Office for National Statistics

National population projections, mortality assumptions: 2022-based

The data sources and methodology used to produce mortality assumptions in the UK 2022-based national population projections.

Contact:
Population and Household Projections
pop.info@ons.gov.uk
+44 1329 444661

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1 . Main points

- Period life expectancy at birth for UK males is projected to increase from 79.0 years in 2022 to 82.1 years in 2047; for UK females, period life expectancy at birth is projected to increase from 82.9 years in 2022 to 85.7 years in 2047.
- The assumed long-term rate of annual mortality improvement in 2047 for the UK and each of its countries has been set at 1.1% for ages 0 to 90 years.
- Lower long-term rates of annual mortality improvement are proposed for ages 91 to 109 years, declining to zero mortality improvement for ages 110 years and over.
- The 2022-based principal projections of period life expectancy at birth in the UK in 2047 are 0.3 years lower for males and 0.1 years higher for females than the 2020-based interim projection.

2 . Overview

This article provides detailed information on the principal and variant mortality assumptions used in the 2022-based national population projections (NPPs). It sets out an overview of the model used, adjustments made and our rationale for setting the long-term improvement rates. It also sets out comparisons with the 2020-based interim NPPs.

All figures in this article are presented on a calendar year basis. Therefore, there may be small differences between the figures presented in this article and the national population projections published datasets. This is because the underlying deaths data used in setting the mortality assumptions are available on a calendar year basis.

The mortality assumptions are projections of future mortality trends. We base these assumptions on analysis of mortality data and advice from the external NPP Mortality Expert Advisory Panel and the Government Actuary's Department (GAD).

We project future age-specific mortality rates based upon an assumed annual percentage change of mortality rates, which vary by age and sex and over time. We refer to these assumed percentage changes as "mortality improvements".

Life expectancy is calculated from mortality rates. Lower mortality rates lead to higher life expectancy and higher mortality rates lead to lower life expectancy. When mortality improvements are given as a positive value, this indicates both lower mortality rates and a rise in life expectancy. A negative value for mortality improvements indicates higher mortality rates and a fall in life expectancy.

3 . Method for setting the mortality assumptions

General approach

In our projections of life expectancy, we model age-specific mortality improvements in the base year and assume they will converge to a long-term rate of improvement in the 25th year of the projection. These are assumed to be the same for males and females. All future years' mortality improvements by age beyond the 25th year are assumed to be at the level of the long-term rate for that age.

All life expectancy figures given within this article are period life expectancies. Period life expectancy is calculated using the mortality rates for a particular calendar year and, unlike cohort life expectancy, does not allow for future assumed changes in mortality rates. We have published a full explanation of the differences between cohort and period life expectancy.

Age-Period-Cohort model

For the 2022-based projections, we are using an Age-Period-Cohort (APC) model for the first time. In early 2023, we ran a user engagement on the proposal to use the new method and this was accompanied by Prospective new method for setting mortality assumptions for national population projections, UK: January 2023 showing results from the model.

The model separates the contribution of age, period and cohort effects on mortality improvement.

The “age effect” is the baseline annual mortality improvement at age x, for example, to account for the observed improvement in mortality rates for females aged 70 years between 1973 and the base year of the projection.

The “period effect” is the mortality improvement in a given calendar year (period); this is a constant value for each calendar year and may be positive (denoting higher than average mortality rates), or negative (denoting lower than average mortality rates).

The “cohort effect” is mortality improvements for a given birth cohort, that is, people with the same year of birth. It has been shown in the past that some birth cohorts experience higher mortality improvements than others.

The model uses calendar year death registrations and mid-year population estimates from 1973 to the base year to project future mortality rates and improvement rates by age and sex. Previous national population projections (NPPs) have used data from 1961 onwards. The NPP Mortality Expert Advisory Panel suggested that a rolling 50-year period of input data would be sufficient as more historical data may not be a good indicator of future mortality trends and may be of lower quality. All years of input data have been given equal weighting.

The model is split into three parts.

APC model

The main APC model fits mortality improvement based on the age, period and cohort effects. It covers most ages, from age 1 year to years. The specific values of are chosen to allow for a smooth change in the mortality rates from the main model to the old age model and will be reviewed regularly. These are currently set to 90 years for females and 92 years for males.

Old age model

The old age model is for ages plus 1 years to 125 years. The old age model takes the form of a logistic model and models mortality rates rather than improvement rates. The use of a logistic model accounts for sparser data as age increases and ensures that mortality rates converge to a constant value as age increases.

Infant model

The third part of the model is for infants aged zero years. The infant model is the same as the main APC model, except that it does not include a period effect, and it uses estimates of the cohort effect from the main model.

The Office for National Statistics (ONS) worked with academics from the University of Southampton and Warwick University on the development of the model. They have published an explanation outlining the model equations in the Scandinavian Actuarial Journal (PDF, 3.38KB). A specification of the model equations is also available on request from projections@ons.gov.uk.

Model constraints

Following consultation with the NPP Mortality Expert Advisory Panel, we applied the following constraints to the standard APC model to retain desirable features from our previous method for projecting future mortality. This is explained in National population projections, mortality assumptions: 2020-based interim.

In the first years of the projection, the projected improvement rates are determined almost entirely by the fitted age and cohort effects from the model (the period effect is assumed to be zero in the projection). As we progress over the first 25 years of the projection, the modelled improvements are weighted down and the long-term rate is weighted up, so that by the 25th year (and all subsequent years) the projected mortality improvements are set to the long-term rate by age and sex.

We can also adjust the speed of convergence between the base year and the long-term improvement rates, for example, to achieve a certain percentage of the convergence by a given year to the long-term rate. We have assumed that 50% convergence to the long-term rate is achieved by the ninth year of the projection.

The model has the functionality to partially or fully remove any mortality shocks that occur in, or just before, the base year from the projected mortality rates. A mortality shock such as that caused by the coronavirus (COVID-19) pandemic, increases mortality rates resulting in a large positive fitted value for the period effect in the year in which it occurs. A shock adjustment is applied if the shock is judged to be short-term and not something that should be projected forward. The adjustment allows us to specify the proportion of the increased period effect to be removed from the projection and the number of years over which this should happen.

We make decisions on the long-term mortality improvement rate, speed of convergence and the shock adjustment following guidance from the NPP Mortality Expert Advisory Panel (see Section 4: Principal assumption).

Projecting for England, Scotland, Wales and Northern Ireland

Historically, we have always produced separate base year and projected mortality improvement rates for Scotland to the rest of the UK, reflecting the different patterns of mortality observed in Scotland. Following the advice of the NPP Mortality Expert Advisory Panel, and the precedent of previous NPPs, we have treated Scotland separately to the rest of the UK and have run data for Scotland from 1973 to 2022 separately in the APC model. We have applied the same main assumptions (as detailed in Section 4: Principal assumption) to the Scotland data as we have for the rest of the UK.

We have run data from 1973 to 2022 for England, Wales and Northern Ireland combined (referred to as the UK excluding Scotland) through the APC model. To disaggregate to the individual nations, we then derive ratios of observed mortality rates for each country by age and sex against the observed mortality rates for the UK excluding Scotland by age and sex. These ratios are smoothed over three years (2020 to 2022) and applied to the base year mortality rates for the UK excluding Scotland to produce base year mortality rates for the individual countries up to age 100 years. The base year mortality rates for UK excluding Scotland are used at ages over 100 years. The projected improvement rates for the UK excluding Scotland are then applied to these base year mortality rates to produce the projected mortality rates for each country.

4 . Principal assumption

The long-term rates of mortality improvement for the principal and variant projections were derived based on analysis of historical data and feedback from the National Population Projections (NPP) Mortality Expert Advisory Panel. The expert panel provided views on the anticipated impacts on future life expectancy of a range of factors, as well as projections of life expectancy in 2047.

For the principal projection, the long-term rate of annual mortality improvement for the UK for 2047, for both males and females aged 0 to 90 years, is 1.1%. This is then reduced linearly between the ages of 91 to 109 years, from 1.1% to 0%, and the long-term improvement rate is 0% for those aged 110 years and over. Rates of mortality improvement remain constant at the long-term rate by age and sex beyond 2047, and are assumed to be the same for England, Wales, Scotland and Northern Ireland.

The long-term mortality improvement rate in the principal projection is slightly lower than the 1.2% annual mortality improvement rate assumed at most ages for projections since the 2010-based NPPs. This reflects that mortality improvements have been consistently slower for more than 10 years, averaging around 0.8% per year for people aged 20 to 79 years in the UK during the 2010s.

The long-term improvement rate is in line with an average 1.1% long-term improvement rate proposed by the members of the expert panel for people aged 20 to 89 years. However, there remains considerable uncertainty about the prospects for improvement rates in the long term and the expert panel noted that these may remain slow at certain ages, or improvements may increase again, through better access to medical advancements or changes to health and social care policy.

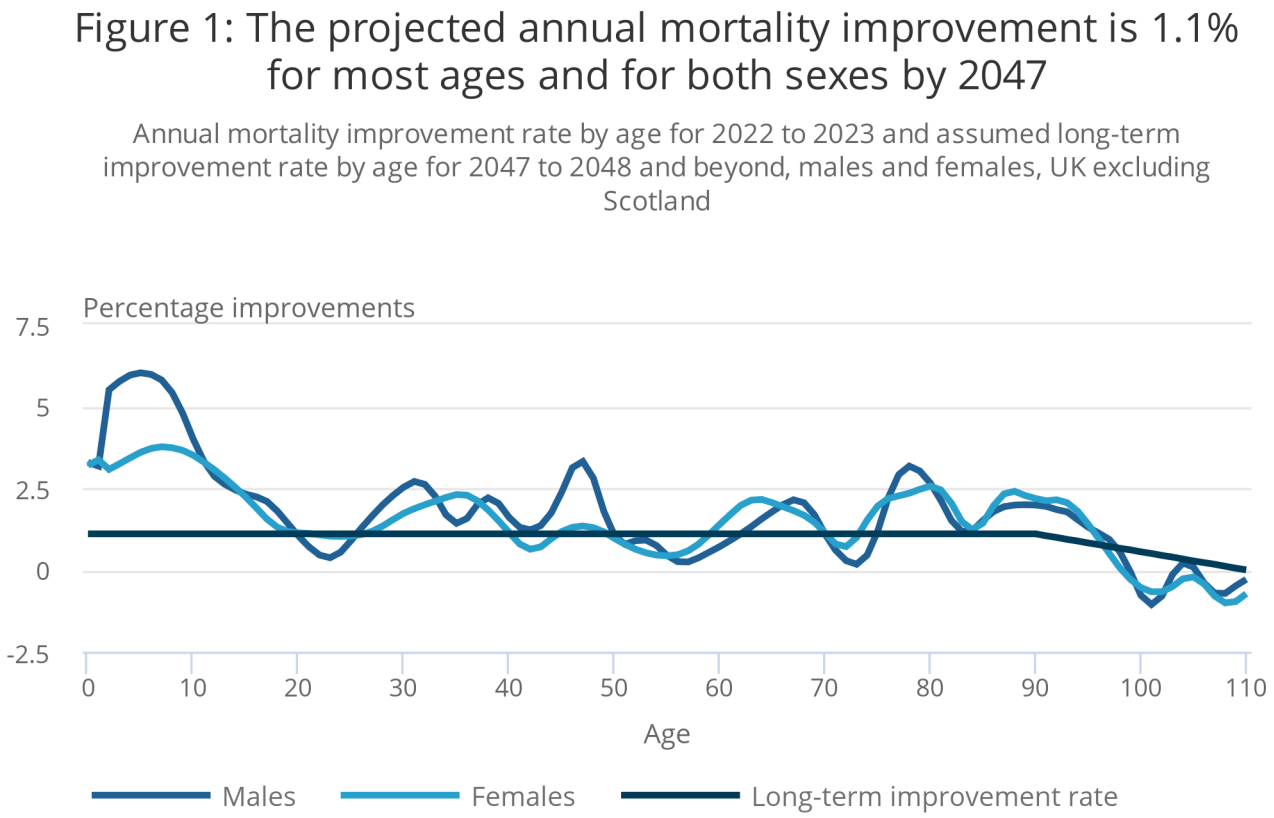
The NPP Mortality Expert Advisory Panel indicated that we should treat 2020 and 2021 as shock years when running the projection. Based on a high-level analysis of age-standardised mortality rates (ASMRs) for the UK, we applied a small cumulative shock recovery (0.1) for males and females and for all geographies, accumulating evenly over the first five years of the projection. This adjustment only has a small impact on projected life expectancies compared with a no-shock recovery scenario. The length of the period of recovery only affects mortality rates in the five-year recovery period and has no impact on mortality rates beyond this. More information on the calculation of the shock recovery is available on request from projections@ons.gov.uk.

Principal assumption of mortality improvement

Figures 1 and 2 show the annual mortality improvement rate by age for males and females in the base year 2022 to 2023 for the UK excluding Scotland and for Scotland, set against the long-term rate of annual mortality improvement of 1.1% for 2047 to 2048 onwards.

Figure 1: The projected annual mortality improvement is 1.1% for most ages and for both sexes by 2047

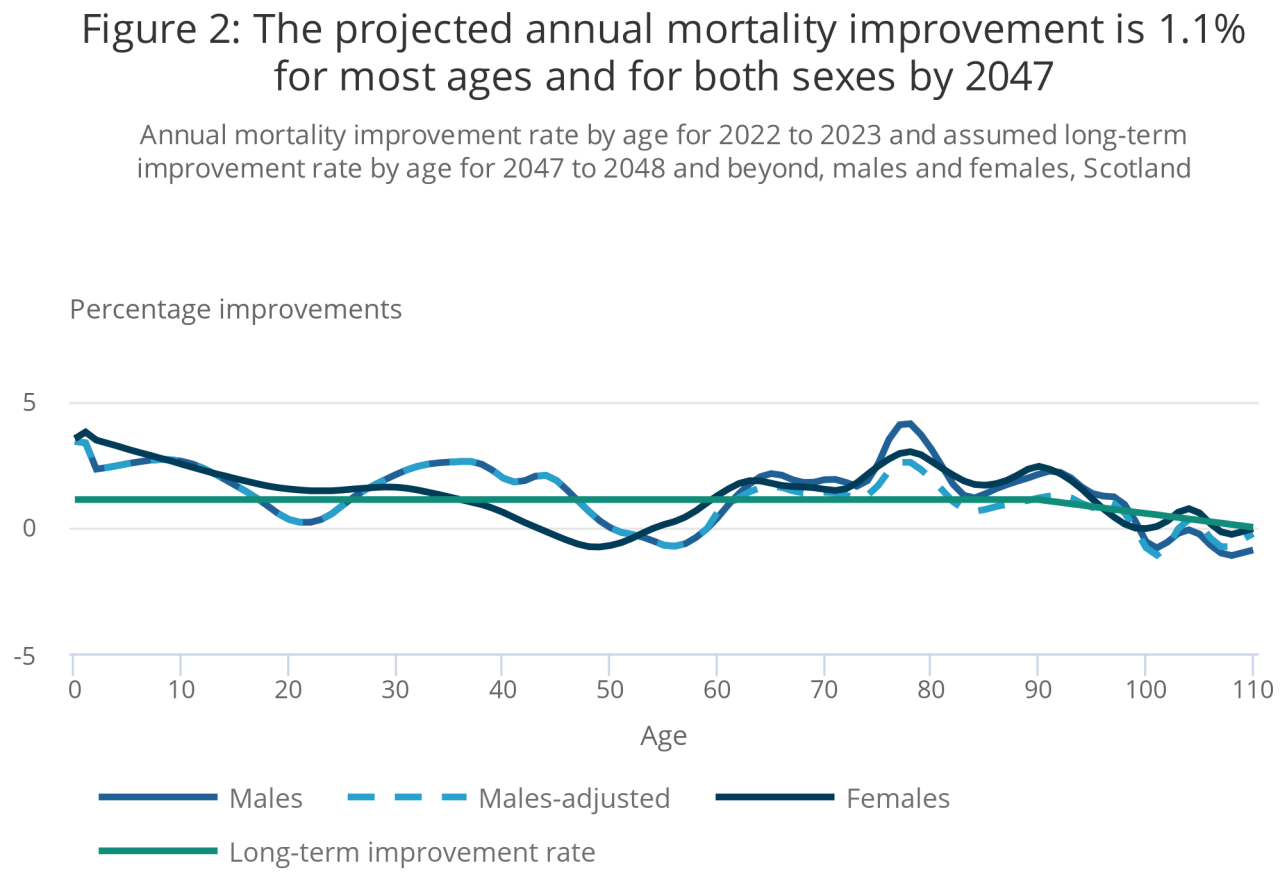
Annual mortality improvement rate by age for 2022 to 2023 and assumed long-term improvement rate by age for 2047 to 2048 and beyond, males and females, UK excluding Scotland



Source: Office for National Statistics

Figure 2: The projected annual mortality improvement is 1.1% for most ages and for both sexes by 2047

Annual mortality improvement rate by age for 2022 to 2023 and assumed long-term improvement rate by age for 2047 to 2048 and beyond, males and females, Scotland



Source: Office for National Statistics

Positive mortality improvements between 2022 and 2023 are projected for males and females at all ages up to age 100 years for the UK excluding Scotland, reducing to around 0% for the very oldest ages. Positive mortality improvements are also projected at most ages in Scotland up to age 100 years, with lower (occasionally negative) improvements projected for males and females in their 40s and 50s. Higher improvements are projected for males (and to a lesser extent females) in Scotland in their late 70s and early 80s.

Adjustment for males in Scotland

The model is projecting forward a strong cohort effect observed in the historical data for males (and to a much lesser extent females) in Scotland for those who are aged 75 to 80 years (that is, those born in the 1940s), resulting in very rapid projected improvements in mortality rates for these cohorts in the first years of the projection. This results in lower mortality rates for Scottish males at these ages, and therefore higher life expectancy at older ages, converging more quickly towards the values observed for males in the rest of the UK. The differential between male and female life expectancy in Scotland was also projected to reduce more quickly than might be expected.

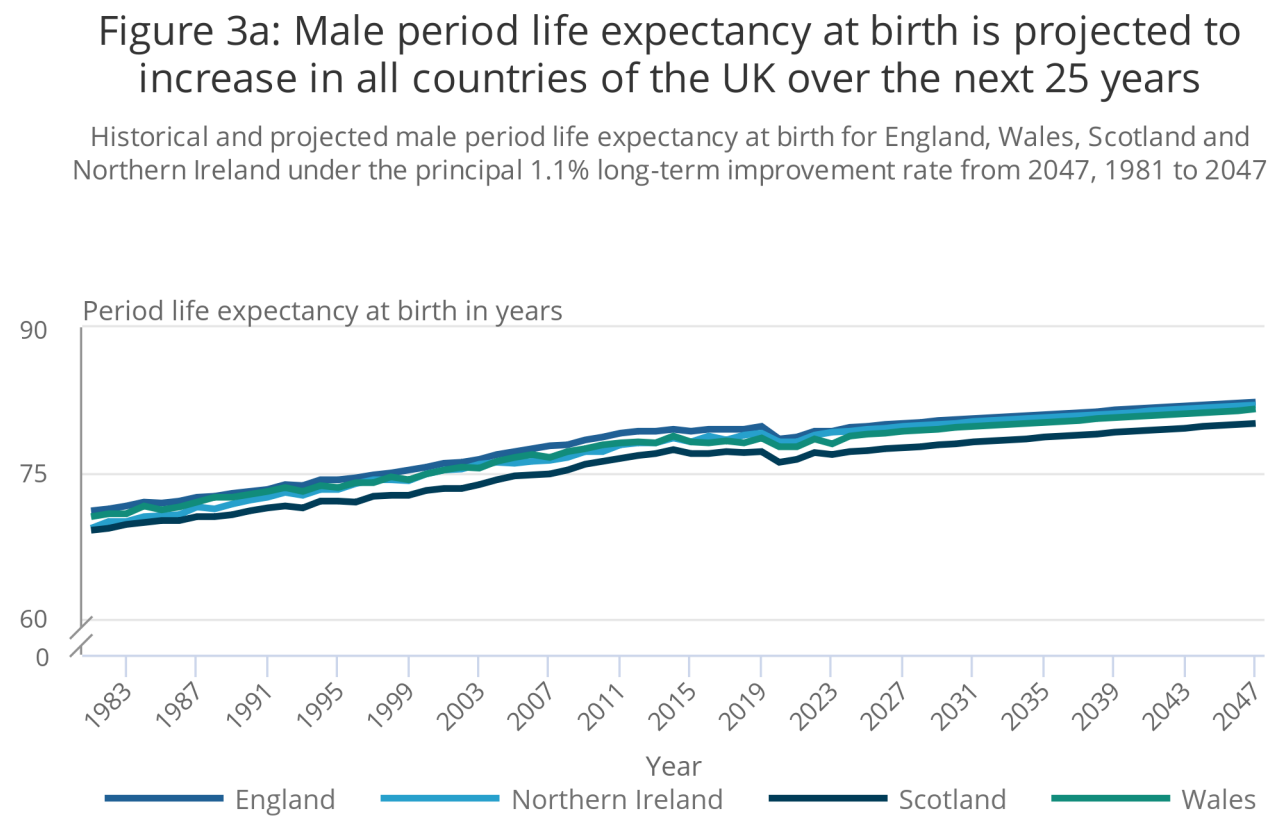
After seeking advice from the National Records of Scotland (NRS) and the Government Actuary's Department (GAD), we applied a post-modelling adjustment to the mortality improvements for Scottish males aged 60 years and over in the first five years of the projection. The adjustment still retains higher improvements for these cohorts but at a slightly reduced level. No adjustments are made for younger males or for females at any age. Further information on the adjustment is available from projections@ons.gov.uk.

Principal assumption for life expectancy

This section shows historical and projected period life expectancy at birth and at age 65 years for males and females in the UK constituent countries based on the principal mortality assumptions for the 2022-based projections.

Figure 3a: Male period life expectancy at birth is projected to increase in all countries of the UK over the next 25 years

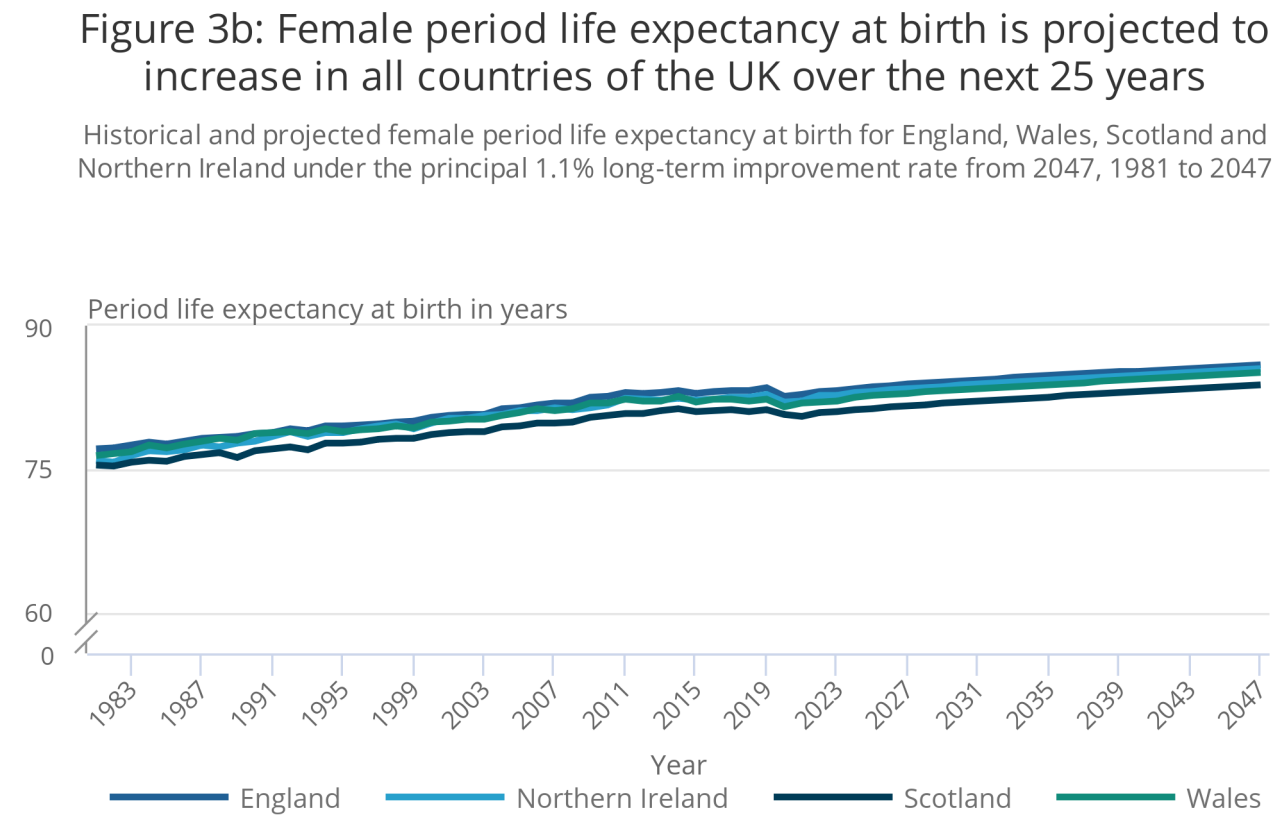
Historical and projected male period life expectancy at birth for England, Wales, Scotland and Northern Ireland under the principal 1.1% long-term improvement rate from 2047, 1981 to 2047



Source: Office for National Statistics

Figure 3b: Female period life expectancy at birth is projected to increase in all countries of the UK over the next 25 years

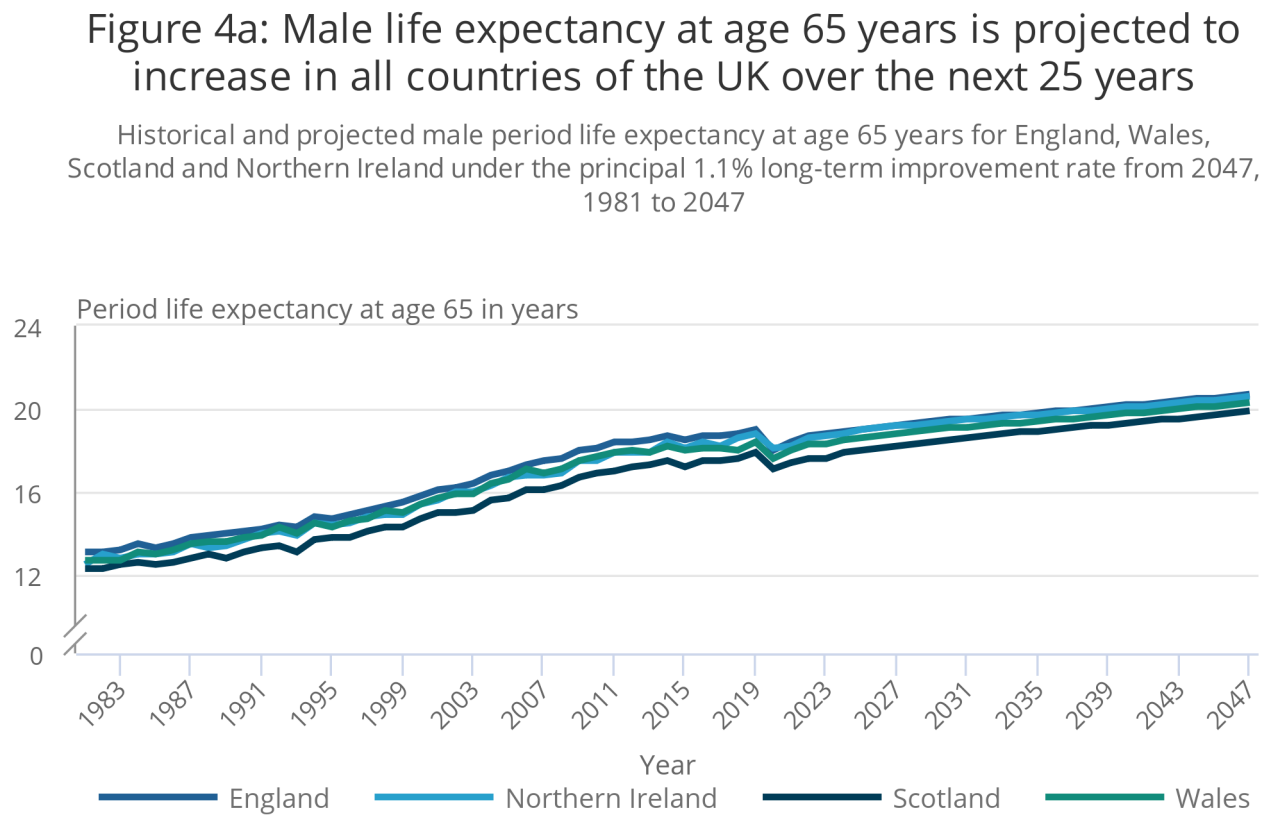
Historical and projected female period life expectancy at birth for England, Wales, Scotland and Northern Ireland under the principal 1.1% long-term improvement rate from 2047, 1981 to 2047



Source: Office for National Statistics

Figure 4a: Male life expectancy at age 65 years is projected to increase in all countries of the UK over the next 25 years

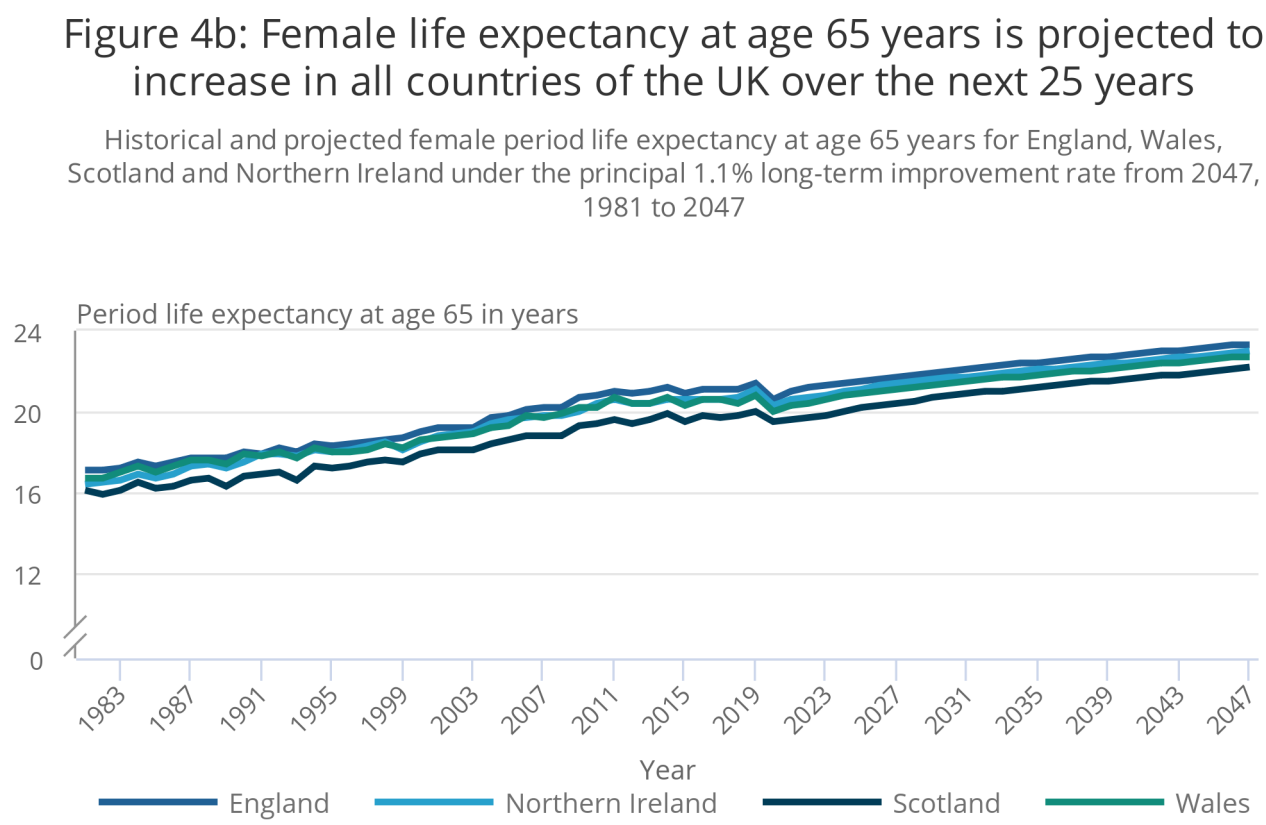
Historical and projected male period life expectancy at age 65 years for England, Wales, Scotland and Northern Ireland under the principal 1.1% long-term improvement rate from 2047, 1981 to 2047



Source: Office for National Statistics

Figure 4b: Female life expectancy at age 65 years is projected to increase in all countries of the UK over the next 25 years

Historical and projected female period life expectancy at age 65 years for England, Wales, Scotland and Northern Ireland under the principal 1.1% long-term improvement rate from 2047, 1981 to 2047



Source: Office for National Statistics

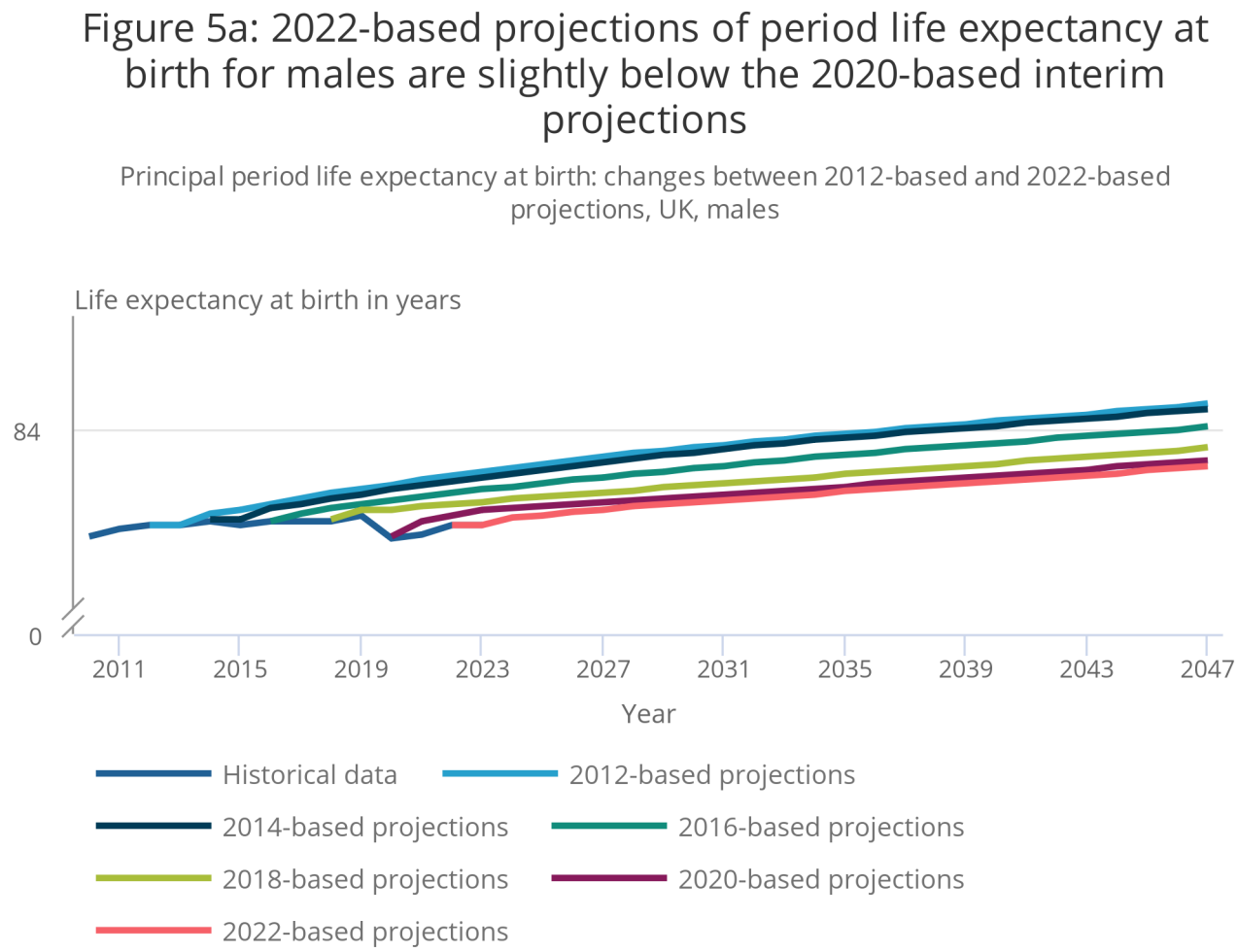
Figures 3a, 3b, 4a and 4b show that period life expectancy at birth and at age 65 years is projected to increase from current levels under the principal 1.1% long-term improvement rate for the constituent countries of the UK for both males and females. Life expectancy is projected to remain highest in England and lowest in Scotland. Life expectancy for Northern Ireland is projected to be slightly higher than for Wales. Projected life expectancies for England, Northern Ireland and Wales are more similar for males than for females.

5 . Comparisons with previous projections of life expectancy

This section compares projections of period life expectancy at birth for the UK from the 2022-based national population projections (NPPs) with the same measure from the most recent previous NPPs and observed historical data.

Figure 5a: 2022-based projections of period life expectancy at birth for males are slightly below the 2020-based interim projections

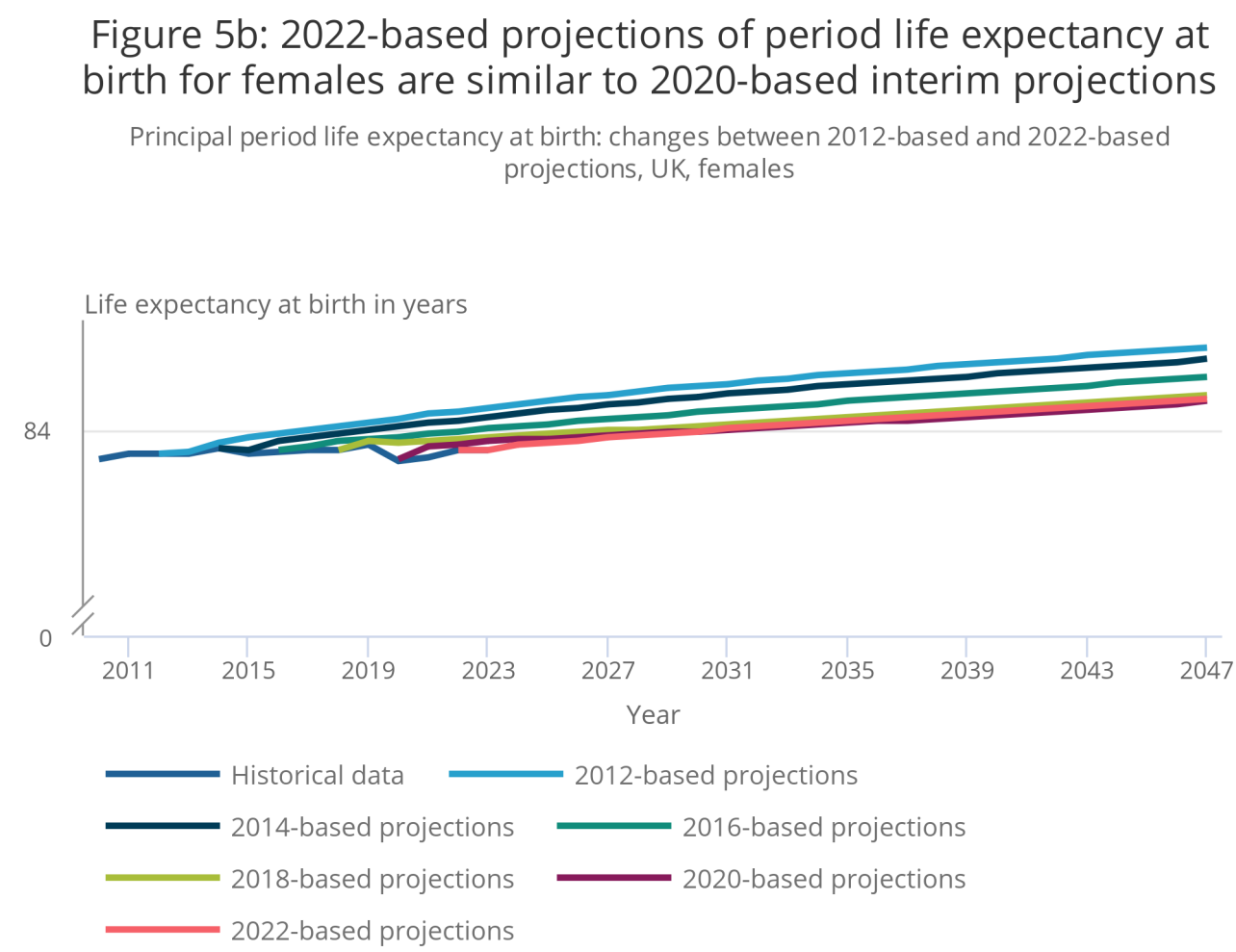
Principal period life expectancy at birth: changes between 2012-based and 2022-based projections, UK, males



Source: Office for National Statistics

Figure 5b: 2022-based projections of period life expectancy at birth for females are similar to 2020-based interim projections

Principal period life expectancy at birth: changes between 2012-based and 2022-based projections, UK, females



Source: Office for National Statistics

Figures 5a and 5b show that lower life expectancies have been projected in successive sets of projections since the 2012-based projections, reflecting the slower increases in life expectancy observed in recent years. The impact of the coronavirus (COVID-19) pandemic is seen in the drop in period life expectancy observed in 2020.

For males, the 2022-based projected period life expectancy at birth is lower than the 2020-based interim projections.

For females, the 2022-based projected period life expectancy at birth is initially lower than the 2020-based interim projection, before rising slightly above the 2020-based interim projection in 2031. In the longer term (not shown on this chart) the 2022-based life expectancy at birth for females goes below the 2020-based life expectancy, primarily because of the lower long-term improvement rate in the 2022-based projection.

Table 1 shows 2022-based projections of period life expectancy at birth and at age 65 years for the UK and its constituent countries 25 years from the base year, and how much these projections have changed from our 2020-based interim NPPs.

Table 1: Life expectancy at birth and at age 65 years in 2047
2022-based principal projection of period life expectancy at birth and at age 65 years compared with 2020-based interim principal projection, UK and UK constituent countries, 2047

	Males				Females			
	Age 0		Age 65		Age 0		Age 65	
	2022-based LE	Change over 2020-based projection	2022-based LE	Change over 2020-based projection	2022-based LE	Change over 2020-based projection	2022-based LE	Change over 2020-based projection
UK	82.07	-0.34	20.58	-0.21	85.66	0.11	23.15	0.25
England	82.31	-0.39	20.7	-0.25	85.92	0.09	23.32	0.23
Wales	81.56	-0.11	20.3	-0.05	85.05	0.09	22.73	0.19
Scotland	80.12	-0.27	19.86	-0.02	83.82	0.17	22.15	0.48
Northern Ireland	82.01	0.1	20.6	0.11	85.47	0.33	22.97	0.35

Source: Office for National Statistics

Notes

1. LE means life expectancy, and it refers to number of years a person is expected to live from a given age.

For males, the 2022-based principal projection is producing lower projected life expectancies at birth and at age 65 years in 2047 than the 2020-based interim projection, except for males in Northern Ireland.

For females, the 2022-based principal projection produces slightly higher projections of life expectancy at birth and at age 65 years in 2047.

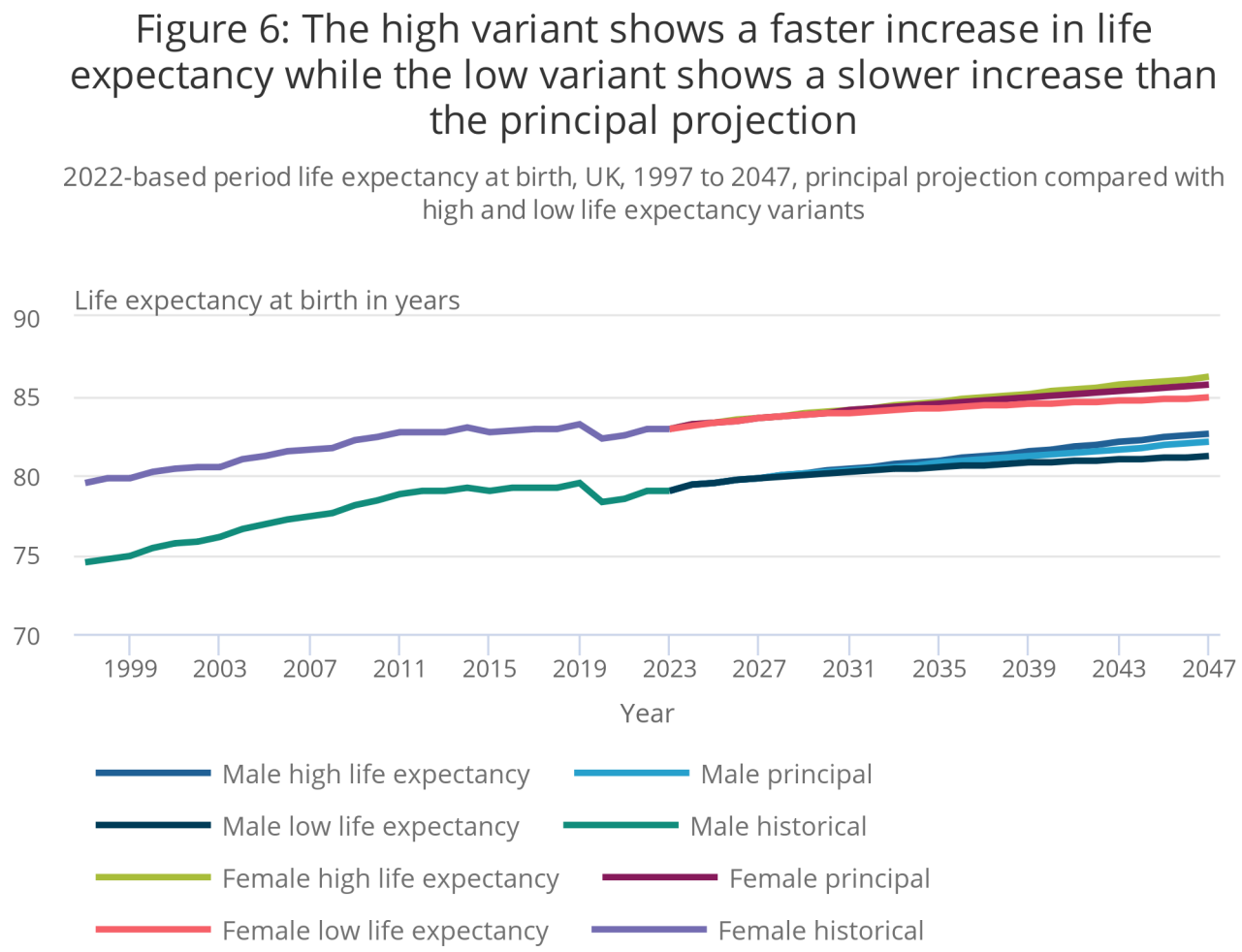
6 . Assumptions for mortality variants

Variant projections illustrate how life expectancy might change under different future demographic scenarios. For example, the low life expectancy variant assumes lower levels of annual mortality improvement and results in lower projected life expectancies over the projection period.

Figure 6 shows historical and projected period life expectancy at birth for males and females in the UK from 1997 to 2047 using the principal and variant assumptions from 2022 to 2047.

Figure 6: The high variant shows a faster increase in life expectancy while the low variant shows a slower increase than the principal projection

2022-based period life expectancy at birth, UK, 1997 to 2047, principal projection compared with high and low life expectancy variants



Source: Office for National Statistics

To produce the variant assumptions, it is assumed that the mortality improvements will converge to specific long-term rates at most ages and for both sexes by 2047 and will continue at these rates in all subsequent years.

The variant projections assume all other assumptions apart from the long-term improvement rate are the same as for the principal projection. The long-term rate assumptions for the variant mortality projections for the UK and its constituent countries are as follows:

- high life expectancy variant: long-term improvement rate of 1.5% for males and females aged 0 to 90 years, reducing linearly between ages 91 and 110 years to 0% for ages 110 years and over

- low life expectancy variant: long-term improvement rate of 0.5% for males and females aged 0 to 90 years, reducing linearly between ages 91 and 110 years to 0% for ages 110 years and over

- no long-term improvement variant: long-term improvement rate of 0% for males and females for all ages starting in 2047

The previous high life expectancy variant for the 2018-based projections used a 1.9% long-term improvement rate. We have reduced this to 1.5% for the 2022-based projections to bring it more in line with average observed improvement rates; 1.5% is the approximate average improvement rate for males and females aged 20 to 79 years for 1980 to 2019 for the UK. It is consistent with the advice of the NPP mortality expert advisory panel for the high life expectancy variant for ages 20 to 79 years.

The previous low life expectancy variant used in the 2018-based projections had a 0% long-term improvement rate. Although mortality improvements have slowed considerably in the last 10 to 15 years, we have still seen small improvements at most ages (averaging around 0.8% per year for people aged 20 to 79 years in the UK). For people aged 90 years and over, improvements have been closer to 0%. The NPP Mortality Expert Advisory Panel suggested an average low life expectancy variant of 0.7% to 0.8% for people aged 20 to 79 years and 0% for people aged 90 years and over. We have therefore produced a 0.5% low life expectancy variant, reducing linearly to 0% at ages over 90 years, reflecting a plausible low value for long-term mortality improvements.

We have also produced a no long-term improvement variant to model a scenario where mortality improvement stalls completely in the long term. The no long-term improvement variant applies a 0% annual improvement rate from 2047 and is equivalent to the low life expectancy variant from the 2018-based NPPs.

This differs from the “no improvement variant” applied in the 2018-based projections which applied a 0% annual mortality improvement from the base year. We have not produced an equivalent variant to this for the 2022-based projections following advice from expert advisory panel that this added little value as it is equivalent to keeping period life expectancy constant at the base year values.

7 . Related links

National life tables – life expectancy in England and Wales: 2021 to 2023
Bulletin | Released 23 October 2024
Trends in period life expectancy, a measure of the average number of years people will live beyond their current age, analysed by age and sex for England and Wales.

Past and projected period and cohort life tables, 2020-based, UK: 1981 to 2068
Bulletin | Released 12 January 2022
Life expectancy (e), probability of dying (q) and number of persons surviving (l) from the period and cohort life tables, using past and projected mortality data from the 2020-based interim national population projections (NPPs), for the UK and constituent countries.

Guide to interpreting past and projected period and cohort life tables
Methodology | Released 2 December 2019
Explanation and guidance on how to use the data published in the past and projected period and cohort life tables.

Life expectancy releases and their different uses
Article | Released 29 November 2022
The different life expectancy releases and their potential uses.

8 . Cite this methodology

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