British Medical Bulletin, 2022, 1–11
https://doi.org/10.1093/bmb/ldac036

OXFORD

Invited Review

Slowing down or returning to normal? Life expectancy improvements in Britain compared to five large European countries before the COVID-19 pandemic

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Received 28 July 2022; Revised 3 November 2022; Accepted 8 November 2022

Abstract

Introduction or background: Life expectancy is an important summary measure of population health. In the absence of a significant event like war or disease outbreak, trends should, and historically have, increase over time, albeit with some fluctuations.

Sources of data: Data were extracted from the human mortality database for life expectancy at birth and age 65 years from 1980 to the latest available year for England & Wales, Scotland (Great Britain), France, Spain, Italy, the Netherlands and Germany.

Areas of agreement: It is well established that life expectancy improvements in Great Britain have stalled in recent years, and that a similar stalling was seen in other high-income countries during the mid-2010s.

Areas of controversy: The significance and causes of the slowdown in improvement in life expectancy in Britain are disputed. First, was Britain's slowdown in progress in life expectancy in the 2010s a deviation 'from' earlier sustained improvements or simply returning to normal (slower)

improvement rates following faster gains in the 2000s? Second, did other European countries have slowdowns comparable to that in Britain?

Growing points: Life expectancy, as a summary measure, conceals inequalities. Other measures, such as lifespan disparity, complement it in understanding changing trends. While annual fluctuations in life expectancy are expected, continued stalls should raise concern. The three British nations examined were the only ones among these European countries to experience stalling of life expectancy gains in both sexes.

Areas timely for developing research: While it is clear that Britain is making less progress in health than similar countries, more research is needed to explain why.

Key words: life expectancy, public health, austerity

Introduction

'Even with coronavirus out of the picture, Britain is the sick man, woman and child of Europe'.[1] Richard Horton wrote these words in 2020, when the Global Burden of Disease study placed the UK close to the bottom of European rankings. In 2019, before the pandemic, we said much the same.[2] Pointing to stalling life expectancy, rising infant mortality, widening inequalities and difficulties in accessing healthcare, we recalled Yeats' words from 1919, 'things fall apart'.[3]

More than 2 years on, the world has changed in ways few could have imagined. While the full impact will not be known for some time, death rates from COVID-19 have been higher in the UK than in many comparable countries.[4] There are many reasons, but several commentators have argued that the poor health of the British population prior to the pandemic may have left them more vulnerable.[5–7] This seems plausible. The average annual gain or improvement in life expectancy in the UK in the 2010s, from around 2012–14, was lower than the late 1990s/2000s.[8] This fact is not controversial. What is controversial is what this slowdown in life expectancy gains represents. First, was the UK an outlier or following a trend in comparable European nations, and second, when did it diverge, a key question in understanding the reasons for any divergence.

Before we explore these areas further, a note on terminology. We use the term 'slowdown' throughout this paper in its literal meaning of the rates of improvements in life expectancy at birth slowing down or declining. We refer to 'stalling' also in its literal meaning of 'to stop making progress' i.e. when there is no improvement occurring.

Some have highlighted that the UK's fall in the European rankings could be partially attributed to the 'catch up' by ex-Soviet states and Eastern European countries recovering from the trauma of the 1980s and 1990s, and that the same patterns (or at least similar) have been seen in other Western European countries.[9–11] This would suggest wider factors were at play. Indeed, the stalling of life expectancy improvements in the UK in the 2010s was seen in some other Western European countries, although it was more marked in the UK than in other countries, except the USA and, depending on the comparison, Iceland. This conclusion is reached consistently by studies examining different periods and selections of high-income countries.[10,12–14] However, few studies have compared countries after 2016, and especially, the 'good' mortality year, 2019, before COVID-19, which was seen by some

Table 1 Two interpretations of a finding that there was slowdown/stalling of life expectancy trends in the 2010s/2020s as compared with the 2000s

Interpretation	Improvement in life expectancy in late 1990s/2000s	Slowdown in life expectancy improvements in 2010s
A	Normal	Slowdown from normal trend
B	Exceptionally good/atypical	Slowdown to/return to normal trends after atypical 2000s

as a positive sign for the UK. This initial sign of encouragement was tempered by news from the Office for National Statistics that those living in the most deprived areas of England had a decrease in life expectancy, not only between 2015 and 2017 but also in 2018–2020.[15] While it is possible that this could also have happened in other European countries at that time, it has not yet been reported.

These worrying developments were especially alarming as they followed a period when the UK had experienced rapid reductions in mortality, with the improvement from 2001 to 2011 noted as 'the highest since records began in 1841'.[9] Explanations, not mutually exclusive, that were offered included reductions in cardiovascular disease mortality, increased funding of the NHS and possibly a 'healthy migrant' effect.[9,16,17] As a result, it may be that the appearance of a slowdown is not as concerning as it first appears, with rates of improvement in fact returning to normal following an unusual period of improvement period in the 2000s.[11]

In terms of the significance of the slowdown itself, initially the controversy arose over the possible 'over-interpretation' of earlier breaks in trend.[18] Early studies, including our own, focused on the 2014–15 increase in mortality in the UK, when the increase in deaths was the largest seen for almost 50 years, subsequently reflected in the increase in age-standardized mortality rate (ASMR).[19,20] However, annual fluctuations are to be expected, and an apparent break in trend might have been due to a single bad winter year around 2014–15, especially given the common use of 3-year smoothed data, or a particularly bad influenza season.[21,22] However, while certainly relevant at that time, the likelihood of a one-off 'bad year' has decreased as additional data have been added, showing that the slowdown in improvements has remained.[8] This has led commentators to argue that austerity policies imposed following the 2008 financial crash resulting in significant public spending cuts were a potential causal factor, both in the UK and other European countries—which mostly suffered less because they had smaller finance service sectors.[20,23–28]

The remaining controversy is whether the slowdown in life expectancy improvements in the UK was a slowdown from 'normal' improvement rates, suggesting that the 2000s trends were 'typical' (interpretation A), or a slowdown to 'normal' improvement rates (interpretation B), suggesting that the 2000s trends were 'atypical' (in a positive way in that life expectancy improvements were higher than the long term 'normal' trend). Table 1 summarizes these two positions.

Most previous research has looked at data series from 2000s onwards, and/or identifying a single break point (BP) in trends.[10,11] While useful, this has two important limitations. First, it is impossible to distinguish between the two interpretations without longer-term data. Second, earlier models, which constrained the analyses to a single breakpoint, do not allow alternative solutions with multiple breakpoints that would differentiate between the two interpretations. To address these limitations, we extend the range of years for analysis back to 1979 and in our analysis allowed up to two BP ('double hinged') models. This enables us to assess whether the slowdown is better interpreted as (a) a fall from normal, (b) a return to normal or (c) a combination of the two.

In this paper, we look at England and Wales and Scotland, so refer to 'Britain' rather than 'the UK', which includes Northern Ireland, from hereon. We address three issues: First, we seek

to determine which of our two interpretations is correct. Was Britain's slowdown in progress in life expectancy from around 2013 a deviation 'from' earlier sustained improvements (interpretation A) or a correction following gains in the 2000s returning 'to' normal (slow) improvement rates (interpretation B)? Second, have other European countries seen slowdowns comparable to that in Britain? Third, if a significant change in trends occurred, when did it happen?

Methods

Data

We extracted publicly available data from the Human Mortality Database (HMD)[29] via the R package HMDHFDplus[30] to compare changes in life expectancy at birth (e_0) and age 65 (e_{65}) for Britain (England & Wales, treated as one population, and Scotland), France, Italy, Spain, Germany (Germany exists as three datasets in the HMD: Total Germany (DEUTNP) from 1991, East Germany (DEUTE) and West Germany (DEUTW).) and the Netherlands. We do not include Northern Ireland as it is a separate entity in the HMD and has a population too small for robust results with the analyses used. The nations selected for comparison are the five largest, by population size, in western Europe and therefore most directly comparable with Great Britain.

Synthetic Germany

We produced a 'Synthetic German' population with data for East and West Germany for years before reunification to allow comparison. We estimated that this could be produced using a weighted average of 20% East Germany and 80% West German life expectancy trends (details in Appendix 1 (All Appendices available online at: https://github.com/JonMinton/change-in-ex/blob/main/appendices/main.md)).

Analysis

We analysed trends in annual rates of change in life expectancy from 1980 to 2019 (or the latest available year) for the selected nations. For both annual changes in e_0 and e_{65} we add smoothed trendlines to the data series calculated using loess (locally estimated scatterplot smoothing),[31] to see whether these trendlines are rising or falling over time, and whether they vary between populations.

We then compare three model specifications for representing life expectancy against time for each population: (a) linear trend over time (no breakpoint); (b) a segmented model specification with a single breakpoint; (c) a segmented model specification with two breakpoints. The one and two breakpoint models are calculated using the segmented package in R.[32,33] As highlighted, most previous breakpoint analyses have used shorter data series and/or have only looked for a single breakpoint.[10,11] These two factors combined preclude separating the two interpretations in Table 1. For each population we identify which of the three models has the best penalized model fit as determined by Bayesian Information Criteria (BIC).[34] The first differences of the predicted values of best performing models are then calculated and plotted against the first differences in the observed values (i.e. annual changes in life expectancy from the previous year), and presented on the same scale and for the same populations as the loess smoother curves.

The loess method is continuous by design and only produces smooth curves that vary continuously over time; the breakpoint models are discontinuous by design and, once differenced, are represented as a series of horizontal lines whose intercepts vary after compared with before the breakpoint years. However, suppose there are genuine changes over time in the trends in life expectancy change for a population. In that case, both approaches should produce qualitatively similar shapes, with either upwards or downwards changes in trends apparent at similar times.

All code used in the analyses is available online at Github (Available at: https://github.com/JonMinton/change-in-ex (accessed 15 March 2022)). An R shiny app was built to compare the results of different possible modelling approaches (Available at: https://datascapes.shinyapps.io/compare_cps_and_bps/ (accessed 13 June 2022)).

Results

Change in life expectancy in these nations

First, we compare the annual change in e0 and e65 for the nations from 1980 to the latest available year by sex (Fig. 1a and b). Trends are reported in Appendix 2.

The dots in the figures show, for each year, how life expectancy compared to the previous year. (For example, 1980 shows the life expectancy in 1980 minus the life expectancy in 1979.) The horizontal line indicates no change from the previous year, with points above the line indicating an increase in life expectancy and points below a reduction from the previous year. All values are converted to weeks per year.

There is considerable variation in these values, with some individual years having life expectancies almost a year higher than the previous year (France, Italy), and others more than half a year lower than the previous year (Scotland). Indeed, the level of variation in changes in life expectancy from the previous year is even higher than would be expected if the data were purely random, and instead the time series 'oscillates' slightly, as discussed in Appendix 3.

The smoothed trendlines indicate that for e_0 (Fig. 1a), the average change became negative by 2019 in England & Wales, and in Scotland; but for all other populations considered the trends have reduced but remain positive. However, the exact position of the lines through the points depends not just on the data, but also on modelling parameters used by the loess algorithm (We have used the default values of these parameters.). This means we cannot definitively conclude that the life expectancy trend fell in these UK nations, whereas merely 'stalled' in the comparator nations; however, the trendlines are indicative of a more severe decline in gains in these UK nations than the comparators.

Another feature in the trendlines is that, for several populations, the line moved upwards slightly during the 2000s or thereabouts, before falling again afterwards. This 'bump' is most apparent for the Netherlands, but also present for England & Wales. This is consistent with the thesis that the 2000s may have been a period of unusually rapid improvement, and so not an ideal 'baseline' period against which to compare the more modest gains in life expectancy (or declines in life expectancy) which occurred during the 2010s. Again, the exact shape of the curve depends on modelling parameters, and so is not definitive evidence that life expectancy trends over this period were exceptionally high.

Segmented regression approach using annual data

The locally estimated scatterplot smoothing (LOESS) smoothed trendlines indicated a more severe decline in trends for England & Wales, and for Scotland, than for the other comparator nations. They also indicated that the 2000s had somewhat elevated trends, though not to the same extent as the Netherlands. However, the curves produced from the loess method are dependent on modelling parameters as well as the data itself. Next, we assess if similar findings are identified using a different method. We present these for all nations at e_0 (Fig. 2a) and e_{65} (Fig. 2b).

For England & Wales, for both e_0 and e_{65}, a two breakpoint model was selected for both males and females. Like the loess smoother, this identified the 2000s has having a somewhat increased trend, then a decline from around 2013. Unlike with the loess smoother, the final trend value was still positive rather than negative but is more modest than for most comparators. In summary, it shows a moderate annual increase throughout the 1980s and 1990s, a greater increase throughout the late 1990s/early 2000s, and then a consistent and severe decrease after around 2012.

For Scotland, two breakpoint models were selected for e_0 trends for males, and both sexes for e_{65}; for e_0 females a single breakpoint model was selected. All models identified a break after 2010, and a reduced rate of improvement thereafter. For e_0, the life expectancy trends after 2010 are negative, with declines of around 1 or 2 weeks per year indicated.

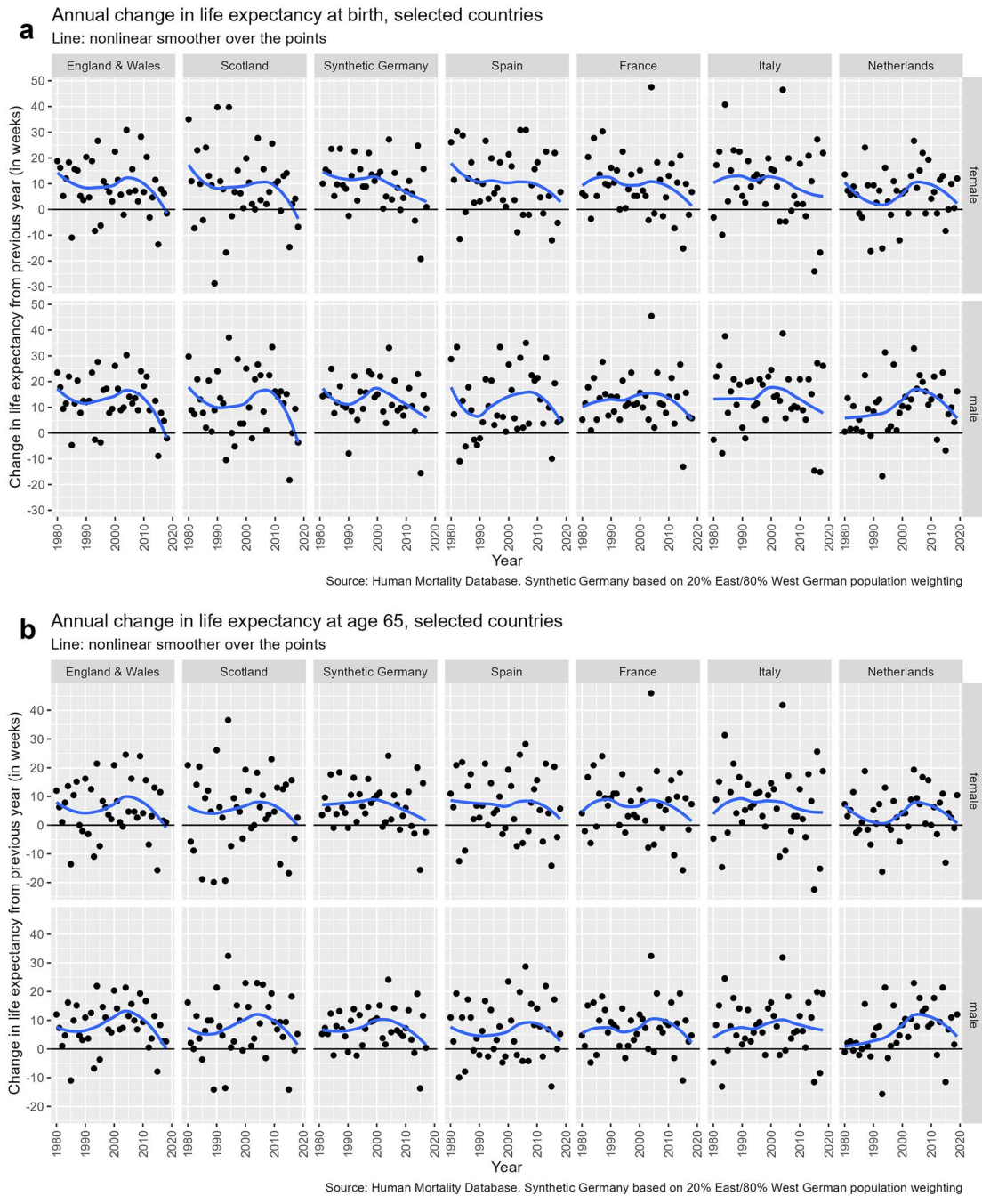

Fig. 1 Observed (points) and predicted (lines) annual changes in life expectancy at birth (a) and age 65 years (b); loess smoother approach

For other nations, two or one breakpoint models were selected in most cases, though the best performing models for e_{65} for Italian males had no breakpoints (i.e. standard linear regression), indicating continual annual gains in life expectancy of around 9 weeks per year. The Netherlands is notable

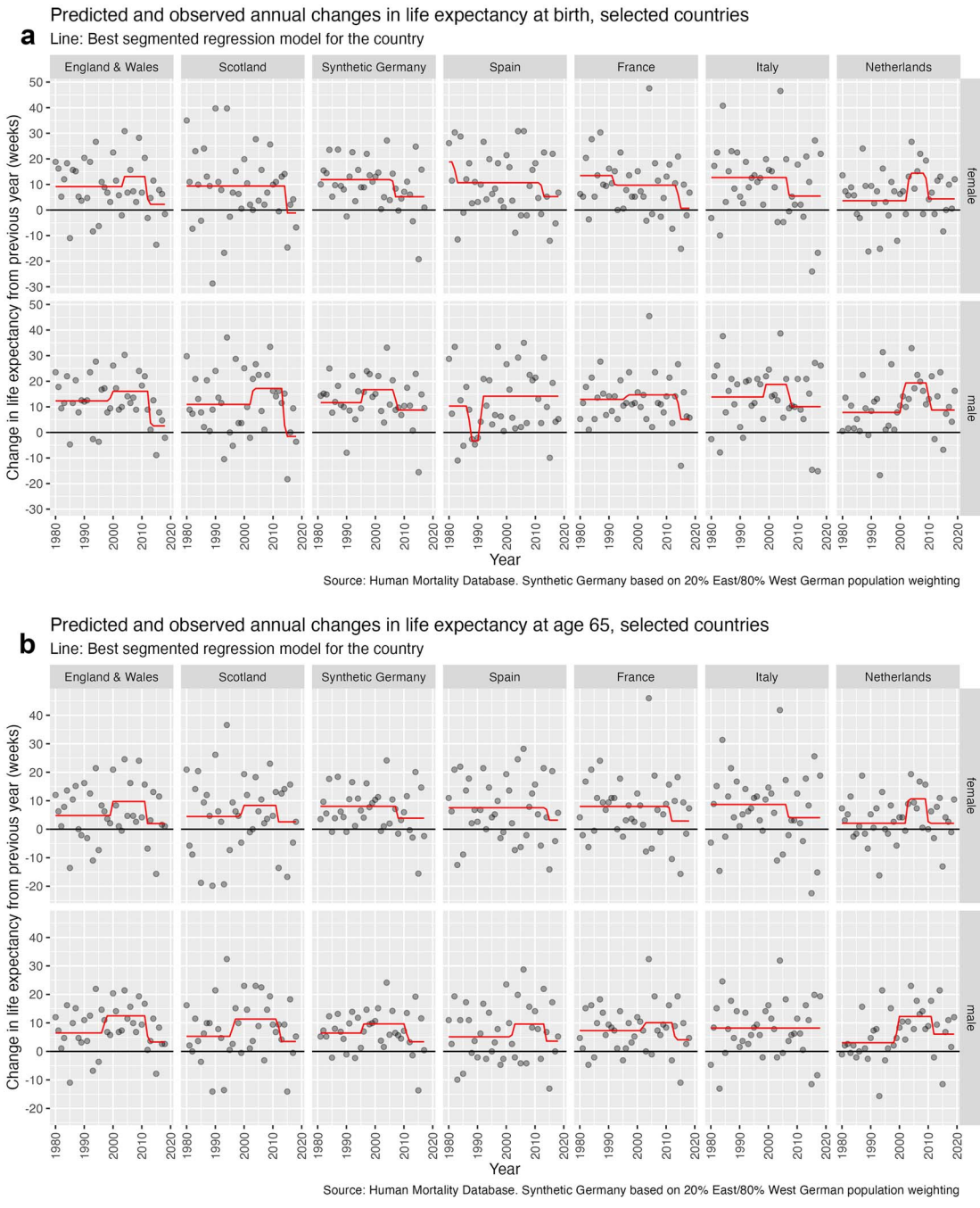

Fig. 2 Observed (points) and predicted (lines) annual changes in life expectancy at birth (a) and age 65 years (b); segmented regression approach

in that the 2000s were associated with substantial increases in trends, which then declined from the late 2000s/early 2010s. However, the post-2000s declines were not to levels appreciably below those in the 1980s and 1990s. For males, instead, they appear somewhat higher than these initial values.

Conversely, however, the rates in the 1980s and 1990s in the Netherlands were somewhat below those observed in UK and other comparator nations. Further analyses of the other nations are available in Appendix 4.

Discussion

Main findings

In this paper, we asked whether the changes in trends in e_0 seen in Britain in the early 2010s represented a slowing of what were 'normal' improvement rates in the first decade of the 21st century or a reversion to 'normal' rates after a period of better than expected performance (Table 1), whether these changes occurred in other European countries in the same way, and if changes in trends did occur, when they happened. We studied e_0 and e_{65} from 1980 to the latest available year for England & Wales, Scotland, France, Germany, Italy, and Spain.

First, while almost all countries experienced a reduction in annual average life expectancy improvements, for both ages and sexes over the years examined, except for e_{65} in Italy, only in British nations did average improvements stop completely and/or decrease for both sexes. However, while this is an obvious cause for concern in the UK, there are no grounds for complacency in the other countries. Second, for England & Wales, we present evidence that the two apparently 'competing' interpretations of life expectancy trends are both correct: i.e. that it is simultaneously true that the late 1990s and 2000s were a period of unusually rapid average improvements in life expectancy, and that after around 2012 there has been a severe stalling of annual gains. Third, the Netherlands has previously been highlighted as a country that experienced a similar pattern to England & Wales,[17] and the lowest improvements at both e_0 and e_{65} for the countries examined (Appendix 2). However, the breakpoint analysis suggested that, for both women and men in the Netherlands, the increase in life expectancy over time accelerated slightly and then decelerated slightly around the years 2000 and 2010, respectively; in the 2010s it rose just as quickly as it had been rising in the 1980s and 1990s. Thus, when the time period is extended beyond the year 2000, it appears that there was not a slowdown in rates of improvement comparable to that in the UK in the Netherlands.

It is important to put improvements in the 1990s and 2000s into a longer international context. By 1998, the ASMR from coronary health disease in men in England & Wales had fallen to 250 men per 100 000 per year; down from a peak above 500 per 100 000 in the 1970s. The rate for women was already much lower but also halved. The improvements in the 1990s and 2000s were a continuation of these trends, as reported by Lawlor *et al*.[35] These trends were seen across many countries. In the USA, the rate for men fell from over 500 in the 1970s to under 150 per 100 000 men per year by 2010, as shown by Blanchard *et al*.[36] The same patterns were seen in Spain, Italy and France in a comparative study that did not include Germany.[37] It is highly probable this occurred in Germany as well. Thus, the greater slowdown in Britain after 2010 was not because it had unusually high rates of heart disease. Rates had already fallen substantially by the year 2000.

Our findings, based on a data series starting 1979–80, strengthen the evidence base supporting the stalling life expectancy hypothesis, because most previous analyses used data starting in the early 2000s and/or a single breakpoint. Without the longer time series here, it would not have been possible to discount the possibility that any breakpoint identified around 2010/12 represents a return to earlier more modest improvement, rather than the emergence of a new trend of unusually low longevity gains. There are some limitations in this approach, as outlined in Appendix 4. However, collectively the results provide good evidence that England & Wales experienced a substantial stalling in annual mortality improvements after around 2012, as well as fairly good evidence that the Scottish population may have experienced a decline as or more severe contemporaneously. For Scotland, the segmented regression approach implies that life expectancy has fallen, rather than simply stalled, in recent years; however, there is greater discordance between

the results of the segmented and changepoint approaches, and smaller population size for Scotland compared with England & Wales, suggests the estimates for Scotland may be less reliable than those for England & Wales.

The analyses also reveal some similarities and differences between England & Wales and other European nations. In particular, England & Wales was not unique in the finding that the segmented regression approach identified both a period of increased followed by a period of slower improvement in life expectancy. When looking at trends in life expectancy at birth, this jump-then-fall pattern is seen in Italy, Germany (synthetic) and to a lesser extent France for males, though not for females. When looking at comparable trends in life expectancy change from age 65, a jump-then-fall pattern is evident in Spain, France, Germany, for males only. Among females, the fall component was seen in Germany, Spain, France and Italy, but the jump component in males was not; this appears to be the case both for trends in life expectancy from birth and from age 65.

Though the presence of a fall component—i.e. a reduced rate of improvement starting in the late 2000s or early 2010s—was identified in these other European nations as well as England & Wales, where the extent of the recent fall appears to be more uniform across population subgroups, more consistently identifiable using the two methods applied here, and more severe than in the other European comparator nations. Within Scotland, despite a smaller population and greater discordance between the segmented and changepoint methods, there are indications that life expectancy may be falling, rather than simply 'stalling', with the trend in annual changes in life expectancy from birth being negative for both males and females. (It should also be noted that, for females, the French trends from birth are also close to zero.)

In summary, it appears that patterns in life expectancy change over time are not qualitatively dissimilar in England & Wales (and Scotland) as compared with other European nations, but are quantitatively dissimilar in terms of both the increase in rate of improvement in trends during the late 1990s and 2000s, and the severity of the fall in improvement in trends seen since around 2012. Put more simply, it appears that what has occurred in England & Wales has also occurred in other European nations, only more so. This suggests that factors specific to England & Wales (and with more uncertainty, Scotland too) may have exacerbated the international factors behind a general slowdown in improvements in life expectancy in these affluent European states.

Limitations and strengths

These analyses have important strengths. First, the HMD provides robust comparable data. Second, we cover a longer period than previous research and include annual changes. Third, we could select multiple breakpoints, using two separate methods.

However, there are also limitations. The data conceal large variations within countries, whether geographic, ethnic or social. Life expectancy is a summary measure and can miss important information, such as increasing death rates at certain ages in the UK, detected initially by other methods.[38] In addition, readers should consider our results alongside previous analyses conducted into this topic, and consider the extent to which differences in data and methods used, as well as in interpretation of results, may explain any discordance in conclusions drawn by different researchers. Finally, we cannot attribute causality.

Future research

This research adds to the evidence base by firstly, extending the period examined, and secondly, by using models assessing for more than one (or no) breakpoints in trends. However, by using annual changes the models pick up particularly good or bad years in terms of high or low mortality (e.g. cold weather, bad flu seasons). Future research could take paired years to limit this artefact.

More countries could be examined, including the 18 OECD countries Ho and Hendi examined, and in particular the USA—whose life expectancy fell for 3 years after 2015.

Disaggregating the data by deprivation may also be revealing, as would the inclusion of Northern Ireland, one of the poorest parts of the UK. More insights into differences in access to health and social care may also further help explain some of the trends.

Examining the impact of the trend on COVID-19 outcomes and whether higher death rates prior to the pandemic left fewer frail people available to die matters. In contrast, the remarkable record of mortality improvement in old age in Italy prior to the onset of the pandemic could have contributed to more deaths in the pandemic. Migration might also matter,[16] especially as many young Europeans returned to their home countries during the pandemic, exacerbated by Brexit in the UK.

Conclusion

All the countries examined were affected by the international financial crisis of 2008 and its aftermath, but each experienced different rates of slowdown in health improvements. The countries of the UK were most affected. A slowdown in the rapid decline of mortality from heart disease in the 1980s and 1990s may have contributed to the changes observed, but this should not explain trends since 2000. The onset of the pandemic in Europe in early 2020 complicates comparisons but as COVID-19 deaths fall, the underlying trends will likely re-emerge. Understanding these differences is now even more important; as we were completing this paper a new analysis showed that the UK was the only one of 38 industrialized nations where the loss of people of working age from the labour force had not recovered.[39]

Data availability

All data used are publicly available from the Human Mortality Database. All analyses and code are available at: https://github.com/JonMinton/change-in-ex.

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