# **Title page**

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# **Abstract**

**Background**

All-cause age-specific mortality has been falling in England & Wales for more than a century. The period 2008-2015 has seen both a global recession and an ‘austerity’ agenda of reduced investment in public services. Death rates amongst the elderly have increased in this period, reversing the long-term trends.

**Aim**

To quantify the level of ‘excess deaths’ over the period 2010-2015 in England & Wales by comparing actual age-specific death rates in each year against modelled estimates if previous mortality improvements had continued.

**Methods**

Office for National Statistics data on population counts and death counts at each age in single years were used to construct projections of mortality risk per year based on the trend from 1990 to 2010. Actual mortality risks were compared with estimated risks over 2011-2015 to produce estimates of ‘excess deaths’ in each year by ages 50, 70 and 89 years.

**Results**

Between 2010 and 2015 there were almost 32,000 more deaths up to the age of 89 years than would have been expected from prior trends. Excess elderly deaths (up to age 89 years) increased sharply after 2011, with 42,018 more deaths than expected occurring between 2012 and 2015.

**Discussion**

Falling levels of investment in social and health care services in England & Wales since 2010 may be responsible for mortality rates at older ages either increasing or falling more slowly than would have been expected if previous improvements had continued. Mortality for males was improving rapidly before 2010 so had that trend continued many more men would have been alive at older ages by 2015. The actual rise in mortality was greater for older women.

# **Introduction**

## **Austerity and elderly mortality**

Recently, there has been growing evidence of the possible effects of austerity on elderly mortality within the UK. One study exploring the correlation between falls in Pension Credit and social care budgets in the UK, and changes in mortality rates in pensioners aged 85 years and older, found that each 1% fall in social care spending was associated with a statistically significant 0.08% rise in deaths in this age group, with similar but weaker rises in persons aged 75 to 84 years. (1) The focus on elderly mortality was prompted by a 2014 *New Statesman* article commenting on provisional estimates by Public Health England, leaked in the online Health Services Journal in 2014, of deaths amongst over 75s in England, suggesting increased mortality in both 2012 and 2013. (2)

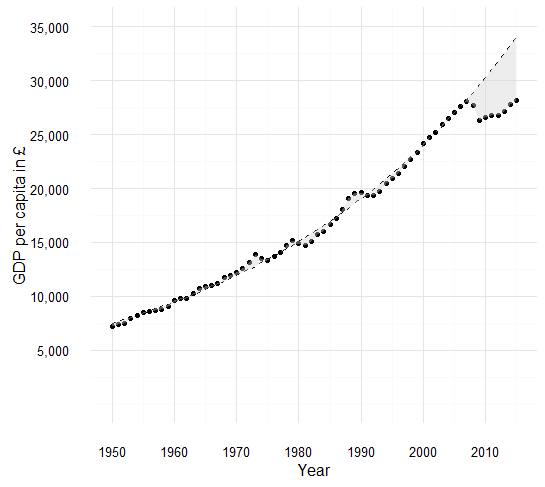
A 2015 Public Health England report considered three possible explanations for the trends: influenza, cold weather, and statistical artefact. (3) If either influenza or cold weather were the main causes of these rises then the following would be expected: firstly, the mortality rate rises would be spatially patterned, and secondly the rises would be a ‘blip’ associated with particular years rather than a trend. Preliminary analysis has found no evidence of spatial patterning. (1,4) Artefactual explanations could relate to aggregation biases caused by inadequately controlling for changes in age-composition within an age group, such as those witnessed in a recent high profile paper describing rising middle aged mortality rates in the US. (5) However, this cannot explain similar changes in multiple population age strata, such as multiple five or ten year age groups, occurring over the same time period, as have recently been identified in English population records. (1,4) The scope for such biases also reduce as more age-disaggregated data are used. (5) Similar patterns of rising mortality rates were observed in the most recent mid-year estimates [4,14], and the consistency of these patterns point towards austerity as opposed the other findings.

## **Slower improvements are still falls against expectations: changing ‘fundamentals’?**

The fact that death rates in some elderly age groups have risen in recent years should be of great concern as the tendency and expectation for many decades has been for the risk of death at most ages, especially older ages, to decline. Reasons for the previous declines are multifactorial and include both specific medical innovations and broader improvements in living conditions, such as improved housing and sanitation. (6) Only a severe and prolonged shock and assault to the factors which contribute to such steady improvements could alter these long-term dynamics(7).

Wealth, and economic change more generally, affects health, and Figure 1 shows that the economic fundamentals changed rapidly in England & Wales, perhaps irreversibly, after 2008. The figures show per capita GDP (not inflation adjusted) increased between 1950 and 2008 in England & Wales, using annual estimates from the Office for National Statistics (ONS). (8) The line shows the time trend to 2008 inclusive, which is then extrapolated to 2015. Between 1950 and 2008, the statistical fit of this trend line to actual GDP per capita is extremely high (R2 = 0.98) but after 2008 the shaded region, showing the difference between actual and projected per capita GDP, has grown ever larger. In 2009 the gap amounted to £6,800 per person; by 2015 it had grown to more than £13,400 per person. Before 2008, all previous recessions had been followed by one or more years of catch-up growth in per capita GDP. Nothing similar occurred after 2008; instead per capita GDP in 2015 has barely recovered to earlier levels. Many other rich countries increased public spending as a proportion of GDP to protect their populations. In the UK the government after 2010 cut public spending as a proportion of GDP even as GDP itself fell. Both the fall against trend in economic growth and reduction in public spending after 2010 are of such a scale as to negatively impact on population health, in particular in people most dependent on public services, especially healthcare. Stuckler and colleagues have argued that the health effects of economic recessions and political responses to those recessions are distinct, (e.g. (9)) and that the 2010-2015 Coalition government’s ‘Austerity’ response was harmful to population health.

**Figure 1 Per capita gross domestic product (GDP) (dots), 1950 to 2015, against trend (dashed line) over period 1950-2008.**



**Notes**: **Data Source: Office for National Statistics.**

# **Methods**

## **Data**

Mid-year population estimates and registered deaths in England & Wales, for each year from 1990 to 2014, were downloaded from the ONS website. (10) Mid-year population estimates and registered deaths for 2015 were released on 23 June 2016 for England & Wales. These are disaggregated by age in single years up to the age of 89 years. (10,11)

## **Modelling strategy**

The approach taken to estimating ‘excess mortality’ in each year after 2010 involves two stages. Firstly separate linear regression models are produced for both sexes, and each age in single years from birth to 89 years, in which log mortality is the response variable and a number of intercepts and trend terms are included as predictor variables. These allow the overall trend in falling age-specific mortality to be estimated over the period 1990-2015, as well as any changes in this trend over the period 1997-2010 (i.e. during the period of the New Labour (NL) government); additional terms are used to capture any additional effect (‘shock’) associated with the global financial crisis (GFC) of 2008-2010 to avoid biasing trend terms associated with the NL period. The precise details of the modelling strategy are detailed in the appendix, which also includes a sensitivity analysis using an alternate model specification to allow for nonlinearities in trends over time.

In stage two, the regression models are used to produce counterfactual death rates at different ages for each year 2011 to 2015, if trends in death rates observed during the period 1997-2010 had continued throughout the latter period. The counterfactual mortality risks are then applied to actual population counts observed in 2011-2015 to produce ‘expected death counts’ in each year and at each age, and then compared with the observed deaths at each age in each year to produce both age-specific and total ‘excess deaths’ in each year.

## **Results**

## **Model projections**

Figure 2 shows the mortality rates projected at different ages in single years, had trends in age specific mortality rate reduction observed during the period 1997 to 2010 continued in the years 2011 to 2015 inclusive, for ages 60 to 85 years. Each point is a data point, the line shows the best fit of the trend, and the band shows the 95% credible interval around this line. The top row shows the mortality trends on the log scale and the bottom on the identity scale.

During the period 1997 to 2010 there was a steady fall in age specific mortality risk on the log scale, steeper than in the period 1990 to 1997 for older ages in particular. After 2010 mortality rates at specific ages tended to move towards the top of the credible interval band, moving above these bands for most of the ages plotted by 2015. The log scale subfigures show statistically significant higher-than-projected mortality rates at ages 70 and 75 years, with more deviation between actual and projected rates for males than females. The identity scale helps raise the important distinction between statistical and substantive significance, with the borderline statistically significant ‘excess’ mortality at age 85 in 2015 implying a much greater additional mortality risk than the clearly statistically significant ‘excess’ mortality at ages 60 or 70.

**Figure 2 Model projections and actual mortality risks age ages 60 to 85 years. (A) log10 mortality; (B) absolute mortality**

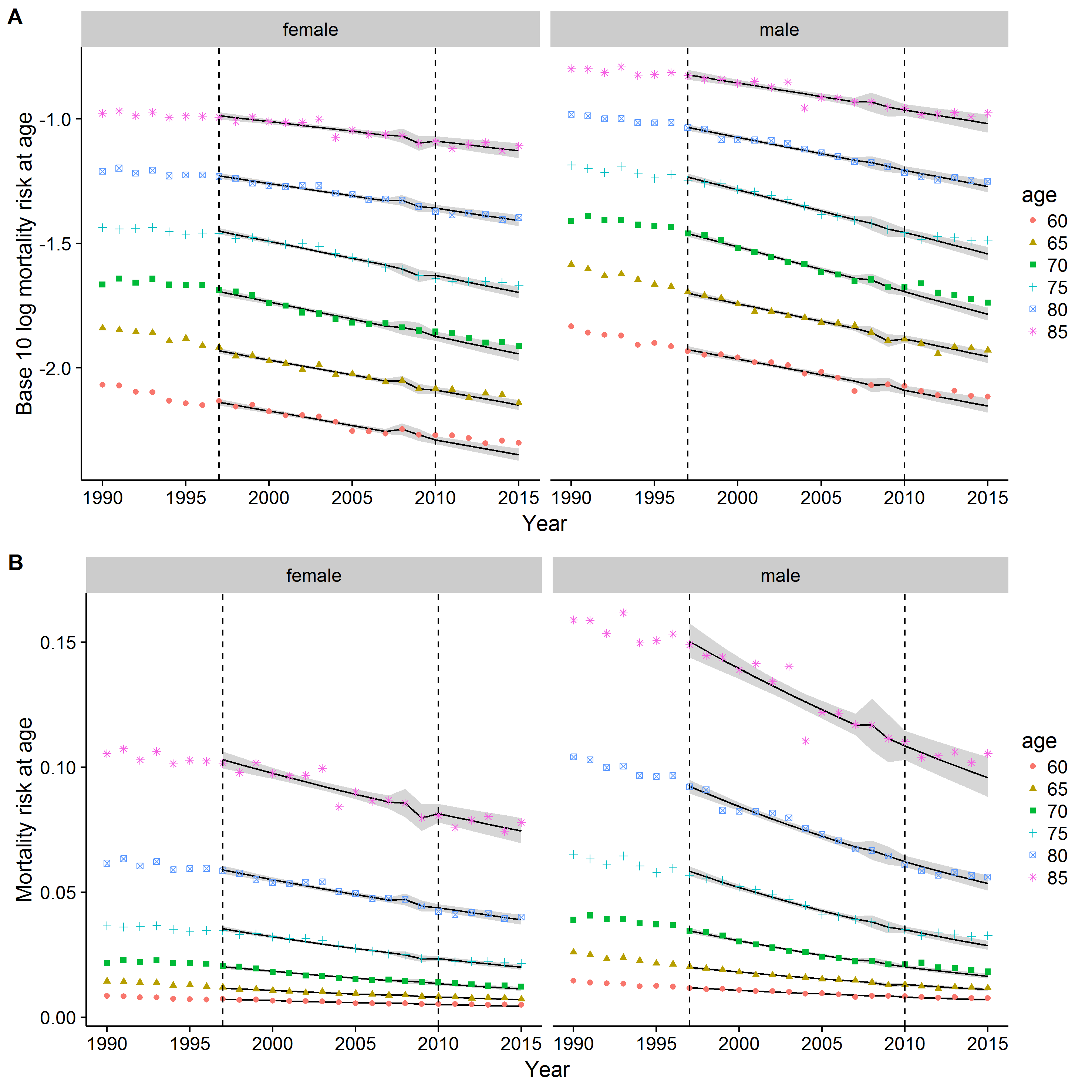


Figure 1 in the appendix shows equivalent projected and actual mortality rates in infancy, and at ages 15, 25, 35 and 45 years. In this figure it is clear that mortality rates in infancy fell rapidly between 1990 (in fact since the 1960s) and 1992, steadily but more slowly afterwards, including the period 1997-2010. Mortality rates for males aged 35 also fell after 2010 below the projected range. At other ages actual rates were largely as expected from the model. The projected and actual mortality risks at all ages in single years are used in the projection of total estimated excess deaths, below. Figure S\_02 in the appendix summarises the model coefficients; it is worth noting the first row of this figure, the intercept term, successfully identifies the Gompertz-Makham law of mortality risk against age (also known as the ‘bathtub curve’), (12) suggesting an appropriate model specification; and also that the trend terms are all negative and statistically significant, suggesting it is appropriate to model falling mortality risks over time.

## **Total Estimated Excess Deaths, 2010-2015**

Figure 4 shows the total ‘excess’ deaths in each year from 2010 to 2015, between birth and the age indicated on the horizontal axis, if the 1997-2010 (‘New Labour’) trends had continued. A vertical dashed line is added at age 65 years, as it seems this age marks an important turning point in excess death trends. In each year after 2010 there were fewer deaths than expected between birth and age 65, but more after these years, and this increasing excess has grown with time. Most of the excess deaths between the ages of 65 and 89 years occurred from 2012 onwards. 2015 saw a greater number of excess deaths by age 89 than the years 2012 to 2014 combined.

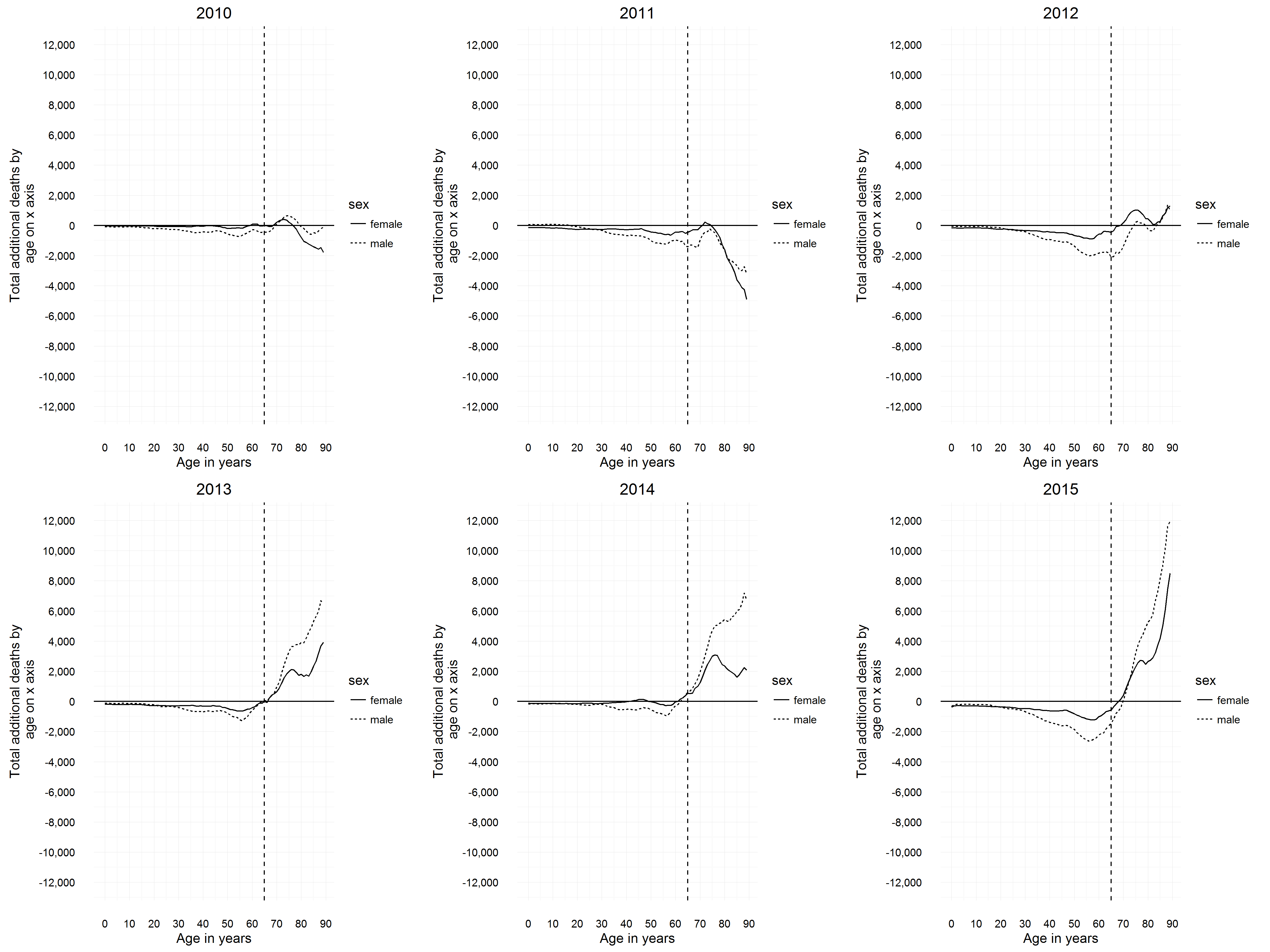
Results from the model are summarised in Tables 1 and 2. Table 1 shows the ‘excess’ deaths by the ages of 50, 70 and 89 years for each year from 2010 to 2015, with positive excesses highlighted in bold. Table 2 further summarises these results to show the combined excess deaths either over the period 2010 to 2015, or the period 2012 to 2015. The models project 2,303 fewer deaths than observed in 2012, 10,430 fewer deaths in 2013, 8,820 fewer deaths in 2014, and 20,465 fewer deaths in 2015. In total, there were 31,973 more deaths than projected between 2010 and 2015, and 42,018 more deaths than projected between 2012 and 2015.

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Year** | **Age** | **Males** |  |  |  |  |  | **Females** | |  |  |  |  | **Combined** | | |  |  |  |
| 2010 | 50 | -554 | ( | 19,094 | - | 19,648 | ) | -206 | ( | 11,786 | - | 11,992 | ) | -760 | ( | 30,880 | - | 31,640 | ) |
|  | 70 | **111** | ( | 75,811 | - | 75,700 | ) | **210** | ( | 49,994 | - | 49,784 | ) | **321** | ( | 125,805 | - | 125,484 | ) |
|  | 89 | -113 | ( | 212,724 | - | 212,837 | ) | -1,795 | ( | 192,910 | - | 194,705 | ) | -1,908 | ( | 405,634 | - | 407,542 | ) |
| 2011 | 50 | -998 | ( | 18,455 | - | 19,453 | ) | -423 | ( | 11,460 | - | 11,883 | ) | -1,421 | ( | 29,915 | - | 31,336 | ) |
|  | 70 | -950 | ( | 74,013 | - | 74,963 | ) | -110 | ( | 49,391 | - | 49,501 | ) | -1,060 | ( | 123,404 | - | 124,464 | ) |
|  | 89 | -3,235 | ( | 207,606 | - | 210,841 | ) | -4,902 | ( | 185,925 | - | 190,827 | ) | -8,137 | ( | 393,531 | - | 401,668 | ) |
| 2012 | 50 | -1,366 | ( | 17,817 | - | 19,183 | ) | -658 | ( | 11,097 | - | 11,755 | ) | -2,024 | ( | 28,914 | - | 30,938 | ) |
|  | 70 | -1,392 | ( | 73,161 | - | 74,553 | ) | **170** | ( | 49,648 | - | 49,478 | ) | -1,222 | ( | 122,809 | - | 124,031 | ) |
|  | 89 | **1,002** | ( | 209,909 | - | 208,907 | ) | **1,301** | ( | 189,135 | - | 187,834 | ) | **2,303** | ( | 399,044 | - | 396,741 | ) |
| 2013 | 50 | -786 | ( | 18,025 | - | 18,811 | ) | -465 | ( | 11,062 | - | 11,527 | ) | -1,251 | ( | 29,087 | - | 30,338 | ) |
|  | 70 | **973** | ( | 74,741 | - | 73,768 | ) | **652** | ( | 49,853 | - | 49,201 | ) | **1,625** | ( | 124,594 | - | 122,969 | ) |
|  | 89 | **6,505** | ( | 213,466 | - | 206,961 | ) | **3,925** | ( | 189,046 | - | 185,121 | ) | **10,430** | ( | 402,512 | - | 392,082 | ) |
| 2014 | 50 | -546 | ( | 17,908 | - | 18,454 | ) | -15 | ( | 11,291 | - | 11,306 | ) | -561 | ( | 29,199 | - | 29,760 | ) |
|  | 70 | **1,963** | ( | 74,625 | - | 72,662 | ) | **1,257** | ( | 49,967 | - | 48,710 | ) | **3,220** | ( | 124,592 | - | 121,372 | ) |
|  | 89 | **6,741** | ( | 212,499 | - | 205,758 | ) | **2,079** | ( | 185,505 | - | 183,426 | ) | **8,820** | ( | 398,004 | - | 389,184 | ) |
| 2015 | 50 | -1,845 | ( | 16,288 | - | 18,133 | ) | -816 | ( | 10,279 | - | 11,095 | ) | -2,661 | ( | 26,567 | - | 29,228 | ) |
|  | 70 | **82** | ( | 71,541 | - | 71,459 | ) | **392** | ( | 48,525 | - | 48,133 | ) | **474** | ( | 120,066 | - | 119,592 | ) |
|  | 89 | **11,952** | ( | 215,870 | - | 203,918 | ) | **8,513** | ( | 189,683 | - | 181,170 | ) | **20,465** | ( | 405,553 | - | 385,088 | ) |

**Table 1: Modelled estimates of ‘excess deaths’ (observed and predicted deaths in brackets), by ages 50, 70 and 89 years for each year in the period 2010-2015, for males, females and combined. Additional deaths are indicated in bold**.

|  |  |  |  |
| --- | --- | --- | --- |
| **Period** | **Males** | **Females** | **Combined** |
| 2010-2015 | 22,852 | 9,121 | 31,973 |
| 2012-2015 | 26,200 | 15,818 | 42,018 |

**Table 2: Total ‘Excess’ deaths by age 89 years over the period 2010-2015 and 2012-2015**



**Figure 2 Total 'excess deaths' (actual - projected) in England & Wales, for each year from 2010 to 2015.**

# **Discussion**

Our results demonstrate that, after 2010, mortality rates at many older ages fell more slowly in England & Wales than they had previously. We estimate 31,973 additional deaths than projected since 2010, and 42,018 more deaths than projected since 2012. Excess deaths were concentrated amongst the elderly.

These estimates should be considered conservative for two reasons. Firstly, these only cover deaths up to the age of 89 years. Estimates of death and population counts above the age of 89 years are available for 2010 to 2014, but not in the 2015 release. We expect that the number of excess deaths above the age of 89 would add to our estimates. Secondly, our model specification produced relatively conservative estimates of total additional deaths. A slightly more complex model specification (Appendix B), which allowed for nonlinear trends in rates of mortality risk improvement at various ages, produced even higher estimates of total ‘excess’ mortality, with 60,073 additional deaths estimated between 2010 and 2015, and around 65,045 additional deaths between 2012 and 2015, for all ages up to and including 89 years. While the alternative model specification had slightly better fit, both indicated 2012 as a turning point in mortality trends.

Our findings appear consistent with what might be expected from a period that has seen the longest decline in long-term economic growth rate, and longest period of lack of investment in healthcare and associated social care services since World War 2. This is both in terms of much increased and increasing levels of excess deaths amongst the elderly, but paradoxically also with somewhat reduced deaths within working ages, particularly for males (detailed in the appendix). It is known that mortality rates tend to fall for people of working age during recessions, in part because the costs of risky behaviours rise (13). Changes in these drivers of acute causes of mortality tend to react quickly to ‘environmental stimuli’. All-cause mortality among the elderly is more likely to be influenced by changes to the funding and functioning of social care and healthcare which may take longer to materialise.

Increasing elderly death rates may be ‘canaries in a coal-mine’, indicating an underlying decline in population health, wellbeing, and quality of life. [4] Since the Coalition government introduced annual measurements of subjective wellbeing in 2010, there has been declining wellbeing for most age groups in each successive year. (14) The combined effects of the GFC followed by the Coalition’s Austerity experiment appear to be resulting in wider impacts on the population that may contribute to deteriorating health and wellbeing, including not just the rising elderly mortality reported here, but also increasing suicides rates (15).

Though the working age working poor (and their children) experienced some of the most overtly adverse changes to social security provision in the UK, leading for instance to an explosion since 2010 in food bank use, (16) it is among the sick and frail that cuts to the quality of social and healthcare services appear to be a matter of . This is despite, on paper, pensioners being one of the most generously treated demographic groups by consecutive UK governments. (17) Although commitments to maintaining the relative value of pensions benefit the elderly who are still in good health, with ageing comes frailty and expensive-to-treat multi-morbidity. It is once health deteriorates to a point where pensioners become dependent on state social care and health care that they become exposed to a system undergoing both rapid reinvention and disruption, and increasing financial pressures and constraints. (18)

The longer-term consequences of austerity may take decades to become apparent. Long-term demographic records show that especially severe environmental change can cause lower cognitive functioning, increased morbidity, and an increased mortality risk to be carried by exposed populations throughout their lives. (19) Evidence of more subtle cohort effects associated with shifts in labour market conditions have been identified for specific types of mortality. Research exploring patterns in Scottish alcohol mortality and suicide trends has, for example, indicated there may be cohort effects associated with the years in which people first enter the formal labour market, with higher rates of suicide and alcohol-related deaths amongst males, in particular, who started their work life after the start of ‘neoliberal’ labour market reforms in the early 1980s, compared with cohorts who first started work in the 1970s and before. (15,20)

## **Limitations**

Population estimates for ages over 90 years are not routinely available disaggregated by age in single years as part of standard UK population estimates, and are estimated by the ONS. Our results indicate that much of the additional burden of excess mortality has been at some of the oldest ages, and we considered it important to produce estimates of total excess deaths up to 95 years, despite these limitations. Effective measurement and dissemination of age-disaggregated population and death counts at and above the age of 90 years should be a national record keeping priority.

As has been noted many times, “all models are wrong, but some are useful”. (21) Our models are ‘wrong’ in the sense that they apply projected mortality rates to observed population counts for a number of consecutive years, and of course different mortality rates at any particular age would affect the number of people alive and thus exposed to the mortality rate of people one year older in the following year. However, we believe our approach is appropriate for aggregate quantification of harms or benefits, because otherwise sufficiently large premature mortality could give the impression that deleterious trends are actually positive. For example, if there were a sudden rise in deaths due to cardiovascular events occurring in populations in their late sixties there may then be a fall in deaths due to cancer amongst people in their seventies a few years later as there would be fewer people left to be exposed to this risk; this would not be evidence of improvements in cancer treatment and care. For similar reasons, we have not altered the population sizes exposed to age-specific mortality risks in each of the years, only the degree of risks such populations are exposed to at each age.

**Conclusion**

Overall, the model estimates suggest there has been a deleterious shift in ‘the fundamentals’ of mortality improvements, similar to that seen after 2008 in economic growth, and that this has resulted in many more deaths that would otherwise have been expected. But unlike the change to the fundamental of economic growth, which occurred after 2008, mortality trends worsened in England and Wales after 2012, and have tended to become progressively worse each year since. Despite the relatively generous political support for pensions through the ‘Triple Lock’ guarantee, and the shockingly harsh increases in conditionality and sanctioning for recipients of working age unemployment social security, it is amongst the elderly, rather than working age, that the human costs of worsening public service provision can be counted in additional deaths by the tens of thousand.

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