PLSA Longevity Model

Guide to Scenarios

May 2018

Introduction

Welcome to our Guide to Scenarios, supporting our 2017 Longevity trends report. This document is intended to be read alongside both the Longevity trends report and the associated technical appendices, which give more detail of the underlying methodology[1].

In our report we set out eight diverse potential future health scenarios, in each case considering the projected evolution of life expectancy and the likely impact on liabilities.

The scenarios include a range of future outcomes, some which might be considered more central (i.e. what some might view as 'best estimates'), and others which result in relatively high or low improvements. Note that the extreme scenarios are not intended to reflect bounds of potential outcomes.

In order to generate the scenarios we calibrated the CMI Mortality Projections Model to pension scheme data, split by socio-economic group ('VitaSegments'). The CMI_2016 version of the model was used throughout (this version was first published alongside Working Paper 97 in March 2017).

This paper sets out further details of each of the scenarios, including the assumptions underpinning each case.

In some cases there are features required by the scenarios that cannot readily be modelled in the CMI Model, and so additional adjustments were carried out separately. We also describe these adjustments.

In all cases, we compare the scenario to the PLSA 2017 model (the CMI_2016 model, calibrated to each VitaSegment, assuming a long term rate of 1.5% p.a., tapering above age 90 to 0% p.a. at age 120). This is a change from the Longevity trends report, which showed relative to CMI_2015, but we have received feedback that it would be clearer to show which scenarios gave 'high' or 'low' life expectancy projections.

The eight scenarios considered are:

Description	Type
C1: Low for Longer	'Central'
C2: Improvement Decline	'Central'
C3: Alzheimer's Wave	'Central'
C4: Health Cascade	'Central'
L1: Back to the Fifties	Extreme low
L2: Challenging Times	Low
H1: Cancer Revolution	High
H2: Extended Youth	Extreme high

On behalf of all the team we thank you for your interest in this research and we would be delighted to respond to any questions you may have.



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[1] See https://www.clubvita.co.uk/collaborative-research/trends

Reliances and Limitations

The Pensions and Lifetime Savings Association ("PLSA") and Club Vita LLP ("CV LLP") have provided, to the UK pensions industry as a whole, both: an understanding of how differently longevity has been improving for different groups of defined benefit ("DB") pensioners (such as those at different ends of the deprivation spectrum); and materials that pension schemes, and their advisors, can use in practice to better inform the assumptions that are adopted for longevity trends (together, the "Research").

The Research is based upon the PLSA and CV LLP's actuarial understanding of legislation and events as at May 2017 and therefore may be subject to change. The Research is the PLSA and CV LLP's understanding of how differently longevity has been improving for different groups of DB pensioners and is not, nor is it intended to be, specific to the circumstances of any particular pension scheme.

The information contained herein is therefore not to be construed as advice and should not be considered a substitute for specific advice in relation to individual circumstances. Where the subject of the Research refers to legal matters please note that neither the PLSA nor CV LLP are qualified to give legal advice therefore we recommend that you seek legal advice. Neither the PLSA nor CV LLP (nor their respective licensors) accept liability for errors or omissions in the Research and neither the PLSA nor CV LLP (nor their respective licensors) owe nor shall accept any duty, liability or responsibility in regards the use of the Research except where we have agreed to do so in writing.

If you are seeking to use the information contained in the Research some time after the date it was produced then please be aware that the information may be out of date and therefore inaccurate. Please consult the PLSA and Club Vita websites for updates or contact enquiries@clubvita.co.uk

We recommend that you speak with your appointed longevity consultant and/or other professional advisers should you have any queries in relation to applying the Research findings within your scheme. Alternatively please contact Joe Dabrowski, Head of Governance & Investment of the PLSA at joe.dabrowski@plsa.co.uk or Steven Baxter of Club Vita LLP at steven.baxter@clubvita.co.uk, who will be pleased to discuss any of the issues highlighted by this research in greater detail.

Contents

1 Data underpinning our analysis

In this section we discuss the individual member data underpinning our analysis. For more details of the data see the technical appendices[2].

1.1 Club Vita dataset

The Club Vita database (VitaBank) is a pool of data of individual pension scheme member records, submitted by over 200 participating occupational DB pension schemes. This database (as at February 2017) consists of nearly 6 million member records; including:

- Over 2.5 million pensioners and widow(er)s; and
- 1 million deaths.

The records collected include personal, but non-sensitive, information recorded by pension scheme administrators. This includes information relevant to predicting longevity, such as date of birth, sex, postcode, pension, final salary and retirement health.

We carry out a suite of checks on data received, designed to ensure the data for each pension scheme is as reliable as possible. This includes checks on both individual records and overall schemes, excluding records where necessary.

We also establish for each scheme the dates over which we believe we have a complete history of deaths, allowing for both the date before which we believe death records are incomplete (for example if historical death records were previously discarded) and the date after which there is a risk of deaths which are 'incurred but not reported'. We adjust the period included for each scheme to only allow for complete years to avoid seasonal bias.

1.2 Making maximum use of available data

As noted above, the scheme data used in our analysis has undergone a thorough data quality control process to determine what data will be used in the onward analyses and ensure reliability of data. This is done both at the scheme level and at the covariate level (for example, a particular scheme may have reliable postcode data but suspect pension amounts).

Levels of 'unknown' covariates can be expected to increase as we go further back in time (due to having less stringent administration standards historically, records not being updated, etc.). These issues are more likely to affect deaths (i.e. higher levels of unknowns), so there is the possibility that we could be biasing the results by excluding more deaths relative to living pensioners in a given calendar year.

At a scheme level, the proportions of 'unknowns' is again likely to increase as we go back in time, until, in some cases, reaching the exclusion 'trigger' level – the point in time before which no exposures are included.

There is, therefore, a growing risk of understating rates of mortality historically (if we exclude more deaths than lives, we are reducing the mortality rate). This will have a knock on effect on mortality improvements, which will again be lower than their 'true' level.

We have sought to overcome this issue, and maximise the available data, without compromising on overall data quality, by reallocating 'unknown' data, using the same process as in our 2014 analysis. For more details see our original technical appendices[3].

The impact on our results of this reallocation approach is relatively small (increasing the total exposure allocated to our groups by 4-5%). However

[2] See https://www.clubvita.co.uk/collaborative-research/trends

[3] See https://www.clubvita.co.uk/collaborative-research/longevity-model

we can be confident that we have removed a possible area of bias in our analysis of historical improvements.

1.3 Data extract used in this analysis

1.3.1 Exposed to risk & deaths

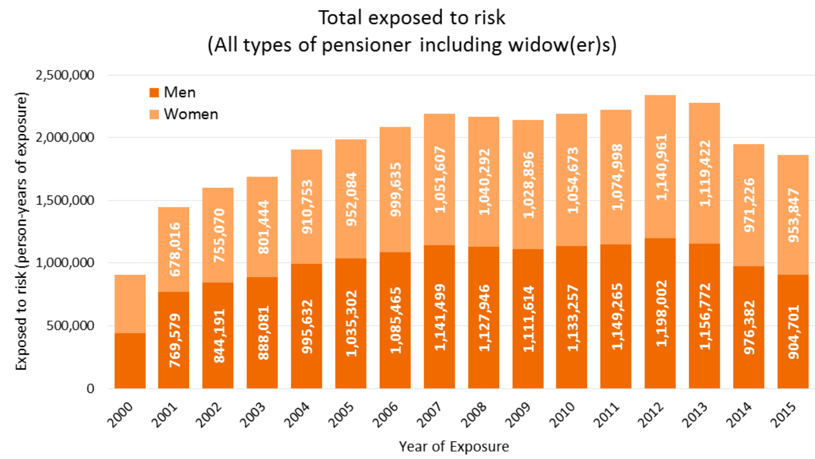
The charts (right) show the pattern of (pensioner and dependant) 'exposed to risk'[4] and deaths over time for men (dark orange bars) and women (light orange bars) within the data analysed in our report.

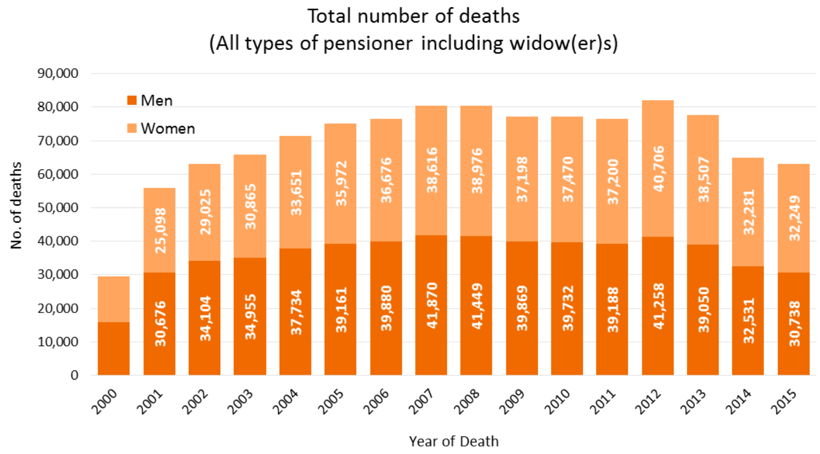
We can see how:

- The exposures increase over time reflecting
  - schemes within the Club having reliable data starting at different points in time due to historical administration practices; and
  - the maturation of pension schemes leading to larger numbers of pensioners
- There is a step-up in 2001 – the point at which a number of the larger schemes first have reliable data.
- The deaths follow a similar pattern to the exposed to risk.

We have seen more than a 10% increase in overall data volume since our first Longevity Model report was published in 2014.

However, as a result of the quality checks discussed in Section 1.1, not all of the data shown here was used in the analysis presented in this paper. In practice we use around 65% of the data shown here in the analysis.

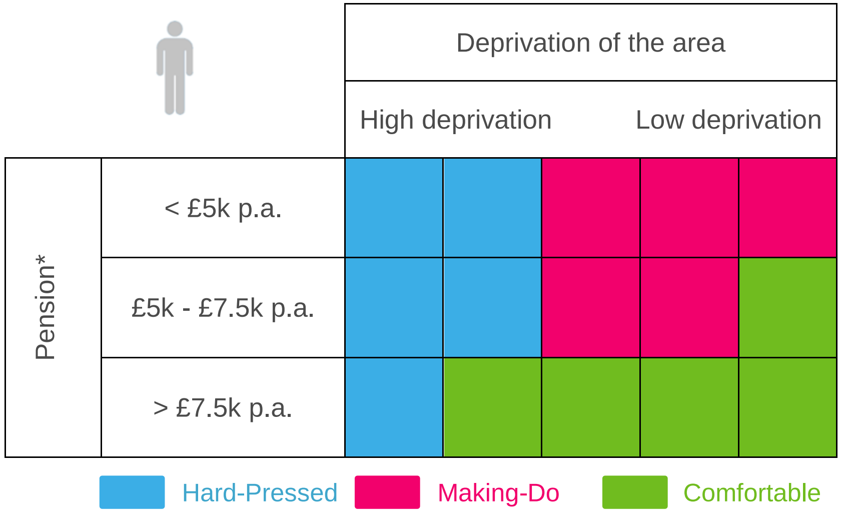


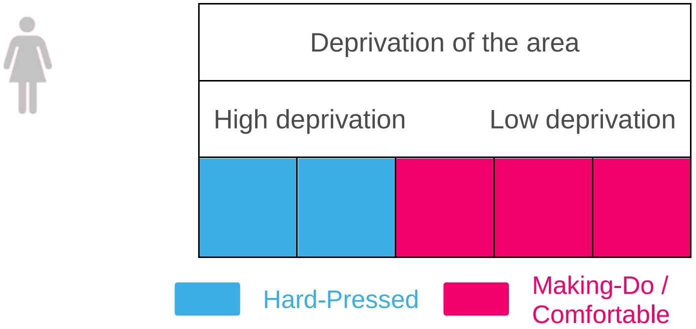


[4] Broadly speaking a measure of the number of lives in each year, but adjusted to allow for the fact that some individuals were only in the analysis for part of that year. As such, exposed to risk is typically slightly lower than a lives count.

2 Our socio-economic groups (VitaSegments)

For our analysis we generated 3 (2 for women) distinct socio-economic groups (VitaSegments), based on a combination of (adjusted) IMD quintile and (for men) pension band.





* In 2010 monetary terms

Group	Characterisation
Hard-Pressed	Living in more deprived areas and generally with lower levels of retirement income.
Making-Do	Modest retirement income levels and living in areas of average to low levels of deprivation.
Comfortable	Higher levels of retirement income (over £7,500 p.a. unless living in the least deprived 20% parts of the UK when this can be reduced to £5,000 p.a.). This group naturally includes some pensioners with retirement incomes much higher than £7,500 p.a.

For more for more details on the methods used to create these socio-economic groups, see our technical appendices[5].

[5] See https://www.clubvita.co.uk/collaborative-research/trends

3 Calibrating CMI_2016 to VitaSegments

For our scenarios, we have calibrated the CMI_2016 mortality projections model to pension scheme data, subdivided into the socio-economic groups (VitaSegments) set out in Section 2. In doing so we make a number of adjustments to the parameters of the CMI_2016 model.

3.1 Deriving initial rates of improvement

3.1.1 Data range used

The core setup of the CMI_2016 model is calibrated to (England & Wales) population data, using ages 20 to 100 and calendar years 1976 to 2016. When fitting to pension scheme data we use an age range of 60 to 95 (inclusive) and calendar years 1993 to 2015 (inclusive).

Above age 95, historical improvements are assumed to taper to 0% p.a. at age 110 (the same age as the core model).

3.1.2 Constraint on cohort component

The cohort component is constrained to be 0% at ages 60 and below (the core model uses age 30). The CMI model requires that this value must be no lower than the lower bound of the data set used to calibrate the model.

3.1.3 Smoothing parameter

A key parameter of the CMI_2016 model is the level of smoothing that is applied in the period dimension. This reflects a general belief that period effects (the component of improvement due to the individual year, applying to all ages) are a key contributor to year on year improvements, rather than variations from year to year just due to seasonal volatility.

For many of the scenarios (but not all) we have chosen to adjust the period smoothing parameter (referred to in the CMI_2016 model as S_κ) to a value of 6 (from a core value of 7.5). This has the effect of applying 'less' smoothing in the period dimension, and so picks up more of the recent decline in improvement rates.

The use of a lower smoothing parameter captures some element of a period effect when calibrating to VitaSegments. Note however that the underlying pension scheme data does not readily suggest that there are strong period effects, and so this choice is purely to reflect some element of period effect.

3.2 Projecting into the future

3.2.1 Long term rate

The long term rate (in both the age/period and cohort dimensions) adopted for each scenario is set out in the description of the scenario. In some cases the assumption varies across VitaSegments.

In addition, we also specify the age range over which the long term rate declines linearly to 0% p.a. for each scenario.

3.2.2 Shape of transition from initial to long term rates

The CMI model allows users to adjust the shape of the transition from initial rates to long term rates by adjusting both the time taken and the proportion of the change from initial to long term that remains at the midpoint of the transition period.

Again for each scenario we set out our assumptions for these settings, in both age/period and cohort dimensions, in some cases varying by VitaSegment.

4 Central scenario C1: Low for Longer

4.1 Description

One suggestion is that changes in our approach to health and social care, driven by increasing demand and reduced resources in times of austerity, may be influencing recent longevity experience. It is next to impossible to find evidence of a direct relationship, or establish causality. However, there is an increasing body of circumstantial evidence which is difficult to ignore[6].

It remains to be seen how long it will take for any impacts of austerity to be fully felt (to the extent that this is yet to be the case) and whether 'Brexit' will lead to further tough economic decisions, or be a stimulus for growth.

In this scenario we consider an eventuality where some combination of austerity, 'Brexit' and a generally poor economic outlook leads to a period of sustained lower economic growth, which acts to slow longevity improvements for a number of years.

We therefore assume that long term improvements are lower than typically assumed, particularly for the lower socio-economic groups, reflecting a slow-down in the level of sustainable improvements compared to the average over the last 60-70 years. We assume that this will impact the socio-economic groups differently, with the **Hard-Pressed** most impacted and seeing very modest improvements in life expectancy. In contrast the **Comfortable** group will continue to exhibit greater resilience, and so experience the greatest improvements.

Whilst this scenario focusses on the outcome for longevity, were the circumstances described to happen, there would likely be material impacts on pension schemes' investments and the outlook for gilt yields. Therefore this is a scenario that schemes may wish to use in combination with stressing their investment assumptions.

4.2 How we modelled this scenario

We applied different adjustments to the core parameters of the CMI_2016 model for each VitaSegment, as follows:

Hard-Pressed 40% of change remaining at mid-point for both age-period and cohort elements (ensuring improvement rates drop more quickly in the short term towards the long term rate).

Long term rate of 0.75% p.a. (in age-period dimension).

Making-Do 40% of change remaining at mid-point for both age-period and cohort elements.

Long term rate of 1.0% p.a. (in age-period dimension).

Comfortable 50% of change remaining at mid-point for both age-period and cohort elements (i.e. core parameters)

Long term rate of 1.25% p.a. (in age-period dimension).

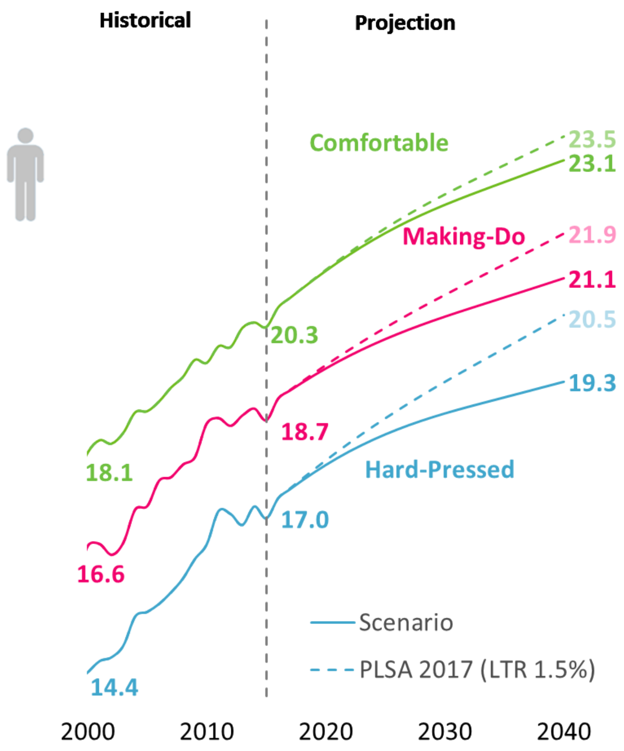
In each case the long term rate is assumed to tail off above age 85 to 0% p.a. for ages 110 and above (i.e. in line with the CMI model's core parameter).

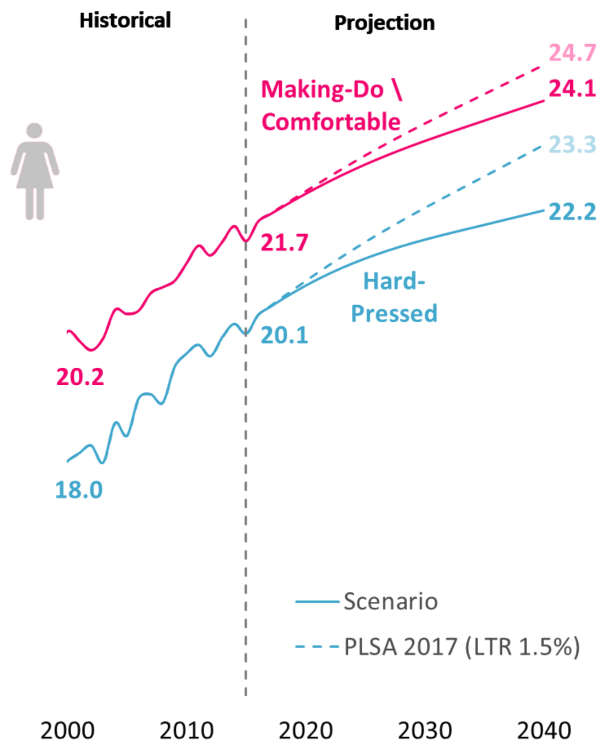
For the female **Making-Do/Comfortable** group, we project the **Making-Do/Comfortable** initial rates using both the **Making-Do** and **Comfortable** set ups above, then, for each age/year, take the average of the two mortality improvements (in q_x) at that age/year.

[6] For example, see Hiam L, Harrison D, McKee M, et al. Why is life expectancy in England and Wales 'stalling'?. J Epidemiol Community Health 2018;72:404-408

4.3 Projecting life expectancy under the scenario

The following charts show the pace of longevity improvement implied by the scenario for each VitaSegment, looking at life expectancy at age 65. We have also shown for comparison how life expectancy would be assumed to evolve under the PLSA 2017 model (i.e. the CMI_2016 model, calibrated to each VitaSegment, assuming a long term rate of 1.5% p.a. for each VitaSegment, tapering above age 90 to 0% p.a. at age 120).





This scenario impacts differently on each VitaSegment. As expected, the **Comfortable** men are least impacted (due to the only change being to the long term rate), while the biggest impact of the scenario is felt by the **Hard-Pressed** group.

5 Central scenario C2: Improvement Decline

5.1 Description

In this scenario we assume improvements will decline over time, as the frequency and impact of medical advances diminish, coupled with rising obesity and other detrimental lifestyle factors. This means that the “golden cohort” of individuals born between the wars continues to exhibit faster improvements in longevity than those born either side.

The benefits of healthy behaviours (e.g. smoking cessation) and the introduction of the NHS are inherited by subsequent generations. However you can only give up smoking once. For subsequent generations medical advances, and benefits of health interventions such as screening, provide a driver for some continued improvements, but the behaviours and lifestyle of younger cohorts throughout their life course are assumed to result in longevity improvements slowing almost to stagnation.

Specifically, long term improvements for the post WWII birth generations drop to around ¾ year per decade (compared to the long run historic average of around 1 year per decade)

5.2 How we modelled this scenario

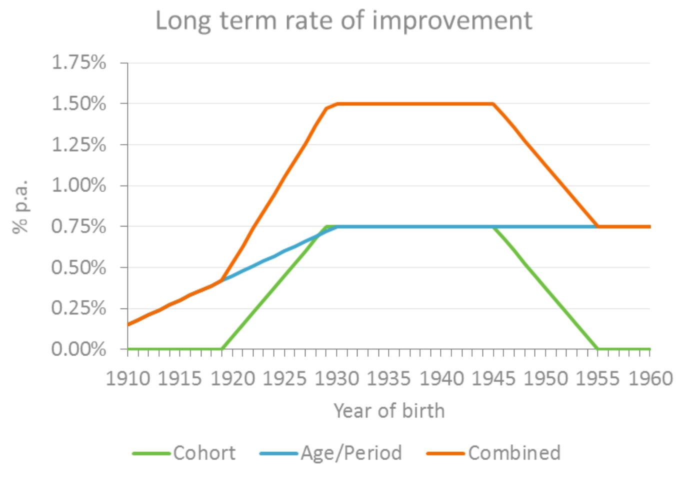
In terms of the CMI_2016 model, we have adjusted the assumed long-term rate of improvement as follows (with the same setup applied to each VitaSegment, with only the initial rates varying):

- Age-period long term rate set to 0.75% p.a., with this rate declining above age 85 to 0% p.a. at 110 and above.
- Cohort long term rate
  - 0% p.a. for cohorts born before 1920 and after 1954;
  - 0.75% p.a. for cohorts born between 1929 and 1945 (inclusive);
  - Moving linearly between 0% p.a. and 0.75% p.a. for cohorts born between 1920 and 1928 and between 1946 and 1954

Under this parameterisation, the combined long-term rate (allowing for both age-period and cohort elements) equals 1.5% p.a. for cohorts born between 1930 and 1945 (so aged 70 to 85 in 2015) (inclusive), becoming gradually lower for all other birth cohorts, with a minimum of 0.75% p.a. for the cohorts born after 1954.

Note that as the convergence periods vary between age-period and cohort components for a given age/birth year, altering the balance of long term rates between components will alter the shape of projected improvements.

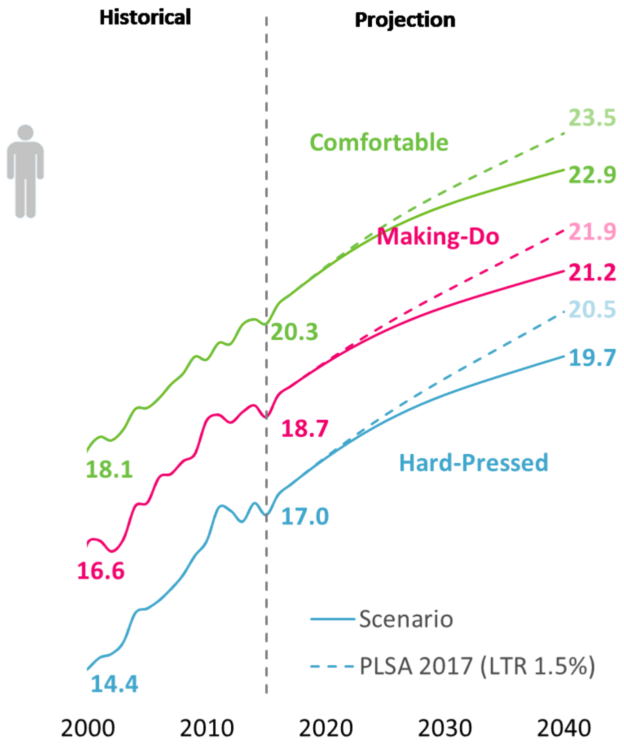
The assumed long term rates (based on age in 2015) are summarised in the chart below.

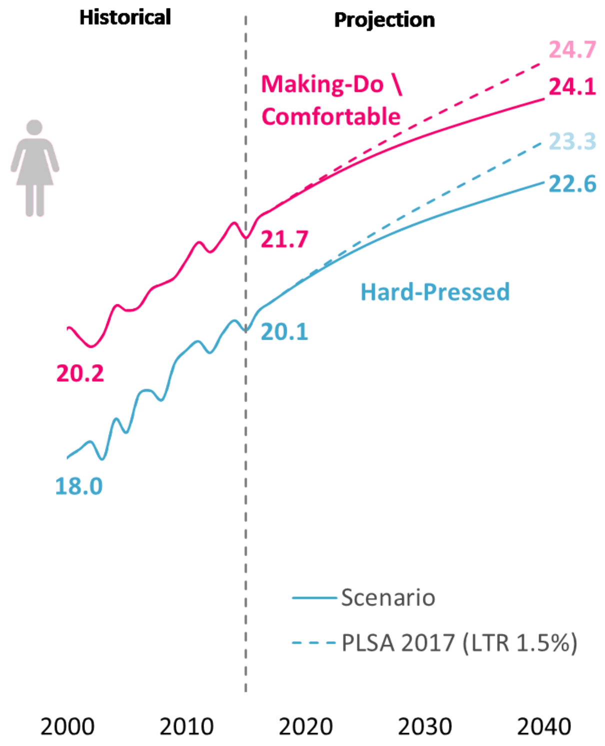


Age-period long term rate shown is based on age in 2015, and tails off above age 85

5.3 Projecting life expectancy under the scenario

The following charts show the pace of longevity improvement implied by the scenario for each VitaSegment, looking at life expectancy at age 65. Again we have also shown how life expectancy is assumed to evolve under the PLSA 2017 model (i.e. the CMI_2016 model, calibrated to each VitaSegment, assuming a long term rate of 1.5% p.a. for each VitaSegment, tapering above age 90 to 0% p.a. at age 120).





This scenario has similar impacts on each VitaSegment. Note that given the cohort based structure of the scenario, the impact on a scheme level will vary depending on the age profile of the scheme, with those currently below 70 seeing a more material impact.

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6 Central scenario C3: Alzheimer's Wave

6.1 Description

The past few years has seen a marked increase in death rates attributed to dementia and Alzheimer's disease. While some of this is due to factors such as recoding of deaths[7], diagnosis incentives[8], as well as an aging population, there does not appear to be a corresponding drop in other causes of death.

Under this scenario we explore the situation where deaths attributed to Alzheimer's and dementia continue to increase in the short term, before declining, so follow a 'humped' shape. A similar picture has been seen historically with cardiovascular disease, and is plausible in the same sense that, as one cause of death is targeted, another typically rises in prominence, which then becomes the focus of attention.

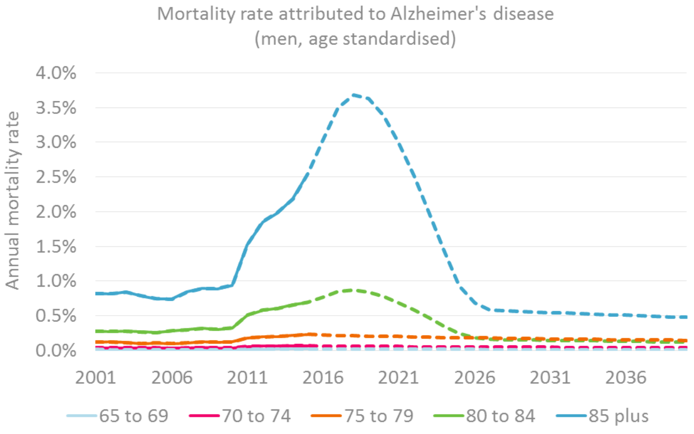
The hump could be due to a combination of lifestyle and dietary changes (both believed to have links to Alzheimer's and dementia) and medical interventions. For example, the second most common type of dementia is vascular dementia; some experts believe that this will naturally fall as the generation who generally have better cardiovascular health enter the older population.

6.2 How we modelled this scenario

We derived age standardised mortality rates (separately for men and women) for each cause of death, for the period up to 2015, using cause of death data for England & Wales, as published by the World Health Organisation[9]. The age standardisation process used the ONS population projection data for the UK in 2008 as a reference population, separately for men and women[10].

As shown below, we fitted a cubic polynomial 'hump' to the mortality rates for Alzheimer's and dementia, which assumed a short term continuation of the recent upwards trend, followed by a more rapid deceleration in mortality rates.

In the longer term, by around 2025, it was assumed that deaths would fall to slightly below the level that they would have been at, had mortality rates in 2010 continued to fall in line with a 'base' scenario (core settings of the CMI 2016 model, with a long term rate of 1.5% p.a., applied to the initial rates of improvement derived for aggregate DB pension data).



[7] In 2011 the ONS changed the cause of death coding so deaths from vascular dementia were coded to dementia rather than cerebrovascular disease. Further changes in 2014 also increased the numbers of deaths attributed to dementia.

[8] GP practices received £55 per diagnosis from September 2014 to March 2015

[9] See http://www.who.int/healthinfo/mortality_data/en/

[10] Cause of death data was available in 5 year age bands up to 2014, but only in 10 year bands for 2015. We therefore allocated the data for 2015 into 5 year bands by assuming the same proportions across 10 year age bands as in 2014.

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On materiality grounds, this process was only applied to the 80-84 and 85+ bands (as mortality rates for younger ages are very low).

Mortality rates at younger ages, along with mortality rates for other causes of death, were assumed to improve in line with the 'base' scenario, as follows:

- for each 5 year age band, the improvement corresponding to the middle age of the band is used (e.g. age 62 for the 60 to 64 band);
- for the age 85+ band the improvements for age 90 are used; and
- for age bands below age 60, improvements assumed to be the same as for the 60-64 age band (i.e. age 62).

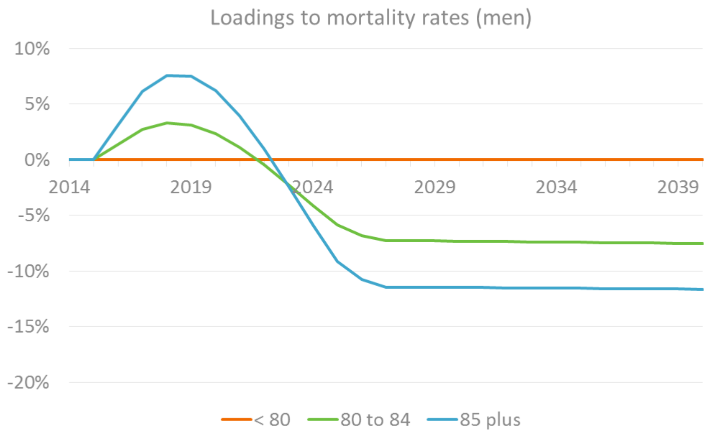
Total mortality rates for each age band were then derived by summing the projected mortality rates across each cause of death.

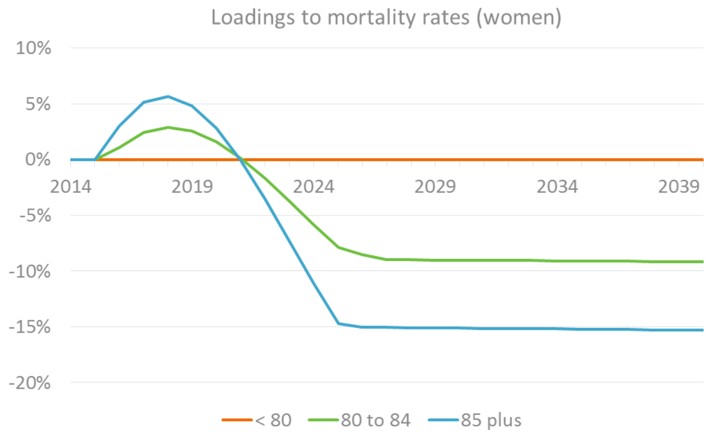
These projected mortality rates could then be compared with those generated by the 'base' scenario to obtain the loading factors to apply (to mortality rates) in each future calendar year (by age band).

The charts on the right summarise the resultant loadings, for men and women separately.

As expected, below age 80 the loadings are zero, while at older ages the loadings are positive in the short term (so will increase mortality rates and hence deaths) before becoming negative in the early 2020s, and stabilising as we approach the 2030s.

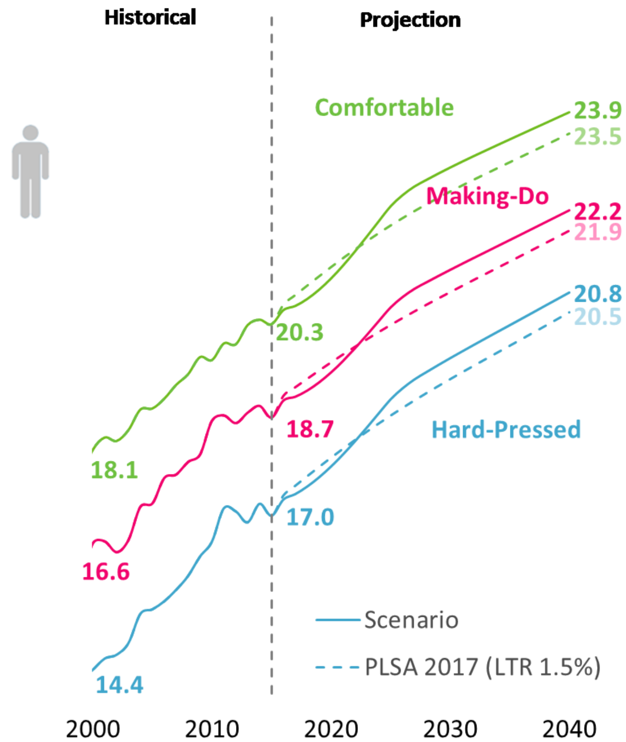
Note that the loadings are greater for women, as mortality rates attributed to Alzheimer's are higher for women than men.

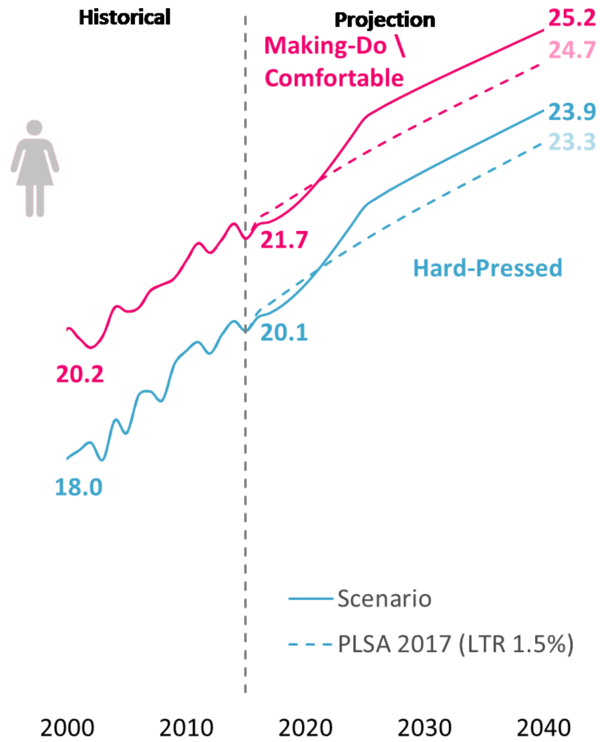




6.3 Projecting life expectancy under the scenario

The following charts show the pace of longevity improvement implied by the scenario for each VitaSegment, looking at life expectancy at age 65. Again we have also shown how life expectancy is assumed to evolve under the PLSA 2017 model (i.e. the CMI_2016 model, calibrated to each VitaSegment, assuming a long term rate of 1.5% p.a. for each VitaSegment, tapering above age 90 to 0% p.a. at age 120).





We can see how in the short term the impact of assumed increases in deaths from Alzheimer's disease acts to slow improvements in life expectancy. Over time as the effects of the 'cure' are felt, life expectancy increase more rapidly, before the rate of improvement stabilises in the longer term.

7 Central scenario C4: Health cascade

7.1 Description

Recent improvements in life expectancy for the 'golden cohort' (the generation born between the two world wars) are believed to be driven by a number of behavioural changes (such as smoking cessation) and medical interventions (including free access to medical care via the NHS).

A theory (supported by empirical data from the ONS on smoking cessation) is that uptake of such behaviours and services 'cascades' through society, with the most educated (our 'Comfortable' group) adopting the behaviours first and most fully. As the benefits of these behaviours become more evident so they 'cascade' through society.

This 'health cascade' is reflected in this scenario:

- In the immediate short term the pace of longevity improvements is highest for the Comfortable group, leading to continued divergence in life expectancy.
- Over the next 5-10 years the pattern reverts to convergence as any effects of austerity wane and the 'cascading' effect of lifestyle factors such as smoking cessation work through the Hard-Pressed and Making-Do groups.
- Over the longer term, new medical therapies / behavioural changes are likely to be accessed first by the Comfortable group, leading to a slightly faster reduction in their mortality, and so ultimately a return to divergence in life expectancy.

7.2 How we modelled this scenario

We used two distinct parameterisations of the CMI_2016 model:

- An '**Extended**' parameterisation[11] (with an Sκ value of 6, so less smoothing than core), with a long term rate of 1.5% p.a. for the Hard-Pressed and Making-Do groups, and 2.0% p.a. for Comfortable, in each case assuming this rate declines above 85 to 0% at 110.
- An **Alternative** basis with 'core' smoothing (Sκ value of 7.5) and:

Hard-Pressed & Making-Do[12]	75% of change remaining at mid-point for both age-period and cohort elements (ensuring some continued rise in improvements in the short term)
	50% addition to convergence periods for age-period and cohort elements, retaining maximum of 40 years (to ensure a gradual tail off to the long term rate)
	Long term rate of 1.5% p.a., declining above 90 to 0% at 120
Comfortable	50% of change remaining at mid-point for age-period and cohort elements (i.e. core parameters)
	Core convergence periods for age-period and cohort elements
	Long term rate of 2.0% p.a., declining above 90 to 0% at 120

For women the outcome for the Making-Do / Comfortable group is based on the average of the Making-Do and Comfortable scenarios above.

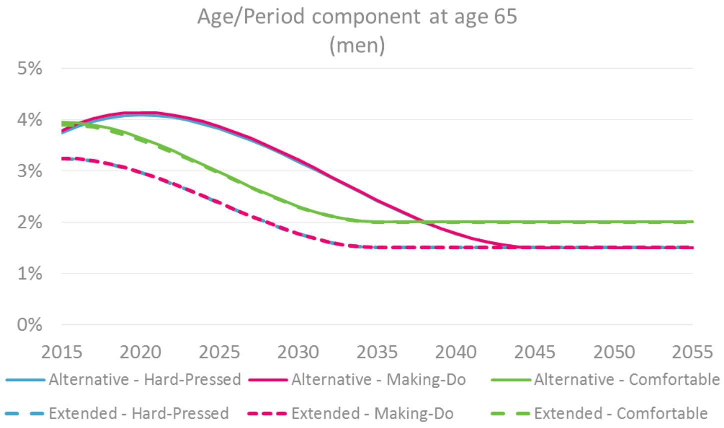
[11] The CMI introduced this option, which allows only the period smoothing parameter to be varied while other parameters are in line with core values, with CMI_2016

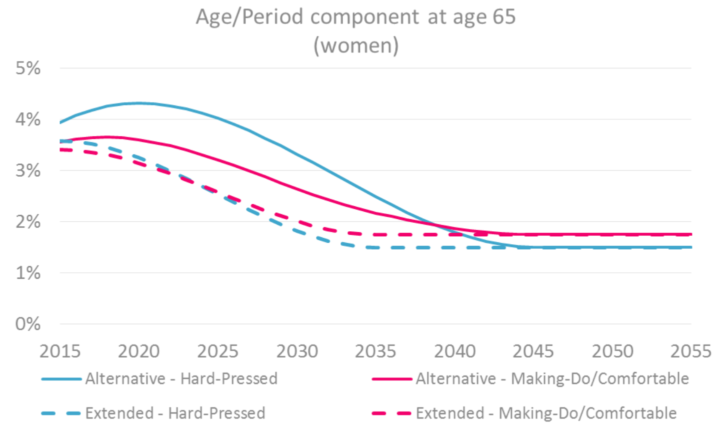
[12] Where the initial rate is below the long term rate for a particular age/birth year, we assume core settings for both proportion remaining and convergence period for that age/birth year

The projected age/period component for men and women at age 65 (for illustration) for these two bases are shown in the charts on the left below.

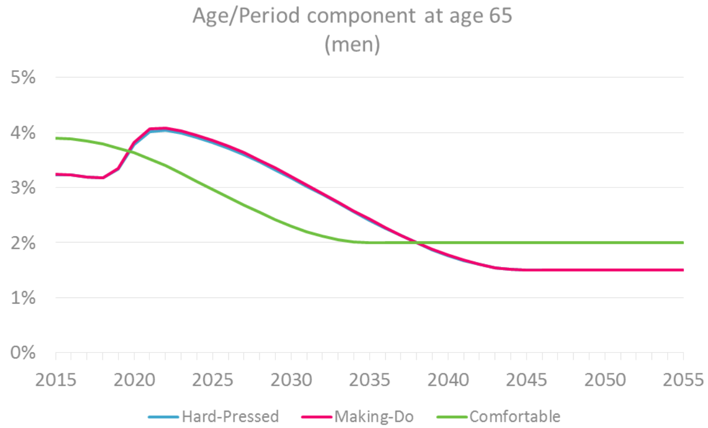
We then 'blend' improvements from the *extended* basis to the *alternative* over a 5 year period from 2018 (so fully on the *extended* basis in 2017, and fully on the *alternative* basis by 2022). The resultant age/period component is shown on the right below.

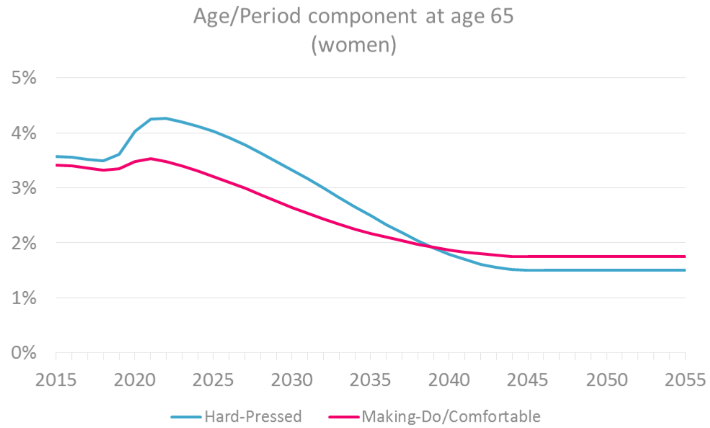
Components under each approach





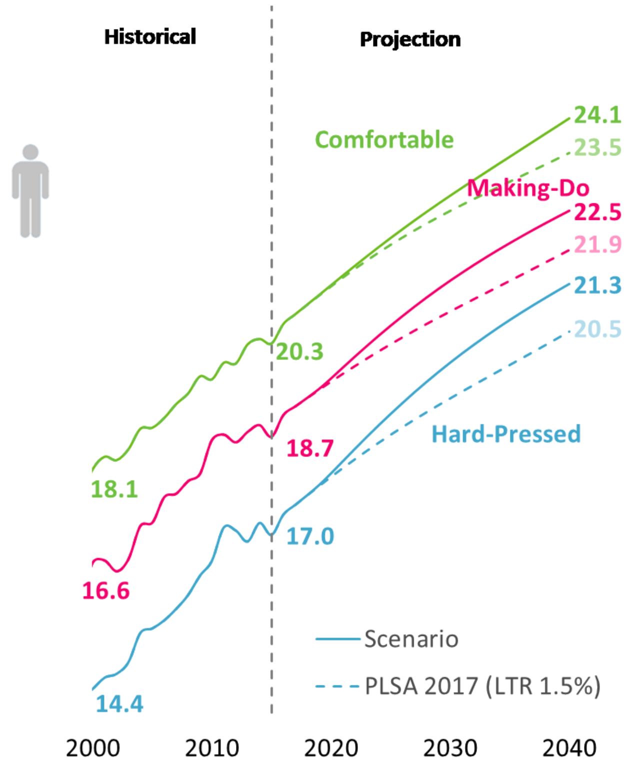
Combined components

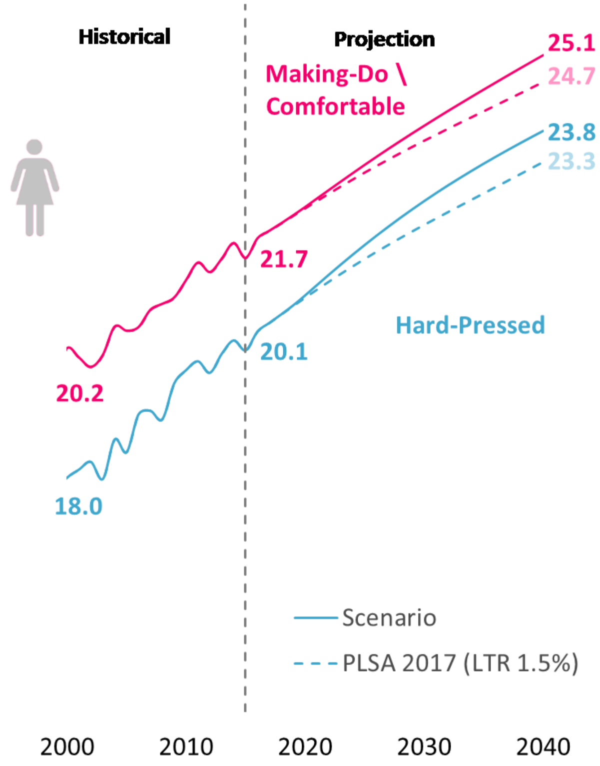




7.3 Projecting life expectancy under the scenario

The following charts show the pace of longevity improvement implied by the scenario for each VitaSegment, looking at life expectancy at age 65. Again we have also shown how life expectancy is assumed to evolve under the PLSA 2017 model (i.e. the CMI_2016 model, calibrated to each VitaSegment, assuming a long term rate of 1.5% p.a. for each VitaSegment, tapering above age 90 to 0% p.a. at age 120).





In the short term life expectancy at 65 improves in line with the central assumption. As the higher improvement rates for Hard-Pressed and Making-Do begin to impact in the 2020s, the gap compared to Comfortable reduces somewhat. In the longer term the gap is expected to widen again due to the differences in long term rates of improvement, i.e. when the next 'wave' of improvements impacts the Comfortable group.

8 Low scenario L1: Back to the Fifties

8.1 Description

One of the great success stories of the 20th century was the rapid improvement in health outcomes and commensurate rise in life expectancy.

With modern medicine and technology advances we are naturally inclined to assume life expectancy will continue to rise. However this has not always been the case. We also see several examples internationally of how political change can lead to dramatic changes in life expectancy, for example Russia post-Glasnost.

For this scenario we have assumed that mortality rates will rise in the future (and so life expectancy will fall). As this is a 'doomsday scenario' (though, as noted above, it is possible to conceive of more extreme outcomes), we assume that this will happen very soon e.g. by the end of this decade.

Given the dramatic changes involved in this scenario we do not offer a very specific narrative. However it could involve a combination of a number of societal and health changes, possibly including widespread antibiotic resistance, obesity, severe austerity impacting the NHS (possibly to point of dissolution), severe resource constraints (oil and rare earth metals) impacting heating / access to imported fruit and veg / medical equipment.

8.2 How we have modelled this scenario

Reducing life expectancy improvements immediately to zero from 2015 would lead to a material reduction in liabilities. However we took the view that this was not a plausible pattern of improvement rates, as there would be an abrupt extreme discontinuity in the improvement rates.

Instead, for this scenario we assume a negative long term rate of 'improvement' which is reached more quickly than would typically be assumed within the CMI model.

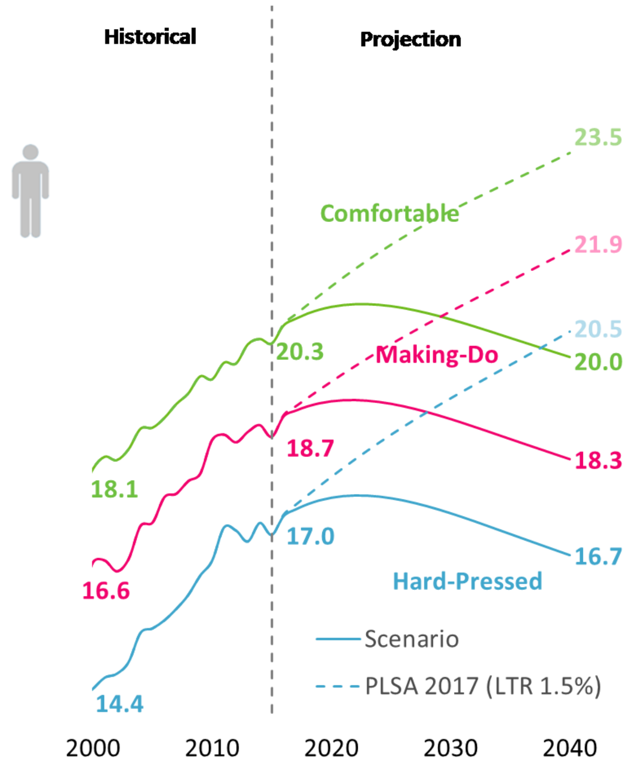
In terms of parameterising the CMI_2016 model, we have assumed (for each group):

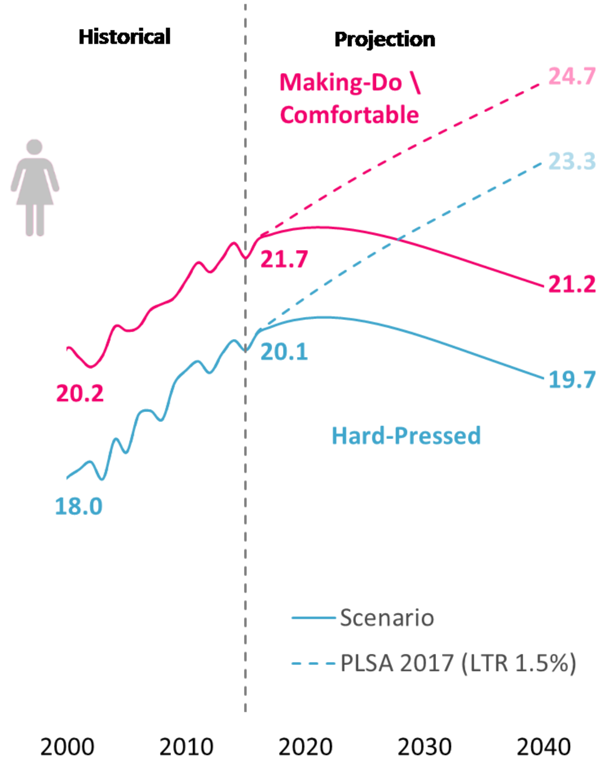
- a negative long term rate of -1% p.a., which is assumed to apply at all ages – that is, we have removed the taper between ages 85 and 110 from the core parameters.
- the proportion of change remaining at the midpoint is 25% for both the age/period and cohort components.

  This has the effect of assuming that improvement rates move more quickly towards the long term rate than would be assumed in the core parameters model.

8.3 Projecting life expectancy under the scenario

The following charts show the pace of longevity improvement implied by the scenario for each VitaSegment, looking at life expectancy at age 65. Again we have also shown how life expectancy is assumed to evolve under the PLSA 2017 model (i.e. the CMI_2016 model, calibrated to each VitaSegment, assuming a long term rate of 1.5% p.a. for each VitaSegment, tapering above age 90 to 0% p.a. at age 120).





As expected, this scenario leads to dramatic impacts on each VitaSegment, with life expectancy beginning to fall in the short term.

9 Low scenario L2: Challenging Times

9.1 Description

In this scenario we consider the implications of climate change and finite resources, for example fossil fuels. We consider the implications of the possibility that we have reached ‘peak oil flow’ and that the availability of oil will become a constraint to economies in the future.

A consequence of this could be increasing fuel prices, leading to severe constraints in finances and funding of the NHS. Alongside this, reduced access to and increased cost of imported food stocks could have a detrimental impact on health outcomes via for example greater difficulty in maintaining healthy fruit and vegetable rich diets throughout the year.

We reflect this by assuming that a significant proportion of the Hard-Pressed and Making-Do groups are unable to afford their basic needs (heating, fuel, medicine) and that this leads to life expectancy ceasing to improve. In contrast we assume that resource constraints impacts are less severe on average for the Comfortable group, meaning that this scenario leads to longevity improvements that are below the long-term trend, but above zero for this group.

Whilst this scenario focusses on the longevity outcome, were the circumstances described to come to pass then there is likely to be material impacts on a pension scheme’s investments and the outlook for gilt yields. This is a scenario that schemes may wish to use in combination with stressing their investment assumptions.

9.2 How we modelled this scenario

In terms of parameterising the CMI_2016 model, we have used a long-term rate of improvement of:

- 0% p.a. for the Hard-Pressed and Making-Do groups; and
- 1% p.a. for the Comfortable group.

The only change we have made to the core parameters is to increase the convergence parameter to 75% (rather than 50%) at midpoint for the Hard-Pressed and Making-Do groups (for both age/period and cohort components). This means that improvements are assumed to converge more slowly to the lower long-term rate for these groups.

Core parameters were used throughout for the Comfortable group.

For women the outcome for the Making-Do / Comfortable group is based on the average of the Making-Do and Comfortable scenarios above.

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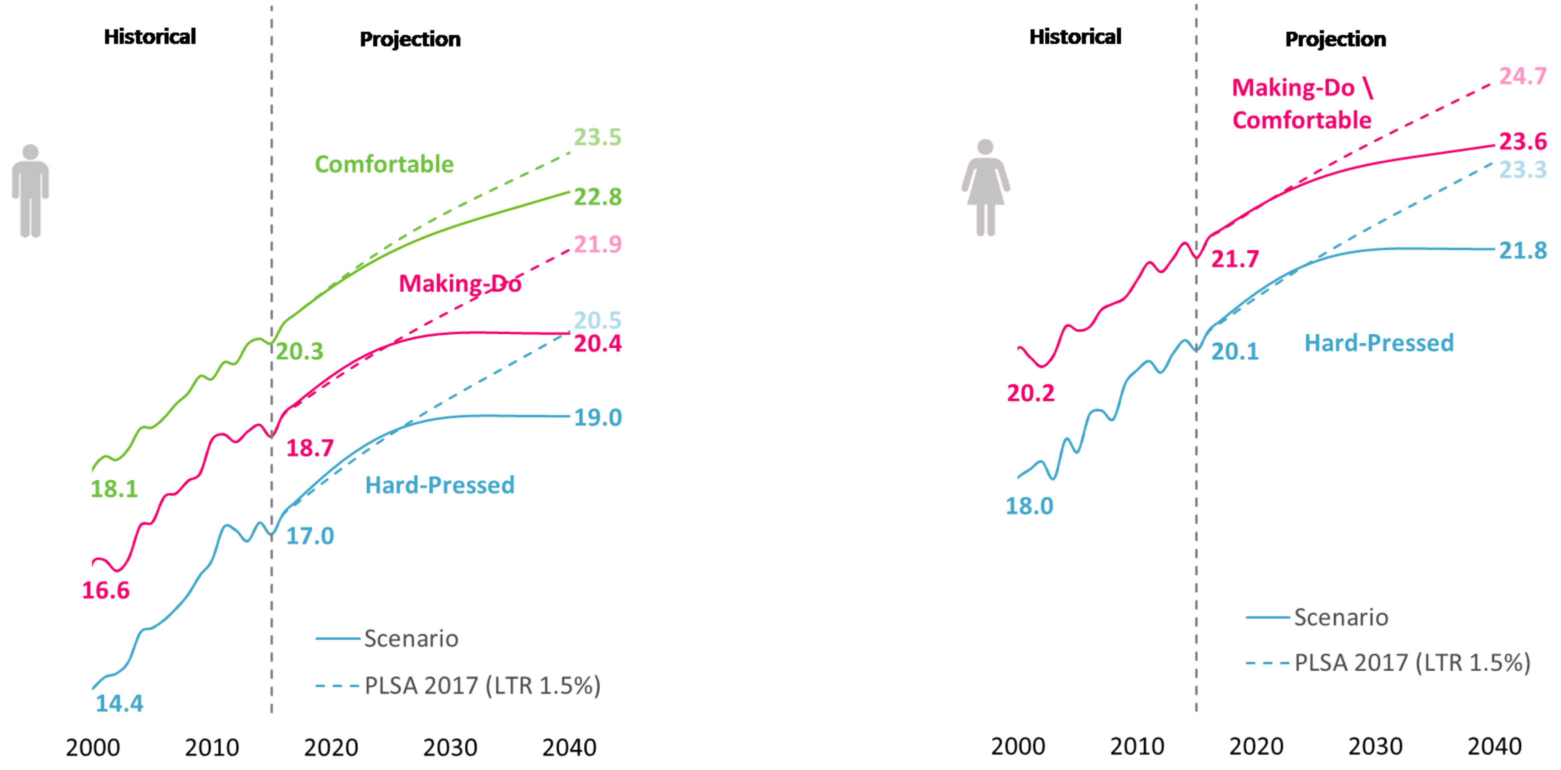
9.3 Projecting life expectancy under the scenario

The following charts show the pace of longevity improvement implied by the scenario for each VitaSegment, looking at life expectancy at age 65. Again we have also shown how life expectancy is assumed to evolve under the PLSA 2017 model (i.e. the CMI_2016 model, calibrated to each VitaSegment, assuming a long term rate of 1.5% p.a. for each VitaSegment, tapering above age 90 to 0% p.a. at age 120).



This scenario clearly impacts differently on each VitaSegment. We can see how the assumed long term rate of 0% leads to a flat-lining of life expectancy for Making-Do and Hard-Pressed groups, while the Comfortable group continues to see improvements, albeit at a slower pace.

10 High scenario H1: Cancer Revolution

10.1 Description

The eradication of a significant cause of death (typically, but not always, cancer) is a typical suggestion when projecting mortality improvement using scenarios. Whilst a cure for any specific major cause of death is unlikely over any reasonable time horizon, this type of scenario is a useful way of illustrating the impact of any material advance in healthcare.

This scenario would require a step-change in cancer treatment, for example effective national screening (both traditional and genetic) and perhaps a 'pill' being developed to target hard-to-treat cancers. We assume that these changes begin to be available in ten years' time, and are fully taken up over the following 5 year period – this was chosen as being the fastest reasonable time taken for widespread take-up of such an innovation in healthcare.

Very broadly speaking, in the UK population as a whole cancer accounts for around

- 20% of deaths below age 55,
- 40% between ages 55 and 79, and
- 25% at age 80 and above

To keep the scenario reasonably simple, we assume these proportions are the same for each of the groups. This assumption is very roughly borne out in practice based on research on cancer incidence by IMD.

Note this does not mean that the initial cancer mortality rates are the same for each subgroup – because overall death rates are higher in the Hard-Pressed category, cancer mortality rates are also assumed to be higher for this group.

Because older individuals are more likely to have multiple diseases, we assume that, whilst cancer is eradicated, the reduction in mortality is less than implied by the percentages above, as some people who would previously have died of cancer die of another cause soon afterward.

We have also assumed that the long-term rate of improvement 'post-cancer' is slightly lower than it would have been 'pre-cancer' because part of the previously assumed long term rate is likely to have been driven by some gradual improvements via cancer interventions.

10.2 How we modelled this scenario

The 'pre-cure' period assumes core settings (apart from assuming reduced period smoothing) with a long term rate of 1.5% p.a..

To model the 'post-cure' trajectory of improvements, we have used a long term rate of mortality improvement structured by age as follows:

Below 55:	1.2% p.a.
55-79:	1.1% p.a.
80-90:	1.5% p.a.
90+:	Tapering to 0% p.a. at age 120

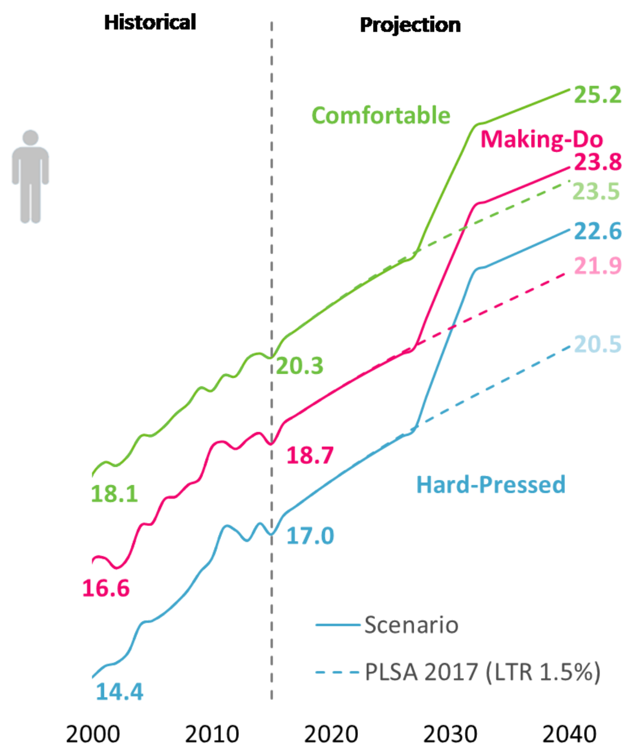
To model the 5-year period (2027-2032) over which a cure is assumed to take effect, we apply a 'patch' to improvements of:

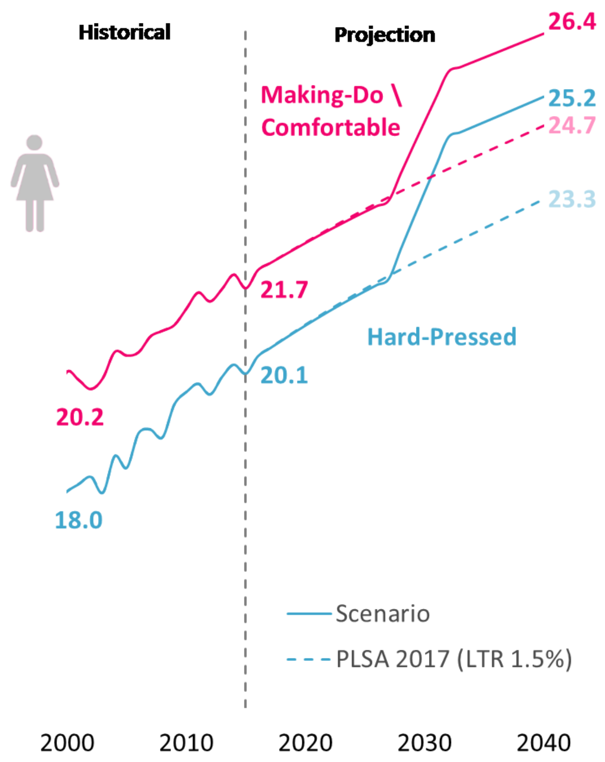
Below 55:	+4% p.a.
55-79:	+8% p.a.
80+:	+4% p.a.

So mortality rates from 2032 will be either 18.5% ($1-0.96^5$) or 34.1% ($1-0.92^5$) lower than the projections produced by the CMI model

10.3 Projecting life expectancy under the scenario

The following charts show the pace of longevity improvement implied by the scenario for each VitaSegment, looking at life expectancy at age 65. Again we have also shown how life expectancy is assumed to evolve under the PLSA 2017 model (i.e. the CMI_2016 model, calibrated to each VitaSegment, assuming a long term rate of 1.5% p.a. for each VitaSegment, tapering above age 90 to 0% p.a. at age 120).





We can see the impact of the applied 'patch' on mortality improvements as there is a sharp jump in life expectancy as the cure comes into effect in the late 2020s for each group. After that point the life expectancy improves at a similar gradient to the central assumption, albeit at a higher starting point.

11 High scenario H2: Extended Youth

11.1 Description

Across the whole UK population, improvements in life expectancy for a man aged 65 over the 2000s were 2.4 years. For women, the increase in life expectancy over the 2000s was 1.7 years.

However, the experience of each of our VitaSegments improved in a different way to the population as a whole, with the Hard-Pressed male group seeing a 2.5 year improvement over the 2000s, the Making-Do group a 2.3 year improvement, and the Comfortable group a 1.9 year improvement. For women the Hard-Pressed group saw an improvement of 2 years, whilst the Making-Do / Comfortable subgroup saw a 1.6 year improvement in life expectancy.

In this scenario we consider the possibility that the low improvements seen in the 2010s thus far are a 'blip' and that some combination of factors will lead to the improvements seen between 2000 and 2010 being sustainable over the longer term.

Just as it would have been hard to predict the last 40 years of strong improvements back in 1970 - let alone the catalysts - we do not offer a very specific narrative for this scenario; however possible contributory factors could be a combination of highly successful screening programs, poly-pills, smart pills aimed to improve drug adherence, ageing medicine breakthroughs increasing survivorship from the multiple diseases of later life, increased later life activity and exercise and reduced obesity.

We can translate the life expectancy improvements listed above into long-term rates of improvement for each group:

- For men, we assume a long term rate of 3.0% p.a. for Hard-Pressed and Making-Do groups, while the long term rate for the Comfortable group is assumed to be 2.25% p.a..
- For women, the Hard-Pressed group are assumed to have a long-term rate of 2.5% p.a., while the Making-Do / Comfortable group are assumed to have a long-term rate of 1.75% p.a..

It is worth noting that this scenario leads to convergence in (period) life expectancies.

This also implies that the cohort life expectancy will converge – the life expectancy produced by this scenario is higher for a Hard-Pressed male aged 65 in 2030 than for a Making-Do / Comfortable female.

Whilst this may not be a very plausible outcome, it illustrates how life expectancies would change over the very long term if a simple straight-line extrapolation were adopted for each group.

11.2 How we have modelled this scenario

In terms of the CMI_2016 model, we have used long-term rates of mortality improvement between 1.75% p.a. and 3.0% p.a., as listed above.

We have assumed that these rates persist at all ages – that is, we have removed the taper between ages 85 and 110 from the core parameters.

In addition we assume that the 'core' level of period smoothing is applied in each case, rather than reducing the smoothing, so as to avoid increasing the allowance for recent heavy experience in the lower socio-economic groups. Initial rates of improvement are slightly higher as a result.

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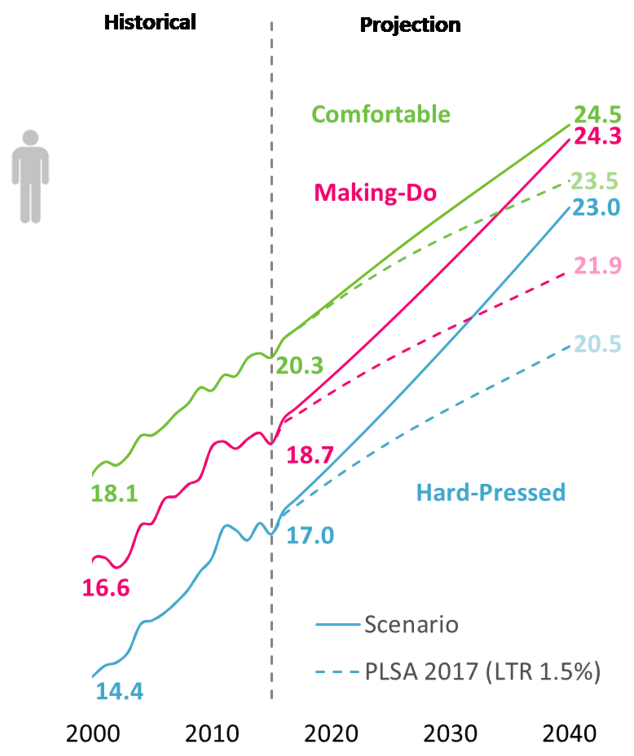
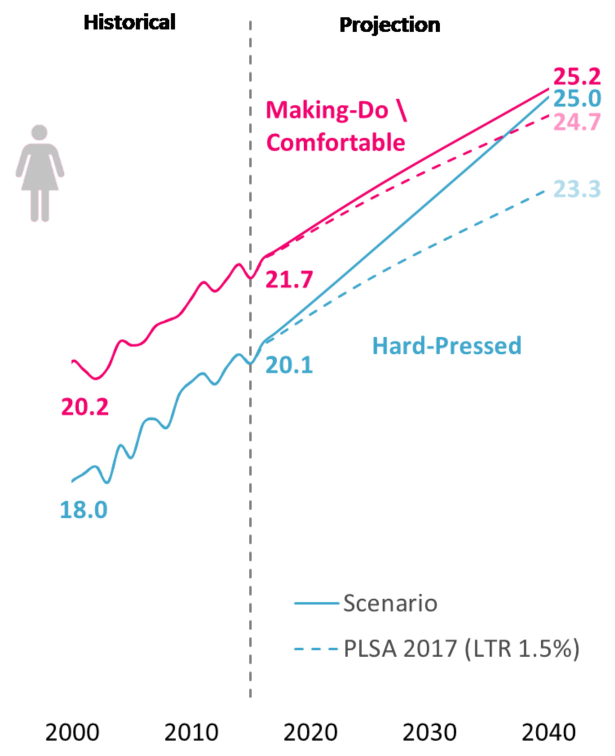
11.3 Projecting life expectancy under the scenario

The following charts show the pace of longevity improvement implied by the scenario for each VitaSegment, looking at life expectancy at age 65. Again we have also shown how life expectancy is assumed to evolve under the PLSA 2017 model (i.e. the CMI_2016 model, calibrated to each VitaSegment, assuming a long term rate of 1.5% p.a. for each VitaSegment, tapering above age 90 to 0% p.a. at age 120).





As expected, under this scenario there is a noticeable convergence of life expectancies, as the higher long term rates assume for Hard-Pressed and Making-Do groups lead to a higher rate of improvement.

Appendix – Summary of calibrations

The following table sets out the calibrations of the CMI_2016 model used for each scenario (where **HP** = Hard-Pressed, **MD** = Making-Do, **C** = Comfortable).

Scenario	Period smoothing parameter (Sκ)	LTR Age/period	LTR Cohort	Tapering of LTR	% remaining at midpoint (Age/period & Cohort)	Convergence period (Age/period & Cohort)	Adjustments
Back to 50s	6.0	-1% p.a.	0% p.a.	None	25%	Core	-
Challenging times	6.0	0% p.a. for **HP** & **MD** 1% p.a. for **C**	0% p.a.	New (85 – 110) (only impacts **C**)	75% for **HP**/**MD** Core (50%) for **C**	Core	Female **MDC** group average of **MD** and **C** improvements
Improvement decline	6.0	0.75% p.a.	0% p.a. pre 1920, post 1954 0.75% p.a. 1929 to 1945 (incl) Linear in between	New (85 - 110)	Core (50%)	Core	-
Health Cascade	Extended - 6.0 Advanced - 7.5	1.5% p.a. for **HP** & **MD** 2% p.a. for **C**.	0% p.a.	Extended - New (85 - 110) Advanced - Old (90 - 120)	Extended - Core (50%) Advanced - 75% for **HP** and **MD** (unless initial rate less than LTR), 50% for **C**	Extended - Core Advanced - 50% loading for **HP** and **MD** (unless initial rate less than LTR), no loading for **C**, max 40 yrs	100% of Extended basis up to 2017 From 2018 blend into Advanced basis over 5 years 100% Advanced basis from 2022 Female **MDC** group average of **MD** and **C** improvements

Scenario	Period smoothing parameter (S_κ)	LTR Age/period	LTR Cohort	Tapering of LTR	% remaining at midpoint (Age/period & Cohort)	Convergence period (Age/period & Cohort)	Adjustments
Cancer revolution	6.0	1.5% p.a. up to 2027 Then: 1.2% p.a. pre 55 1.1% p.a. 55-79 1.5% p.a. 80+	0% p.a.	Old (90 - 120)	Core (50%)	Core	Up to 2027 (incl) apply 'base' scenario which has core settings except S_κ of 6.0 Patch for 'cure' applied between 2027 and 2032 (first applied in 2028) 4% p.a. for <55, 80+ 8% p.a. for 55-79 So by 2032, mortality rates are 18.5% or 34.1% lower than model projects
Extended youth	7.5	3.0% p.a. for **HP** men 3.0% p.a. for **MD** men 2.25% p.a. for **C** men 2.5% for HP women 1.75% p.a. for **MDC** women	0% p.a.	None	Core (50%)	Core	Female **MDC** group average of **MD** and **C** improvements

Scenario	Period smoothing parameter (Sκ)	LTR Age/period	LTR Cohort	Tapering of LTR	% remaining at midpoint (Age/period & Cohort)	Convergence period (Age/period & Cohort)	Adjustments
Alzheimer's hump	6.0	1.5% p.a.	0% p.a.	New (85 - 110)	Core (50%)	Core	Manual adjustment calculated outside of model, based on projecting deaths attributed to Alzheimer's (for ages 80+) using a cubic polynomial 'hump', such that deaths increase in the short term before declining.
Low for longer	6.0	0.75% p.a. for **HP** 1.0% p.a. for **MD** 1.25% p.a. for **C**	0% p.a.	New (85 - 110)	40% for **HP** & **MD** Core (50%) for **C**	Core	Female **MDC** group average of **MD** and **C** improvements