# Abstract

**Background**

All-cause age-specific mortality risks have tended to be decreasing in England & Wales for more than a century. The period 2008-2015 has seen both a global recession, and since 2010, two Conservative-led governments pursuing an ‘austerity’ agenda of reduced investment in public services.

**Aim**

To estimate trends in age-specific mortality risks from 1990 to 2010, use these trends to produce estimated age-specific risks over the period 2010 to 2015, and compare actual against projected numbers of deaths by various ages to produce estimates of total excess deaths by age 95 years in each year from 2010 to 2015.

**Methods**

Office for National Statistics (ONS) data on population counts and death counts at each age in single years from birth to age 95 years (2010 to 2014 data) or to age 89 years (2015 data) were used to construct linear regression models of mortality risk against year for each age in single years from 1990 to 2010, including dummy variables to control separately for effects of the New Labour (NL) government (1997-2010) and the 2008-2009 global financial crisis (GFC). The models were used to estimate the mortality risks that would have been expected if mortality trends during the New Labour period had continued. The number of age-specific 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 from up to age 90, and an additional 61,000 additional deaths up to age 95 years, then would have occurred had the previous (1997-2010) rate of improvement continue. Most additional deaths than predicted occurred after retirement age, and were more likely among males than females.

**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 continued many older men would have been alive by 2015. In actual rise in mortality was greater for older women, but we should be aware that mortality improvements among older men slowed most abruptly after 2010.

# Introduction

In England & Wales, as in much of the rich world, continual, incremental, and predictable rates of progress in matters of wealth and health have been the norm for many decades. To not make progress, year on year, at rates that have continued for generations is therefore to underperform as a society, and so to regress in absolute terms, and achieve less than has been achieved before, is to fail badly at what is arguably the most important measure of social progress.

In recent years macroeconomists have been puzzled at the UK’s slow rate of per capita growth in gross domestic product (GDP) which experienced one of the greatest recessions of modern times in the years following 2008, with arguments made about the world economy may have entered a new epoch of ‘secular stagnation’, permanently slower growth in a metric that has for more than sixty years considered a key measure of societal progress. The economic slowdown and stagnation in the UK has, however, been considered exceptionally poor, and has been linked to the Austerity agenda of the Conservative led government of 2010 which continues through to the present day, in contrast to similarly affected countries which pursued policies of economic stimulus and investment instead. [REF: Wren Lewis; Stuckler]. In the UK, this persistent gap between actual and projected GDP per capita grew from around £6,800 per person in 2008 to more than £13,400 per person in 2015. Income inequalities have also grown exceptionally sharply in the UK since 2010, meaning divergences against long term trends in median earnings have been larger still. The best-off 1% saw their incomes and especially their wealth rise after 2008 whereas for the other 99% income levels fell and absolute poverty has increase [Dorling, D. (2014, 2015) Inequality and the 1%, London: Verso]

Progress in health, at least as measured in life expectancy, has tended to improve continually for an even longer period. In the UK, the greatest gains in life expectancy at birth occurred during the first half of the twentieth century, in large part due to exponential falls in infant mortality rates. These rates appear to be continuing to fall exponentially, but because the absolute risk of infant mortality is so much lower than it was three or four generations ago, the overall effect of these further declines on overall life expectancy have declined. Instead, what contributes most to overall changes in longevity are continuing, incremental falls in age-specific mortality risks (ASMRs) throughout adulthood, and in particular in older years. The probability of dying with each additional year of life typically increases, by between 10% and 11% in the UK, from around the age of 35 years onwards in both males and females. This compound growth in probability of death at each age turns a risk of less than 0.2% at age 40 into a risk of over 6.0% at age 80 for men, and from less than 1-in-1000 at age 40 to over 4.3% for women. [own calculations, year 2000] The total probability of dying between any two ages is of course an accumulation of these individually compounding age-specific mortality risks.

There are signals that trends towards greater longevity in England & Wales have slowed down or even reversed in recent years. In England and Wales deaths in the year to July 2015 rose by 46,100; a rise of 9% in the annual death rate as compared to mortality to the mid year of 2014. Deaths rose by 12% in the population who had survived to age 90; by 10% for those aged 85-89; 7% for those aged 80-84; 5% for those aged 75-70; and by 3% for those aged 55-74. [Calculated from ONS mid year estimates released on June 23rd 2016] Figure XX shows, for example, the mean age of death for those age 65 years or over in England & Wales from 1990 onwards, a measure of conditional life expectancy. The two dashed lines indicate linear regressions fit to this trend for each year from 1990 to 2008, and it is clear from this that recent years have seen actual increases in this measure fall below the trend line for both men and women. These differences between actual and projected conditional life expectancy trends amount to around 0.4 years for males and 0.7 years for females.

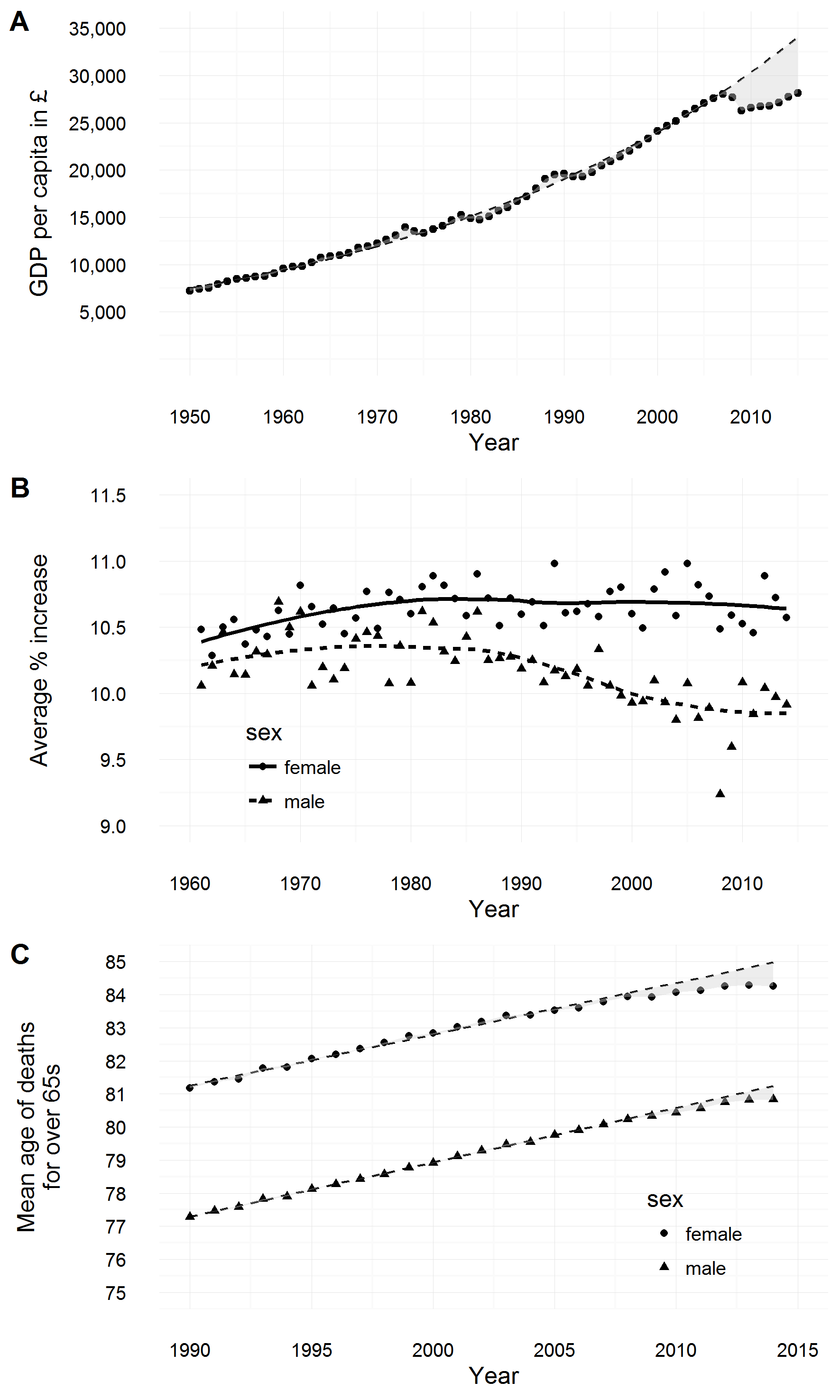
Underlying a single measure of longevity are a much larger number of ASMRs, each of which have been undergoing different rates of change over time. Although it would not be reasonable to compare ASMR trends over a long period of time because earlier medical and broader public health interventions, such as antibiotics and improved sanitation, are likely to have picked the ‘low hanging fruit’ in mortality reduction, and helped bring the epidemiological transition in which communicable causes of death became much less predominant, exploring ASMR trends over more recent decades is likely to be informative in helping to identify whether, as with the collapse in per capita GDP since 2008, there has been a substantive shift away from expected improvements in mortality risk.

Within England and Wales, there are very good and well documented reasons for believing that the relationship between economic growth and health trajectories are more than just analogous. This is because of the particular macroeconomic policy decisions taken by the Conservative-led Coalition government of 2010 to 2015, and later the Conservative government from 2015 onwards, to pursue an austerity agenda aimed (allegedly) at reducing the size of public sector debt following the 2008 GFC. This agenda led to substantial freezes or slow-downs in per capita spend in areas of healthcare and social care, unprecedented in scale and duration in many people’s lifetimes.

Where the increased mortality risk with age, from middle age onwards, tends to be driven by non-communicable disease rather than external causes, the increasing risk of mortality tends to be accompanied by an increasing incidence and prevalence of morbidities: ailments, aches, pains and disabling conditions that lead to individuals becoming increasing reliant on both health care and later adult social services. Where there are per-capita freezes or cuts in spending on these services, the capacity of such services to effectively treat these morbidities can be expected to diminish, and the probability that previously non-fatal conditions and events lead to loss of life can be expected to increase. Inadequate health care and social care mean that strokes, falls, cases of pneumonia or periods of exceptionally cold or hot weather may all be more likely to result in death for frail individuals.

The purpose of this paper is three-fold: firstly, to assess whether, in England & Wales, there is evidence of substantive shifts from ASMR trends in the period after 2010; secondly, to see whether such patterns are consistent with those expected given reduced health care and adult social care spending, i.e. whether they disproportionately affect the frail and elderly; and thirdly, to quantify any effect of such shifts away from historic trends in terms of ‘excess deaths’, rather than in more abstract terms such as the statistical significance or otherwise of regression coefficients.

Figure Three UK time trends. A) Per capita GDP against trend, 1950 to 2015; B) Average percentage increase in mortality risk with each additional age of life, for males and females, from 1961 to 2015; C) Mean age of deaths amongst males and females aged over 65 years from 1990 to 2014, compared with linear trend over the period 1990 to 2008



**Notes**: **Data Sources: (A) ONS; HMD; (B) ONS; (C) ONS [further details to be added]**

Links:

<http://oxrep.oxfordjournals.org/content/31/2/217.full.pdf+html>

<http://ner.sagepub.com/content/231/1/R17.full.pdf+html>

<http://behl.berkeley.edu/files/2015/07/WP2015-06_Eichengreen.pdf>

<http://search.proquest.com/openview/2ff879b9c765e297515ce17b0e947e8c/1?pq-origsite=gscholar&cbl=736333>

<http://link.springer.com/article/10.1057%2Fimfer.2015.6>

<http://heinonline.org/HOL/Page?handle=hein.journals/fora95&div=26&g_sent=1&collection=journals>

<https://assets.documentcloud.org/documents/1678017/growing-fast-and-slow.pdf>

<https://assets.documentcloud.org/documents/1678017/growing-fast-and-slow.pdf>

<https://mainlymacro.blogspot.co.uk/2015/04/mediamacro-myth-7-strong-recovery.html>

<http://www.voxeu.org/article/fiscal-policy-explains-weak-recovery>

<http://www.lrb.co.uk/v37/n04/simon-wren-lewis/the-austerity-con>

# Methods

## Data

Mid-year population count and death registrations for England & Wales for years up until 2015 were extracted from the ONS Excel spreadsheet ‘Population Estimates for England & Wales 1961 to 2014’[[1]](#footnote-1) for ages up to 95 years of age. For 2015 mid year population counts and death counts for each age in single years from birth to 89 years were extracted from the Components of Change database (table MYEB2).[[2]](#footnote-2)

## Model

For each sex, and for each age in single years 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 fitted 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.

All analyses were performed using the R programming environment using publically accessibly data, and the R scripts used to perform the analyses are made freely available to other researchers.

# Results

## Regression Coefficients

Figure 2 summarises the six regression coefficients in each of the nearly two hundred linear regression models which have been estimated. The lines indicate the point estimates for particular coefficients for a given age and gender, and the grey bands around these indicate two standard deviations above and below these point estimates.

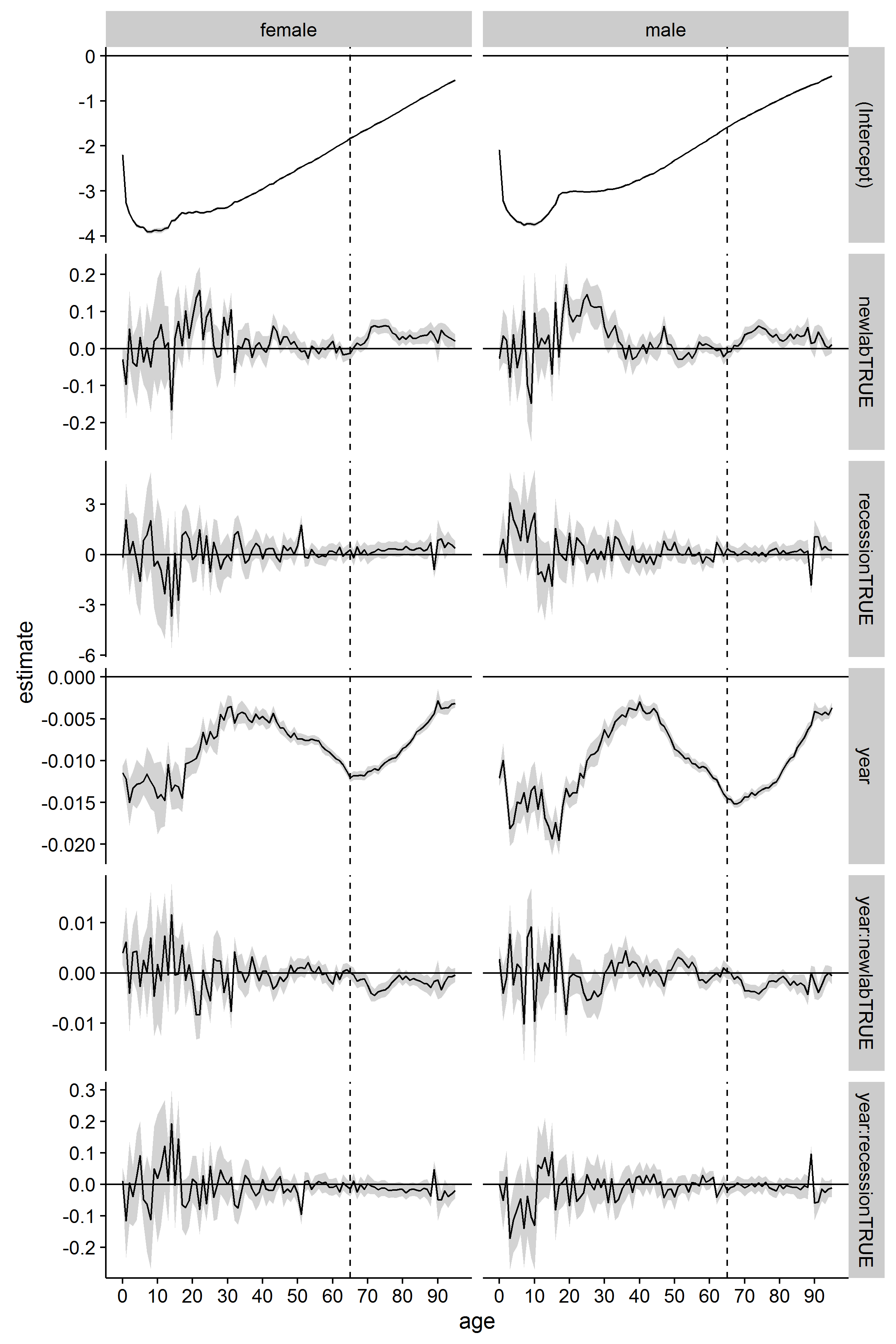
The top row shows the intercept, which clearly identifies the well-known ‘bathtub’ shaped relationship between age and mortality probability for both sexes. As base 10 has been used, -1 indicates a 1-in-10 probability of dying in the next year, -2 a 1-in-100 risk, and so on. For both sexes, there is a plateau in the mortality risk in early adulthood, more evident for males than females, then a log-linear relationship with age from the thirties onwards.

The ‘year’ row shows the overall year-on-year decline in log10 ASMR over the period 1990-2010, once the other variables have been controlled for. It is clear from this that the log mortality trends tend to be greatest in childhood and at around retirement age, as indicated using the vertical dashed line, then smaller at other ages. Given the absolute mortality risk is around one hundred times greater at retirement age than childhood, however, the trend at retirement age represents a larger absolute improvement in mortality over time.

The variables newlabTRUE and year:newlabTRUE allow for both the intercept and trend in these ASMRs to vary over the New Labour period. It appears from these coefficients that the New Labour period had statistically significant effects on both the intercept and trend at ages slightly over male retirement age. For males, in particular, the intercept coefficients indicate a statistically significant elevated mortality risk in early adulthood too, broadly corresponding to those years in which the overall intercept coefficient exhibits a mortality plateau.

The effects of the recession on both the intercept and trend appear not to be statistically significant at any ages, possibly because they include only three years. However the coefficients are included so as to avoid biasing the coefficients associated with the New Labour period.

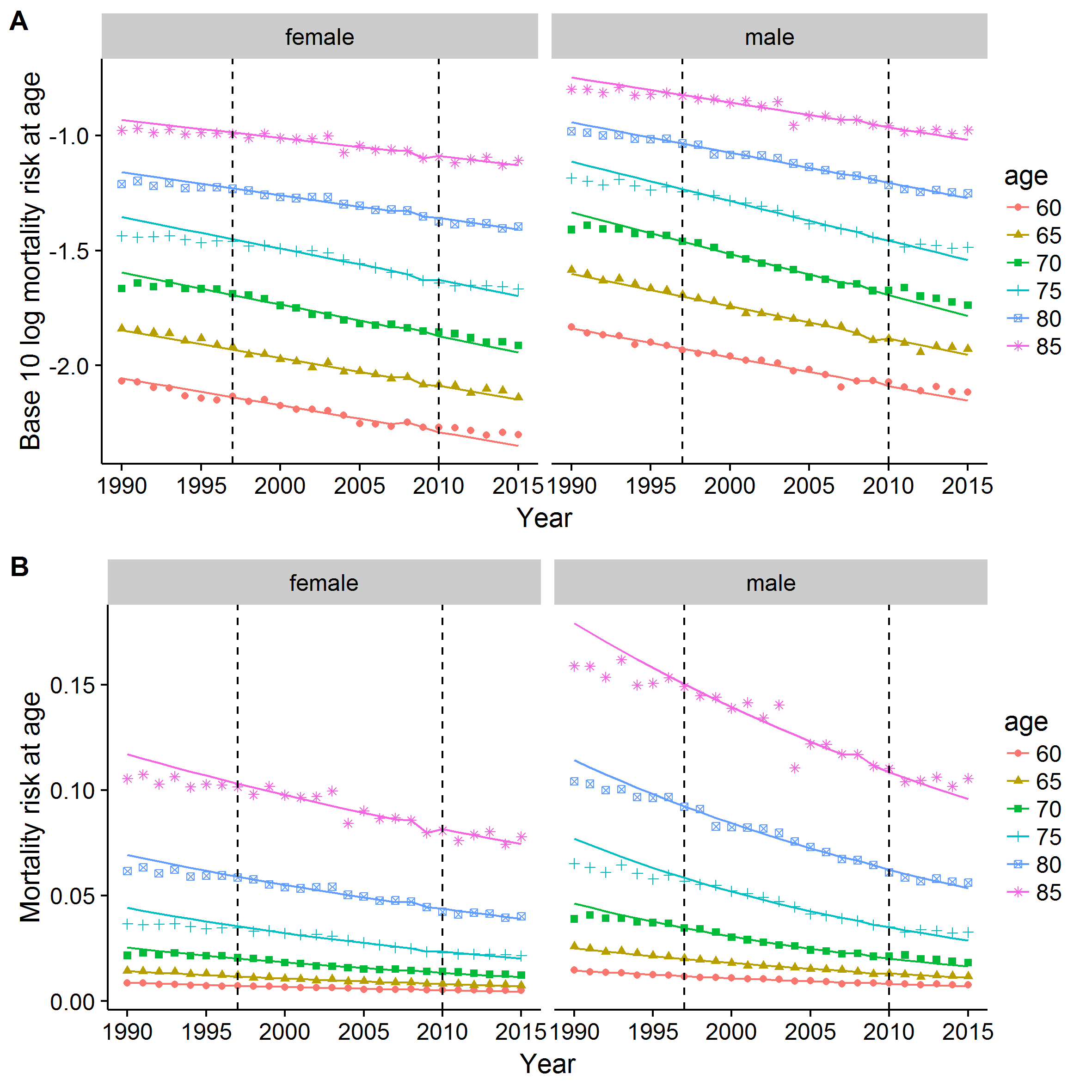
Figure Point estimates and two SD confidence bands for regression coefficients used in the model



## Illustrative model projections

Figure 3 shows both actual ASMRs for select ages in different years from 1990 to 2015 as points, and the levels predicted by the model as a line, if the New Labour effects on intercept and trend were projected to both the pre- and post- New Labour period. The projections tend to be above the observed values for the pre Labour period, and below the observed values for the post Labour 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. This seems particular the case for older ages in the series, especially on the identity scale (Figure 3B) rather than log10 scale (Figure 3 A), as would be expected given the higher baseline mortality risk at these higher ages. Equivalent ASMR trends at younger adult ages, as shown in the appendix, appear to show a contrary effect, but as the absolute mortality risks at these ages are much smaller the effects of elevated mortality in earlier adulthood are much smaller than the increased mortality risks compared with forward projections in at older ages. Greater numbers of excess deaths overall should therefore be expected in the post New Labour period than during New Labour.

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



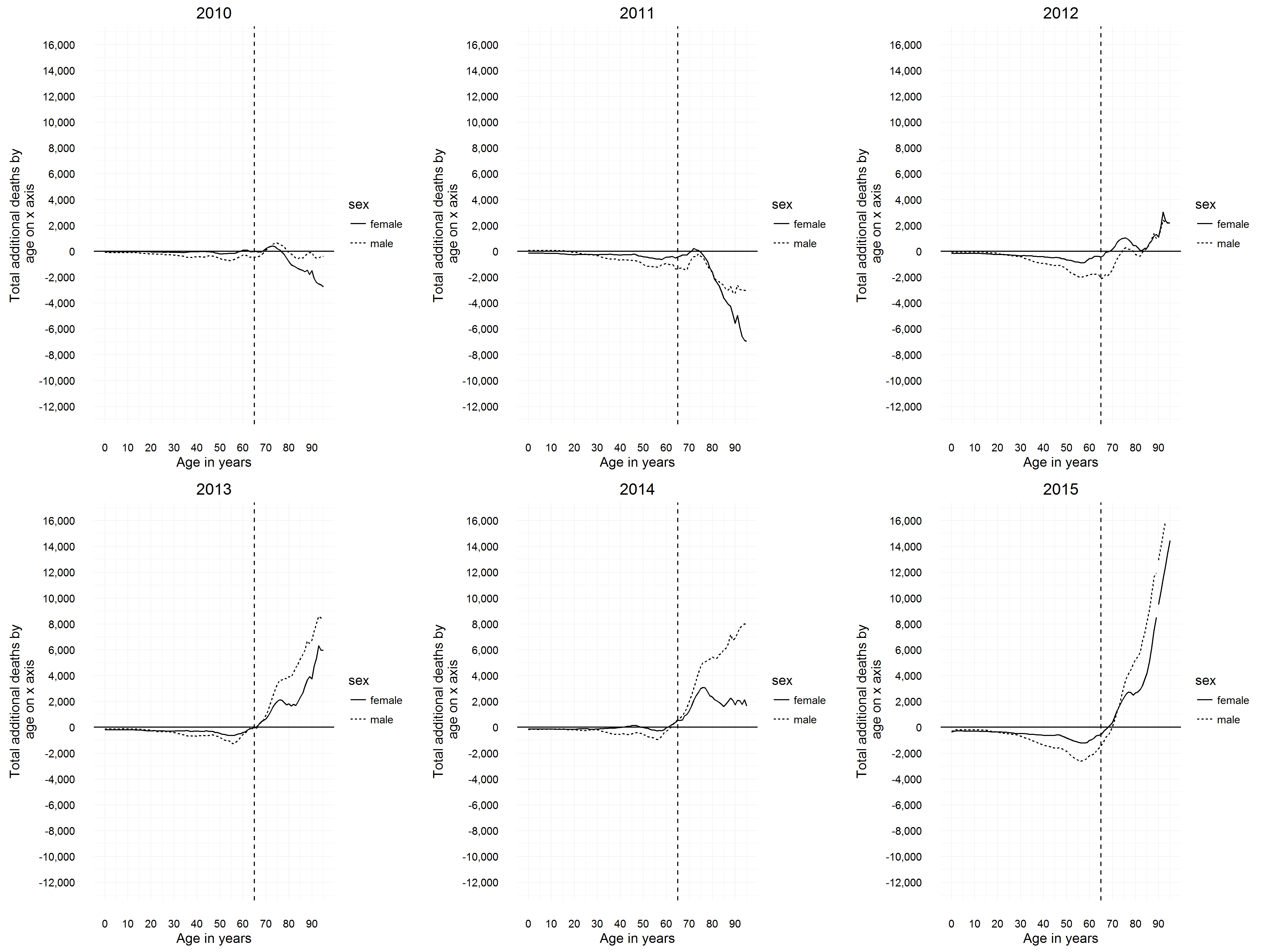
## Total Estimated Excess Death, 2010-2015

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 within these figures this age seems to mark an important turning point in the excess deaths by particular ages.

It appears from these figures that, for each year from 2010 to 2015, there tends to have been somewhat fewer deaths than expected between birth and the start of retirement age, but a much increasing number of excess deaths after retirement age, such that by ages 89 there were many more deaths than expected in total. These differences and worsening tendencies become evident from 2012 onwards, and appear have been getting worse, as in moving further from the New Labour trends, in each subsequent year. For the years 2010 to 2014 inclusive, population counts and death rates are also available at the ages of 90 to 95 years, but for 2015 only population and death counts disaggregated by age in single year up to the age of 89 years were made available by the ONS. The trends in total deaths by given ages are therefore projected to ages 90 to 95 years in 2015 for comparison with other years, using a linear regression of trends observed between ages 85 to 89 years. Even if only the trends in total excess deaths up to the age of 89 years were taken into consideration, however, then it appears 2015 saw a greater number of total excess deaths than the years 2012 to 2014.

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, and 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 by age 89 in these four years rises to around 60,000 excess deaths. However even if there are no additional excess deaths in 2015 after the age of 89 years, this total number of excess deaths over the four years only reduces to around 55,000 excess deaths.

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



# Discussion

The patterns of excess deaths produced by the modelling approach are consistent with what might be expected from a country that has been subject to both the longest decline in long-term economic growth rates, and longest period of lack of investment in healthcare and 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 levels of deaths within working ages, in particular for males. Where people have less money, even when they have their health, they have less opportunity to engage in activities that they enjoy, but that sometimes confer some degree of risk. This includes activities such as smoking cigarettes, drinking alcohol to excess, and driving more than is necessary. The result of reductions in these activities may lead to slight falls in death rates at some ages.

After people get beyond working age, and in particular once they become increasingly dependent on healthcare and social care services to continue living well, and continue living a reasonable quality of life, then the level of investment in these services can be expected to have an effect on their mortality risks. This is exactly what the excess death estimates, and their concentration at older ages, indicate. The people most affected are likely to be particularly old and frail, and so to know the true cost of such cuts on cutting many lives a little shorter, accurate and highly disaggregated population and death count data need to be made available for persons aged more than 90 years of age.

## 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 within the main dataset used in these analyses based on population and mortality rates at younger ages. Given our results indicated that much of the additional burden of excess mortality has been at some of the oldest ages, however, we considered it important to produce estimates of total excess deaths which include ages up to 95 years, despite these limitations. These limitations in the quality and availability of highly disaggregated data at some of the oldest ages are not just limitations affecting our analyses, but limitations which may hide some of the greatest mortality excesses which have occurred in England & Wales within the previous decade. Effective measurement and dissemination of age-disaggregated population and death counts at and above the age of 90 years should therefore be a national record keeping priority.

As has been noted many times before, “all models are wrong, but some are useful”. This model is clearly ‘wrong’ in the sense that it applies 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 argue this 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 then there may a fall in deaths due to cancers, affecting people at slightly older ages, because there would be fewer people living long enough to die of cancer rather than cardiovascular causes. It would be wrong, however, to claim these reductions represent improvements rather than deteriorations in health. 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.

1. Accessed 1 July 2016 https://www.ons.gov.uk/file?uri=/peoplepopulationandcommunity/populationandmigration/populationestimates/adhocs/005825populationestimatesforenglandandwales1961to2014singleyearofage0to105/ewuksyoadeathspopdata19612014cmifilevaluesforissue10122015.xls [↑](#footnote-ref-1)
2. Accessed 1 July 2016 http://www.ons.gov.uk/peoplepopulationandcommunity/populationandmigration/populationestimates/datasets/populationestimatesforukenglandandwalesscotlandandnorthernireland [↑](#footnote-ref-2)