# Abstract

# Introduction

## Austerity and elderly mortality

In their 2013 book The Body Economic, summarising dozens of academic papers [1–3], Stuckler & Basu argued that the fiscal responses of the Obama administration in the US (starting May 2009), and the Conservative-led administration in the UK (starting October 2010), to the 2008 global financial crisis (GFC) can be thought of as a ‘natural experiment’ to assess the comparative effects of austerity versus economic stimulus on population health. [4] Since 2013, the experiment has continued, and disturbing results have started to emerge about the possible effects of austerity on elderly mortality. In 2016 a paper published in the Royal Society for Medicine explored 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, within the period 2007 to 2013. It 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] This focus on elderly mortality was prompted by a 2014 *New Statesman* article by Danny Dorling, commenting on provisional estimates, by Public Health England, of deaths amongst over 75s in England, suggesting increased deaths in this age group occurred in both 2012 and 2013. [6]

The official Public Health England report, published in 2015, considered three possible explanations for the trends: influenza, cold weather, and a statistical artefact. [7] If either influenza or cold weather were the main causes of these rises then the following can be expected: firstly, that the mortality rate rises would be spatially patterned, and secondly that the rises would be a ‘blip’ associated with a single year rather than continuing from one year to the next. Evidence of spatial patterning of elderly death rates have now been explored, both visually using choropleths and statistically through calculation of the Moran’s I statistic of spatial auto-correlation, and suggests that these explorations are unlikely. [5,8,9] Artefactual explanations could relate to uncertainty about population structure within a given year, or to aggregation biases caused by inadequately controlling for changes in age-composition within an age group for which mortality rates are calculated. Recently it was pointed out that an aggregation bias could be responsible for much of the rise in middle-aged mortality rates in the USA over recent years, reported in a highly influential paper by Case & Deaton, as the average age of US populations aged between 45 and 54 years rose slightly between 1999 and 2013, meaning some rise in average mortality rate within this strata should be expected. [10–12] However, this type of explanation is unlikely to 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 been identified in English population records. [5,8] The scope for such biases also reduce as more age-disaggregated data are used. [12] In contrast Dorling, along with Loopstra and colleagues, have suggested that the rises are more likely due to austerity. [5,6,13]

On 23 June 2016, mid-year population estimates for England & Wales (covering 1 July to 30 July) were released by the ONS.[14] These data, disaggregated by age in single years up to age 89 years, provide further evidence with which to assess and compare between competing explanations for rising elderly mortality. If the elevated mortality rates continued in 2015, as they had in 2012, 2013 and 2014, then influenza, cold weather, and statistical artefact become less plausible as explanations, and the evidence supporting austerity as a predominant explanation mounts.

## 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 given that the tendency and expectation for many decades has been for the risk of death at most ages to continue to decline. Even a falling age specific death rate, but at a markedly lower rate than the long-term average, should be of concern, as the consistency and duration over which these declining death rates have occurred sets up an expectation that steady increases in longevity should be the norm rather than the exception and that only a severe and prolonged shock and assault to the factors which contribute to such steady improvements can do much to alter these long-term dynamics. A comparison with economic growth is illustrative. Figure 1 shows how per capita GDP (not inflation adjusted) has risen since 1950 in England & Wales, using total annual GDP estimates from the ONS, and total population estimates extracted from the Human Mortality Database (HMD). The line shows the trend of log per capita GDP against time over the period 1950 to 2008 inclusive, which is then extrapolated to 2015. Over the period 1950-2008 the statistical fit of this trend line is extremely high (R2 of 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 around £6,800 per person; by 2015 it had grown to more than £13,400 per person. Before the 2008 recession, all previous recessions had been followed by one or more years of catch-up, of faster-than-trend growth in per capita GDP. Nothing similar occurred after 2008, and instead per capita GDP in 2015 has barely recovered to pre GFC levels. Although a similar down shift in the fundamental rate of economic growth has occurred in many rich countries, prompting discussion amongst economists of a ‘secular stagnation’, [15,16] the disparity between current and projected levels in the UK are especially severe.

Long-term trends in human longevity are somewhat similar. Trends in life expectancy at birth in the UK and other rich nations have been repeatedly underestimated because the downwards trends in the mortality risks at most ages have not been accounted for in projections, leading to large underestimates of the size of the elderly population and the level of public expenditure in social security and healthcare required to maintain a given standard of living amongst the less infirm elderly and a given standard of care amongst the more infirm elderly. One way of seeing this is to consider figure 2, which shows, for England & Wales, how 12 month mortality rates at different ages have changed between consecutive birth cohorts, presenting these data as if they are an orienteering maps. Within these ‘maps’, a series of contour lines are included. In an orienteering map contours represent height above sea level; in this demographic map the contour lines indicate the age at which different birth cohorts first experience a given 12 month mortality risk. Most of these contour lines have been moving steadily to the right, to be faced at ever older ages, which is equivalent to saying that the 12 month risk of death at any of these ages in single years has tended to decline. Population projections involve, amongst other things, making assumptions about how the trends in these age specific mortality rates will tend to develop over time. In this map, different assumptions about changing mortality risks may be thought about as different ways of extrapolating the contour lines into the ‘unobserved’ region in the top right quadrants of the maps. (For example, the 12 month mortality risks of the 1950 birth cohort when they are 70 years of age.) A standard simplifying assumption made in many population projections is that the age-specific mortality rates observed in the last year will simply continue in future years. (An important exception to this simplifying assumptions is in a recent spatiotemporal model published in the Lancet, which models both linear age-specific trends in mortality rates as well as spatial variations. [17]) Within this map this is equivalent to assuming that each of these contour lines, which at almost all older ages have been moving steadily to the right since birth cohorts born in the 1920s, will suddenly stop moving and become vertical instead, which does not appear a plausible assumption except perhaps for males born between around 1870 and 1900.

Like the need to compare per capita GDP levels in 2015 against the long-term trend, rather than simply against the level in 2007 or 2008, estimating the possible effects of austerity on elderly mortality involves not just looking for absolute increases in mortality rates at some ages, but comparing actual rates at various ages against rates that would have been expected if previously observed trends had continued. This is one of the key motivations for the model developed.

# Methods

The precise details of the modelling strategy are detailed in the appendix, but the intuition is as follows. The approach involves two stages: a ‘statistical stage’, then an ‘actuarial stage’.

In the statistical stage, a series of separate linear regression models are produced to model trends in 12 month mortality risk at each age in single years, given ONS data from 1990 to 2010. ONS data are available disaggregated by age in single years for each age from birth (‘0 years’) to 94 years of age, and separately for males and females, meaning in total 190 separate linear regression models were produced. 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).

In the second, actuarial stage of the modelling strategy, counterfactual age and sex specific mortality rates are produced by predicting age and sex specific mortality rates under the assumption that the New Labour terms (intercept and trend with year) apply for the years 2011 to 2015 (i.e. setting these dummy variables to ‘1’ in the models). The actual population counts for each age and sex, for each year from 2011 to 2015, are then applied to these counterfactual age-specific mortality risks 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 reported for both sexes at different ages.

# Results

# Discussion

# References

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# 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.

