 shows that the main difference in deaths between 2014 and 2015 (apart from artefacts due to public holidays) is in the early part of the year. This is consistent with a lower percentage increase in Figure 14 (30-week periods) compared with Figure 13 (4-week periods).

## 5 Summary

The mortality experience of the first seven months of 2015 has been particularly heavy. Based on an estimate of mortality for the rest of the year, we expect the mortality improvement in 2015 to be the lowest in the 40 years of data used to calibrate CMI_2015. The high mortality in the first seven months of 2015 compared to 2014 has been largely due to experience in the early part of the year.

If we compare 2015 only to 2014, then it may be tempting to treat 2015 as a one-off blip. However mortality improvements were also low in 2012 and 2013, and broadly typical in 2014, leading to the four-year mortality improvement from 2011-2015 being lower than any other comparable period in the data used to calibrate CMI_2015. This could suggest that recent years may be starting to show a change in trend. However, at this stage it is difficult to say whether mortality improvements may return to levels more in line with prior years' experience, or whether we are at the start of a period of prolonged lower improvements. This poses a challenge for the CMI Model – and other projections of mortality – to respond promptly to potential changes in mortality trends without introducing unwarranted volatility.

## Appendix – Details of calculations

This Appendix described the way in which mortality data has been adjusted to allow for changes in population

**Section 2 – for complete calendar years**

Write $D(s, x, y)$ and $E(s, x, y)$ for the numbers of deaths and exposures for sex $s$ at age $x$ in year $y$.

Then define $\mathrm{N}(y_0|y_1)$ as the total number of deaths that would be expected based on the mortality rates of year $y_0$ and the exposure of year $y_1$.

For each year we calculate the standardised mortality ratio:

$$SMR(y|Y) = \frac{N(y|Y)}{N(Y|Y)}$$

where

- $Y$ is the standard year
- $N(y|Y) = \sum_{x,s} \left( \frac{D(s,x,y)}{E(s,x,y)} \times E(s, x, Y) \right)$
- $N(Y|Y) = \sum_{x,s} D(s, x, Y)$, the number of deaths in year $Y$

We use $Y = 2011$ as our standard year.

**Section 3 – for weekly data**

When working with weekly deaths we cannot use the same method as for section 2 as we do not have data for the numbers of weekly deaths for individual ages.

Instead we define the standardised mortality ratio as:

$$SMR(w|T) = \frac{N(w|w)}{N(T|w)}$$

so that the SMR is now standardized with reference to $w$ rather than $T$.

Here

- $T$ is the standard time
- $N(w|w)$ is the number of deaths in a week
- $N(T|w) \; = \sum_{x,s} \big( m(s, x, T) \times E(s, x, w) \big)$
- $m(s, x, T)$ is a mortality rate at time T
- $E(s, x, w)$ for a week is calculated by linear interpolation between adjacent values of from $E(s, x, y)$ for years

We use mid- 2011 as our standard time, and ILT2010-12 as the mortality table $m(s, x, T)$. As this is provided only to age 100, we extrapolate to higher ages assuming that $m$ is exponential and the trend from ages 91-100 continues to higher ages.