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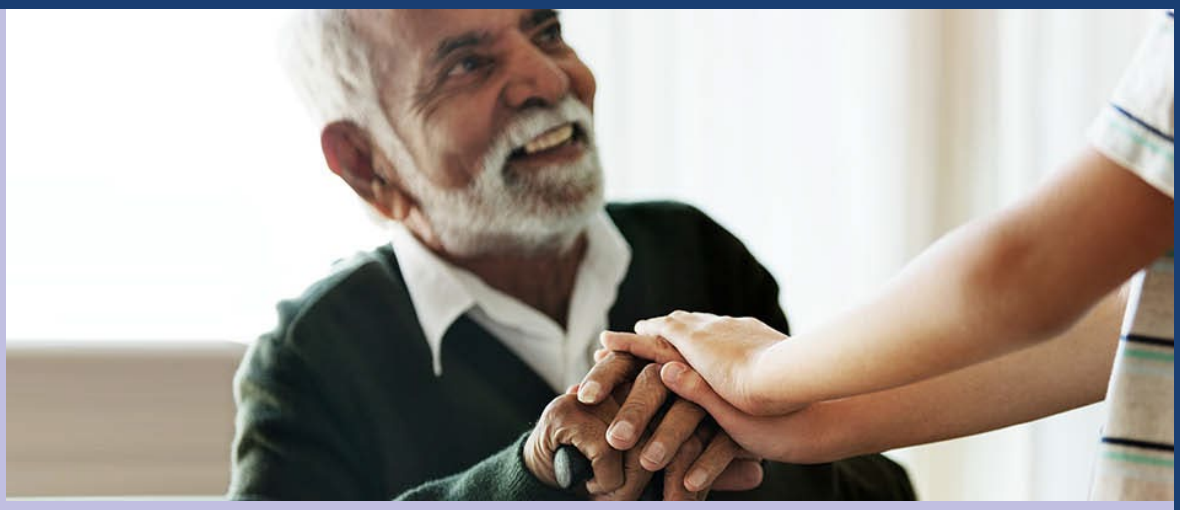

Comparison of trends in life expectancy and disability-free life expectancy between the UK and the remaining countries of the EU28

Claire Welsh, Fiona Matthews, Carol Jagger

Final Report

May 2020

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Background

Life expectancy has been increasing in recent decades, leading to a growth in the size of the older population in many developed nations. Older people are more likely to live with multiple long-term health conditions (MLTC).[1] This means any extensions to life expectancy puts increasing pressures on health and social care systems; the population ages and the prevalence of MLTC and dependence rise.

Longer life expectancy is of limited value if the extra years of life gained are spent in ill health and dependence. Many countries have been directing efforts to maximise the health of the extra life years gained, and compress the years with disability into the smallest possible time before death. In recent years, the UK and the US have seen a reduction in the speed of increase in life expectancy (LE). [2,3] This is important because it may uncover areas for improvement or lead to better understanding of inequalities in health and longevity.[1] Existing evidence has shown that women have longer lives, but, compared to men, they spend a higher proportion of those years with disability.[4] These sex differences are a cause for concern, and a topic of interest across the developed world. Both of these concepts; the extension of healthy life years and reductions in health inequalities, are central to the UK government's Ageing Society Grand Challenge[5].

Comparison of trends in life and health expectancy between developed countries have been limited by the use of different definitions of health. Within Europe the Healthy Life Years (HLY) indicator, a disability-free life expectancy (DFLE), has been harmonised across the European Union (EU).[6] In addition, having benchmark data of the relative performance of the UK in this field from before its exit from the European Union and prior to the COVID-19 pandemic may allow future alterations to be more easily discerned and analysed in context.

In this report we determine how trends and sex differences in UK LE and DFLE over the period 2008 to 2016 compare to the other countries of the EU28.

Methods

Data

Calculation of DFLE requires life tables and the age and sex specific prevalence of disability. Data were retrieved from the EuroHex website (www.eurohex.eu):

a) full life tables for each of the EU28 countries from 2008 to 2016 (data from before 2010 were not available for Croatia), and for males and females separately, based on the EuroStat method;
b) two of the health questions (for Healthy Life Years and for Healthy Life Expectancy) from the European Union-Statistics of Income and Living Conditions (EU-SILC) survey of people of 16 years and older living in private households.

Healthy Life Years (HLY) is based upon question PH030 from the EU-SILC survey.

Question PH030 'For at least the last 6 months have you been limited in activities people usually do, because of a health problem?'
Possible responses: 1) yes, strongly limited, 2) yes, limited or 3) not limited.

Healthy life expectancy (HLE) is based upon question PH010 from the EU-SILC survey.

Question PH010 'How is your health in general?'
Possible responses: 1) very good, 2) good, 3) fair, 4) bad, or 5) very bad, subsequently collapsed into three categories before release (good, fair or bad).

As harmonisation of the EU-SILC survey was considerably improved in 2007-2008, data from before 2008 were excluded.

Statistical analyses

The Sullivan method[7] was used to estimate DFLE ('Not limited' versus any level of activity limitation) and the proportion of remaining life expectancy (LE) expected to be spent disability-free (DFLE%). Disabled life expectancy (DLE) was calculated as LE minus DFLE, and further subdivided into mild DLE (PH030 'limited but not strongly') and severe DLE ('strongly limited'). Healthy-life expectancy (HLE) was estimated using the same method, where those responding 'good' were compared to all other respondents. Confidence intervals were calculated for all estimates of DFLE, DFLE%, HLE, DLE, mild DLE and severe DLE for participants of 16 years and older.[8]

Linearity of trends was assessed visually, and where deviation from clear linear associations was suspected, the basic linear model was compared to a change-point linear model (single knot placement auto-assigned by software) using adjusted R^2 values.[9]

We assessed sex differences in estimates by first calculating the difference in annual values between males and females, and then plotting and analysing the series using simple linear models.

Whether time spent in poor self-perceived health or with disability was expanding or contracting over the timespan for each country was determined by comparing the gradients of LE and DFLE from the simple linear models.

- Absolute expansion of disability was defined as LE increasing significantly faster than DFLE.
- Absolute compression of disability was defined as DFLE increasing significantly faster than LE.
- Relative compression of disability was determined when DFLE% was increasing, and LE and DFLE gradients were not significantly different from each other.
- Relative expansion of disability was defined when DFLE% was reducing, and LE and DFLE gradients were not significantly different from each other.
- Dynamic equilibrium was defined when total DFLE had been significantly increasing but severe DFLE had not.[10]

All analyses were conducted in R version 6.3.2 (R Core Team, Vienna, Austria) including the change- point linear model with package 'segmented'.[11]

Results

Section 1. Life Expectancy at birth in the UK compared to the other countries of the EU28 between 2008 and 2016.

Life expectancy for males and females at birth in the UK showed an overall increasing trend between 2008 and 2016, but the gradient of this trend reduced around 2011 in both sexes (Table 1, Figure 1). Though it is difficult to pick out individual countries, Figure 2 illustrates that, in other EU28 countries, LE increased without substantial slowing in both sexes, the only exceptions being Germany and France. In Germany, male LE appeared to slow significantly in late 2011 (Table 1), whereas for female LE the simple linear model out-performed the change-point model, suggesting a more consistent linear trend (Table 1, Appendix: Figure 24). LE in France between 2008 and 2016 also showed some evidence of a reduction in gradient mid-way through the study period (Table 1, Appendix: Figure 25).

Table 1. Comparison of simple and change-point linear models of life expectancy at birth in European countries with non-linear trends between 2008 and 2016.

	Simple Linear Model		Change-point Linear model			
Country	**Simple linear gradient (95% CI)**	**Adjusted R^2**	**Initial gradient (95% CI)**	**Subsequent gradient (95% CI)**	**Estimated change point (95% CI) ***	**Adjusted R^2**
UK						
Male	0.20 (0.12-0.27)	0.77	0.42 (0.23-0.61)	0.0.6 (-0.08-0.20)	March 2011 (Aug 2009-Oct 2012)	0.92
Female	0.12 (0.05-0.20)	0.53	0.40 (0.04-0.76)	0.01 (-0.11-0.13)	Aug 2010 (Aug 2008-Aug 2012)	0.79
Germany						
Male	0.12 (0.06-0.17)	0.63	0.26 (0.08-0.44)	-0.01 (-0.14-0.12)	Sept 2011 (Aug 2009-Sept 2013)	0.84
Female	0.09 (0.04-0.14)	0.55	0.12 (0.01-0.23)	-0.06 (-0.87-0.76)	*NA*	0.50
France						
Male	0.23 (0.17-0.28)	0.90	0.27 (0.18-0.36)	0.01 (-0.64-0.65)	Jan 2014 (Feb 2010-Dec 2017)	0.92
Female	0.12 (0.05-0.18)	0.59	0.27 (-0.14-0.69)	0.04 (-0.10-0.17)	2011 (Nov 2006-Jan 2015)	0.67

CI confidence interval. *Year used as a continuous variable, coefficient estimates rounded to nearest whole month.

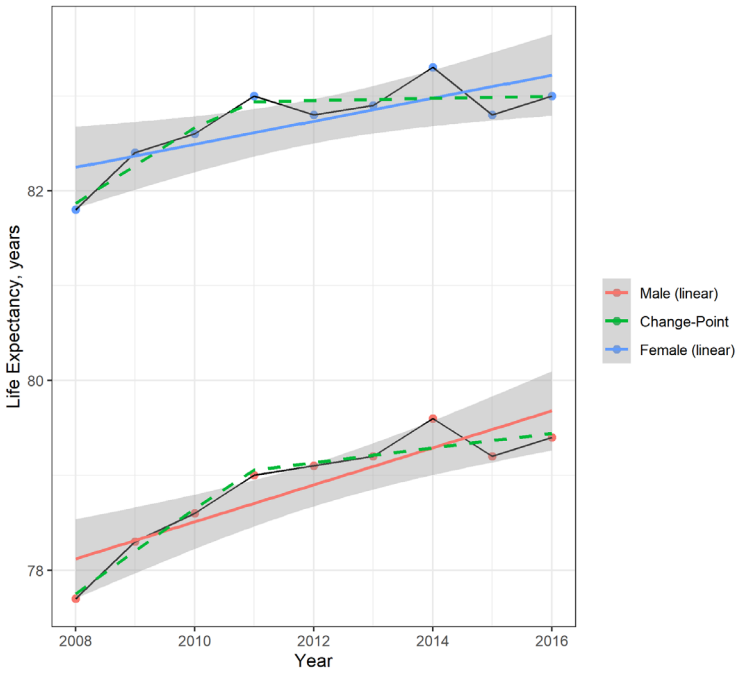

Figure 1. Linear models (with 95% confidence intervals) and change-point linear models of life expectancy at birth for males and females in the UK 2008-2016. Adjusted R^2 for linear and change-point models; women 0.53, 0.79; men 0.77, 0.92, respectively.

By 2016, the countries with the highest LE at birth were Italy (males 81.0 years) and Spain (females 86.3 years) whilst Estonia had the fastest rate of growth of LE at birth in both sexes

(males: 0.52; females: 0.32 years per year). Since LE at birth increased linearly between 2008 and 2016 in these, and most other EU countries with higher LE than the UK, this suggests that the UK findings were not a result of nearing any natural limit to LE.

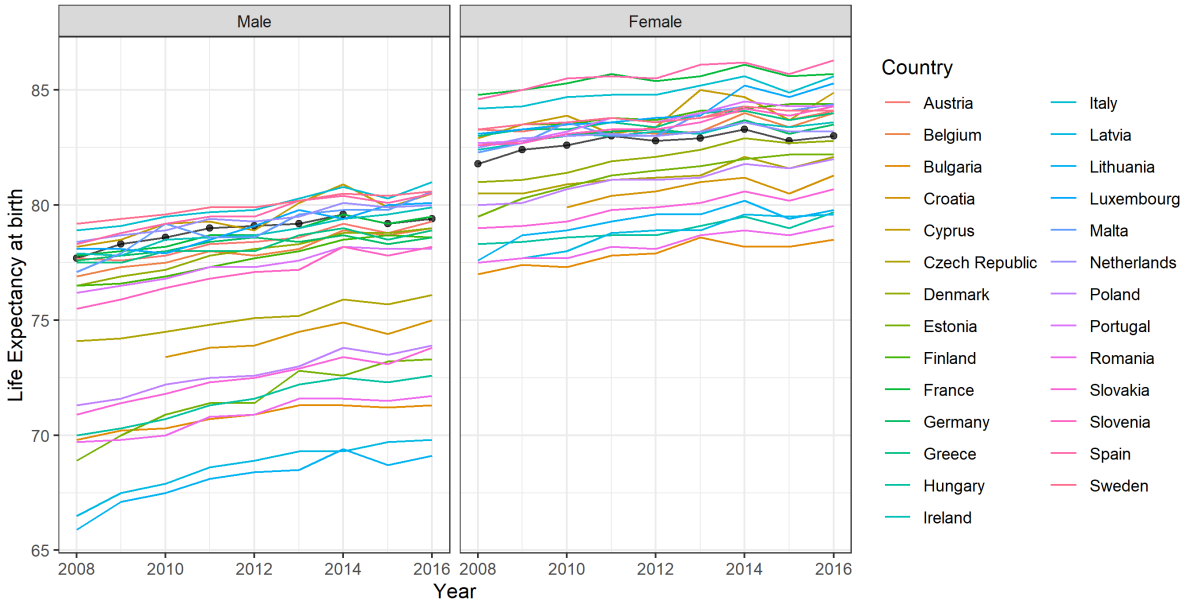

Figure 2. Life expectancy at birth between 2008 and 2016 in males and females in the other countries of the EU28 compared to the UK (black line).

LE in the UK before 2011 was increasing at a rate faster than most other countries of the EU28, but following 2011 the comparative LE gradient showed no significant upward trend (Figure 3).

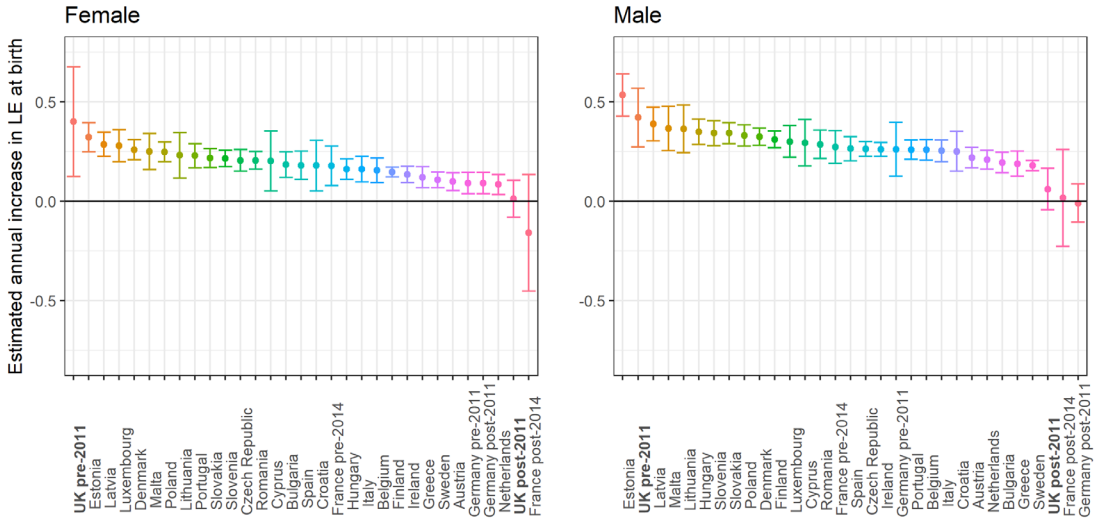

Figure 3. Comparison of gradients of linear life expectancy at birth models, including estimates for the UK, Germany and France before and after their respective change-points.

Section 2. Life expectancy at age 65 years in the UK compared to the other countries of the EU28 between 2008 and 2016.

In 2008, UK men aged 65 could expect to live a further 17.6 years, and women a further 20.2 years. By 2016, these estimates had increased to 18.8 and 21.1 years, respectively. LE at age 65 increased across the period, but slowed in its trajectory. This slowing occurred

earlier than the slowing for female LE at birth (Table 2). Germany and Portugal also saw their increase in LE at 65 slowing around 2011 (Table 2, Appendix: Figure 26, Figure 27), whilst other countries had more linear increases in LE at age 65.

Table 2. Comparison of simple and change-point linear models of life expectancy at 65 years of age in men and women in European countries with non-linear trends between 2008 and 2016.

	Simple Linear Model		Change-Point Linear model			
Country	**Simple linear gradient (95% CI)**	**Adjusted R^2**	**Initial gradient (95% CI)**	**Subsequent gradient (95% CI)**	**Estimated change point (95% CI) ***	**Adjusted R^2**
UK						
Men	0.13 (0.09-0.18)	0.80	0.30 (0.13-0.47)	0.06 (0.00-0.11)	Oct 2010 (Mar 2009-May 2012)	0.95
Women	0.08 (0.02-0.14)	0.40	0.50 (-0.21-1.21)	0.03 (-0.07-0.12)	May 2009 (Aug 2007-Feb 2011)	0.61
Germany						
Men	0.06 (0.01-0.11)	0.36	0.23 (0.10-0.36)	-0.03 (-0.12-0.06)	Feb 2011 (July 2009-Aug 2012)	0.80
Women	0.06 (0.02-0.11)	0.48	0.16 (-0.03-0.35)	0.02 (-0.12-0.15)	2011 (Nov 2006-Jan 2015)	0.51
Portugal						
Men	0.13 (0.09-0.17)	0.84	0.23 (0.06-0.39)	0.09 (-0.03-0.20)	2011 (May 2007-July 2014)	0.87
Women	0.16 (0.10-0.21)	0.80	0.30 (0.09-0.50)	0.09 (-0.06-0.23)	2011 (Feb 2008-Oct 2013)	0.86

CI confidence interval. *Year used as a continuous variable, rounded to the nearest whole month.

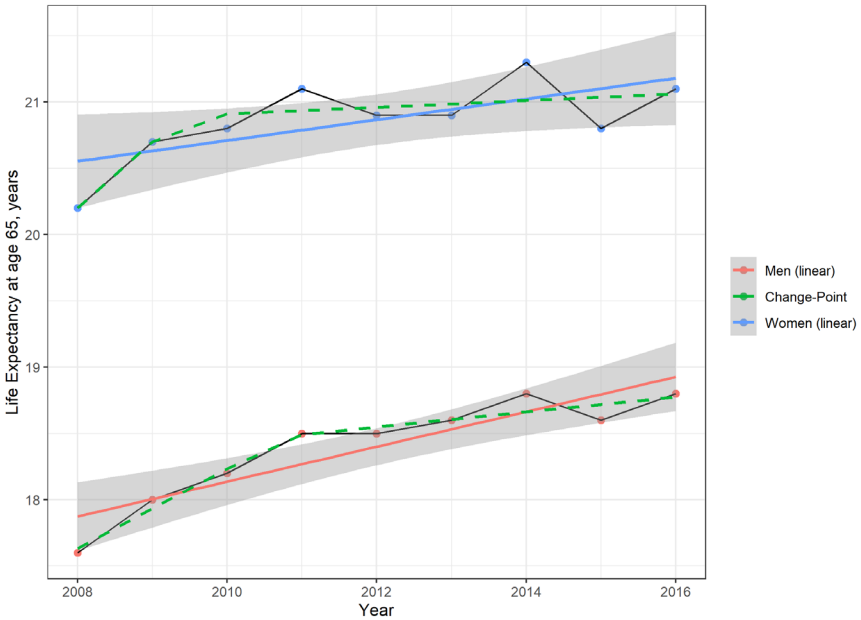

Figure 4. Linear models (with 95% confidence intervals) and change-point linear models of life expectancy at age 65 for men and women in the UK, 2008-2016. Adjusted R^2 for linear and change-point models; women 0.40, 0.61; men 0.80, 0.95, respectively.

By 2016, the highest LE at age 65 was seen in Malta (men 19.7 years) and France (women 23.7 years), with the fastest increases in LE at 65 in Malta (men 0.29 years per year) and Estonia (women 0.24 years per year).

Before 2011, UK LE at age 65 was increasing faster than all other EU28 countries, although, following 2011, it dropped to the slowest (men) or was no longer significantly increasing (women) (Figure 5).

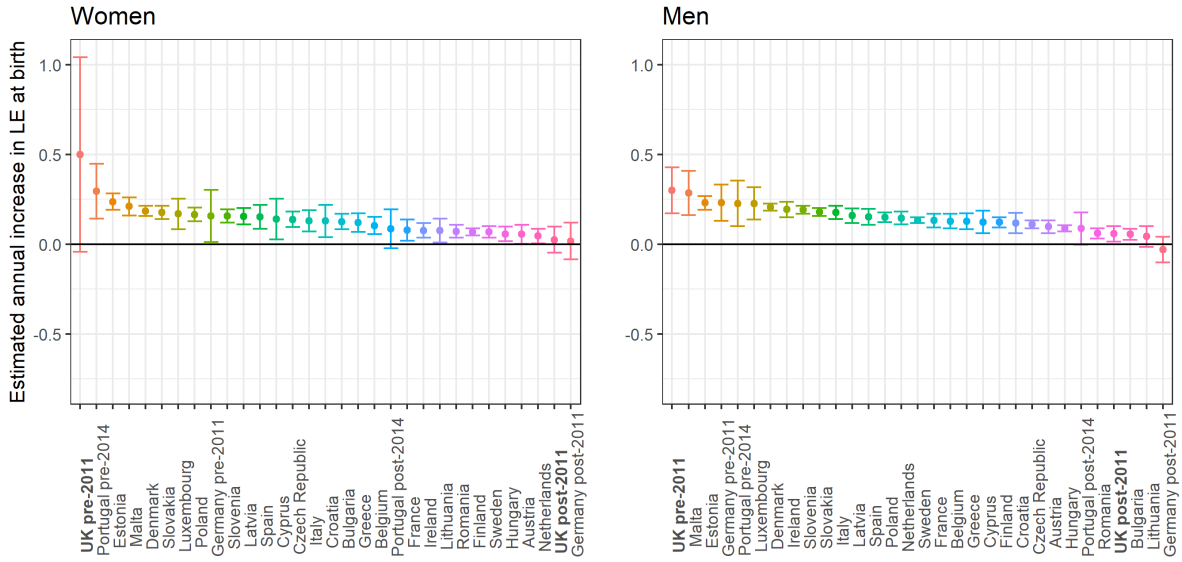

Figure 5. Comparison of gradients of linear models of life expectancy at age 65, including the UK, Germany and Portugal before and after their respective change-points.

Section 3. Disability-free life expectancy at birth in the UK compared to the other countries of the EU28 between 2008 and 2016.

DFLE at birth in UK women reduced at a steady rate of -0.34 years per annum (95% CI -0.41, -0.27, adjusted R^2 of simple linear model 0.93) throughout the study period 2008-2016. However, in UK men, DFLE was stable until around 2011 (95% CI for change-point 2009.24-2012.76) when it began to decrease at a similar rate to that of UK women (-0.31 years per year, 95% CI -0.48, -0.14, adjusted R^2 of segmented linear model 0.87, Figure 6).

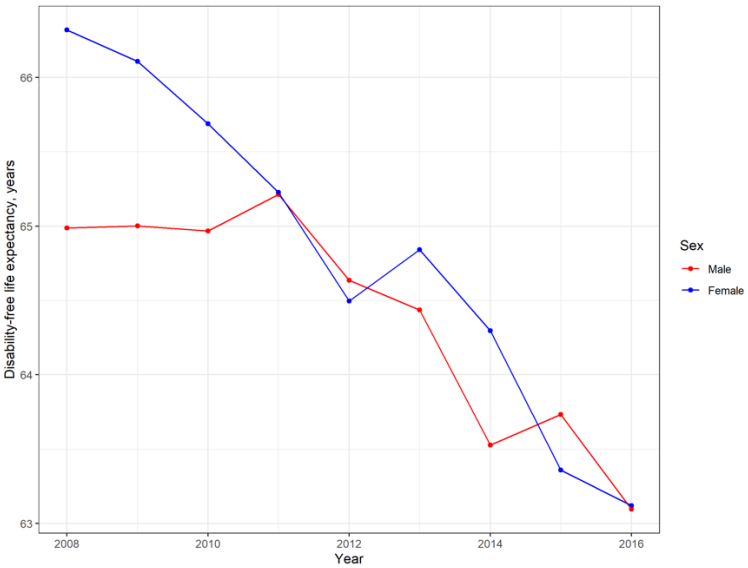

Figure 6. Disability-free life expectancy at birth for males and females in the UK between 2008 and 2016.

Though it is impossible to see the trends for individual countries (other than the UK) in Figure 7, the graphs show three interesting features. Firstly, trends in DFLE at birth between 2008 and 2016 were more variable than trends in LE across the EU28. Secondly, DFLE values were more similar between males and females than LE values. Thirdly, the year-on-year variability in DFLE is not evident in UK trends (Figure 7). The greater variability may reflect alterations to the wording of the PH030 question in different countries, true variability in disability prevalence, or a combination of these and other explanations.

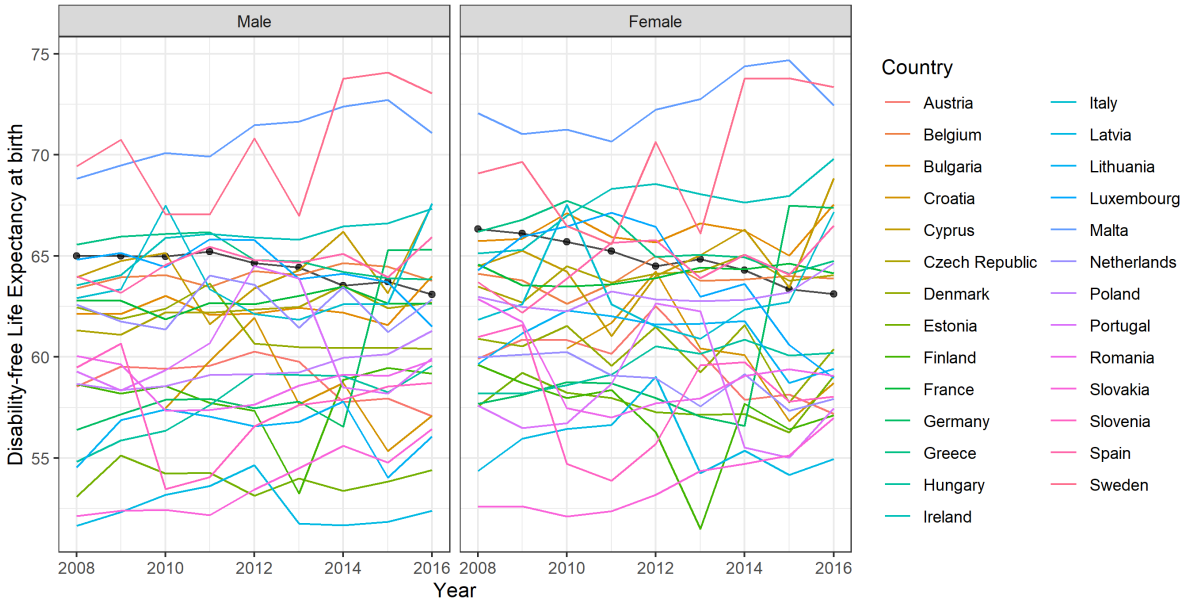

Figure 7. Disability-free life expectancy at birth between 2008 and 2016 for the other countries of the EU28 and the UK (black line).

Irrespective of the intervening trend, there were 18 countries where DFLE at birth in males was higher at the end of the study period than the beginning, and 15 such countries for females. The UK was part of the remaining group of countries whose DFLE at birth in 2016 was lower than that of 2008 in both sexes (Figure 8).

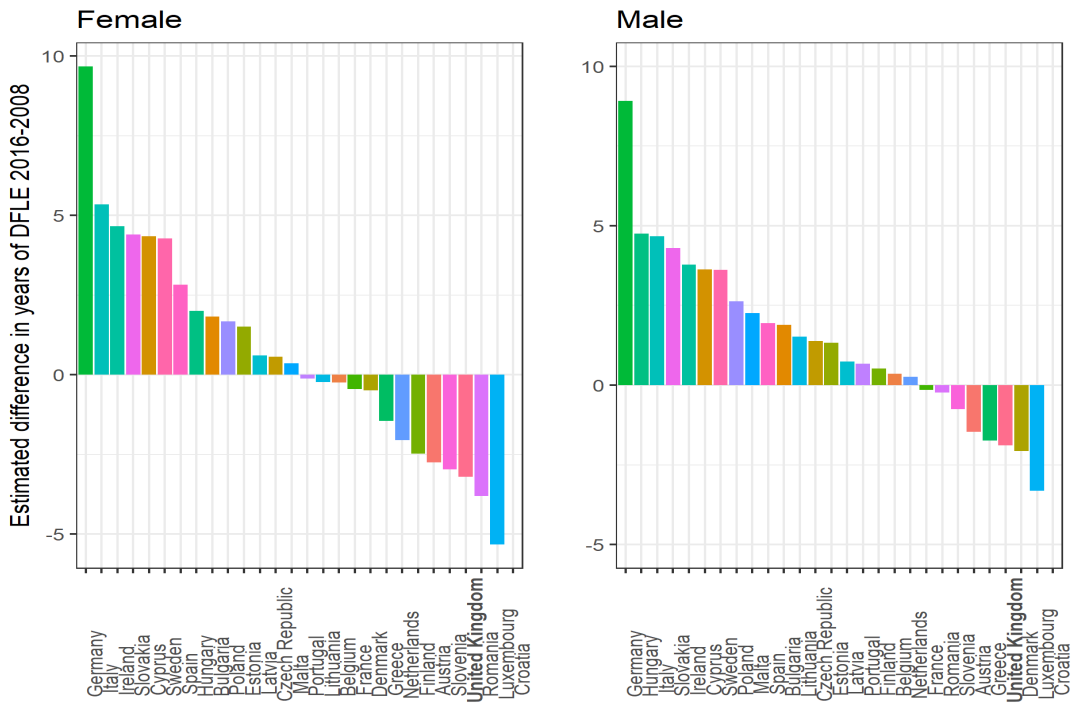

Figure 8. Difference in years of disability-free life expectancy at birth between 2008 and 2016 in the EU28.

Life expectancy with disability (DLE= LE-DFLE) at birth increased in the UK over the period. After partitioning DLE into mild and severe DLE, much of the increase in female DLE was due to an increase in severe DLE from 2011 (Figure 9). In males over the same period, increasing DLE was a result of comparable increases in both mild and severe DLE.

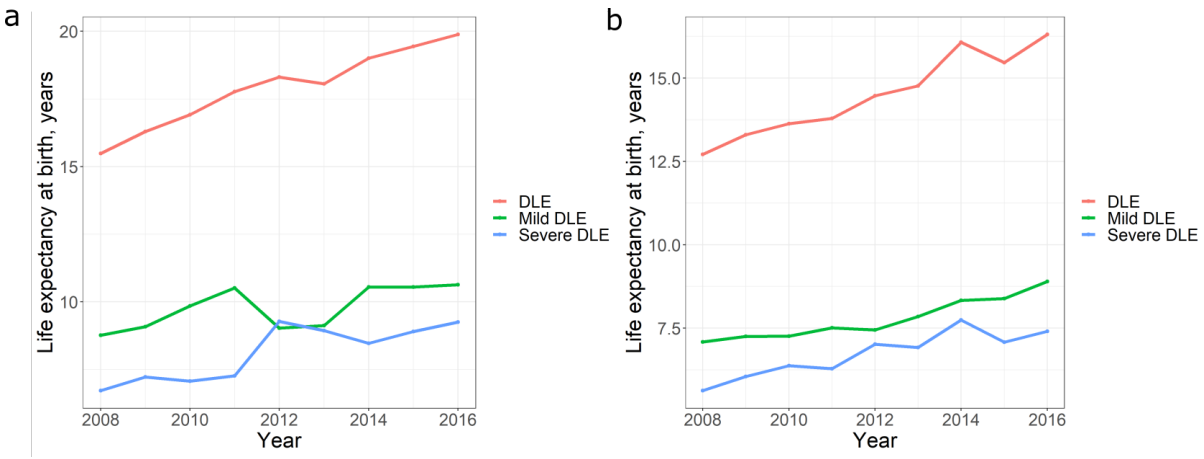

Figure 9. Trends in mild, severe and overall disabled life expectancy at birth in females (a) and males (b) in the UK between 2008 and 2016.

Although Germany appeared to share similarities with the UK in its LE trends in men, DFLE in Germany was significantly different. A large increase in DFLE appeared to occur in Germany after 2014, which is not reflected in the healthy life expectancy (HLE) data. This did not occur in any other EU country (Appendix: Figure 28). The reasons for this are unknown and may therefore represent a significant alteration in the formulation or delivery of the activity limitation question in Germany around this time.

Three countries appeared to share a similar trajectory for DFLE at birth to the UK: Austria, Greece and Luxembourg. A decline in DFLE for both sexes appeared to occur around 2012 in Austria, and 2011 in Greece and Luxembourg (Figure 10). Luxembourg was the only country where, in some years, DFLE in males exceeded that of females (Figure 10). Austrian DLE at birth in males and females increased due to an increase in mild DLE, with severe DLE remaining relatively stable. In Greece, the pattern of alteration in DLE and its components was similar to the UK. A steep drop in DFLE occurred in Luxembourg after 2011, and the consequent increase in DLE resulting from an increase in both mild and severe DLE. In Luxembourg, the increase in severe DLE was more pronounced in females.

Figure 10. Disability-free life expectancy at birth for males and females in Austria (a), Greece (d) and Luxembourg (g), with DLE trends in females (b, e, h) and in males (c, f, i) for each country, respectively.

As for trends in DFLE, there was much variability in year-on-year changes in male and female DFLE as a percentage of LE (DFLE%) at birth, although in the UK DFLE% showed a consistent reduction across the study period, with males having consistently higher DFLE% than females (Figure 11). DFLE% in other countries showed a variety of trajectories, some increasing (Germany, Hungary, Ireland, Slovakia and Sweden), some decreasing overall (Austria, Croatia, Denmark, Estonia, Greece, Latvia, Lithuania, Romania, France, Luxembourg and the UK), and some with no clear trend or relative stability (Belgium, Bulgaria, Cyprus, Czech Republic, Finland, Italy, Malta, the Netherlands, Poland, Slovenia, Spain and Portugal). Of the countries with decreasing DFLE%, Greece and Luxembourg showed an increasing speed of reduction around 2010/2011 (Figure 12). In 2016, Sweden had the highest DFLE% of all countries in both men (90.6%) and women (87.2%).

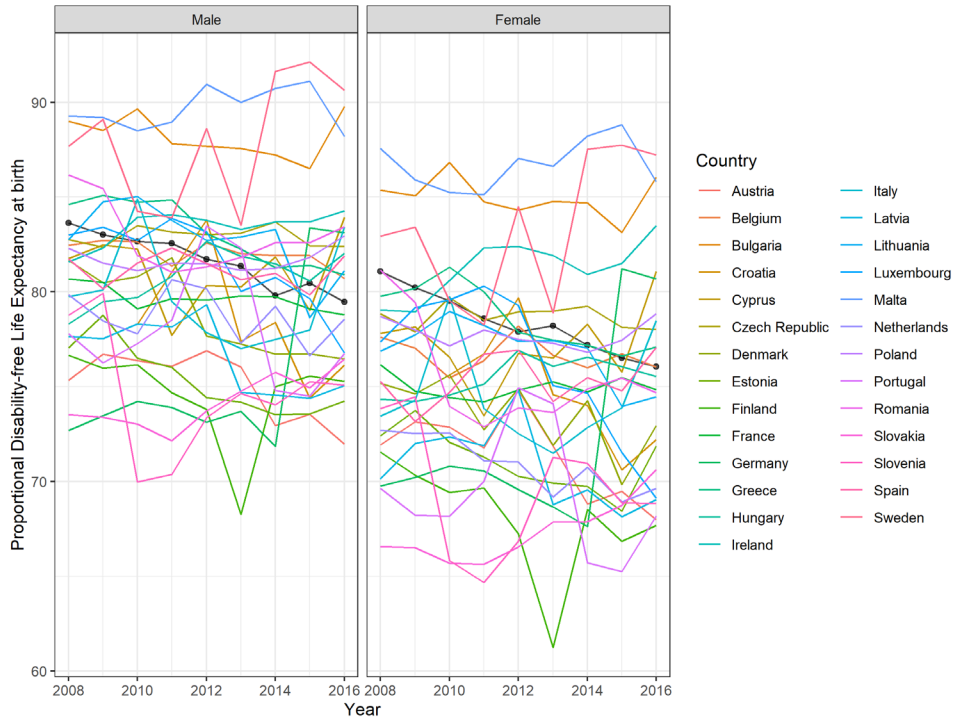

Figure 11. Disability free life expectancy as a proportion of total life expectancy (DFLE%) at birth in the countries of the EU28 (UK black line).

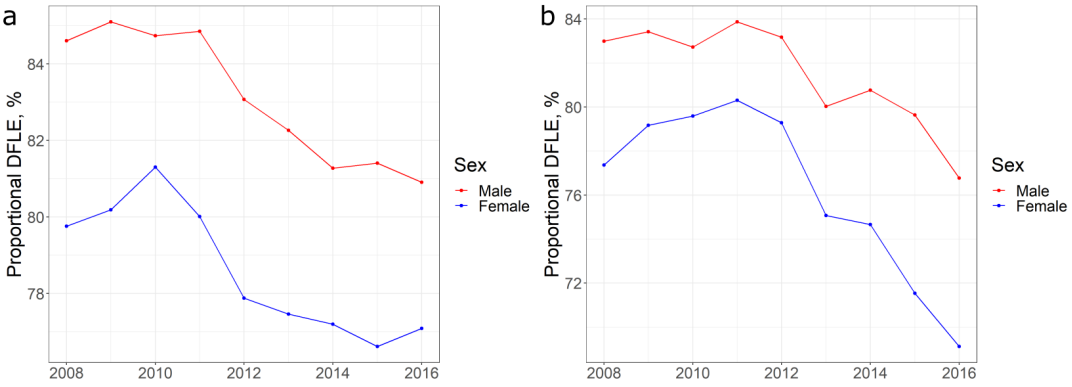

Figure 12. Proportion of DFLE (DFLE%) at birth in males and females in Greece (a) and Luxembourg (b).

Section 4. Disability-free life expectancy at age 65 years in the UK compared to the other countries of the EU28 between 2008 and 2016.

Between 2008 and 2016, DFLE at age 65 in the UK reduced in men and women but again showed considerable variability within that timeframe (Figure 13). Trends in DFLE at age 65 in other countries were equally variable. As with DFLE at birth, when comparing DFLE at age 65 between 2008 and 2016 (irrespective of intervening variation), the UK ranked among the minority of countries where DFLE at 65 had reduced (Figure 14).

Figure 13. Disability-free life expectancy (with 95% confidence intervals) at age 65 in men and women in the UK between 2008 and 2016.

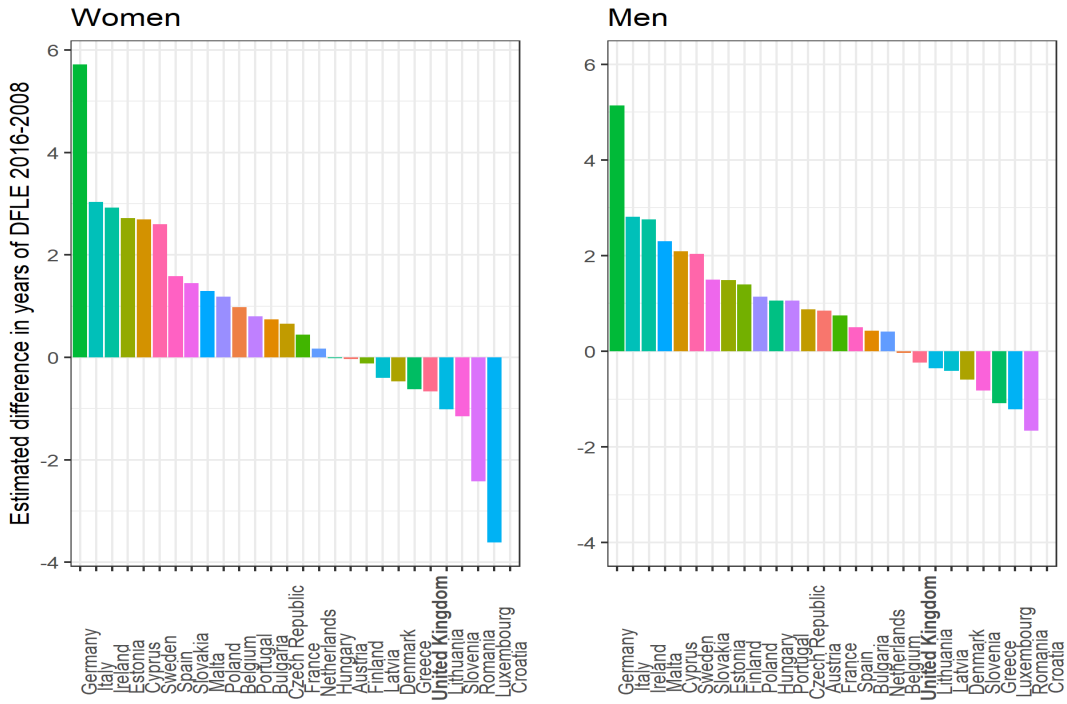

Figure 14. Difference in years of disability-free life expectancy at age 65 between 2008 and 2016 in the EU28.

Section 5. Sex differences in life expectancy and disability-free life expectancy at birth in the UK compared to the other countries of the EU28 between 2008 and 2016

Life-Expectancy

In the UK, as in many countries, on average women live longer than men. A clear linear trend towards reduction in the sex difference in LE at birth between UK males and females was seen between 2008 and 2016 (p-value <0.001). This linear trend was seen in all EU28

countries, but the gradient of the reduction varied, and was not significantly different from zero in some (i.e. no evidence of a change in the sex difference over time: Bulgaria, Croatia, Cyprus, Germany and Luxembourg). This gradient was estimated for all countries and compared (Figure 15), the more negative the gradient, the faster the sex gap appeared to be closing. The speed of reduction in the sex difference in the UK was the sixth slowest.

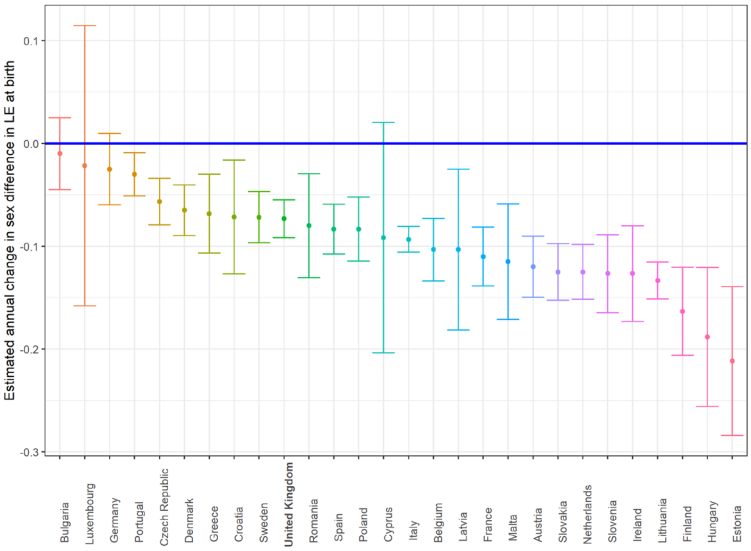

Figure 15. Estimated gradient of the sex difference between male and female life expectancy at birth (female – male) over the period 2008 to 2016.

Disability-free life expectancy

DFLE was more variable than LE across the study period, but the sex difference in DFLE (female-male) was more linear over the period 2008 to 2016. Only nine countries showed a significant reduction in the sex difference in DFLE at birth, and the UK had the third slowest trajectory of these (Figure 16) (countries with non-significant change: Belgium, Bulgaria, Croatia, Cyprus, Denmark, Estonia, France, Germany, Greece, Ireland Italy, Latvia, Lithuania, Malta, Portugal, Slovenia, Slovakia, Spain, Sweden). No significant change in the sex difference in DFLE% was found in the UK (p-value for linear gradient 0.264). However in four countries this inequality significantly increased over the period (Spain, Cyprus, Italy, Sweden), and in four it had reduced (Poland, Romania, Finland, Luxembourg)(Appendix: Figure 29) (countries with no significant change: Austria, Belgium, Bulgaria, Croatia, Czech Republic, Denmark, Estonia, France, Germany, Greece, Hungary, Ireland, Latvia, Lithuania, Malta, Netherlands, Portugal, Slovakia, Slovenia, UK).

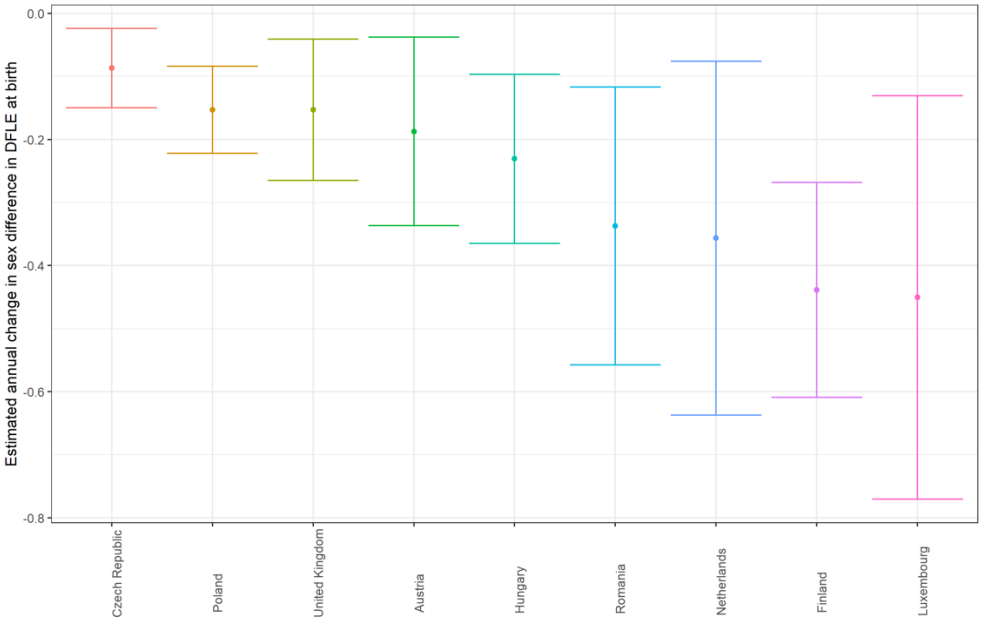

Figure 16. Gradient of linear trend in the sex difference in disability-free life expectancy at birth (female-male) among EU28 countries whose gradient was significantly different from zero.

Section 6. Sex differences in life expectancy and disability-free life expectancy at age 65 years in the UK *compared to the other countries of the EU28 between 2008 and 2016*

Life expectancy

The sex difference in LE at 65 years (female-male) in the UK over the period 2008 to 2016 showed a predominantly negative linear trend (i.e. a tendency for the difference between the sexes to reduce, p-value for linear gradient <0.01), along with nine other countries (Figure 17). The sex difference in LE at 65 in Bulgaria increased over the same time period, and many countries showed no significant trend in sex difference of LE at 65 years (countries with no significant change: Belgium, Croatia, Cyprus, Czech Republic, Estonia, Germany, Greece, Hungary, Latvia, Lithuania, Malta, Poland, Portugal, Romania, Slovakia, Spain).

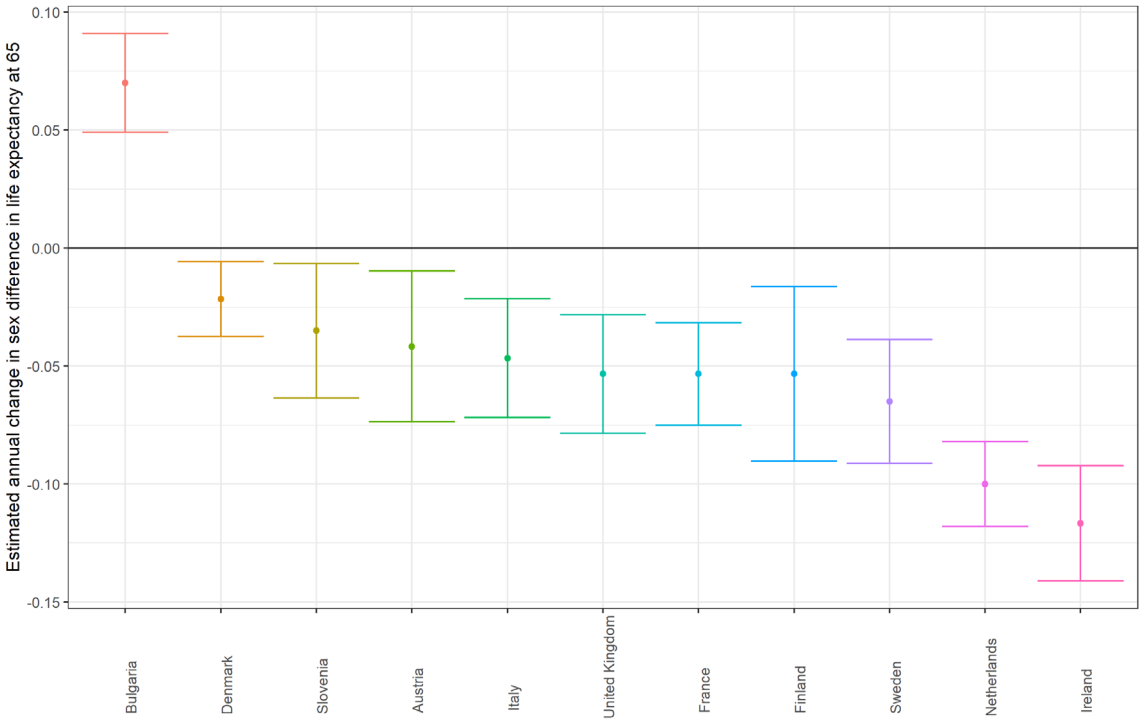

Figure 17. Gradient of trend in the sex difference in life expectancy at age 65 over the period 2008 to 2016 among EU28 countries whose gradient was significantly different from zero.

Disability-free life expectancy

The sex difference in DFLE and DFLE% at age 65 in the UK between 2008 and 2016 showed no consistent trend (linear model p-value 0.279, 0.975, respectively). Only Hungary, Finland and Luxembourg showed a significant reduction in the sex difference in DFLE at age 65 over the study period.

Compression of disability describes a situation in which DFLE is increasing significantly faster than LE, and expansion of disability is the inverse of this. A third possible scenario, dynamic equilibrium, is by one definition, the situation in which life expectancy with disability (DLE) is increasing but life expectancy with severe disability is not (or is reducing); thus although DLE is increasing, disability is becoming less severe. Between 2008 and 2016, the UK experienced a period of absolute expansion of disability for both sexes. Other countries that experienced a similar expansion were Luxembourg, Greece, Estonia, Denmark and Austria. Ireland and Slovakia experienced absolute compression of disability for females. Lithuania, Estonia, Denmark and Austria experienced a period of dynamic equilibrium (that is, where DLE has been increasing but severe DLE has not) for both sexes (Figure 18, Figure 19), with Estonia, Denmark and Austria also experiencing absolute expansion of disability.

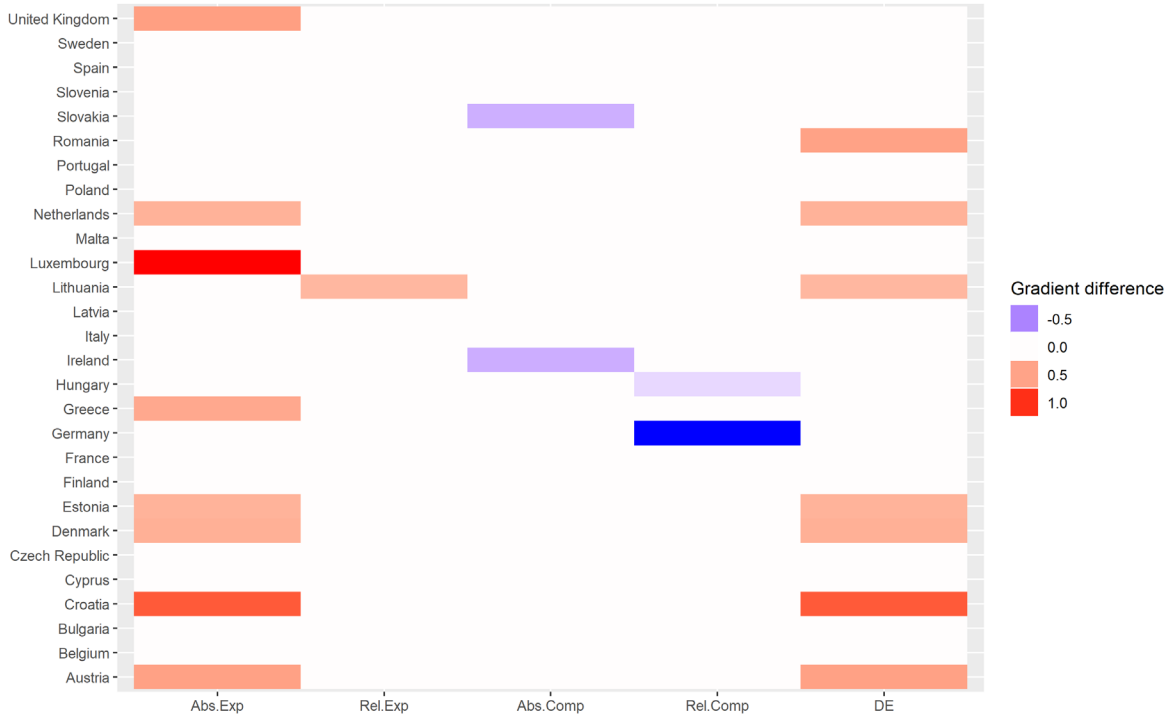

Figure 18. Heat map of differences in linear gradients between life expectancy and disability-free life expectancy at birth in females. Abs. absolute; Rel. relative; Exp. Expansion; Comp. compression; DE dynamic equilibrium.

Figure 19. Heat map of differences in linear gradients between life expectancy and disability-free life expectancy at birth in males. Abs. absolute; Rel. relative; Exp. Expansion; Comp. compression; DE dynamic equilibrium.

Figure 20 and Figure 21 show the relationship between the linear gradients of LE and DFLE at birth in females and males, respectively. The blue diagonal line represents LE=DFLE, such that, below this threshold, expansion of disability may be occurring, and above it represents compression of disability. However Figures 20 and 21 do not incorporate

evidence of significant differences between LE and DFLE, whereas the heat maps show absolute expansion and compression when there was evidence of a significant difference between LE and DFLE in the countries featured.

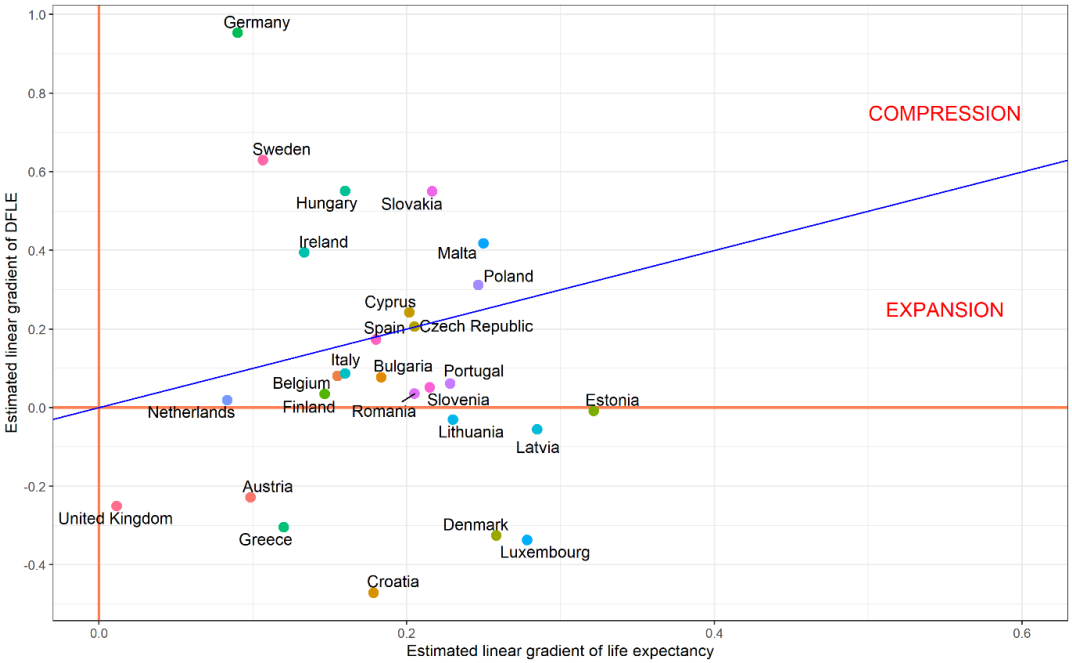

Figure 20. Comparison of linear gradients for life expectancy and DFLE at birth in women in all EU28 countries, including post-changepoint gradients for those countries whose trajectory altered (LE: UK, France, DFLE: Germany). Blue line represents identity.

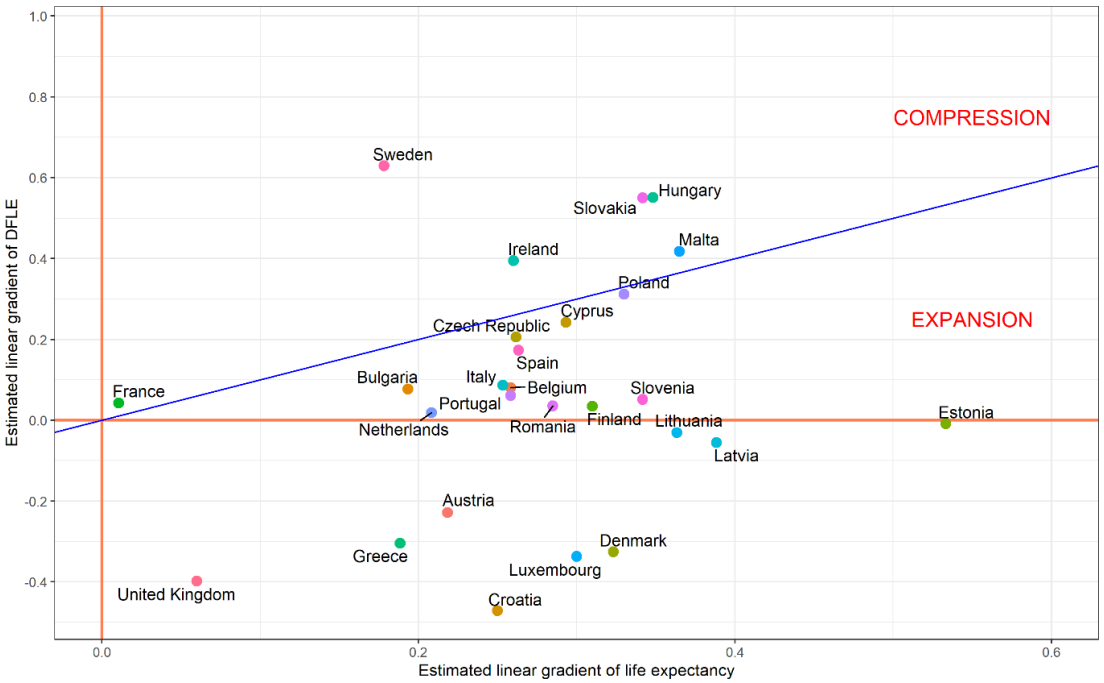

Figure 21. Comparison of linear gradients for life expectancy and DFLE at birth in men in all EU28 countries, including post-changepoint gradients for those countries whose trajectory altered (LE: UK, Germany, France, DFLE: UK, Germany). Blue line represents identity.

The theoretical 'ideal' scenario for any country involves maximising LE as well as the DFLE%, so that disability is limited to the shortest possible period before death. No one country represents this ideal, as countries could be ranked according to absolute values of

LE and DFLE%, or according to the speed of improvements in each (i.e. linear model gradients). Figure 22 and Figure 23 show sex-specific comparisons of LE at birth in the most recent study year (2016) and the DFLE%, using first the absolute values in 2016, and secondly the estimated rate of change. Blue lines indicate the sex-specific 80th centile for each measure, an arbitrary cut-off to isolate the 'best performing' countries. Countries occupying the top-right area of each plot represent those performing well in both dimensions. In 2016, Cyprus was the only country to be among the top 20% of countries for DFLE% and LE at birth in both sexes, with Sweden and Malta both being in the top 20% only in males.

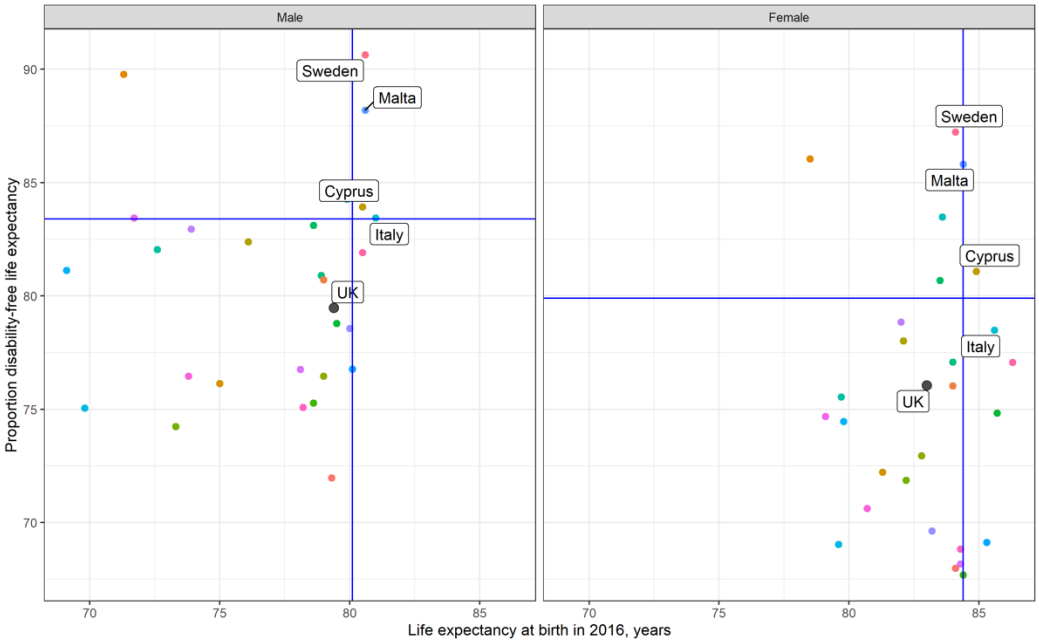

Figure 22. Comparison of absolute values of life expectancy and DFLE% at birth in 2016 in all EU28 countries. Blue lines indicate sex-specific 80th centile cut-offs.

When comparing linear gradients of LE and DFLE% across the study period (including the gradients after the change-point in countries whose trajectory altered), Malta was within the top 20% in both sexes, showing rapid growth in both LE and DFLE% (Figure 23). In both comparisons (absolute values in 2016 and growth over the period), the UK was placed in the lower left quadrant.

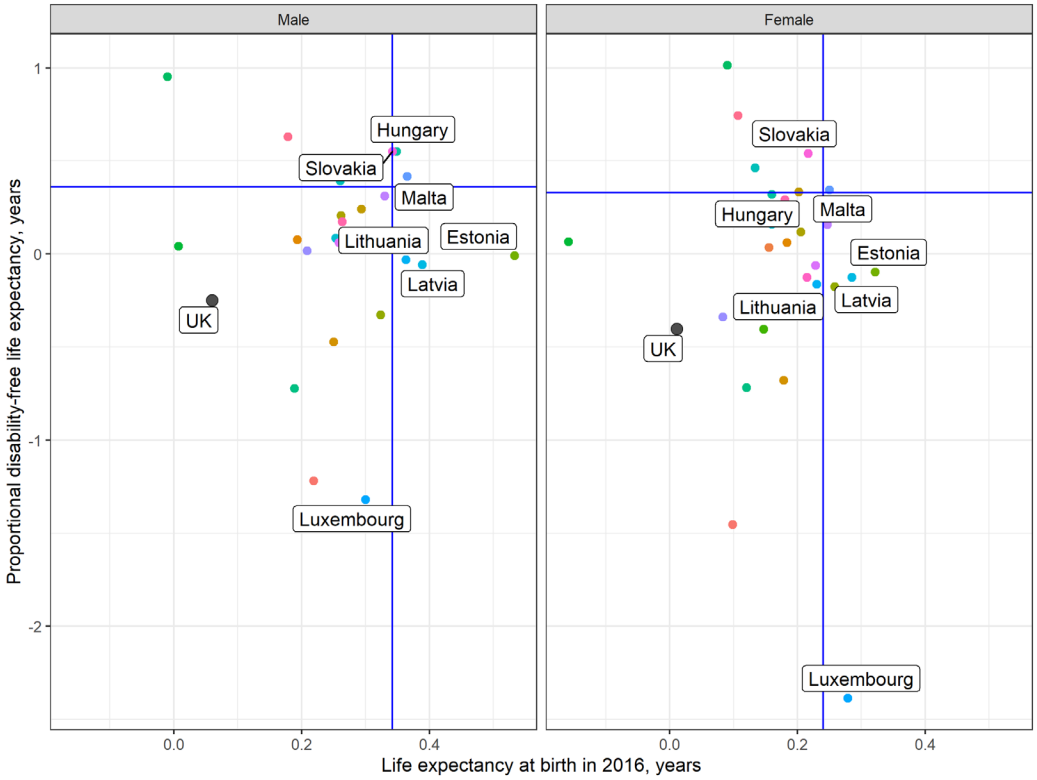

Figure 23. Comparison of estimated linear gradients of life expectancy and proportional DFLE in 2016 in all EU28 countries, including gradients subsequent to the respective change-point in those countries whose trajectory altered. Blue lines indicate sex-specific 80th centile cut-offs.

Healthy life expectancy compared to disability-free life expectancy

Since the underlying survey question for HLE has remained more stable than that for DFLE, we repeated all comparisons for HLE at birth and at age 65. Trends (and absolute values) of HLE at birth and age 65 in the UK were similar to those for DFLE. However, for all other EU28 countries, there were wide differences in absolute values and trends of HLE and DFLE. Full details of the comparisons are provided in the Appendix.

Discussion

Between 2008 and 2016, the UK performed poorly in terms of LE and DFLE compared to other countries of the EU28. Increases in LE at birth and 65 slowed to a rate below that of most other countries (gradient often not significantly different from zero), despite starting the period as one of the fastest increasing. There was some evidence of a slowing in the rate of increase of LE in other countries (Germany, France and Portugal), but most countries showed consistent increases across the study period. DFLE at birth fell throughout the period for UK females, and from 2011 for UK males. In most countries in the EU28, DFLE and HLE increased over the period, but a similar slowing to the UK was evident in a few countries: Austria, Greece and Luxembourg. These alterations seemed to result from an increase in severe DLE in Greece and the UK (for females in particular), an increase in mild DLE in Austria, and comparable increases in both mild and severe DLE in Luxembourg. Greece and Luxembourg also displayed a slowing in DFLE% at birth similar to the UK. DFLE at 65 in the UK also fell over the study period, along with a small group of other countries.

In terms of sex differences in the UK, the gap between males and females in LE and DFLE at birth was reducing between 2008 and 2016, but more slowly than in other countries. No change was seen in the sex gap of DFLE% at birth in the UK, in contrast to Poland, Romania, Finland and Luxembourg where the sex gap in DFLE% was reducing. At age 65, the sex gap in LE in the UK was significantly reducing but the gap in DFLE and DFLE% were not. However, improvements in sex differences in DFLE and DFLE% at age 65 were rare, and in one case (Bulgaria) sex differences were widening. In all countries, female LE and DFLE were greater than male LE and DFLE, at all time-points. The only exception to this was DFLE at birth in Luxembourg, where the usual relationship was reversed in the early part of the period, but by the end of the period, female DFLE was again higher than male DFLE. Male DFLE% and HLE% at birth exceeded that for females in all countries in all years.

Compression of disability/morbidity is now a stated goal in most EU countries and is given similar, or greater, importance than life expectancy. For instance, the Estonian government has prioritised increasing healthy life years in order to increase people's years of economic activity, which in turn offers the possibility to increase retirement age and may ensure sustainability of the pension system.[3] Between 2008 and 2016, the UK was in the minority of EU28 countries as it saw a period of absolute expansion of disability, where improvements in LE outstripped those of DFLE.

Strengths and Limitations

This study used life tables and disability prevalence data from all 28 EU countries across eight years, which were gathered using harmonised methods, and corresponded to the routine estimates produced by EuroStat. As such, longitudinal inter-country comparisons were possible in terms of LE and DFLE, and related measures. Given the size of the population samples on which the disability prevalence was based, confidence intervals were relatively narrow, allowing statistical comparisons to be made. Having eight years of results also allowed for a more nuanced assessment of non-linear trends than some previous studies.

The main limitation of this study was the harmonisation and interpretation of the two questions used to construct the DFLE and HLE parameters. Although much work has been done to ensure that the formulation, delivery and interpretation of these questions across countries has remained static, the information on which respondents based their answers may have varied both over time and between countries. This may affect comparison of estimates between countries at a single time point, but, if the question has remained the same over the period, trends will be more robust. Life tables were not available other than by sex (for example by education), thus subgroup analyses were not possible. Although having eight data points per time series is an improvement on previous work of this type, it is still relatively little data on which to base time series analyses. Thus, all identified trends should be interpreted with caution. Given the wide variations in demographic, economic and policy factors between and within countries over the study period, the causes underlying the trends and comparisons seen here are, as yet, unknown.

A further limitation is that the period covered does not include the recent COVID-19 pandemic. It is likely that UK LE will continue to plateau or fall, in comparison with other EU countries where death rates during the pandemic have been lower. The long-term effects of the pandemic, both directly on respiratory and heart health, and indirectly through reduced physical activity, may well increase the prevalence of activity limitation, which will lead to further reductions in UK DFLE.

Conclusions

- Between 2008 and 2016, rates of increase in UK LE at birth and age 65 moved from being amongst the highest of the EU28, to a rate below most other EU28 countries in 2011. Most other countries, including those with higher LE than the UK, saw linear increases in LE, suggesting the UK findings were not a result of nearing any natural limit to LE.
- DFLE at birth and age 65 in the UK fell significantly between 2008 and 2016, as did DFLE as a proportion of LE (DFLE%) and HLE. A small number of other countries showed similar trends, but the majority improved (increased) these indicators over the same time period.
- The reduction in DFLE at birth and age 65 and the greater increase in severe rather than mild DLE in the UK has implications for demand on health and care services.
- The slowing of the increase in LE at birth and at age 65, and reductions in DFLE and DFLE%, led to a period of **absolute expansion of disability** in the UK. In other words, a greater number of years would be lived in a disabled state. This again has implications for potential demand on health and care services. Unless these trends are reversed, there is little likelihood of attaining the Ageing Society Grand Challenge target of increasing healthy, independent life by five years by 2035.
- A small group of other EU countries (Austria, Denmark, Estonia, Greece and Luxembourg) were also in a period of absolute expansion of disability. In contrast Ireland and Slovakia experienced a period of **absolute compression of disability** but only for females.
- Sex differences in LE at birth and 65 in the UK narrowed between 2008 and 2016, albeit slowly compared to other countries. The sex difference in DFLE at birth in the UK was also reducing significantly, but not DFLE at age 65, and the sex difference in DFLE% did not change significantly. The UK was therefore in a favourable position compared to other countries in this regard, as many did not experience any significant change in sex differences in DFLE and DFLE%, and some saw an increase in these differences.

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Appendix

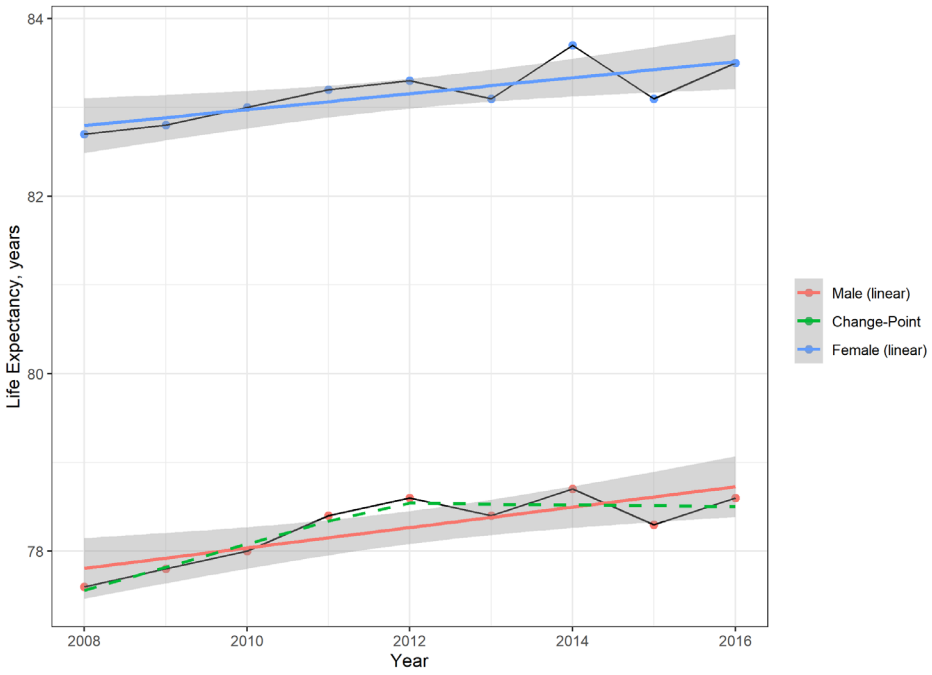

Figure 24. Linear models (with 95% confidence intervals) and change-point linear models (males only) of life expectancy at birth for males and females in Germany. Adjusted R^2 for males' linear and change-point models; 0.63 and 0.84, respectively.

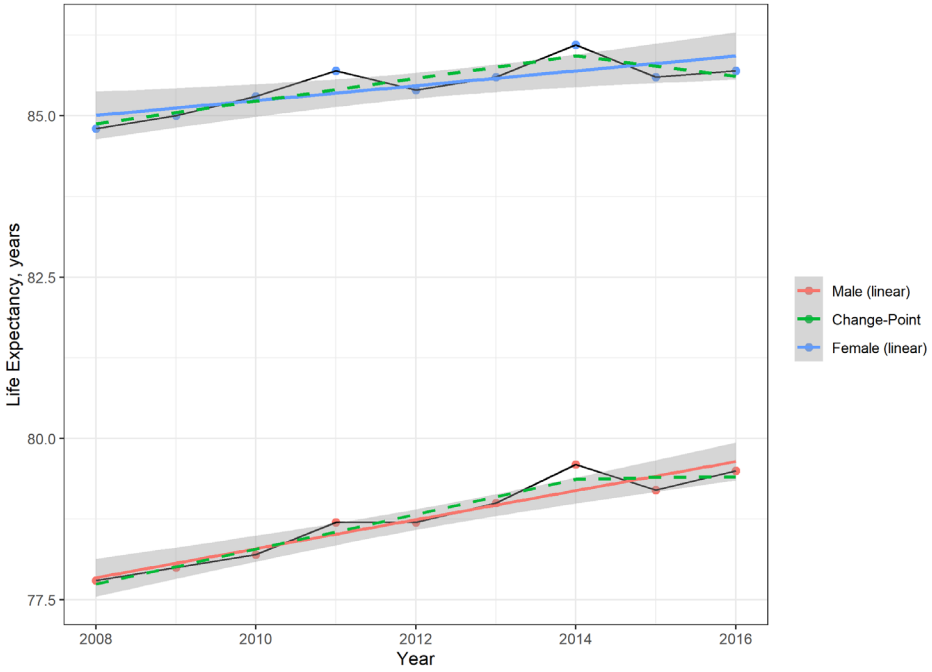

Figure 25. Linear models (with 95% confidence intervals) and change-point linear models of life expectancy at birth for males and females in France. Adjusted R^2 for linear and change-point models; women 0.59, 0.67; men 0.90, 0.92, respectively.

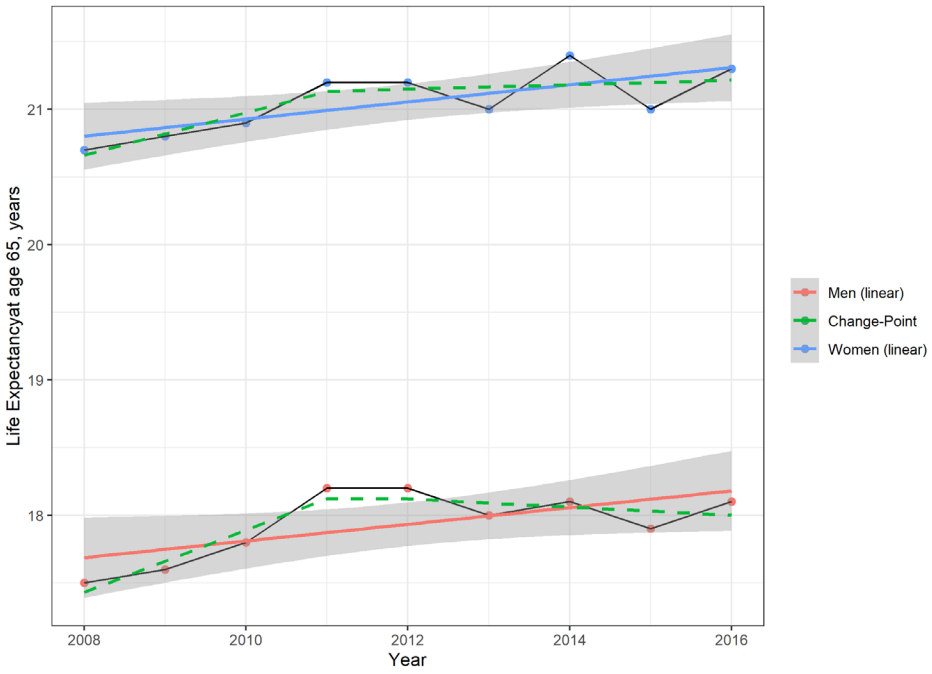

Figure 26. Linear models (with 95% confidence intervals) and change-point linear models of life expectancy at age 65 for men and women in Germany. Adjusted R^2 for linear and change-point models; women 0.48, 0.51; men 0.36, 0.80, respectively.

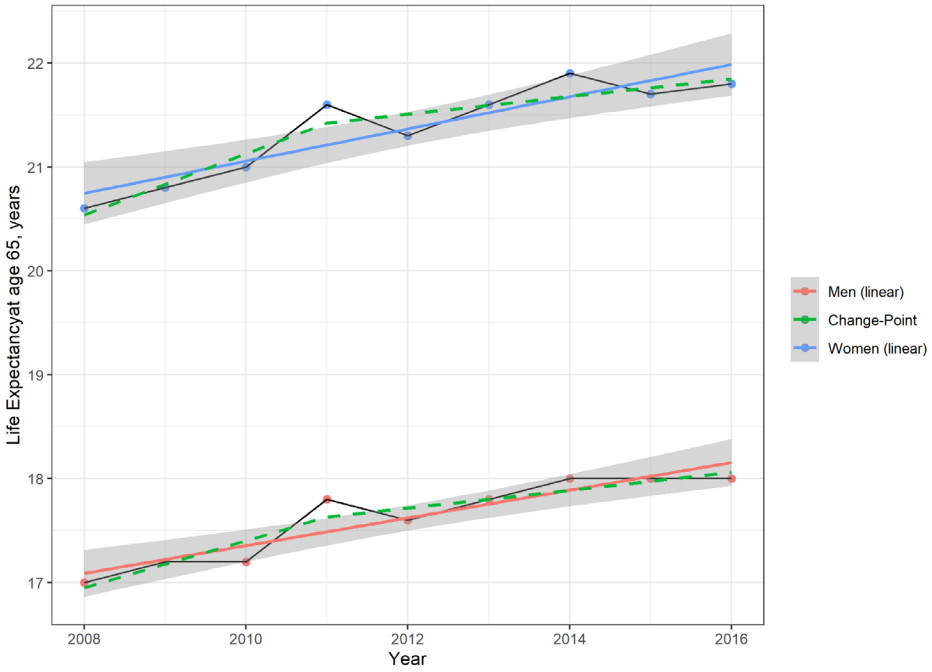

Figure 27. Linear models (with 95% confidence intervals) and change-point linear models of life expectancy at age 65 for men and women in Portugal. Adjusted R^2 for linear and change-point models; women 0.80, 0.86; men 0.84, 0.87, respectively.

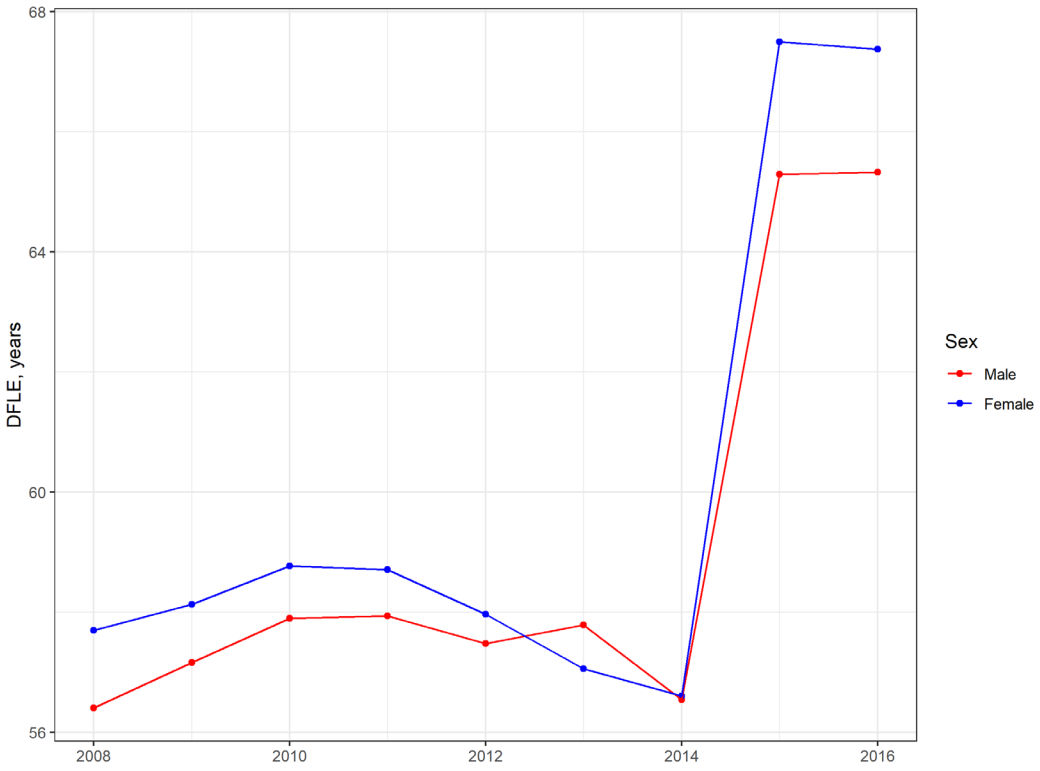

Figure 28. Disability-free life expectancy at birth for men and women in Germany between 2008 and 2016.

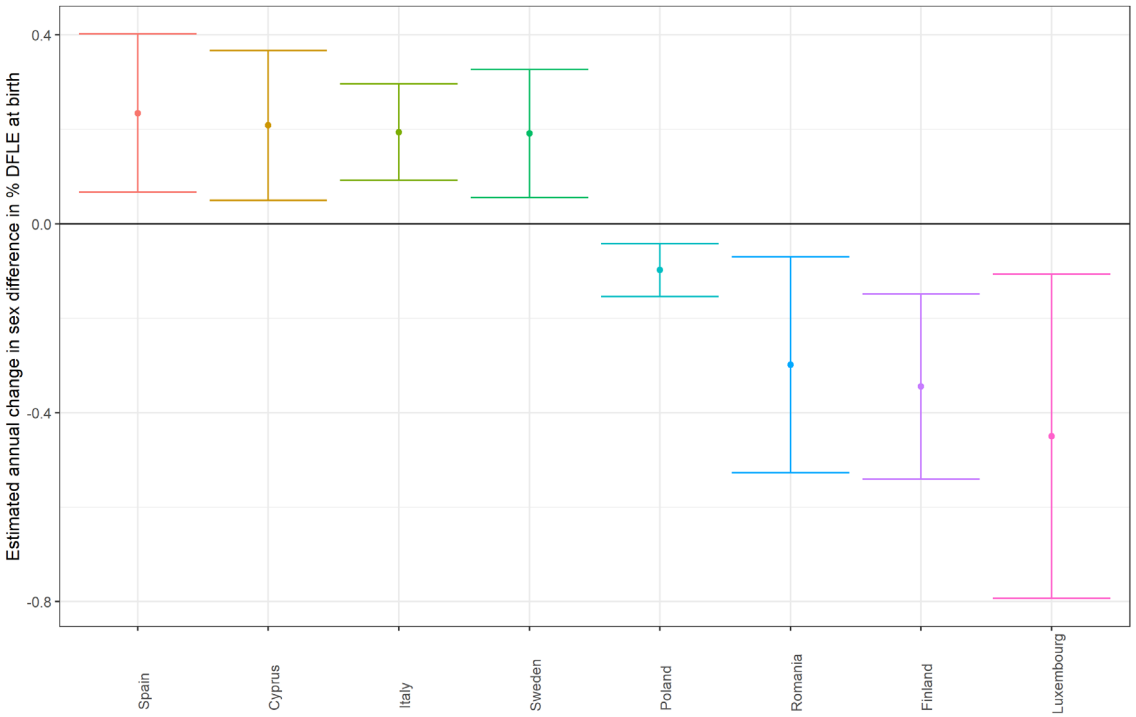

Figure 29. Gradient of linear trend in annual sex difference in proportional disability-free life expectancy (DFLE%) at birth among EU28 countries whose gradient was significantly different from zero.

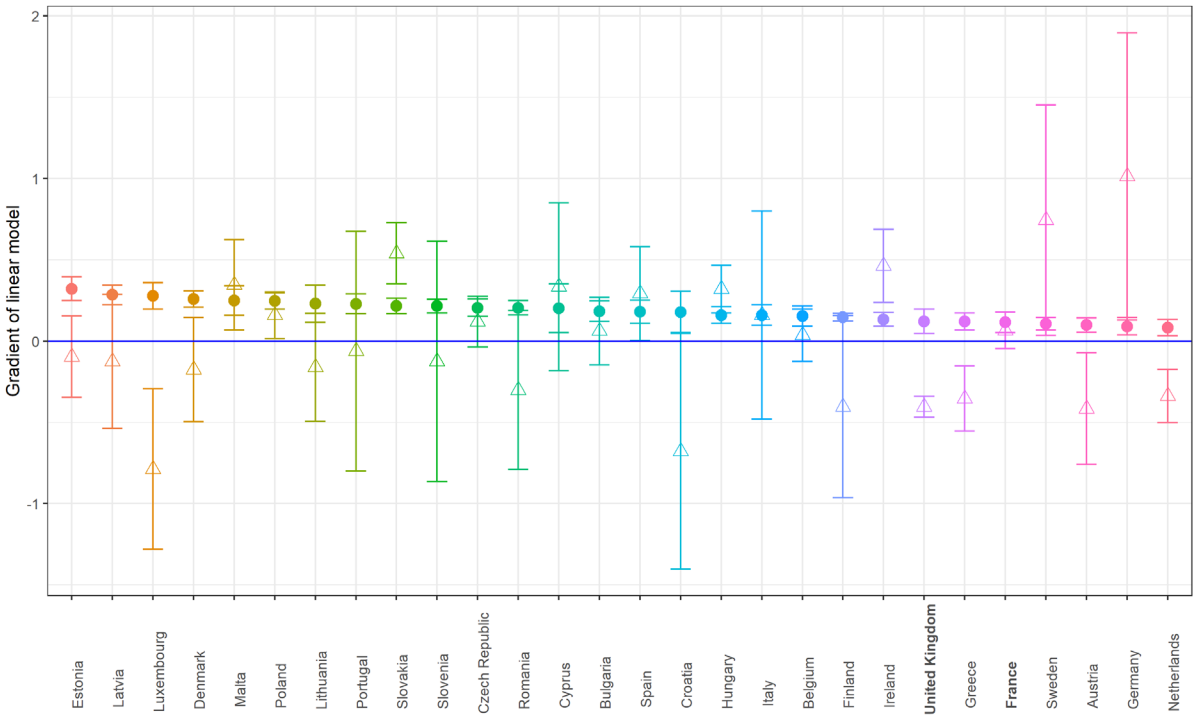

Figure 30. Comparative estimated gradients of linear models of life expectancy (circles) and disability-free life expectancy (triangles) at birth in women across the EU28. Those countries where a significant change in trajectory was noted are represented by their post-changepoint gradients (UK and France).

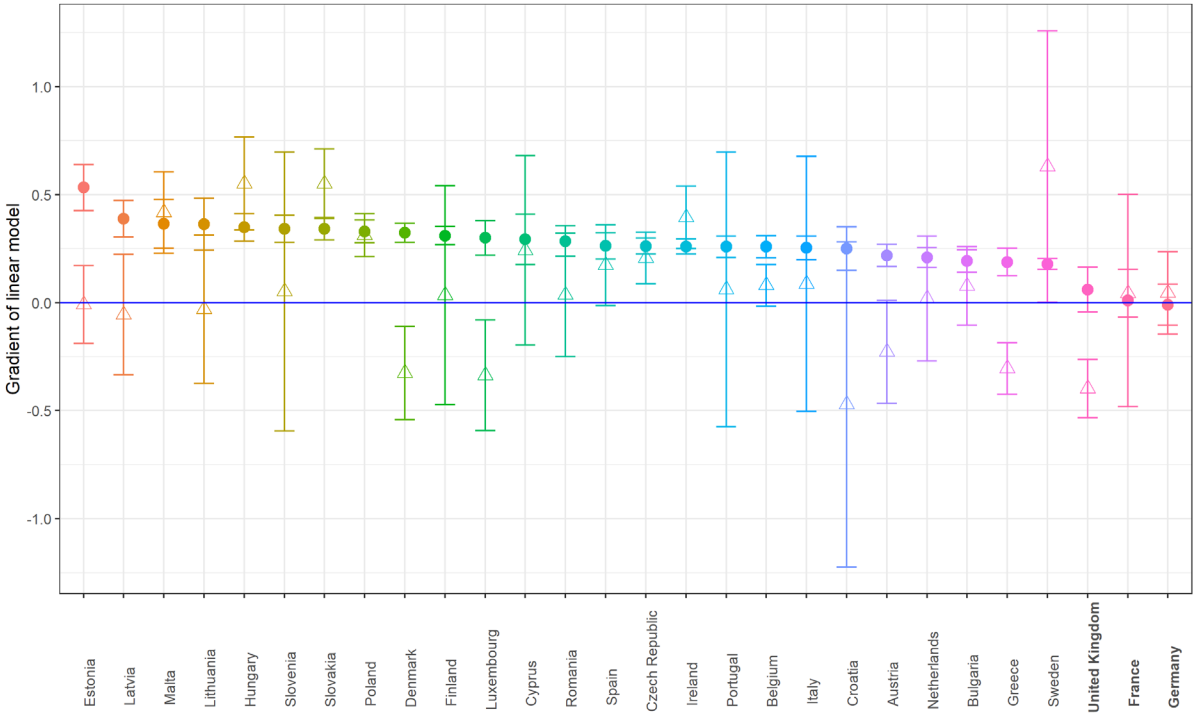

Figure 31. Comparative estimated gradients of linear models of life expectancy (circles) and disability-free life expectancy (triangles) at birth in men across the EU28. Those countries where a significant change in trajectory was noted are represented by their post-changepoint gradients (UK, France and Germany).

Part 1: Additional methods

EU-SILC data are collected only for non-institutionalised persons of 16 years and over, thus the estimation of DFLE and related variables for ages below 16 involve some assumptions of the prevalence of disability in these ages. In this report we adopted the method of EuroStat, whereby the prevalence of disability at age 15 was assumed to be the same as that of 16-19 year olds, and the prevalence below 15 was assumed to be half the prevalence of the 16-19 year old group (and zero at birth). The upper bound to the highest age group (reported as 85+ years by EuroHex), was assumed to be 100 for calculation purposes, and the unweighted number of respondents to the EU-SILC questions for each single year of age was assumed to be the total number for that age group, divided by the number of whole years in the age group.

Part 2: Healthy life expectancy compared to disability-free life expectancy

HLE at birth

The trends in UK males and females in DFLE at birth are largely similar to those in HLE, a question whose formulation has remained more stable over the study period. HLE in females was again reducing approximately linearly throughout the period, and UK males' HLE began to decline after a short period of stability, however this point of change occurred earlier when considering HLE compared to DFLE (2009.63, 95% CI 2007.85-2011.40)(Figure 32).

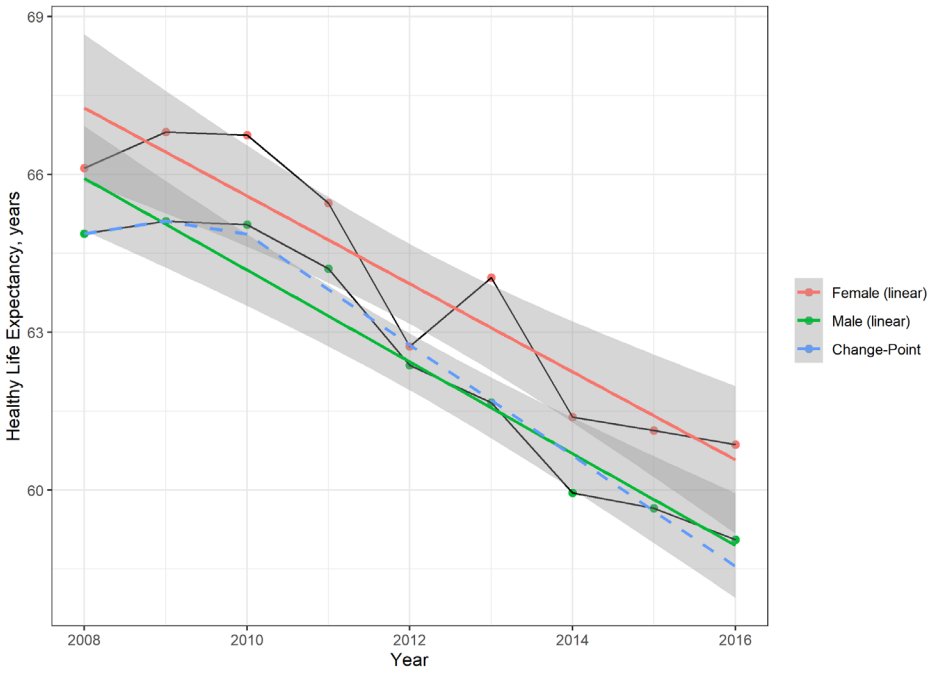

Figure 32. Linear (with 95% confidence intervals) and change-point models (males only) of healthy life expectancy at birth in UK males and females.

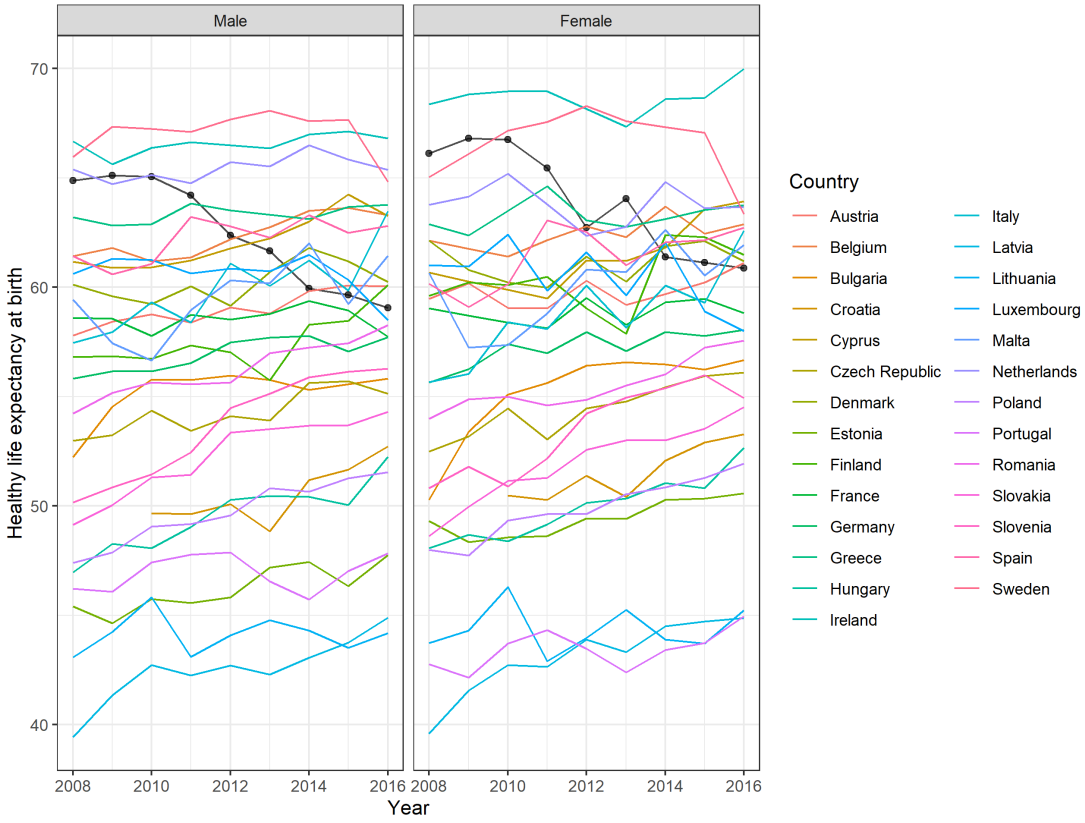

Figure 33. Healthy life expectancy at birth between 2008 and 2016 among the other countries of the EU28 and the UK (black line).

When comparing DFLE and HLE in those countries whose DFLE trends showed some similarity to the UK, HLE tended to increase rather than decrease across the study period, albeit with fluctuations. The only exception to this was Luxembourg, whose HLE in men and women tended to reduce after 2014 (Figure 34).

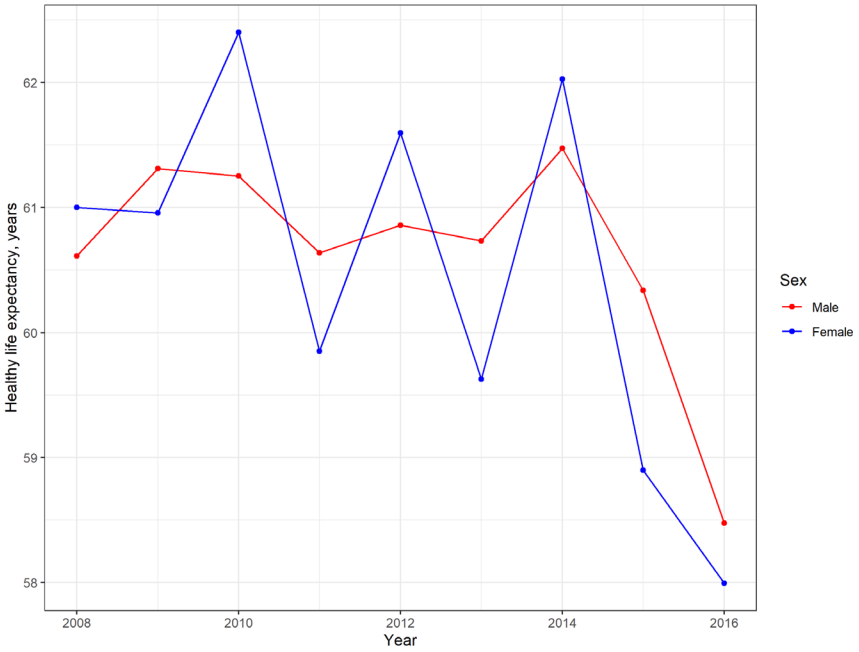

Figure 34. Healthy life expectancy at birth in males and females in Luxembourg between 2008 and 2016.

HLE at 65 years

HLE at age 65 in the UK, as with DFLE, appeared to reduce significantly mid-way through the study period, but remained somewhat stable at the lower level rather than continuing to descend (Figure 35), with women's HLE consistently being higher than men's. DFLE and HLE at 65 were also broadly similar for Luxembourg and Austria.

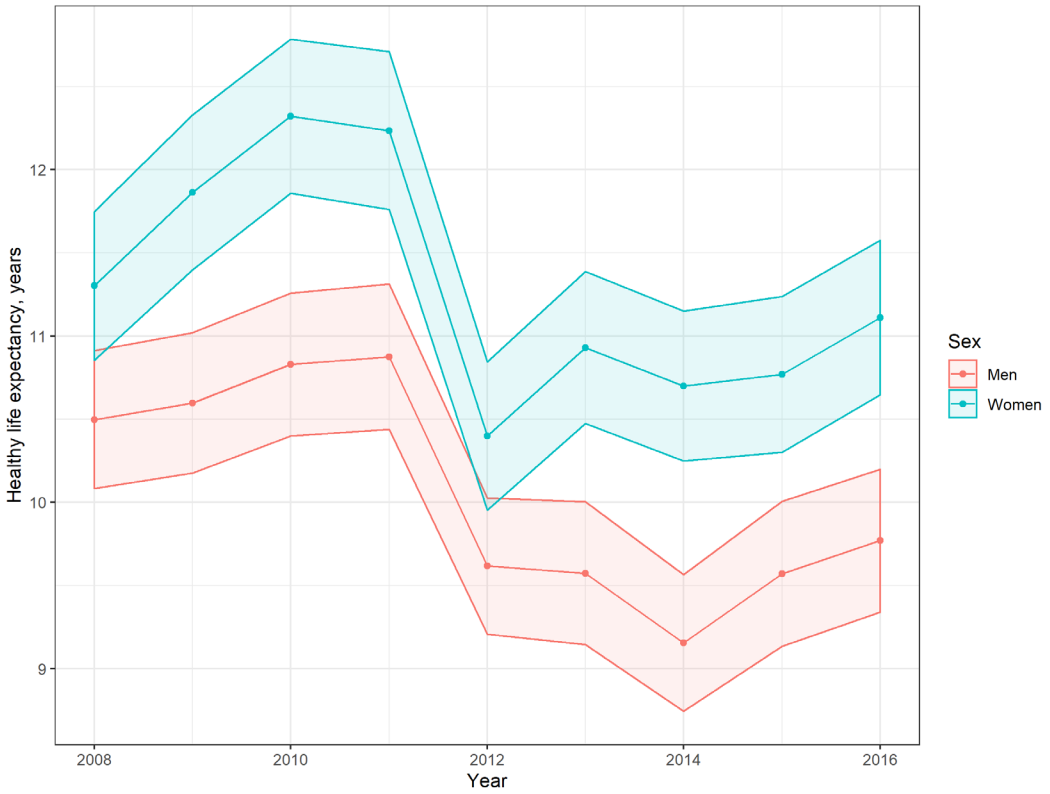

Figure 35. Healthy life expectancy at 65 (with 95% confidence intervals) in men and women in the UK.

Sex difference in HLE at birth

The absolute and HLE% sex difference at birth in the UK was not found to be significantly reducing (p-value for linear gradient 0.634, 0.07 respectively), whereas the sex difference in absolute DFLE (but not DFLE%) was (p-value 0.03). The sex difference in HLE% was significantly increasing in Bulgaria, Spain, Czech Republic, Lithuania and Cyprus, and the absolute HLE sex difference was significantly increasing in Bulgaria and reducing in Slovenia (data not shown).

Sex difference in HLE at 65

The sex difference in HLE% at 65 was significantly increasing across the study period in the UK (p-value for linear gradient 0.01), along with Greece and Bulgaria, but the sex difference for absolute HLE was not (p-value 0.368). This compares to no significant trends in the sex differences for DFLE and DFLE% in the UK. Only Luxembourg saw a significant reduction in sex differences in absolute and HLE%, as well as absolute and DFLE% over the study period.

Part 3: Linear model performance

In both sexes, across the EU28 over the study period, there was a general trend towards greater annual increases in LE in countries whose LE at the start of the period was lower. The UK was not an exception to this rule, having one of the higher estimated LE in 2000 (extrapolated from the linear model), but being one of the countries with more slowly increasing LE (Figure 36).

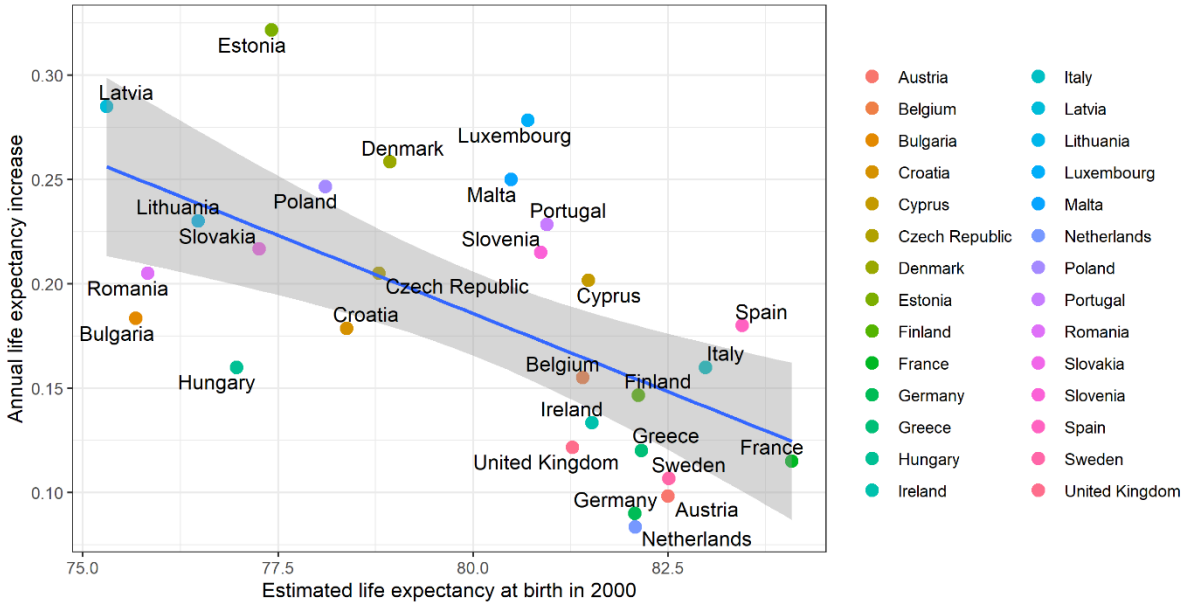

Figure 36. Comparison of estimated life expectancy at birth in 2000 and gradient of change among females in the EU28, assuming a linear trend in life expectancy.

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