# Abstract

**Background**

All-cause age-specific mortality risks have 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.

**Aim**

To produce estimated age-specific mortality risks over the period 2010 to 2015 based on previous trends, and compare actual against projected numbers of deaths by various ages to produce estimates of total excess deaths up to age 95 years each year from 2010 to 2015.

**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 against year based on the trend from 1990 to 2010. The models were used to estimate the mortality risks that would be expected if mortality trends prior to the austerity period had continued. The number of deaths at each age in each year from 2011 to 2015 were estimated given population counts in each year, and compared with observed number of deaths in each year.

**Results**

There were slightly fewer deaths than predicted from the models in 2010 and 2011, but from 2012 to 2015 there have been an additional 42,800 deaths in England and Wales than predicted up to age 90, and an additional 61,000 additional deaths up to age 95 years, than would have occurred had the previous (1997-2010) rate of improvement continued.

**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 older men would have been alive by 2015. The actual rise in mortality was greater for older women.

# Introduction

## Austerity and elderly mortality

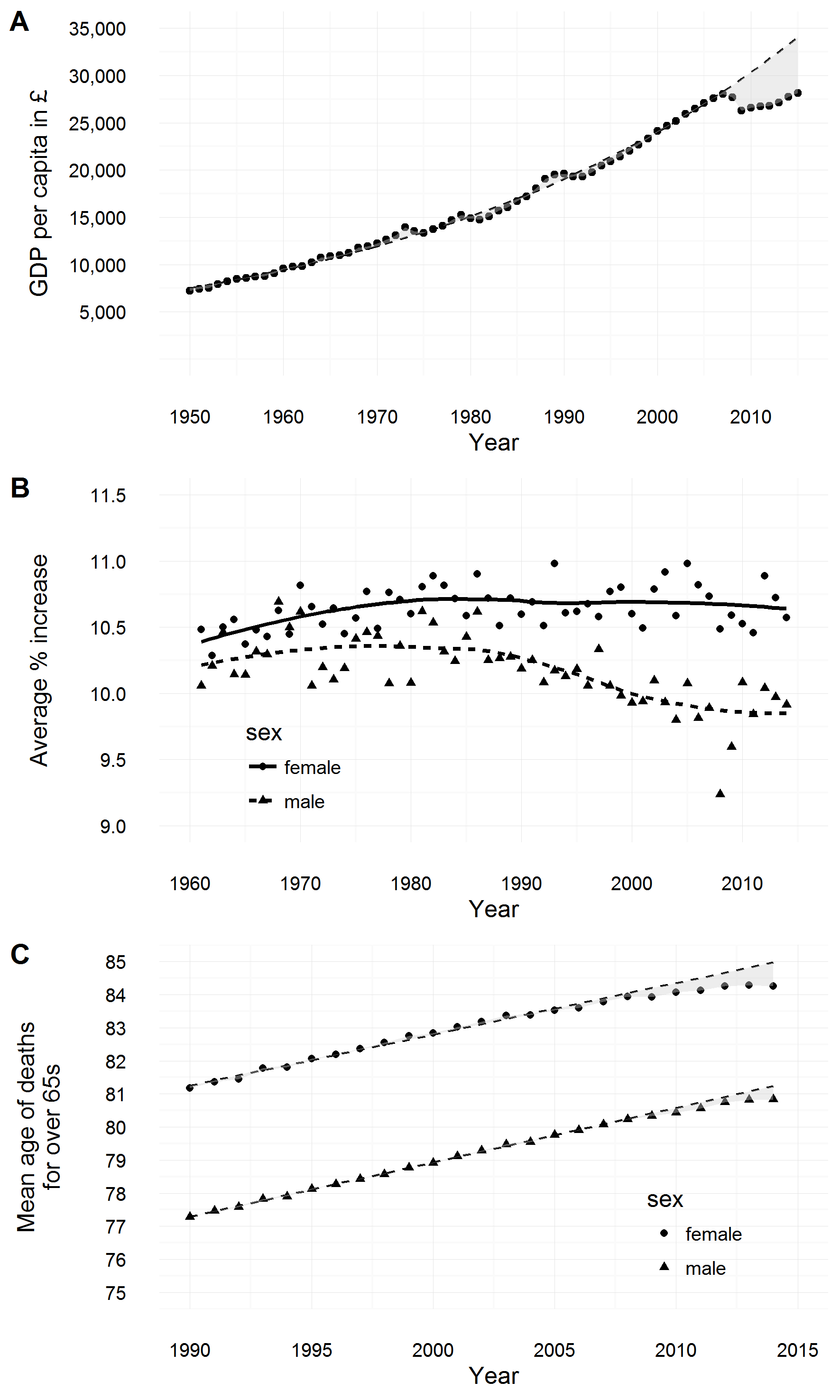
Recently, there has been growing evidence of the possible effects of austerity on elderly mortality within the UK. One study exploring the correlation between falls in Pension Credit and social care budgets in the UK, and changes in mortality rates in pensioners aged 85 years and older, found that each 1% fall in social care spending was associated with a statistically significant 0.08% rise in elderly mortality, with similar but weaker rises in persons aged 75 to 84 years. [5] Thes 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. [6]

A 2015 Public Health England report considered three possible explanations for the trends: influenza, cold weather, and statistical artefact. [7] If either influenza or cold weather were the main causes of these rises then the following would be expected: firstly, that the mortality rate rises would be spatially patterned, and secondly that the rises would be a ‘blip’ associated with particular years rather than a trend. Preliminary analysis has found no evidence of spatial patterning. [5,8,9] 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 case of rising middle aged mortality rates in the US. [10–12] 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, which have recently been identified in English population records. [5,8] The scope for such biases also reduce as more age-disaggregated data are used. [12] Similar patterns of rising mortality rates were observed in the most recent mid-year estimates [14], and the consistency of these patterns point towards austerity as opposed the other findings.

## Slower improvements are still falls against expectations

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. [15,16] Only a severe and prolonged shock and assault to the factors which contribute to such steady improvements could alter these long-term dynamics[17–19]. Figure 1 shows how per capita GDP (not inflation adjusted) increased between 1950 and 2008 in England & Wales, using annual estimates from ONS. [20] The line shows the trend against time to 2008 inclusive, which is then extrapolated to 2015. Between 1950-2008, the statistical fit of this trend line 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 pre-GFC levels. Although similar down shift in economic growth occurred in many rich countries, the disparity between actual and projected levels in the UK are especially severe. Furthermore 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.

Figure Per capita GDP against trend, 1950 to 2015;



**Notes**: **Data Sources: (A) ONS; HMD**

# 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. [27] These data are presented for each age in single years up to 104 years, though mid-year population counts are estimated for ages 90 and above [28] 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 rather than 104 years. [14]

## Modelling strategy

The precise details of the modelling strategy are detailed in the appendix, which also includes a sensitivity analysis[[1]](#footnote-1).

Our approach is to estimate models which formalise intuitions developed through visual inspection of shaded contour plots of the type shown in Figure 2. These suggest to us that there have been long-term trends towards reduced 12 month mortality risks throughout much of later life. It is also well known that mortality risk rises log-linearly with each additional year of life throughout much of adulthood. [39] We therefore estimate separate linear regression models for each sex and for each age in single years, using ONS data over the period 1990 to 2010, from birth (‘0 years’) to 94 years of age; a total of 190 separate linear regression models were produced. The start period of 1990 was used because we expected the assumption of a linear trend would be reasonable over this period, whereas it may be more nonlinear and complex over a much longer period of time. (A sensitivity analysis was also performed to see whether results were similar if a nonlinear trend specification were used.)

Within each of these models the response variable is the log mortality rate for a particular age and sex, and in a particular year. Predictor variables include an intercept at the start of the time series, a linear trend term with year, and separate intercepts and trend terms for both the years of New Labour government (1997-2010), and for the peak years of the GFC (2008-2009).

We then estimated the predicted age and sex specific mortality rates between 2010 and 2015 under the assumption that the New Labour terms (intercept and trend with year) continued. The actual population counts for each age and sex, for each year from 2011 to 2015, are then applied in order to produce counterfactual estimates of the numbers of deaths that would be ‘expected’ at each age and for each sex for each of these years. These counterfactual age and sex-specific death counts are then compared, for each year, with the actual numbers of deaths to produce the ‘excess’ number of deaths during the austerity period

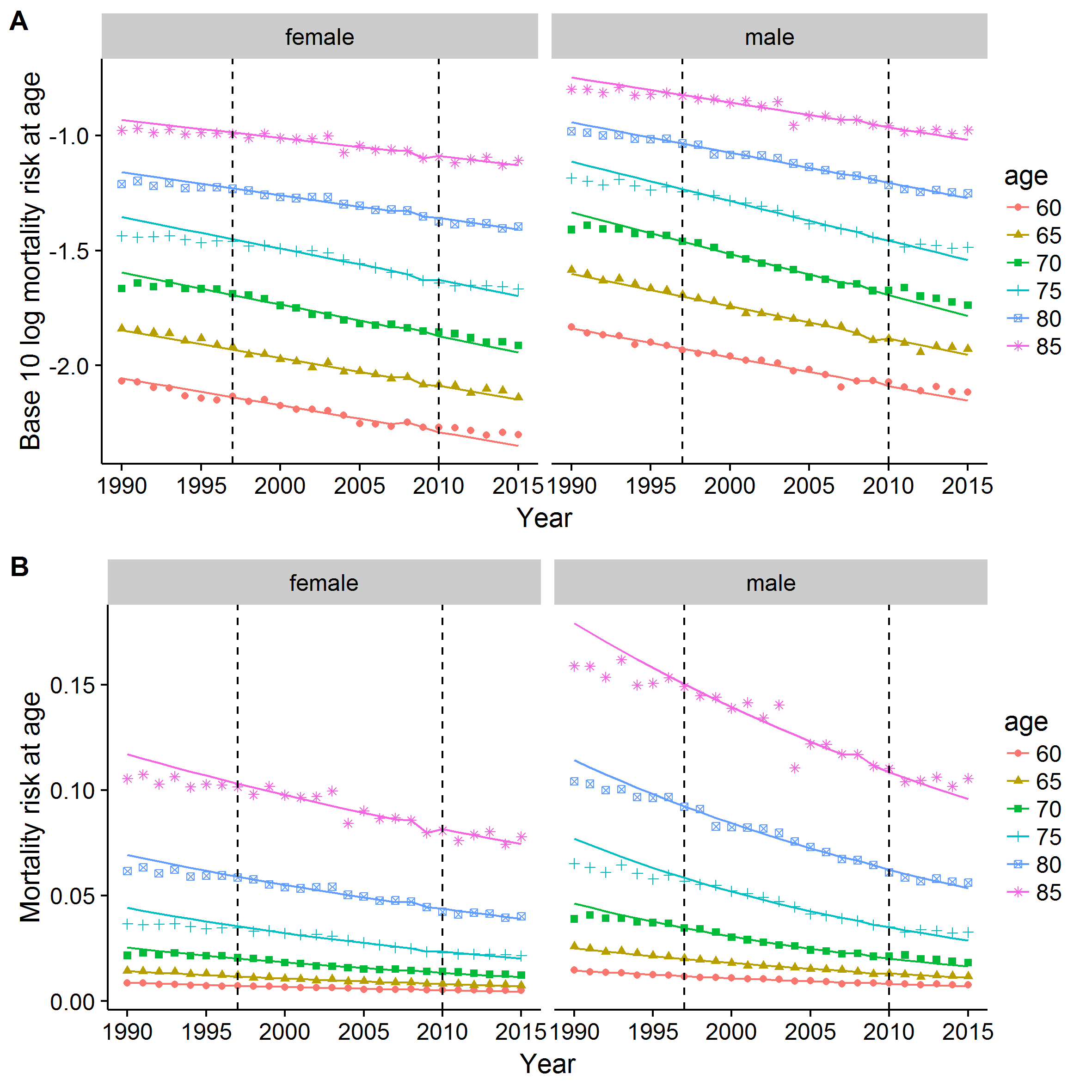
To show the age distribution of the differences between actual and expected levels in each year from 2011 to 2015, graphs are produced showing the summed differences in total deaths by different ages in each of these years. For example, the value on the vertical axis when the horizontal axis is age 50 shows the sum of differences between actual and expected deaths in that year from birth up to age 50, the value at age 60 is the sum of differences from birth to age 60, and so on. This means that the summed differences up to certain ages can be negative if there are fewer than expected deaths at some ages.

## Results

## Model projections

Figure 3 shows both the actual age-specific mortality rates (ASMRs) for select ages in different years from 1990 to 2015 as points, and the levels predicted by the model as a line. The projections tend to be above the observed values for the pre New Labour period, and below the observed values for the austerity period, indicating that during the New Labour years ASMRs at these older ages tended to decrease at a faster rate compared with the earlier and later period. Equivalent ASMR trends at younger adult ages (shown in the appendix) appear to show a contrary effect to trends at older ages. As the absolute mortality risks at these ages are smaller, the effects of elevated mortality in earlier adulthood are also smaller than the increased mortality risks compared with forward projections at older ages.

Figure Forwards and backwards model projections of select ASMRs. (A) log10 mortality; (B) absolute mortality

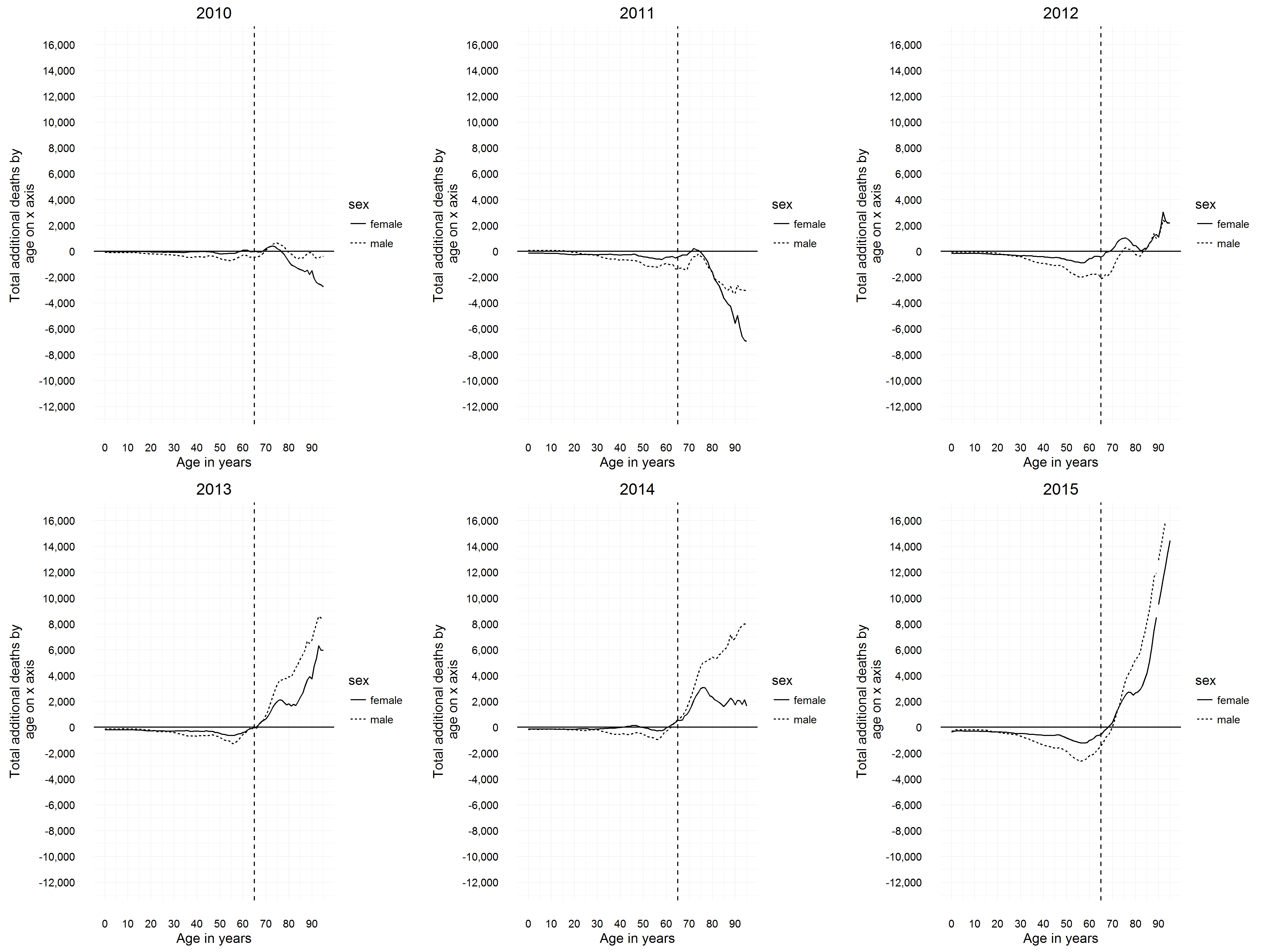


## Total Estimated Excess Deaths, 2010-2015

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 New Labour trends and intercepts were projected forwards and applied to age-specific population counts in each year. A vertical dashed line is added at age 65 years, because it seems to mark an important turning point in the excess deaths. For each year from 2010 to 2015, there has been fewer deaths than expected between birth and the start of retirement age, but an increasing number of excess deaths after retirement age, such that by age 89 there were many more deaths than expected in total. These differences and worsening tendencies become evident from 2012 onwards, and have been getting worse in each subsequent year; 2015 saw a greater number of total excess deaths than the years 2012 to 2014 combined.

The models suggest that, between birth and the age of 89 years, there were around 20,000 excess deaths in 2015 (12,000 excess male deaths, 8,000 excess female deaths), up from around 9,000 excess deaths in 2014 (7,000 male and 2,000 female), 11,000 excess deaths in 2013 (7,000 male and 4,000 female), and around 2,000 excess deaths in 2012 (1,000 male and 1,000 female). This produces a total of around 42,000 excess deaths by age 89 years in these four years. If the trend extrapolation to age 95 years in 2015 is accurate, then the total number of excess deaths in these four years rises to around 60,000 excess deaths.

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



# Discussion

Our results demonstrate that since 2010, mortality rates for England and Wales have increased in comparison to longer term trends prior to the period of austerity. These increases have been particularly high among the elderly, with mortality rates for some younger ages continuing to fall. We estimate that the total number of excess deaths that have occurred since 2010 is XXXX.

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 [refs]. This is both in terms of much increased and increasing levels of excess deaths amongst the elderly, but paradoxically also with somewhat reduced levels of deaths within working ages, in particular 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 [4,12,45]. Changes in these drivers of acute causes of mortality tend to react quickly to ‘environmental stimulus’. 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 death rates must be ‘canaries in a coal-mine’, indicating an underlying decline in population health, wellbeing and quality of life. For example, 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. [46–48] 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 at both the short- and long-term including not just the rising elderly mortality reported here, but also increasing suicides rates [ref] and decreasing mental health [ref].

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, [50–52] it is within the sick and frail that cuts to the quality of social and healthcare services appear to be a matter of life or death, indeed tens of thousands of excess deaths. This is despite, on paper, pensioners being one of the most generously treated demographic groups by consecutive UK governments, including the Coalition Government’s commitment in 2011 to a ‘Triple Lock’ to uprate the Basic State Pension such that its value will not decline in relative terms over time. [53] Although such 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 to survive from year to year and month to month that they become exposed to a system undergoing both rapid reinvention and disruption, and increasing financial pressures and constraints. [54]

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; to an extent that the 1918 Influenza pandemic was still felt years after it, by increasing age-specific mortality risks for decades following. [24,55–57] 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. [58–60]

## 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. Given that our results indicate that much of the additional burden of excess mortality has been at some of the oldest ages, we considered it important to produce estimates of total excess deaths which include ages 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”. [62] 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, but 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.

The issue of how to accurately estimate the counterfactual is intrinsic to quantifying the consequences of different actions or clusters of actions. In our study consequences are measured as excess deaths, and the cluster of actions that are thought to have caused these deaths are known as ‘austerity’. Alternative, and arguably more sophisticated, statistical modelling strategies could be applied, and the actuarial estimates of excess deaths produced would change. However the sensitivity analysis included in our appendix suggests that, if anything more sophisticated models produce less conservative results.

# References

1 Reeves A, Basu S, Mckee M, *et al.* Austere or not? UK coalition government budgets and health inequalities. *J R Soc Med* 2013;**106**.

2 Stuckler D, Basu S, Suhrcke M, *et al.* The public health effect of economic crises and alternative policy responses in Europe: an empirical analysis. *Lancet* 2009;**374**:315–23. doi:10.1016/S0140-6736(09)61124-7

3 Stuckler D, Basu S, Suhrcke M, *et al.* Effects of the 2008 recession on health: a first look at European data. *Lancet* 2011;**378**:124–5. doi:10.1016/S0140-6736(11)61079-9

4 Stuckler D, Basu S. *The Body Economic: Eight experiments in economic recovery, from Iceland to Greece*. London: : Penguin 2013.

5 Loopstra R, McKee M, Katikireddi S V., *et al.* Austerity and old-age mortality in England: a longitudinal cross-local area analysis, 2007-2013. *J R Soc Med* 2016;**109**:109–16. doi:10.1177/0141076816632215

6 Dorling D. Why are old people in Britain dying before their time? *New Statesman* 2014;:34–8.http://www.newstatesman.com/politics/2014/02/why-are-old-people-britain-dying-their-time

7 Public Health England. Recent trends in life expectancy at older ages. London: 2015. https://www.gov.uk/government/uploads/system/uploads/attachment\_data/file/403477/Recent\_trends\_in\_life\_expectancy\_at\_older\_ages.pdf

8 Green M, Dorling D, Minton J. The Geography of a rapid rise in mortality in England and Wales, 2014-2015. 2016.

9 Moran P. Notes on Continuous Stochastic Phenomena. *Biome* 1950;**37**:17–23.

10 Case A, Deaton A. Rising morbidity and mortality in midlife among white non-Hispanic Americans in the 21st century. *Proc Natl Acad Sci* 2015;:201518393. doi:10.1073/pnas.1518393112

11 Gelman A. Correcting rising morbidity and mortality in midlife among white non-hispanic Americans in the 21st century to account for the increase in average age of people in the 45-54 category. http://andrewgelman.com. 2015.http://andrewgelman.com/2015/11/06/correcting-rising-morbidity-and-mortality-in-midlife-among-white-non-hispanic-americans-in-the-21st-century-to-account-for-bias-in/ (accessed 30 Dec2015).

12 Minton J, Shaw R, Green M, *et al.* Two cheers for a small giant? Why we need better ways of seeing data. A commentary on: ‘Rising morbidity and mortality in midlife among white non-Hispanic (WNH) Americans in the 21st century’. *Int J Epidemiol* Published Online First: 2016. doi:10.1093/ije/dyw095

13 Dorling D. *A better politics: How government can make us happier*. London: : London Publishing Partnership 2016.

14 ONS. UK Mid year estimates 2015. 2016.https://www.ons.gov.uk/file?uri=/peoplepopulationandcommunity/populationandmigration/populationestimates/datasets/populationestimatesforukenglandandwalesscotlandandnorthernireland/mid2015/ukmye2015.zip

15 Woolf SH, Johnson RE, Phillips RL, *et al.* Giving Everyone the Health of the Educated: An Examination of Whether Social Change Would Save More Lives Than Medical Advances. *Am J Public Health* 2007;**97**:679–83. doi:10.2105/AJPH.2005.084848

16 Dwork D. *War is Good for Babies and Other Young Children: A History of the Infant and Child Welfare movement in England 1898-1918*. London: : Tavistock 1987. http://books.google.co.uk/books?id=lqAOAAAAQAAJ&printsec=frontcover&source=gbs\_ge\_summary\_r&cad=0#v=onepage&q&f=false

17 Smith GD, Marmot MG. Trends in Mortality in Britain: 1920–1986. *Ann Nutr Metab* 1991;**35**:53–63. doi:10.1159/000177678

18 Leon DA. Trends in European life expectancy: a salutary view. *Int J Epidemiol* 2011;**40**:271–7. doi:10.1093/ije/dyr061

19 Oeppen J, Vaupel JW. Broken limits to life expectancy. *Science (80- )* 2002;**296**:1029–31.

20 Human Mortality Database. Univ. California, Berkeley (USA), Max Plank Inst. Demogr. Res. 2014.www.mortality.org

21 Summers LH. Have we Entered an Age of Secular Stagnation? IMF Fourteenth Annual Research Conference in Honor of Stanley Fischer, Washington, DC. *IMF Econ Rev* 2015;**63**:277–80. doi:10.1057/imfer.2015.6

22 Crafts N. Economic growth: onwards and upwards? *Oxford Rev Econ Policy* 2015;**31**:217–41. doi:10.1093/oxrep/grv014

23 Minton J. Real geographies and virtual landscapes: Exploring the influence of place and space on mortality Lexis surfaces using shaded contour maps. *Spat Spat Epidemiol*

24 Minton J, Vanderbloemen L, Dorling D. Visualizing Europe’s demographic scars with coplots and contour plots. *Int J Epidemiol* 2013;**42**:1164–76. doi:10.1093/ije/dyt115

25 Minton J. Real geographies and virtual landscapes: Exploring the influence on place and space on mortality Lexis surfaces using shaded contour maps. *Spat Spatiotemporal Epidemiol* 2014;**10**:49–66. doi:10.1016/j.sste.2014.04.003

26 Bennett JE, Li G, Foreman K, *et al.* The future of life expectancy and life expectancy inequalities in England and Wales: Bayesian spatiotemporal forecasting. *Lancet* 2015;**386**:163–70. doi:10.1016/S0140-6736(15)60296-3

27 Mills J. File containing number of death registrations by single year of age for England & Wales and the UK 1961-2014; and Mid-year population estimates by single year of age for England & Wales and the UK 1961-2014. 2015.https://www.ons.gov.uk/file?uri=/peoplepopulationandcommunity/populationandmigration/populationestimates/adhocs/005825populationestimatesforenglandandwales1961to2014singleyearofage0to105/ewuksyoadeathspopdata19612014cmifilevaluesforissue10122015.xls

28 Kannisto V, Lauritsen J, Thatcher a R, *et al.* Reductions in Mortality at Advanced Ages: Several Decades of Evidence from 27 Countries. *Popul Dev Rev* 1994;**20**:793–810. doi:10.2307/2137662

29 Gregory I. Longitudinal Analysis of Age- and Gender-Specific Migration Patterns in England and Wales. *Soc Sci Hist* 2000;**24**:471–503. doi:10.1017/S0145553200010270

30 Yang Y, Fu WJ, Land KC. A Methodological Comparison of Age-Period-Cohort Models: The Intrinsic Estimator and Conventional Generalized Linear Models. *Sociol Methodol* 2004;**34**:75–110. doi:10.1002/cncr.20987

31 Yang Y, Schulhofer‐Wohl S, Fu WJ, *et al.* The Intrinsic Estimator for Age‐Period‐Cohort Analysis: What It Is and How to Use It. *Am J Sociol* 2008;**113**:1697–736. doi:10.1086/587154

32 Yang Y. Bayesian inference for hierarchical age-period-cohort models of repeated cross-section survey data. Sociol. Methodol. 2006;**36**:39–74. doi:10.1111/j.1467-9531.2006.00174.x

33 Yang Y, Land KC. Age-Period-Cohort Analysis of Repeated Cross-Section Surveys: Fixed or Random Effects? *Sociol Methods Res* 2008;**36**:297–326. doi:10.1177/0049124106292360

34 Bell A, Jones K. Another ‘futile quest’? A simulation study of Yang and Land’s hierarchical age-period-cohort model. *Demogr Res* 2014;**30**:333–60. doi:10.4054/DemRes.2014.30.11

35 Bell A, Jones K. The impossibility of separating age, period and cohort effects. Soc. Sci. Med. 2013;**93**:163–5. doi:10.1016/j.socscimed.2013.04.029

36 Reither EN, Masters RK, Yang YC, *et al.* Should age-period-cohort studies return to the methodologies of the 1970s? *Soc Sci Med* 2015;**128**:356–65. doi:10.1016/j.socscimed.2015.01.011

37 Bell A, Jones K. Should age-period-cohort analysts accept innovation without scrutiny? A response to Reither, Masters, Yang, Powers, Zheng and Land. *Soc Sci Med* 2015;**128**:331–3. doi:10.1016/j.socscimed.2015.01.040

38 Wilmoth JR. Age-Period-Cohort Models in Demography. In: Caselli G, Vallin J, Wunsch G, eds. *Demography: Analysis and Synthesis*. Burlington, MA: : Academic Press 2006.

39 Gompertz B. On the Nature of the Function Expressive of the Law of Human Mortality, and on a New Mode of Determining the Value of Life Contingencies. *Philos Trans R Soc London* 1825;**115**:513–83. doi:10.1098/rstl.1825.0026

40 King G, Tomz M, Wittenberg J. Making the Most of Statistical Analyses: Improving Interpretation and Presentation. *Am J Pol Sci* 2000;**44**:341–55.

41 Claxton K, Sculpher M, McCabe C, *et al.* Probabilistic sensitivity analysis for NICE technology assessment: not an optional extra. *Health Econ* 2005;**14**:339–47. doi:10.1002/hec.985

42 Dibben C, Popham F. Are health inequalities evident at all ages? An ecological study of English mortality records. *Eur J Public Health* 2013;**23**:39–45. doi:10.1093/eurpub/cks019

43 Vallejo-Torres L, Hale D, Morris S, *et al.* Income-related inequality in health and health-related behaviour: exploring the equalisation hypothesis. *J Epidemiol Community Health* 2014;**68**:615–21. doi:10.1136/jech-2013-203306

44 Vanderbloemen L, Minton J, Dorling D. Visualizing sex differences in mortality, USA, 1933-2010. *J Epidemiol Community Heal*

45 Newton JN, Briggs ADM, Murray CJL, *et al.* Changes in health in England, with analysis by English regions and areas of deprivation, 1990–2013. *Lancet* Published Online First: 2015. doi:10.1016/S0140-6736(15)00195-6

46 Dorling D. Brexit: the decision of a divided country. *BMJ* 2016;:i3697. doi:10.1136/bmj.i3697

47 ONS. Measuring National Well-being: Domains and Measures. https://www.ons.gov.uk/peoplepopulationandcommunity/wellbeing/datasets/measuringnationalwellbeingdomainsandmeasures

48 ONS. Measuring National well-being: Life in the UK: 2016. http://www.ons.gov.uk/peoplepopulationandcommunity/wellbeing/articles/measuringnationalwellbeing/2016

49 Catalano R, Goldman-Mellor S, Saxton K, *et al.* The Health Effects of Economic Decline. *Annu Rev Public Health* 2011;**32**:431–50. doi:10.1146/annurev-publhealth-031210-101146

50 Lambie-Mumford H, Green MA. Austerity, welfare reform and the rising use of food banks by children in England and Wales. *Area* 2015;:n/a – n/a. doi:10.1111/area.12233

51 Loopstra R, Reeves A, Stuckler D. Rising food insecurity in Europe. *Lancet* 2015;**385**:2041. doi:10.1016/S0140-6736(15)60983-7

52 Loopstra R, Reeves A, Taylor-Robinson D, *et al.* Austerity, sanctions, and the rise of food banks in the UK. *Bmj* 2015;**350**:h1775–h1775. doi:10.1136/bmj.h1775

53 Thurley D. State Pension uprating - 2010 onwards. London: 2016. http://researchbriefings.files.parliament.uk/documents/SN05649/SN05649.pdf

54 Lafond S, Arora S, Charlesworth A, *et al.* Into the red? The state of the NHS’ finances: An analysis of NHS expenditure between 2010 and 2014. 2014. http://www.nuffieldtrust.org.uk/sites/files/nuffield/publication/into-the-red-report.pdf

55 Almond D, Mazumder B. The 1918 Influenza Pandemic and Subsequent Health Outcomes: An Analysis of SIPP Data. *Am Econ Rev* 2005;**95**:258–62. doi:10.1257/000282805774669943

56 Almond D. Is the 1918 Influenza Pandemic Over? Long‐Term Effects of In Utero Influenza Exposure in the Post‐1940 U.S. Population. *J Polit Econ* 2006;**114**:672–712. doi:10.1086/507154

57 Barker DJP. The Developmental Origins of Adult Disease. *J Am Coll Nutr* 2004;**23**:588S – 595S. doi:10.1080/07315724.2004.10719428

58 Parkinson J, Minton J, Lewsey J, *et al.* Recent cohort effects in suicide in Scotland: a legacy of the 1980s? *Under Rev*

59 McCartney G, Bouttell J, Craig N, *et al.* Explaining trends in alcohol-related harms in Scotland, 1991–2011 (I): the role of incomes, effects of socio-economic and political adversity and demographic change. *Public Health* 2016;**132**:13–23. doi:10.1016/j.puhe.2015.12.013

60 McCartney G, Bouttell J, Craig N, *et al.* Explaining trends in alcohol-related harms in Scotland 1991–2011 (II): policy, social norms, the alcohol market, clinical changes and a synthesis. *Public Health* 2016;**132**:24–32. doi:10.1016/j.puhe.2015.12.012

61 Benach J, Vives A, Tarafa G, *et al.* What should we know about precarious employment and health in 2025? framing the agenda for the next decade of research. *Int J Epidemiol* 2016;**45**:232–8. doi:10.1093/ije/dyv342

62 Box GEP. Science and Statistics. *J Am Stat Assoc* 1976;**71**:791–9. doi:10.1080/01621459.1976.10480949

# Appendices

## The modelling approach

## Model

For each sex, and for each age in single years, a, from birth to 95 years old, a separate linear regression model was fit with the following specification:

|  |  |
| --- | --- |
|  | (1) |

Where is the mortality rate (death count divided by population count) in year t, at age a, and for sex s; t is year; L is a dummy variable indicating the years, 1997 to 2010, in which New Labour were in government; R is a dummy variable indicating 2008 and 2009, the years in which the UK economy entered a recession as a result of the GFC, and is an error term. The R term is included to capture any additional short-term changes in mortality rates to be captured in a separate term rather than influence the coefficients including New Labour years, and . The use of interaction terms Lt and Rt allowed for the gradients of change in log mortality rates over time to be different over the New Labour and GFC recession periods.

The above model specification was fit to ONS data for each year from 1990 to 2010 inclusive. Redefining , projected log mortality rates were calculated for years 2011 to 2015 inclusive by setting t to these year values and L to 1, i.e.

|  |  |
| --- | --- |
|  | (2) |

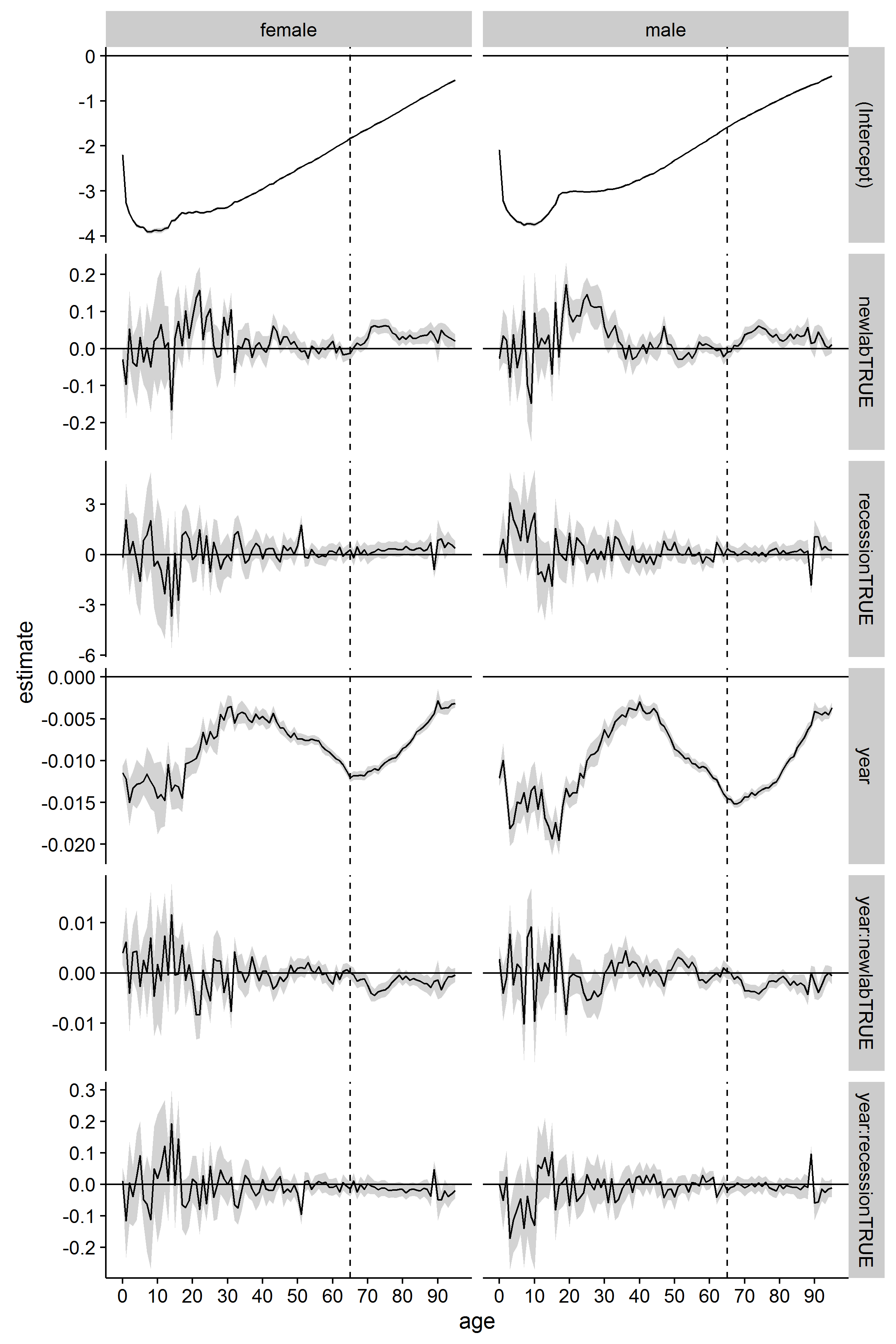
Predicted numbers of deaths at each age, for each sex, and in each year from 2011 to 2015 were therefore calculated by multiplying the relevant age-year-sex specific population counts by the requisite projected mortality rates, i.e.

|  |  |
| --- | --- |
| or equivalently | (3) |

Where is the projected mortality rate rather than log rate.

The age-sex specific differences in deaths are therefore , and the total difference in deaths by age A, shown in figures xxx, is .

As death and population counts from the ONS for the year 2015 was aggregated for years 90 and above rather than disaggregated by age in single years, for ages 90 to 95 years was estimated by extrapolating over ages 84 to 89 years.



1. ## A structural sensitivity analysis with a non-linear specification of the trend in age specific mortality rates over time and a probabilistic sensitivity analysis, using a quasi-Bayesian statistical simulation approach are presented in the appendix.

   [↑](#footnote-ref-1)