Office for National Statistics

Article

Changing trends in mortality in England and Wales: 1990 to 2018

An expansion of previous analysis of recent changes in the trends of mortality rates in England and Wales from 1990 to 2018 (Experimental Statistics).

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Release date:
10 March 2020

Next release:
To be announced

Table of contents

1 . Other pages in this release

Changing trends in mortality by national indices of deprivation, England and Wales: 2001 to 2018

Changing trends in mortality by leading causes of death, England and Wales: 2001 to 2018

2 . Main points

- There was a statistically significant slowdown in the long-term improvement in age-standardised mortality rates for both England and Wales (1990 to 2018) around the early 2010s, in line with previous analysis.
- This was true for both sexes and for the different age groups investigated, with some variations in the timing of the change in trend.
- In Wales, the inclusion of 2018 data meant that for females there was a much later time point in the trend (Quarter 3 (July to Sept) 2013 to Quarter 2 (Apr to June) 2014), when compared with the previous analysis (Quarter 3 1995 to Quarter 2 1996); this brings the pattern of slowing mortality improvement in females more into line with males.
- For all females aged 75 years and over in England, and for females aged 75 to 84 years and 90 years and over in Wales, there were two time points where the trend in mortality changed; after the first time point, there was an improvement in mortality, which then slowed after the second time point, in line with the general slowdown in mortality improvement.

3 . Statistician's comment

“Today’s release reports on the continuation in the slowdown in improvement of mortality rates in England and Wales for both males and females. With the addition of 2018 death registrations, the change in mortality in the early 2010s is still evident. We will continue to monitor mortality trends on an annual basis.”

Ben Humberstone, Head of Health Analysis and Life Events

4 . Introduction

In June 2018, we reported on a statistically significant slowdown in the improvement in age-standardised mortality rates in the early 2010's in England and Wales. This article extends the analysis to include 2018 mortality data, and provides new breakpoint analysis (see Section 10 for an overview of the method) by six age groups. We have also published separate but related analyses, which explore changing trends in mortality analysed by cause of death and area deprivation.

We analysed age-standardised and age-specific mortality rates from 1990 to 2018 using segmented regression, a technique that detects the presence of a significant change in trend, known as a “breakpoint” in a time series. The breakpoint signifies that the trends before and after it are different.

We do not forecast the direction the trend may take in the future. The statistical method chosen is an objective test which does not depend on any prior assumptions about the likely date of a change in the trend.

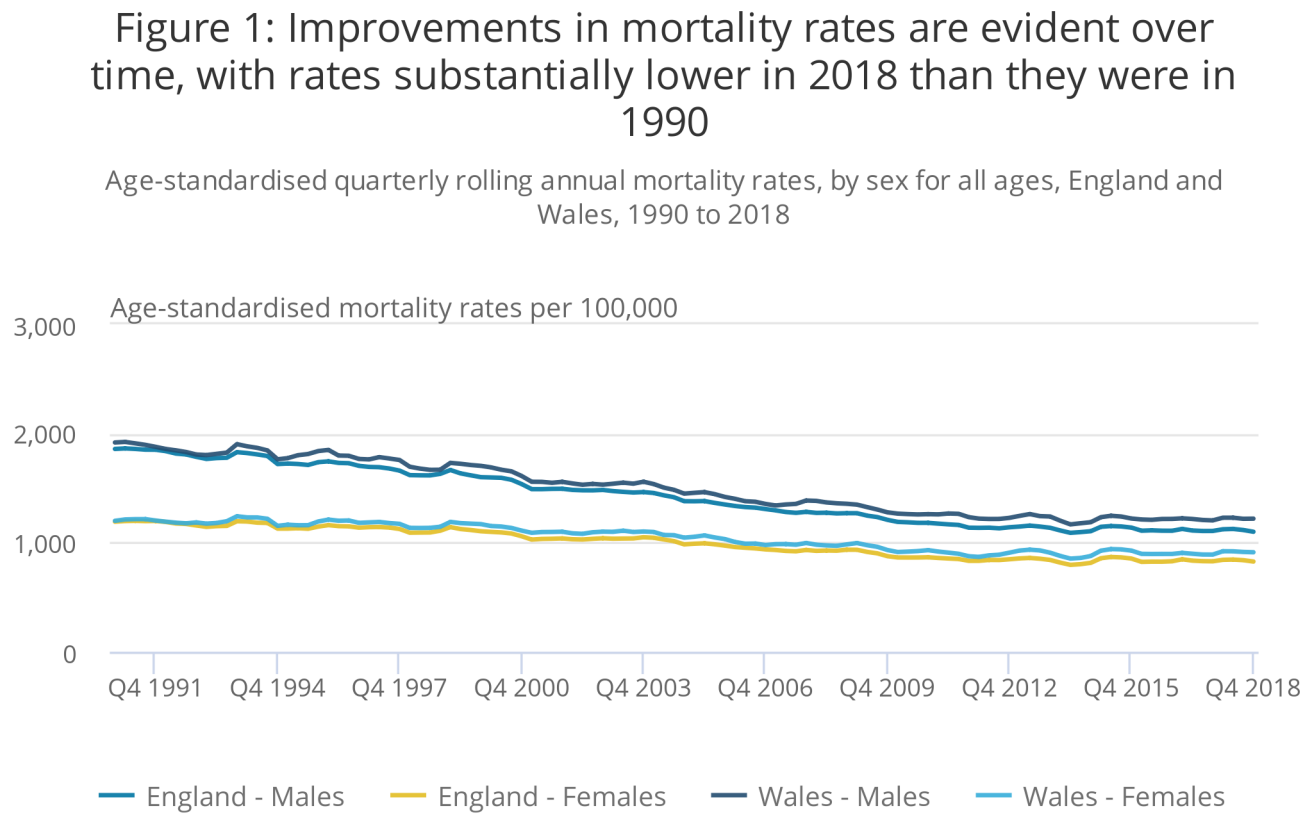
5 . Age-standardised mortality rates in England and Wales, 1990 to 2018

Figure 1 shows the trend in age-standardised quarterly rolling annual mortality rates for all ages, for males and females in England and Wales separately.

In both countries and for both sexes, improvements in mortality rates occurred over this 29-year period, with rates substantially lower in 2018 than they were in 1990. However, the size of improvement between specific time periods differs over time.

Figure 1: Improvements in mortality rates are evident over time, with rates substantially lower in 2018 than they were in 1990

Age-standardised quarterly rolling annual mortality rates, by sex for all ages, England and Wales, 1990 to 2018



Source: Office for National Statistics

Notes:

1. Age-standardised mortality rates per 100,000 population, standardised to the 2013 European Standard Population.

2. Figures exclude non-residents, based on boundaries as of May 2019.

3. Q1 refers to annual period ending Quarter 1 (April to March), Q2 refers to annual period ending Quarter 2 (July to June), Q3 refers to annual period ending Quarter 3 (October to September), Q4 refers to annual period ending Quarter 4 (January to December).

When comparing the change in mortality rates across England and Wales by sex, the greatest improvements were observed for males in England where rates were 40.8% lower in 2018 than 1990. The smallest improvement in mortality rates was for females in Wales, where rates were 24.0% lower in 2018 than in 1990.

As outlined in our previous release, there was a slowdown in improvement during the 2010s. We used segmented linear regression models to determine the timing of changes.

6 . Analysis using one breakpoint: England

Table 1 illustrates the breakpoints detected by the segmented linear regression function for age-standardised and age-specific mortality rates in England.

Our previous release outlined that generally the breakpoints detected by segmented linear regression occurred in the early 2010s, with the exception of females aged 75 years and over, where a breakpoint was identified at period Quarter 2 (Apr to June) 1998 to Quarter 1 (Jan to Mar) 1999.

Within this analysis, we divided the over-75 years age groups further and found similar exceptions within these five-year age groups where breakpoints were identified in the 1990s. These ranged from Quarter 2 1991 to Quarter 1 1992 in those aged 75 to 79 years, to Quarter 2 1998 to Quarter 1 1999 in females aged over 90 years. The Analysis using two breakpoints section provides more information about this breakdown when two breakpoints rather than one were used to detect changes.

Table 1: Breakpoints indicating change in trend in age-standardised and age-specific mortality rates by age group and sex, England: 1990 to 2018

Country	Sex	Age	Breakpoint	Lower 95% confidence limit	Upper 95% confidence limit
England	Males	All ages	Q2 2011 to Q1 2012	Q3 2010 to Q2 2011	Q1 2012 to Q4 2012
England	Females	All ages	Q2 2013 to Q1 2014	Q1 2012 to Q4 2012	Q3 2014 to Q2 2015
England	Males	Under 75s	Q1 2010 to Q4 2010	Q4 2009 to Q3 2010	Q3 2010 to Q2 2011
England	Females	Under 75s	Q2 2011 to Q1 2012	Q4 2010 to Q3 2011	Q4 2011 to Q3 2012
England	Males	75 to 79	Q4 2011 to Q3 2012	Q1 2011 to Q4 2011	Q3 2012 to Q2 2013
England	Females	75 to 79	Q2 1991 to Q1 1992	Q1 1990 to Q4 1990	Q4 1992 to Q3 1993
England	Males	80 to 84	Q3 2011 to Q2 2012	Q1 2010 to Q4 2010	Q4 2012 to Q3 2013
England	Females	80 to 84	Q4 1995 to Q3 1996	Q2 1993 to Q1 1994	Q3 1998 to Q2 1999
England	Males	85 to 89	Q3 2011 to Q2 2012	Q2 2009 to Q1 2010	Q4 2013 to Q3 2014
England	Females	85 to 89	Q1 1996 to Q4 1996	Q2 1993 to Q1 1994	Q1 1999 to Q4 1999
England	Males	90 and over	Q2 2011 to Q1 2012	Q3 2009 to Q2 2010	Q1 2013 to Q4 2013
England	Females	90 and over	Q2 1998 to Q1 1999	Q4 1992 to Q3 1993	Q4 2003 to Q3 2004

Source: Office for National Statistics

Notes

1. The lower and upper 95% confidence limits have been provided. These form a confidence interval, which is a measure of the statistical precision of an estimate and shows the range of uncertainty around the estimated figure. Calculations based on small numbers of events are often subject to random fluctuations. As a general rule, if the confidence interval around one figure overlaps with the interval around another, we cannot say with certainty that there is more than a chance difference between the two figures. Back to table

2. Q1 refers to Quarter 1 (1 January to 31 March), Q2 refers to Quarter 2 (1 April to 30 June), Q3 refers to Quarter 3 (1 July to 30 September), Q4 refers to Quarter 4 (1 October to 31 December). Back to table

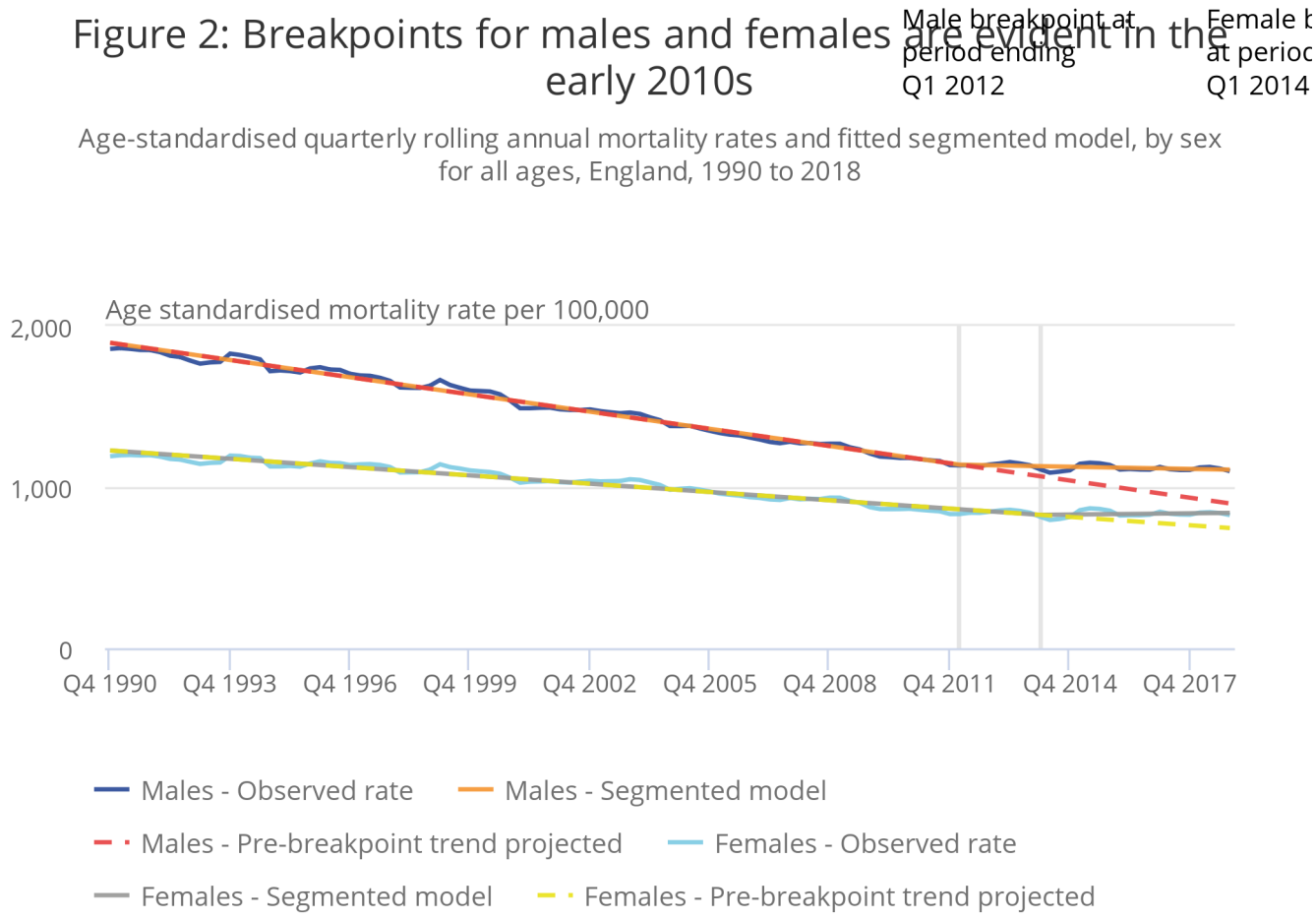
Figure 2 displays the observed all-ages age-standardised mortality rate over time for England by sex; the fitted trendline up until the breakpoint and an extension of this beyond the breakpoint to the end of the series; and the fitted segmented function indicating the trend after the breakpoint.

The breakpoints are indicated by vertical lines. For males, the breakpoint is at period Quarter 2 2011 to Quarter 1 2012, and for females it is later in the time series, at period Quarter 2 2013 to Quarter 1 2014.

The pre-breakpoint trend projection illustrates what mortality rates would have been had the rate of improvement prior to the early 2010s continued. The comparison between this projection, observed rates, and the segmented regression model fitted to the data after the breakpoint demonstrates how the rate of improvement has slowed in recent years; mortality rates are therefore higher than if the pre-breakpoint rate of improvement had continued.

Figure 2: Breakpoints for males and females are evident in the early 2010s

Age-standardised quarterly rolling annual mortality rates and fitted segmented model, by sex for all ages, England, 1990 to 2018



Source: Office for National Statistics

Notes:

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2. Figures exclude non-residents, based on boundaries as of May 2019.

3. Q1 refers to annual period ending Quarter 1 (April to March), Q2 refers to annual period ending Quarter 2 (July to June), Q3 refers to annual period ending Quarter 3 (October to September), Q4 refers to annual period ending Quarter 4 (January to December).

4. Segmented model is the segmented linear regression model produced by our program to best fit the data.

5. Pre-breakpoint trend projected is the trend fitted to the data up until the breakpoint projected forward to the end of the observed data time series.

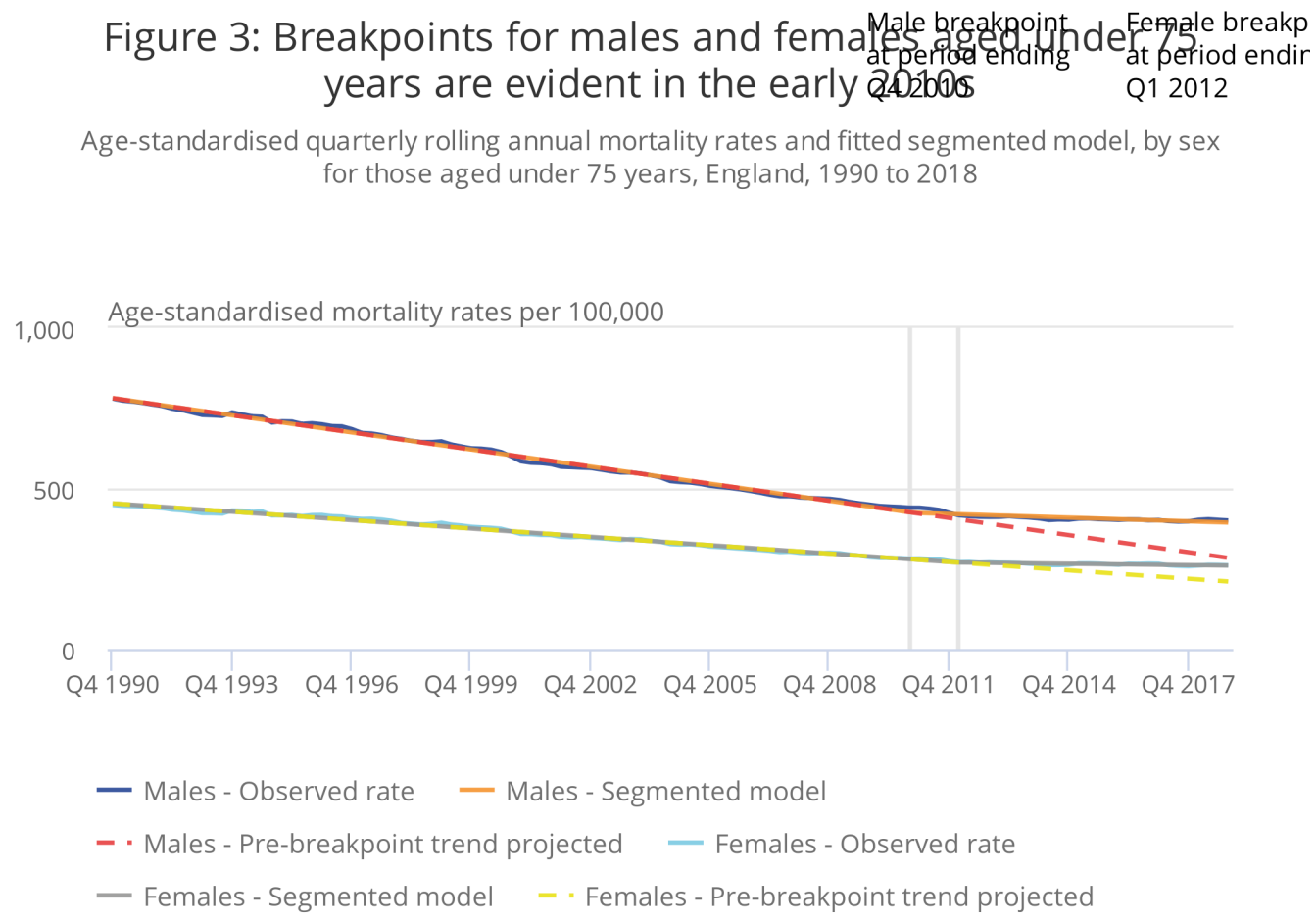
Change in trends in mortality rates at younger ages in England

Looking at different age groups allows us to determine whether any overall change in trend is primarily in the younger or the older populations. This series has been extended to cover 2018 but still supports findings from the previous release where breakpoints have been found in the late 2000s or early 2010s.

Both males and females aged under 75 years show a breakpoint earlier in the time series than all ages together (Figure 2). This suggests that the trend of improving mortality rates had started to tail off earlier for younger age groups. The trends following the breakpoints are shallower than those observed before the breakpoints, indicating a slowdown in the improvement in mortality.

Figure 3: Breakpoints for males and females aged under 75 years are evident in the early 2010s

Age-standardised quarterly rolling annual mortality rates and fitted segmented model, by sex for those aged under 75 years, England, 1990 to 2018



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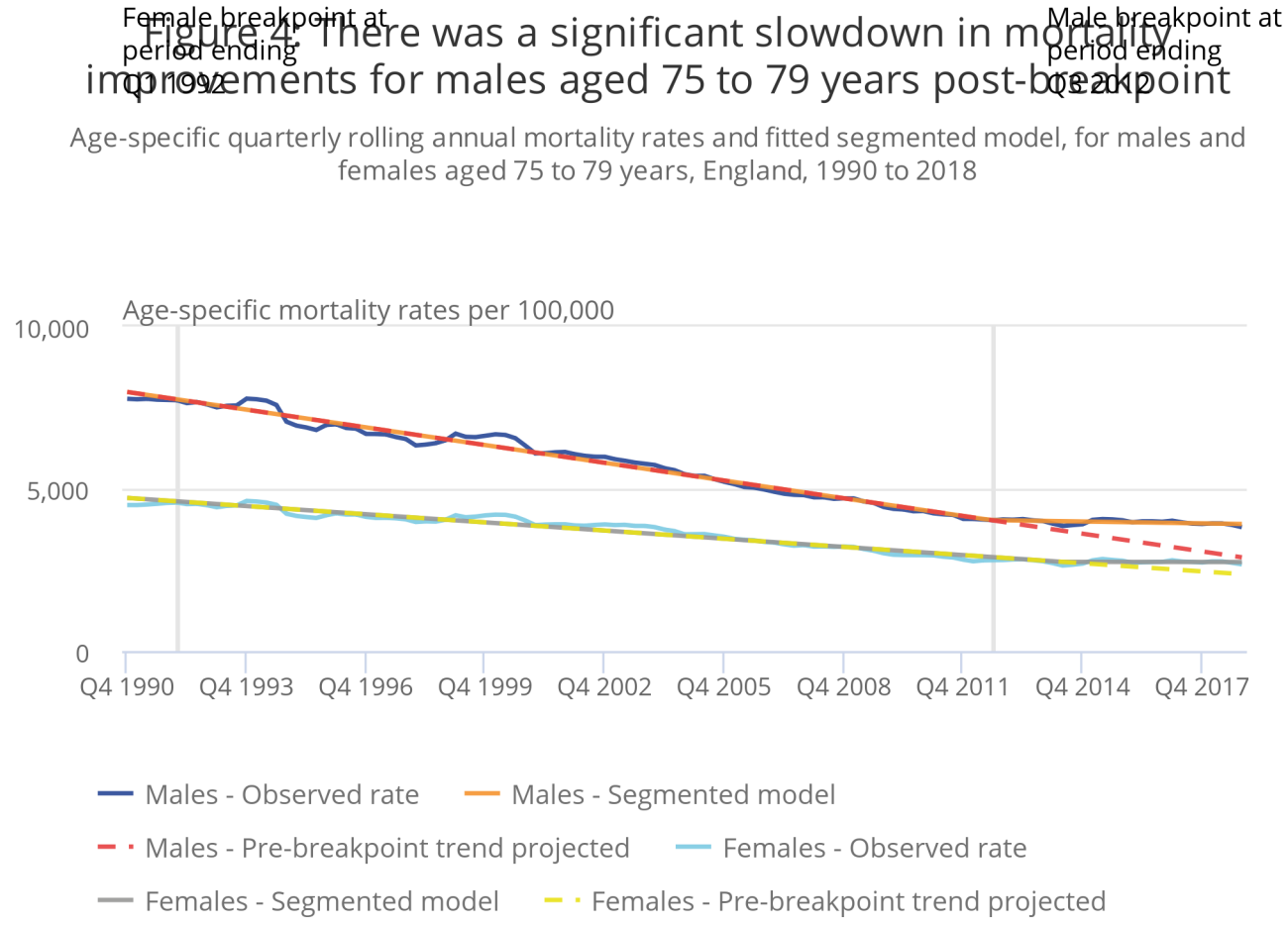
Change in trends in mortality rates in older age groups in England

As outlined in our previous release, the point of change in trend in mortality rates is less clear for those aged 75 years and over in England. While the breakpoint for males remained within the early 2010s, for females the breakpoint was much earlier within the 1990s. To gain a better insight into the change in trend in mortality rates, we extended the analysis and divided up older ages into the groups 75 to 79 years, 80 to 84 years, 85 to 89 years, and 90 years and over.

Figure 4 shows the large disparity after the breakpoint between male mortality rates in those aged 75 to 79 years, and the pre-breakpoint projected trend. This indicates that since Quarter 4 (Oct to Dec) 2011 to Quarter 3 (July to Sept) 2012, there has been a greater slowdown in the improvements in mortality within this age group. Had mortality rates continued to improve at the same rate as pre-breakpoint, male mortality rates would now have been close to female mortality rates.

Figure 4: There was a significant slowdown in mortality improvements for males aged 75 to 79 years post-breakpoint

Age-specific quarterly rolling annual mortality rates and fitted segmented model, for males and females aged 75 to 79 years, England, 1990 to 2018



Source: Office for National Statistics

Notes:

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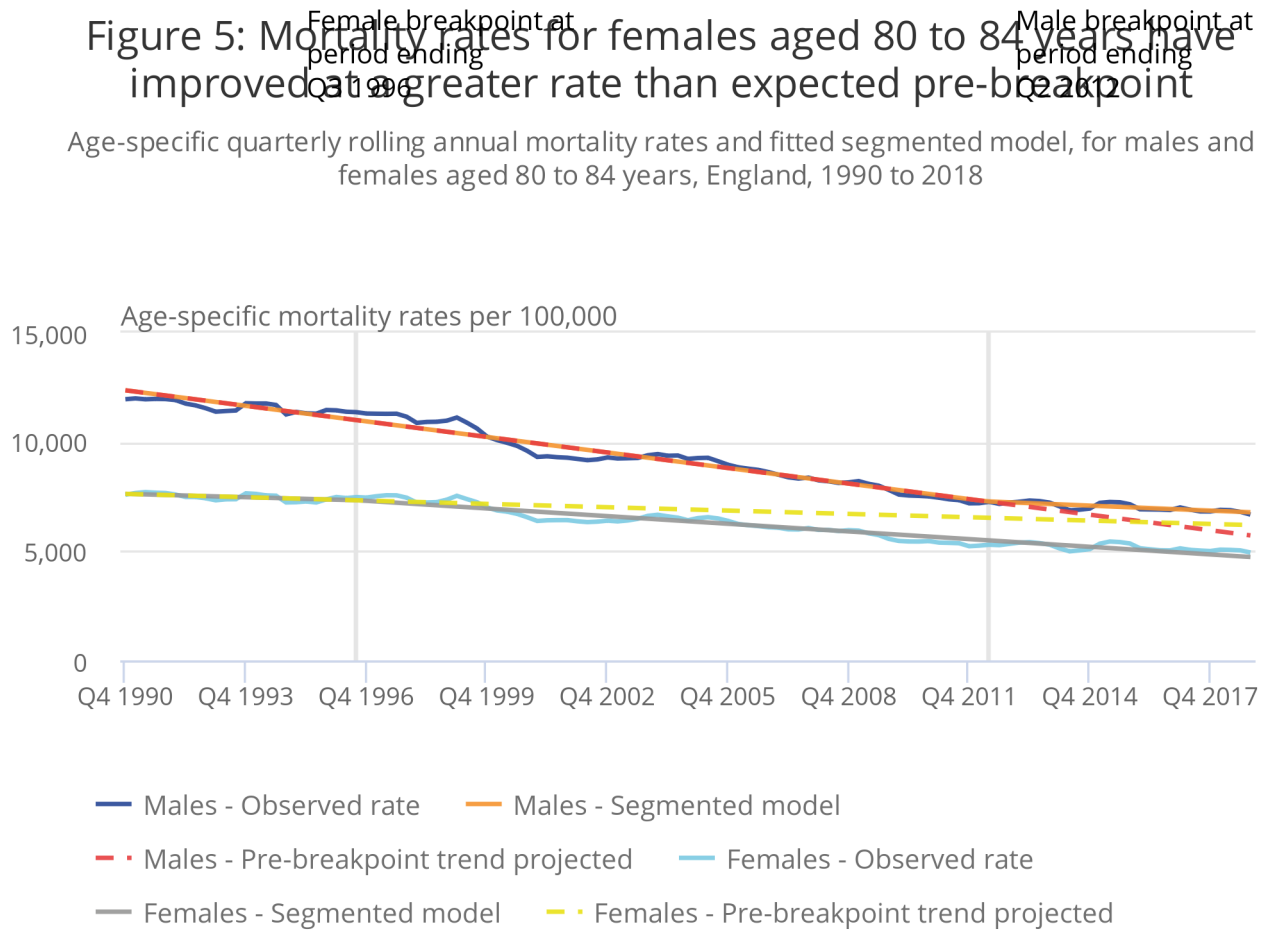
4. Segmented model is the segmented linear regression model produced by our program to best fit the data.
5. Pre-breakpoint trend projected is the trend fitted to the data up until the breakpoint projected forward to the end of the observed data time series.

In contrast to the model for all ages (Figure 2), Figure 5 (aged 80 to 84 years), Figure 6 (aged 85 to 89 years) and Figure 7 (aged 90 and over) paint a slightly different picture. For males, the projected trends continue to show that there has been a slowdown in the improvements in mortality, occurring in the early 2010s, for these older age groups.

The projected trends for females show that mortality rates in these older age groups improved at a greater rate than expected after a breakpoint in the late 1990s. These observations should be treated with caution because the uncertainty around the female breakpoints is relatively high. The Analysis using two breakpoints section provides more information about these findings.

Figure 5: Mortality rates for females aged 80 to 84 years have improved at a greater rate than expected pre-breakpoint

Age-specific quarterly rolling annual mortality rates and fitted segmented model, for males and females aged 80 to 84 years, England, 1990 to 2018



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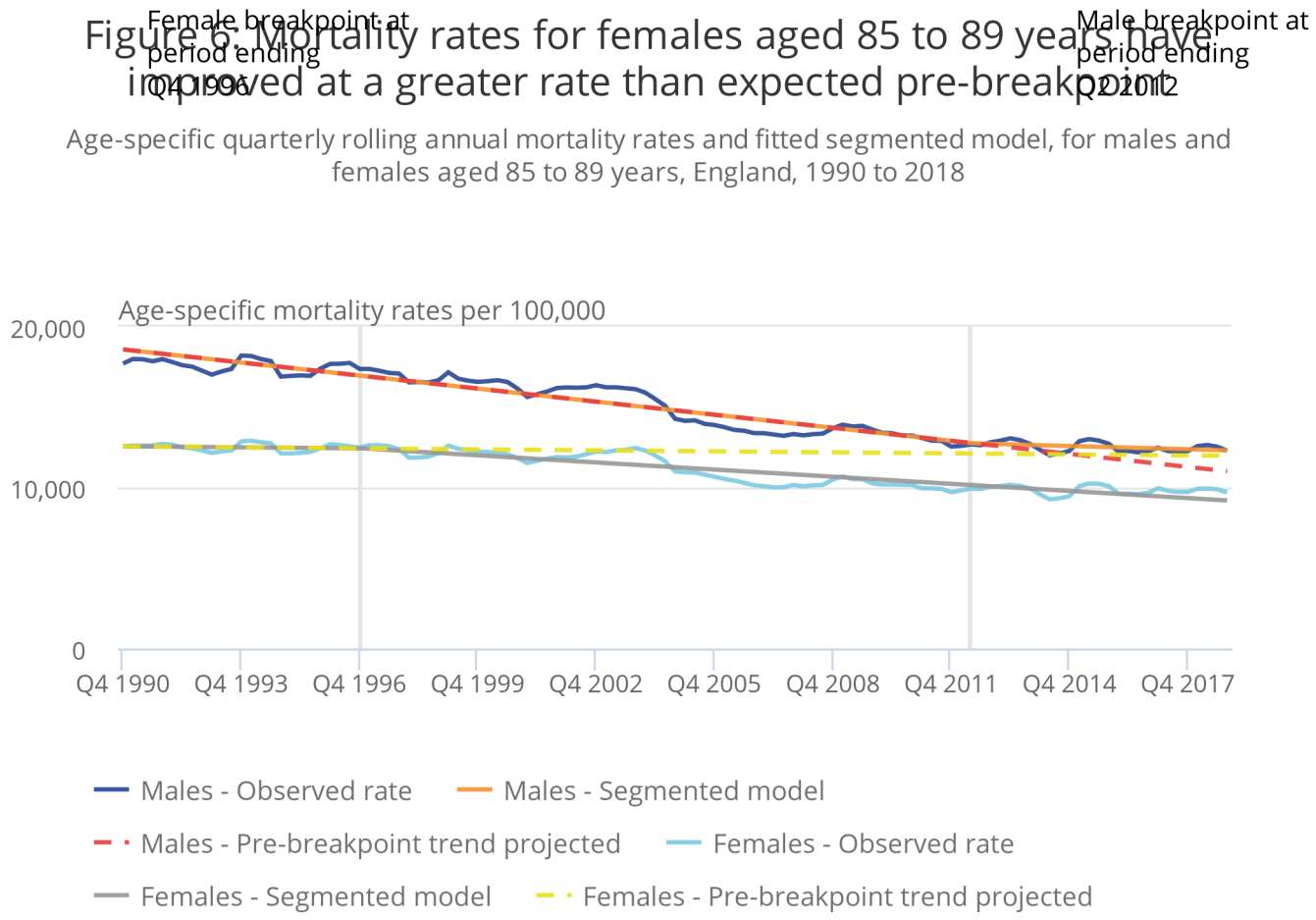
4. Segmented model is the segmented linear regression model produced by our program to best fit the data.
5. Pre-breakpoint trend projected is the trend fitted to the data up until the breakpoint projected forward to the end of the observed data time series.

Figure 6: Mortality rates for females aged 85 to 89 years have improved at a greater rate than expected pre-breakpoint

Age-specific quarterly rolling annual mortality rates and fitted segmented model, for males and females aged 85 to 89 years, England, 1990 to 2018



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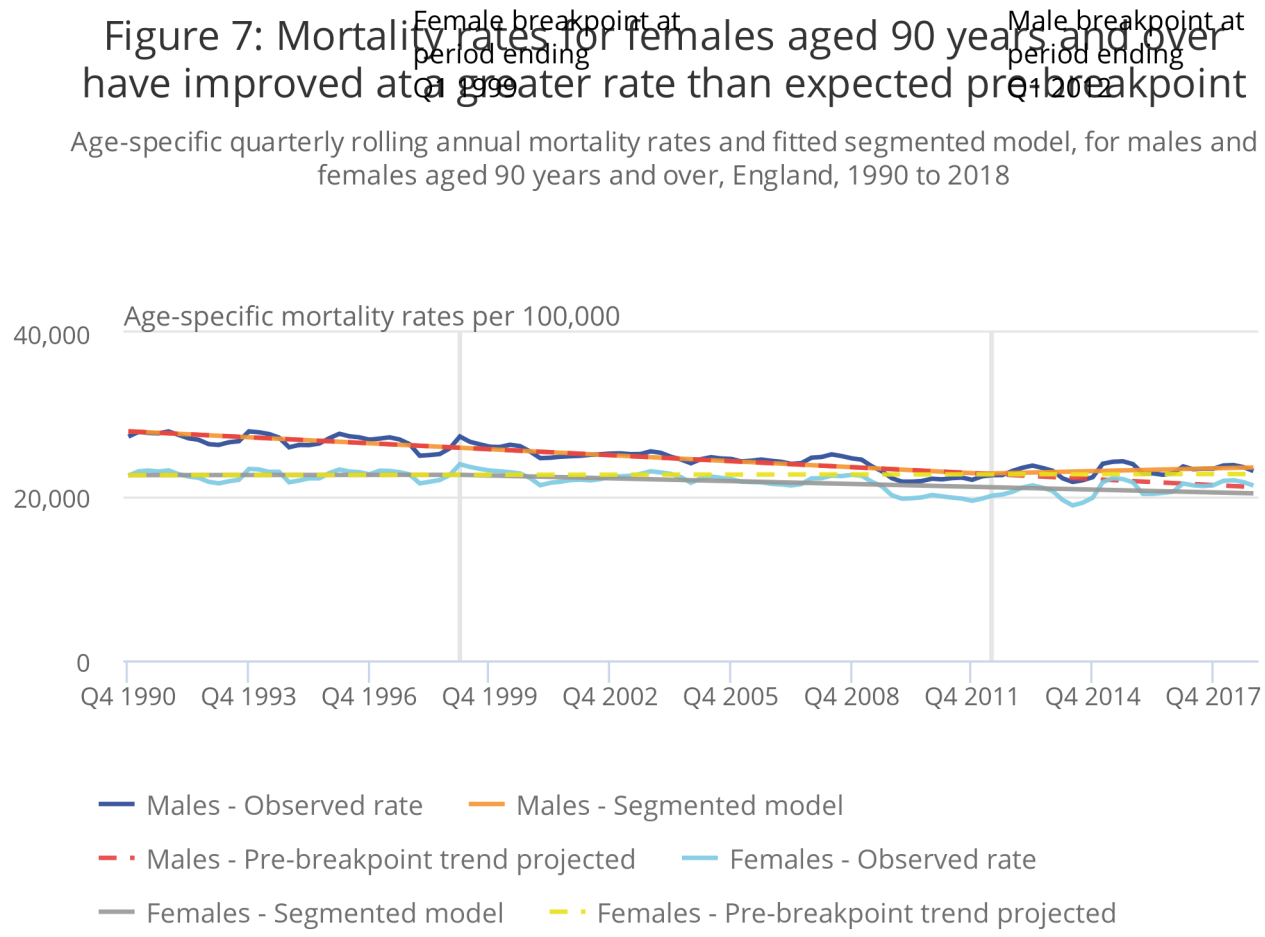
4. Segmented model is the segmented linear regression model produced by our program to best fit the data.
5. Pre-breakpoint trend projected is the trend fitted to the data up until the breakpoint projected forward to the end of the observed data time series.

Figure 7: Mortality rates for females aged 90 years and over have improved at a greater rate than expected pre-breakpoint

Age-specific quarterly rolling annual mortality rates and fitted segmented model, for males and females aged 90 years and over, England, 1990 to 2018



Source: Office for National Statistics

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4. Segmented model is the segmented linear regression model produced by our program to best fit the data.
5. Pre-breakpoint trend projected is the trend fitted to the data up until the breakpoint projected forward to the end of the observed data time series.

7 . Analysis using one breakpoint: Wales

Table 2 shows the breakpoints detected by the segmented linear regression function for age-standardised and age-specific mortality rates in Wales. Similarly to England, for most age groups and sex breakdowns there was a significant breakpoint detected in the early 2010s.

The breakpoints for males, all ages, were the same in Wales as in England. In our previous release, the breakpoint for females was identified in Quarter 3 (July to Sept) 1995 to Quarter 2 (Apr to June) 1996. With this new analysis, the addition of 2018 has identified a much later breakpoint (Quarter 3 2013 to Quarter 2 2014) that is more in line with the breakpoint for males.

In Wales, for females in the older age groups, some breakpoints were identified in the 1990s. However, there were not as many of these as in England; the exceptions were for females aged 75 to 84 years, where the breakpoints were in the 1990s, and in females aged 90 years and over when the breakpoint was identified in the early 2000s.

Table 2: Breakpoints indicating change in trend in age-standardised and age-specific mortality rates by age group and sex, Wales: 1990 to 2018

Country	Sex	Age	Breakpoint	Lower 95% confidence limit	Upper 95% confidence limit
Wales	Males	All ages	Q2 2011 to Q1 2012	Q3 2010 to Q2 2011	Q2 2012 to Q1 2013
Wales	Females	All ages	Q3 2013 to Q2 2014	Q1 2012 to Q4 2012	Q4 2014 to Q3 2015
Wales	Males	Under 75s	Q1 2010 to Q4 2010	Q2 2009 to Q1 2010	Q3 2010 to Q2 2011
Wales	Females	Under 75s	Q3 2011 to Q2 2012	Q3 2010 to Q2 2011	Q3 2012 to Q2 2013
Wales	Males	75 to 79	Q1 2012 to Q4 2012	Q1 2011 to Q4 2011	Q2 2013 to Q1 2014
Wales	Females	75 to 79	Q2 1999 to Q1 2000	Q3 1996 to Q2 1997	Q1 2002 to Q4 2002
Wales	Males	80 to 84	Q1 2014 to Q4 2014	Q4 2012 to Q3 2013	Q1 2015 to Q4 2015
Wales	Females	80 to 84	Q3 1995 to Q2 1996	Q1 1994 to Q4 1994	Q1 1997 to Q4 1997
Wales	Males	85 to 89	Q1 2016 to Q4 2016	Q3 2014 to Q2 2015	Q3 2017 - Q2 2018
Wales	Females	85 to 89	Q1 2011 to Q4 2011	Q4 2006 to Q3 2007	Q2 2015 to Q1 2016
Wales	Males	90 and over	Q2 2011 to Q1 2012	Q3 2007 to Q2 2008	Q1 2015 to Q4 2015
Wales	Females	90 and over	Q4 2001 to Q3 2002	Q3 1996 to Q2 1997	Q1 2007 to Q4 2007

Source: Office for National Statistics

Notes

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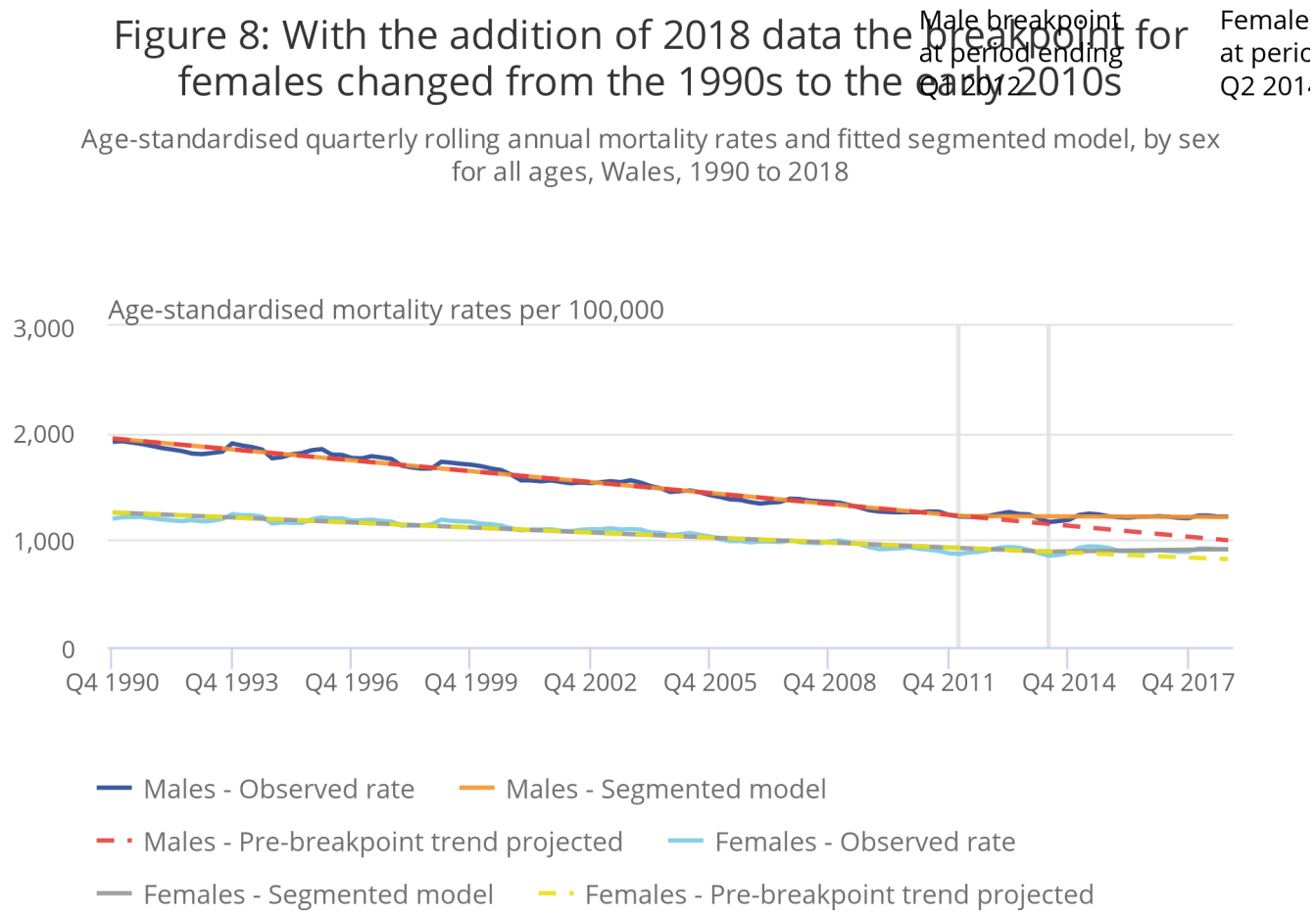
Figure 8 identifies the breakpoints for all ages as vertical lines. For females, the detection of a breakpoint in Quarter 3 2013 to Quarter 2 2014 is later than for males which was in Quarter 2 2011 to Quarter 1 (Jan to Mar) 2012.

Figure 8: With the addition of 2018 data the breakpoint for females changed from the 1990s to the early 2010s

Age-standardised quarterly rolling annual mortality rates and fitted segmented model, by sex for all ages, Wales, 1990 to 2018



Source: Office for National Statistics

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2. Figures exclude non-residents, based on boundaries as of May 2019.

3. Q1 refers to annual period ending Quarter 1 (April to March), Q2 refers to annual period ending Quarter 2 (July to June), Q3 refers to annual period ending Quarter 3 (October to September), Q4 refers to annual period ending Quarter 4 (January to December).

4. Segmented model is the segmented linear regression model produced by our program to best fit the data.

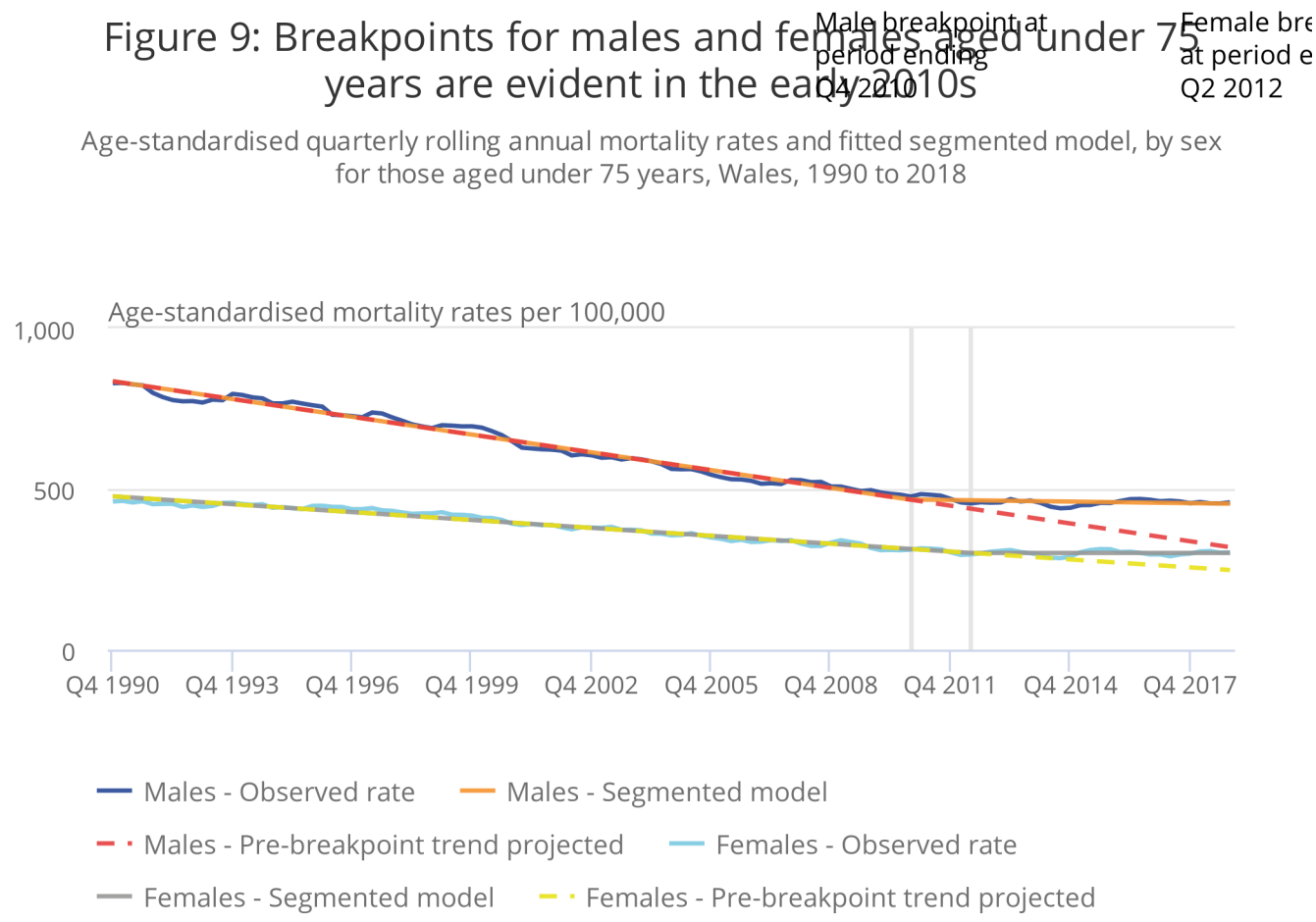
5. Pre-breakpoint trend projected is the trend fitted to the data up until the breakpoint projected forward to the end of the observed data time series.

Change in trend in mortality rates in those aged under 75 years in Wales

Extending the analysis to include 2018 has not altered the breakpoints for either males or females aged under 75 years within Wales, which remain the same as previously published. For males, the breakpoint is at the period Quarter 1 to Quarter 4 (Oct to Dec) 2010, and for females it is detected later in the time series at the period Quarter 3 2011 to Quarter 2 2012.

Figure 9: Breakpoints for males and females aged under 75 years are evident in the early 2010s

Age-standardised quarterly rolling annual mortality rates and fitted segmented model, by sex for those aged under 75 years, Wales, 1990 to 2018



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5. Pre-breakpoint trend projected is the trend fitted to the data up until the breakpoint projected forward to the end of the observed data time series.

Change in trend in mortality rates in older age groups in Wales

In the previous publication, when we looked at males and females aged 75 years and over, the male mortality rate was slowing in comparison with the projected trend. However, female mortality had been increasing at a greater rate than was projected, indicating that females in Wales had better mortality rates after the breakpoint than was expected pre-breakpoint.

Within this analysis we have broken these age groups down further to gain a better insight into the trends in those aged 75 years and over.

For males aged 75 to 79 years, a breakpoint was detected at Quarter 1 to Quarter 4 2012, which was later than that detected for males at all ages in Wales (Figure 8). Since this period, mortality rates for males in this age group have remained relatively stable.

For females, the breakpoint was earlier than that for all ages (Figure 8) at period Quarter 2 1999 to Quarter 1 2000. Mortality rates for females improved at a faster rate during the early 2000s than during the 1990s.

Figure 10: Mortality rates for females aged 75 to 79 years improved at a faster rate during the early 2000s than during the 1990s

Age-specific quarterly rolling annual mortality rates and fitted segmented model, by sex for males and females aged 75 to 79 years, Wales, 1990 to 2018

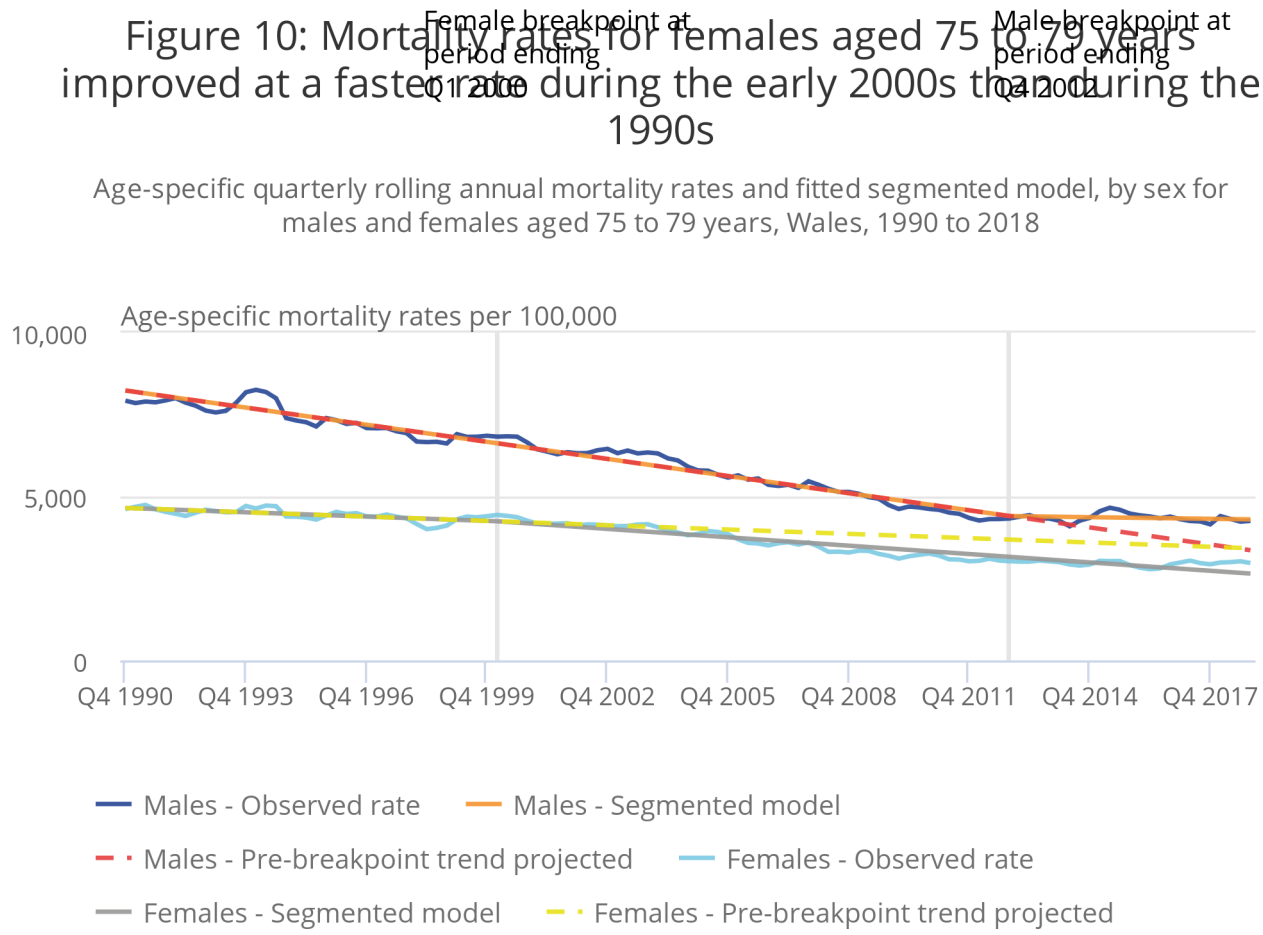

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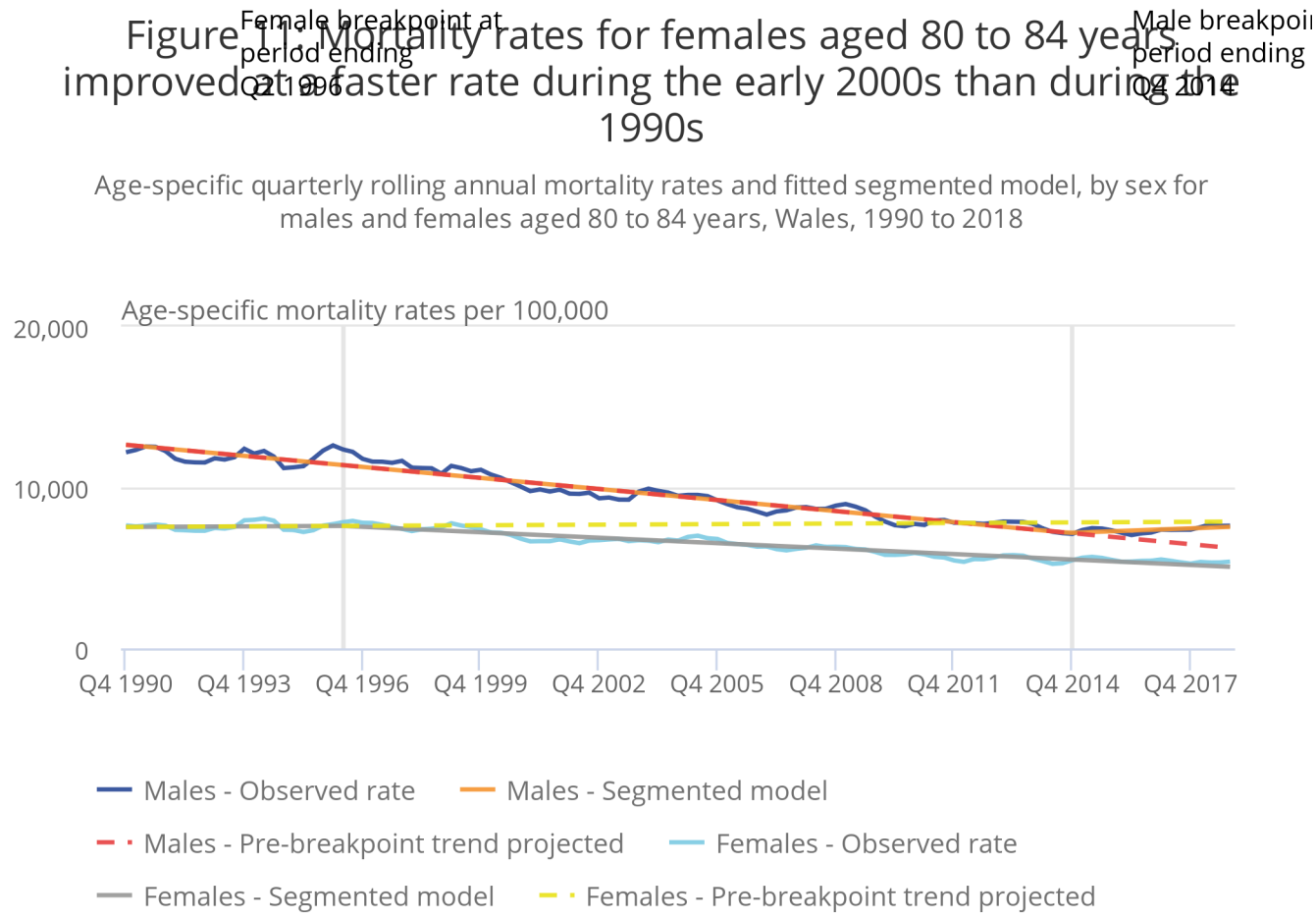
Figure 11 shows a large difference between the observed mortality rate for females and the projected trend. For females aged 80 to 84 years, mortality improved at a greater rate than expected based on the pre-breakpoint trend. Limiting the model to just one breakpoint has the potential to miss features of the trend occurring at other points. For this reason, we explore the trend further using two breakpoints.

Figure 11: Mortality rates for females aged 80 to 84 years improved at a faster rate during the early 2000s than during the 1990s

Age-specific quarterly rolling annual mortality rates and fitted segmented model, by sex for males and females aged 80 to 84 years, Wales, 1990 to 2018



Source: Office for National Statistics

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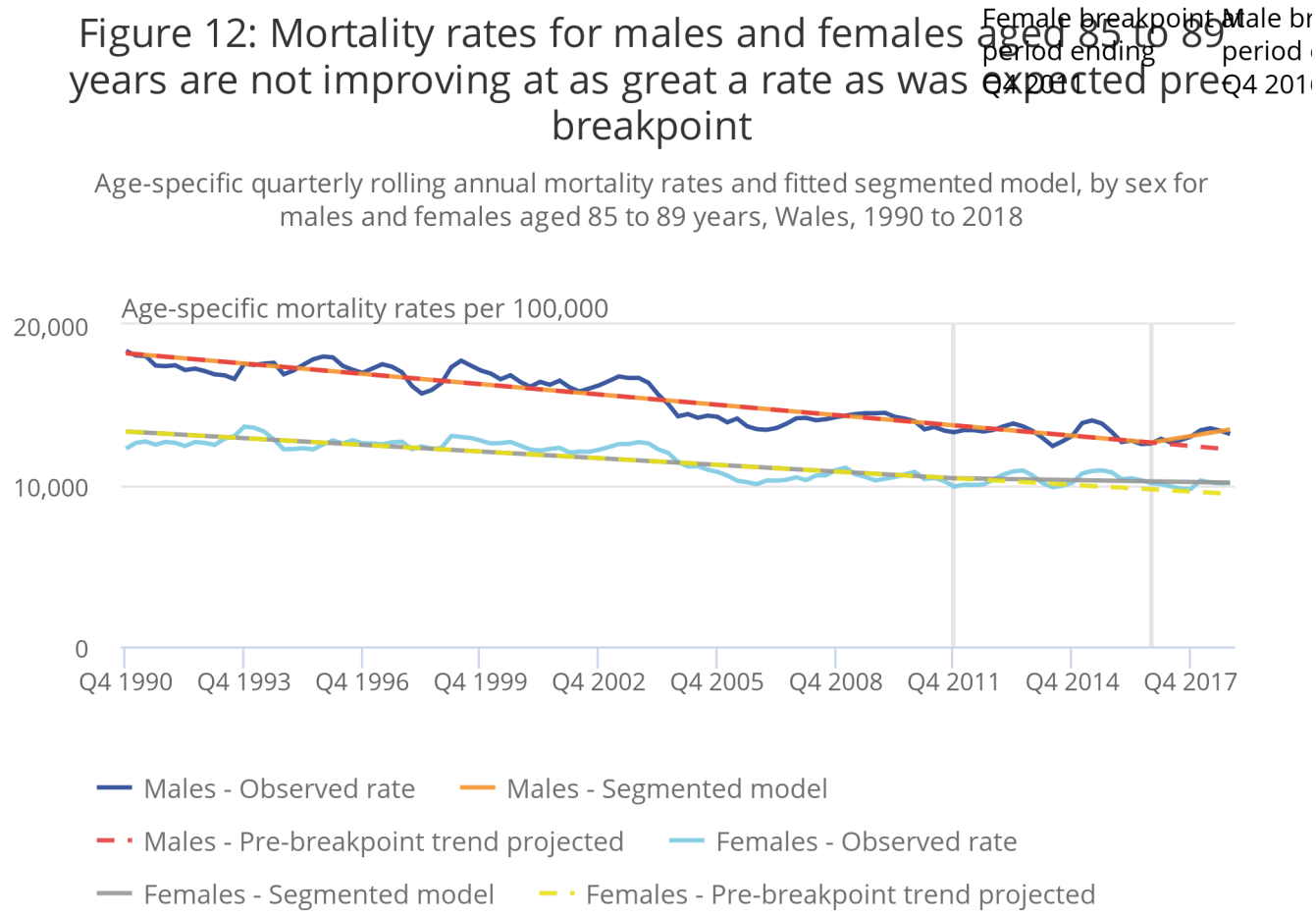
In males and females aged 85 to 89 years, observed mortality rates were worse than the projected trend, indicating that mortality within these age groups is not improving at as great a rate as was expected (Figure 12).

Figure 12: Mortality rates for males and females aged 85 to 89 years are not improving at as great a rate as was expected pre-breakpoint

Age-specific quarterly rolling annual mortality rates and fitted segmented model, by sex for males and females aged 85 to 89 years, Wales, 1990 to 2018



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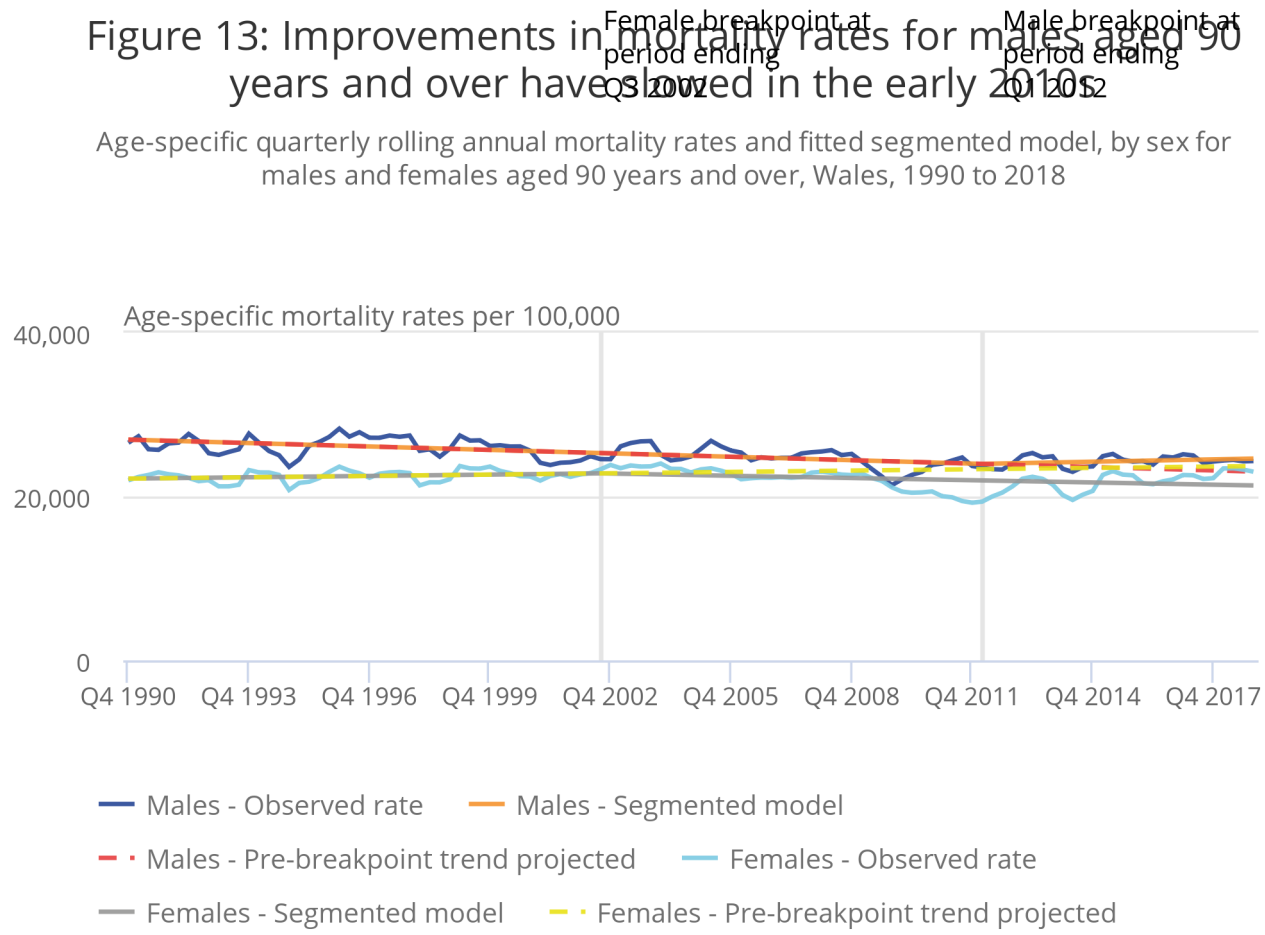
There is a large degree of uncertainty around the breakpoints for males and females aged 90 years and over, as is evident in the confidence intervals (Table 2), because of the smaller numbers within this age group. This also helps to explain the volatility in observed rates evident for this age group (Figure 13). It is still clear to see that for males the projected trends continue to show that there has been a slowdown in the improvements in mortality, occurring in the early 2010s. For females aged 90 years and older, mortality improved at a greater rate than expected based on the pre-breakpoint trend.

Figure 13: Improvements in mortality rates for males aged 90 years and over have slowed in the early 2010s

Age-specific quarterly rolling annual mortality rates and fitted segmented model, by sex for males and females aged 90 years and over, Wales, 1990 to 2018



Source: Office for National Statistics

Notes:

1. Age-specific mortality rates per 100,000 population.
2. Figures exclude non-residents, based on boundaries as of May 2019.
3. Q1 refers to annual period ending Quarter 1 (April to March), Q2 refers to annual period ending Quarter 2 (July to June), Q3 refers to annual period ending Quarter 3 (October to September), Q4 refers to annual period ending Quarter 4 (January to December).
4. Segmented model is the segmented linear regression model produced by our program to best fit the data.
5. Pre-breakpoint trend projected is the trend fitted to the data up until the breakpoint projected forward to the end of the observed data time series.

8 . Analysis using two breakpoints: England and Wales

To further explore the time series we re-analysed the data by allowing the segmented regression model to select two breakpoints. The reasoning for this was that a small number of the breakpoints identified by the one-breakpoint analysis were inconsistent with the majority of the results, and the precision of the model was lower for these breakpoints. At the same time, the observed trend suggested the presence of more than one breakpoint. The uncertainty around the breakpoints detected in the mid or late 1990s was always higher than those detected around early 2010s, suggesting that there may be more than one relevant breakpoint for these time series, and one breakpoint is not sufficient to fit an adequate segmented regression model.

We applied the two-breakpoint analysis to those age and sex groups where the initial analysis identified a breakpoint in the 1990s or early 2000s. This revealed that in each case there was a breakpoint in the early 2010s in addition to the one in the mid to late 1990s or early 2000s. These findings suggest that, for females in the older age groups, there have been two points where there has been a change in trend in mortality rates. The trend in mortality improved at the earlier breakpoint, but then reduced at the later breakpoint.

Table 3 shows these new breakpoints for the seven time series that were re-analysed.

Table 3: Breakpoints indicating two points of change in trend in age-specific mortality rates by age group, sex and country: 1990 to 2018

Country	Sex	Age	Breakpoint 1	Lower 95% confidence limit	Upper 95% confidence limit	Breakpoint 2	Lower 95% confidence limit	Upper 95% confidence limit
England	Females	75-79	Q3 2002 to Q2 2003	Q2 2001 to Q1 2002	Q4 2003 to Q3 2004	Q2 2011 to Q1 2012	Q3 2010 to Q2 2011	Q1 2012 to Q4 2012
England	Females	80-84	Q3 1996 to Q2 1997	Q1 1995 to Q4 1995	Q1 1998 to Q4 1998	Q2 2011 to Q1 2012	Q3 2009 to Q2 2010	Q1 2013 to Q4 2013
England	Females	85-89	Q2 2003 to Q1 2004	Q4 2002 to Q3 2003	Q4 2003 to Q3 2004	Q2 2005 to Q1 2006	Q4 2004 to Q3 2005	Q4 2005 to Q3 2006
England	Females	90+	Q3 2008 to Q2 2009	Q1 2008 to Q4 2008	Q4 2008 to Q3 2009	Q2 2009 to Q1 2010	Q4 2008 to Q3 2009	Q4 2009 to Q3 2010
Wales	Females	75-79	Q4 2002 to Q3 2003	Q4 2001 to Q3 2002	Q4 2003 to Q3 2004	Q3 2009 to Q2 2010	Q3 2008 to Q2 2009	Q2 2010 to Q1 2011
Wales	Females	80-84	Q4 1995 to Q3 1996	Q3 1994 to Q2 1995	Q1 1997 to Q4 1997	Q3 2011 to Q2 2012	Q2 2009 to Q1 2010	Q4 2013 to Q3 2014
Wales	Females	90+	Q3 2007 to Q2 2008	Q1 2007 to Q4 2007	Q2 2008 to Q1 2009	Q2 2010 to Q1 2011	Q4 2009 to Q3 2010	Q1 2011 to Q4 2011

Source: Office for National Statistics

Notes

1. The lower and upper 95% confidence limits have been provided. These form a confidence interval which is a measure of the statistical precision of an estimate and shows the range of uncertainty around the estimated figure. Calculations based on small numbers of events are often subject to random fluctuations. As a general rule, if the confidence interval around one figure overlaps with the interval around another, we cannot say with certainty that there is more than a chance difference between the two figures. Back to table

2. Q1 refers to Quarter 1 (1 January to 31 March), Q2 refers to Quarter 2 (1 April to 30 June), Q3 refers to Quarter 3 (1 July to 30 September), Q4 refers to Quarter 4 (1 October to 31 December). Back to table

For older females in England, and for females aged 75 to 84 years and 90 years and over in Wales, there was a change in trend in mortality following the first breakpoint where mortality improved at a faster rate up to the second breakpoint. The second breakpoint then marks a slowdown in the mortality improvements. These second breakpoints fall in line with the change in mortality trend that began in the early 2010s, except for females aged 85 to 89 years in England where a breakpoint was detected in the mid-2000s.

9 . Conclusion

Of the 24 demographic and geographical breakdowns of age-standardised and age-specific mortality rates examined for England and Wales from 1990, the majority (17 age-sex groups) identified a clear change in mortality trend that began in the early 2010s, when only one breakpoint in the series was identified from the segmented regression model. The other seven, which all affected older females, identified earlier breakpoints in the 1990s or early 2000s.

When a second breakpoint was applied by the model, a second time point was detected in the early 2010s in the majority of cases, in addition to the change in the 1990s or early 2000s. The first breakpoint in the 1990s indicates where the improvement in mortality rates was strong, while the second breakpoint indicates a slowdown in this improvement in mortality.

The analysis used a smoothed time series and made no prior assumptions about the timing of the change. This provides further independent confirmatory evidence that there has been a significant reduction in mortality improvements compared with the durable, long-term mortality declines observed in the decades preceding 2010.

10 . Changing trends in mortality in England and Wales

Changing trends in mortality in England and Wales: 1990 to 2018 data
Dataset | Released 10 March 2020
Segmented regression analysis for annual age-standardised and age-specific mortality rates for England and Wales, 2001 to 2018

11 . Measuring the data

Data used

The figures represent the number of deaths registered; this includes some deaths that occurred in the years prior to this calendar year, while a proportion of deaths occurring in this year will not be registered until subsequent years (more information can be found in our Impact of Registration Delays release).

Data to calculate age-standardised rates for England and Wales is readily available from 1959 onwards. However, we have chosen to focus on more recent trends from 1990 to 2018, while not restricting the analysis to only the 21st century. This time frame ensures sufficient relevance to current trends, but gives an opportunity for breakpoints to be identified in the adjacent 1990s decade so that patterns that are similar to or greater than more recent mortality patterns can be identified.

Age-standardised rates

Population denominators in rate calculations for 2018 are based on population projections. Information on how age-standardised rates are produced can be found in the User guide to mortality statistics. Age standardisation adjusts mortality rates for changes in the age structure of populations, allowing for valid comparisons over time. As five-year age bands are used in the standardisation process, it does not account for changes within age bands. This is particularly relevant for the 90 years and over age group, which encompasses a wider range of ages. The method for calculating quarterly rolling annual population estimates can be found in our Quarterly mortality report.

Age-standardised mortality rates, using the 2013 European Standard Population (2013 ESP), and age-specific mortality rates were calculated for quarterly rolling 12-month periods from Quarter 1 (Jan to Mar) to Quarter 4 (Oct to Dec) 1990 to Quarter 1 to Quarter 4 2018. Age standardisation adjusts mortality rates for changes in the age structure of populations allowing for valid comparisons over time. Age-standardised mortality rates were calculated for all ages and those aged 0 to 74 years. Age-specific rates were calculated for those aged 75 to 79 years, 80 to 84 years, 85 to 89 years, and 90 years and over. This generated 24 different breakdowns of the data.

Segmented regression approach

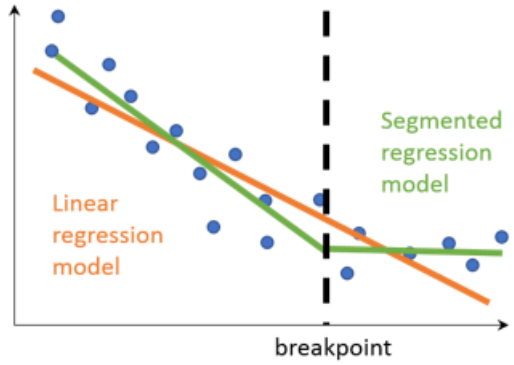
We used a segmented linear regression method to assess whether there has been a statistically significant change in the trend in mortality rates, and if so, at what point in the time series it moves away from the previous trend trajectory. Segmented linear regression fits multiple linear regression models to a series of continuous data to determine a trend using a segmented or broken line of best fit. The point at which one segment meets the next is called a breakpoint and indicates the point of a change in trend where the difference in the coefficients of the slopes before and after the breakpoint is statistically significant. The segmented model produced is continuous so that the end of one segment must meet where the next segment begins. Linear models were chosen for simplicity, and provide a sufficient approximation for this analysis.

We implemented this analysis using an algorithm in the software package R, the theory of which is explained in Segmented: An R Package to Fit Regression Models With Broken-Line Relationships. The “segmented” function in R allows users to specify the number of break points they wish to find. We initially set the function to detect one breakpoint, as we are testing for only one change in trend in our timeseries.

The breakpoints found by the segmented function are the optimal points where linear models before and after the breakpoint have a greater goodness of fit than one model for the whole series. The first breakpoint that the program finds (if only one is specified), will be the most optimal breakpoint for the whole timeseries. Therefore, if a breakpoint is found around a particular quarter in the timeseries, this would serve as evidence favouring the hypothesis that there was a change in the trend of mortality rates that started around this time.

As shown in the schematic diagram (Figure 14), the orange line is a single linear regression model produced to fit all of the data (blue dots). The green line is a segmented regression model produced to fit the data assuming there is one breakpoint in the data. Overall, the green line fits the data much better than the orange line with many more blue data points being closer to the green line than the orange line. The dashed black line shows where the change in trend (breakpoint) occurred. The exact position of this breakpoint does not precisely locate any source of change but can be used to see whether there is consistency across different countries, sexes and age groups about where the change in trend occurred in the time series.

Figure 14: Schematic diagram of a segmented regression analysis



Source: Office for National Statistics

The segmented linear regressions were initially set to identify one breakpoint in each of the 24 breakdowns of the data.

A confidence interval around the breakpoint can also be calculated, indicating the variance and level of uncertainty around where the breakpoint is placed in the timeseries. The breakpoint is found using an iterative process, and so the exact point found may vary each time a model is run, depending on the data. The confidence intervals show the spread of the breakpoints from the iterations of the model. Confidence interval width was used to guide whether the trend was better represented with two breakpoints.

The segmented function also contains within it a significance test called the Davies test (Davies 1987, 2002), which selects one breakpoint and returns the significance of the difference-in-slope before and after the breakpoint. This is conducted independently of the segmented function. We constrained the breakpoints identified by the segmented function to be in line with those detected by the Davies test to ensure a significant breakpoint was identified.

Each data point used within this analysis corresponds to a 12-month period and is one quarter (three months) on from the preceding data point. For example, while Quarter 1 to Quarter 4 1990 encompasses January to December 1990, the next data point Quarter 2 1990 to Quarter 1 1991 encompasses April 1990 to March 1991. This means that each data point overlaps with its two adjacent data points by nine months each, so the points are not independent from one another in the data they contain. This approach was adopted to ensure sufficient data points are available to be able to fit linear models to the time series.

More quality and methodology information on strengths, limitations, appropriate uses, and how the data were created is available in the Mortality statistics in England and Wales QMI and the User guide to mortality statistics.

12 . Strengths and limitations

Strengths

Coding for cause of death is carried out according to the World Health Organization (WHO) ICD-10 and internationally agreed rules.

Information is supplied when a death is registered, which gives complete population coverage and ensures the estimates are of high precision, and representative of the underlying population at risk.

The overlapping data points means that each data point overlaps with its two adjacent data points by nine months each, so the points are not independent from one another in the data they contain. This approach was adopted to ensure sufficient data points are available to be able to fit linear models to the time series. The overlapping data points also mean that the trend over time is smoother than if independent annual data points had been used, reducing the impact of any short-term fluctuations. A breakpoint found in a smoothed series is stronger evidence of a substantive change having occurred. However, using overlapping data points also has limitations (discussed below).

Limitations

The overlapping data points increase the confidence intervals around the breakpoints making it more difficult to state exactly when the significant change occurred.

The breakpoint is found using an iterative process, and so the exact breakpoint found may vary each time that a model is run. However, confidence intervals have been calculated to indicate the level of uncertainty around each breakpoint.

We limited the analysis to dates after 1990 but, had dates prior to this been included within the analysis, alternative breakpoints may have been identified.

13 . Related links

Changing trends in mortality: a cross-UK comparison, 1981 to 2016
Article | Released 7 August 2018
Analysis of age-specific and age-standardised mortality rates for the UK, England, Wales, Scotland and Northern Ireland from 1981 to 2016.

Changing trends in mortality: an international comparison: 2000 to 2016
Article | Released 7 August 2018
Analysis of period life expectancies and mortality in selected countries globally from 2000 to 2016.

What is happening to life expectancy in the UK?
Article | Released 22 October 2019
The Kings Fund think tank provides commentary on the change in life expectancy.

Trends in life expectancy in EU and other OECD countries
Report | Released 28 February 2019
This report outlines that these changes in mortality trends are also evident in other countries.

Recent trends in mortality in England
Report | Released: 11 December 2018
Public Health England reports on the recent trends in life expectancy and mortality.

Mortality in Wales 2002 to 2016
Report | Released 29 May 2018
Public Health Wales reports on the change in mortality trends in Wales between 2002 and 2016.