**Introduction**

Every couple of years, the UK’s ONS produces new population projections, including new assumptions about mortality and longevity. Such projections, whether carried out by national statistical bodies or by private insurers, are vital inputs to a wide range of important decisions for the effective provision of state services and assets, including schools, social and healthcare needs at UK, national and local levels.

Up until 2010, ONS forecasts of life expectancy gains consistently underestimated rates of improvement, and the assumptions were consistently uprated and made more optimistic in successive revisions.(1) However, since 2010 the life expectancy improvement assumptions made by the ONS have been too optimistic, and now been successively made more pessimistic for the fourth revision in a row.

In parallel with the ONS’ attempts to accurately project and predict life expectancy trends, academic demographers and commercial actuaries working for the life insurance and financial industries have also been making predictions.

A number of different approaches to forecasting life expectancy have been tried. The most technically sophisticated approaches have involved forecasting the individual components of life expectancy, mortality rates at individual ages, and calculating life expectancies based on estimated lifetables, (2) made use of Bayesian methods for ‘smoothing’ observations from neighbouring years and age groups, (3,4), and/or incorporating cohort effects in improvement rates which allow for faster or slower gains in some cohorts than others. (5) An important example of this, which when identified by commercial actuaries led to substantial increases in projected life expectancies, was the identification of a so-called ‘Golden Cohort’ in the UK, persons born between around 1925 and 1945, whose rates of mortality improvement appeared systematically higher than for earlier or later cohorts. (6) Though cohort effects had been identified many decades previously, (7) they had often been deleterious rather than positive (8,9), and the UK’s cohort effect was of particular interest to the actuarial profession as they constituted a source of substantial ‘longevity risk’ affecting the viability of both private and state pensions. (10)

Perhaps surprisingly, more complex approaches to demographic forecasting have not been found to outperform simpler approaches, (11), and a very simple approach to forecasting life expectancy, which does not involve forecasting mortality at individual ages, has also been found to be effective. (12) This approach simply involves assuming that life expectancy improvements will tend to continue to improve linearly on average over the long term. This assumption seems to hold more for the average of many similar populations, or for the best performing of a collection of high income nations, (13–15) than for any single population, but has the dual advantages of simplicity, and of allowing uncertainty intervals in projections to be generated using the observed variation in annual changes in life expectancy using well-established time series modelling strategies. (16) This will be the main approach taken in this paper.

Since around 2014, worsening trends in life expectancy improvement have been an increasing area of focus and concern in the UK amongst public health researchers and academics. (17–22) Much of the analysis and commentary surrounding the slowing improvement rates in life expectancy has focused on the role of UK-government austerity policies, and corresponding changes in funding and provision of out-of-work benefits, social and healthcare funding (23–25), continuing concerns raised previously about the adverse health effects of austerity in an international context. (26–28) Analyses conducted and commissioned by Public Health England, The Kings Fund, the Health Foundation, and the OECD have instead focused more on extensive description of trends broken down into disease categories, emphasised the multifactorial nature of the slowdown, and the role of influenza (in 2013-14) and slowing cardiovascular disease improvements in particular. (29–33)

This paper aims to bring some of these divergent strands of researchers together by focusing on the way ONS mortality projections have changed over this period of stalling UK life expectancy, and how new data about UK life expectancies can be better used to inform our assumptions about future life expectancy trajectories in the UK. We introduce a complementary approach to both evaluating and updating beliefs about how substantial and persistent the recent stalling in life expectancy improvements have been, which uses Bayes Factors to estimate the relative likelihood of having observed the life expectancy improvement that have been observed since 2010 if the long-term trends in life expectancy improvement rates previously observed were still continuing. The approach allows quick updating of beliefs about how far short post-2010 improvement rates have fallen from earlier trends, which can rapidly incorporate each new annual release of UK life expectancy data. This means we can produce interim life expectancy projections in the years between the biennial releases.

Though the paper does not aim to resolve disagreement between researchers as to the causes of the recent slowdown, it does aim to make the process of reasoning about the extent and persistence of the post 2010 slowdown more explicit, along with the process of updating our beliefs about the extent of this slowdown as and when new annual life expectancy estimates become available. To the extent the approach can be used to formally quantify and assess divergence between the UK’s life expectancy gains and those in other high income countries, and to demonstrate that slowdown has continued to persist longer than would be expected if it were due to transient factors like ‘bad winters’, the paper does aim to advance causal thinking about the slowdown indirectly, through establishing commonly acceptable strategies for analysis and interpretation of UK life expectancy data, and ‘ground truths’ around which researchers with divergent beliefs and perspectives can agree.

The rest of this paper proceeds as follows: Firstly, we will present annual change rates in life expectancy in the UK as compared with a number of other high income countries, to determine the extent to which the recent slowdown in life expectancy in the UK is an international phenomenon. Secondly, we will calculate changes in life expectancy for each UK nation or group of nations, to see whether the slowdown is similar in magnitude and contemporaneous throughout UK populations; this will be supported by performing change-point analysis of annual life expectancy changes for each of these UK populations. Thirdly, we will present the ONS life expectancy projections for the UK from 2012 onwards, to show how these projections have been successively downrated with each biennial projection. Fourthly, we will formally quantify the extent of the slowing in life expectancy improvement rates since 2010 by proposing a series of 100 modelled scenarios, each corresponding to a different percentage slowdown from earlier trends, and identifying the slowdown rate that maximises the Bayes Factor (ratio of model likelihoods, as compared with no slowdown) given observed life expectancy. Finally, we will estimate the Bayes Factors implied by each of the average improvement rates implied by each of the recent ONS mortality projections, discussing how optimistic or pessimistic each of these scenarios seems to be, and how the Bayes Factor strategy can be applied to more openly update our beliefs about the persistence and extent of a life expectancy slowdown in the UK as and when the 2019 period life expectancy estimate becomes available.

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