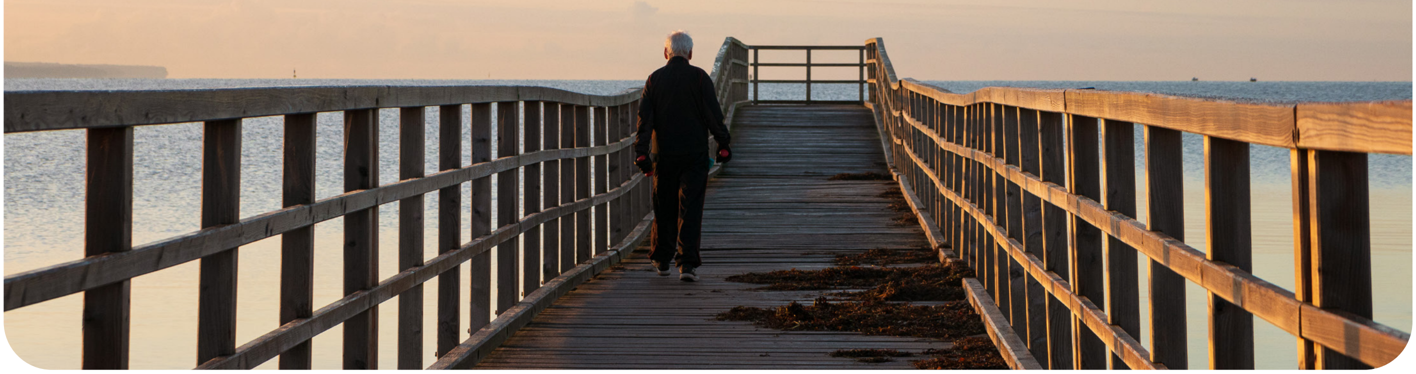
Expert Views

Why Smooth the Past?

Can We Use Pandemic Mortality Experience for Pricing Longevity Deals?

SCOR
The Art & Science of Risk

October 2024



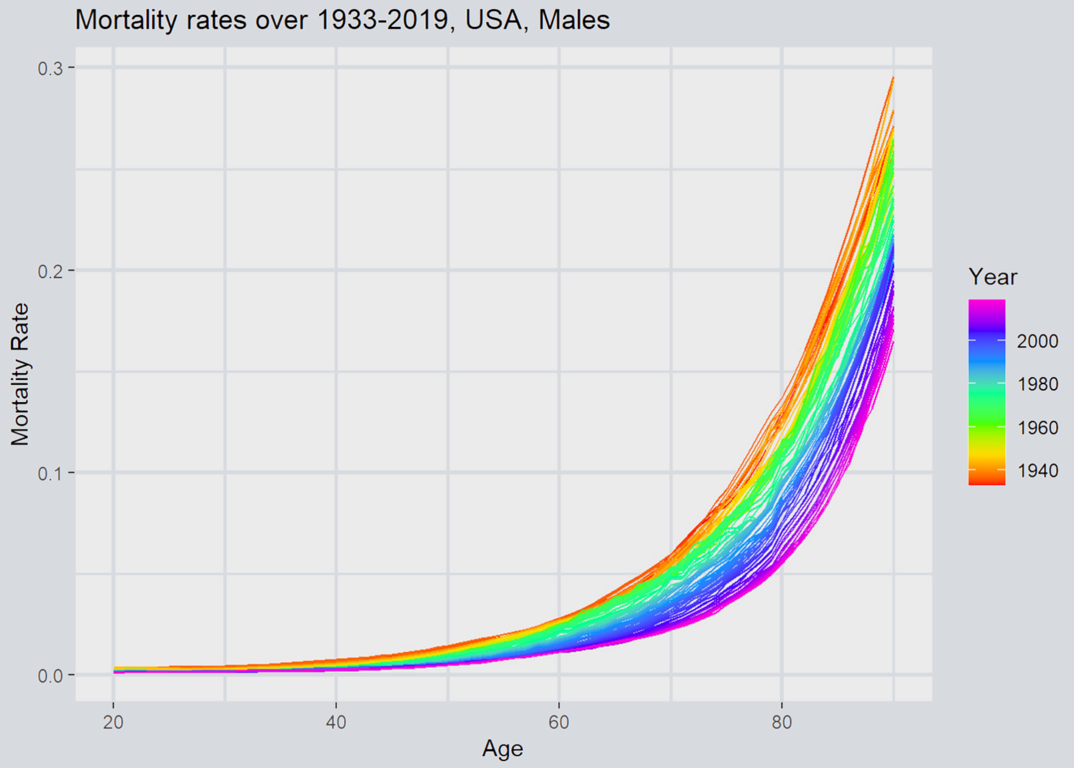
Contents

Introduction

A secure and long-term longevity protection product provides individuals with a happier and more fulfilling retirement, knowing financial security is in place for life. The global pension risk transfer (PRT) market has been growing, reaching $52 billion premiums in 2022.[1] The best estimate prediction of life expectancies is essential to ensure (re)insurers and PRT providers can meet their obligations to pay these annuities for the lifetime of the policyholders.

However, predicting future longevity is not an easy task, even for experienced professionals, as so many factors, both century-old and evolving, need to be taken into consideration.

Figure 1: Changing mortality rates over time for the US national population (males)



Source: SCOR calculations based on data from the Human Mortality Database.

There are several well-known reasons why life expectancies differ from person to person. Risk factors such as smoking, obesity, access to healthcare, education, geographical location, and more all play a role in explaining the reasons why one person may live longer or shorter than another. Within the insurance industry, this is called the "base mortality assumptions," i.e., a snapshot of how mortality rates (and therefore period life expectancies) differ at a specific point in time. In Figure 1 this is represented by the pink line, which shows the probability of death by age as of 2019.

Next, we need to couple the base mortality with the second key factor - mortality trends.

In the past 100+ years, mortality trends have been steadily improving, driven by various favourable factors, including improved medical diagnosis, advancement in treatments, improved access to healthcare, healthier lifestyles, etc. In Figure 1 this is represented by the reduction in mortality rates from the red line (1930s) through to the pink line (2010s). Given longevity protection is about ensuring a guaranteed income over the lifetime of the policyholder, a view as to how mortality rates will evolve over the next 30+ years is crucial.

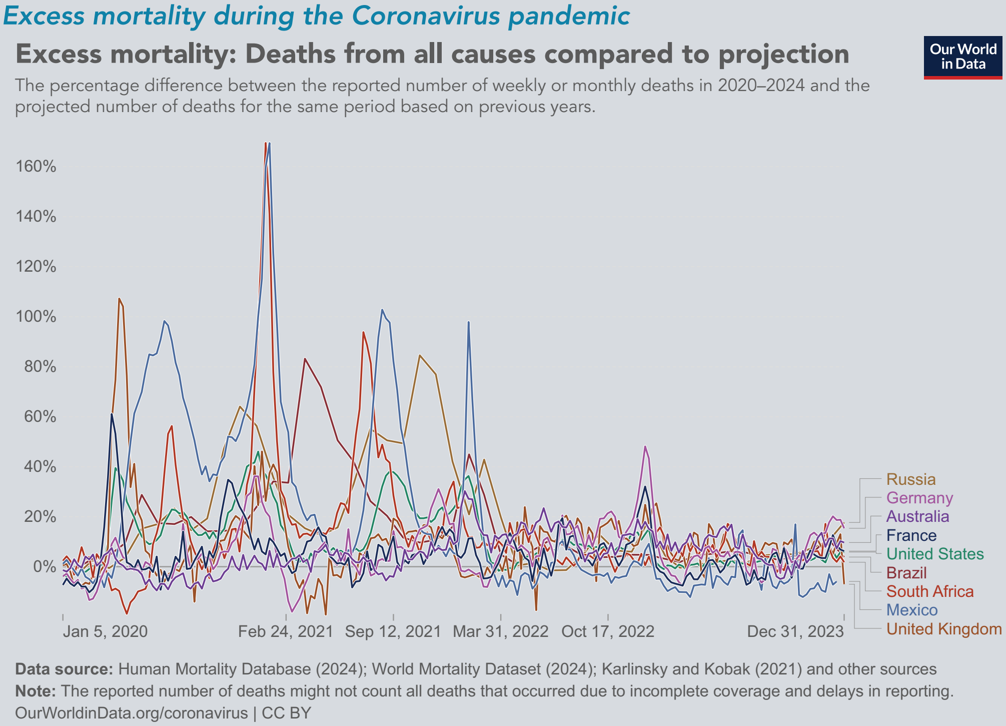
Then came 2020. COVID-19 led to a global scale pandemic, causing nearly 15 million excess deaths worldwide in 2020 and 2021, resulting in the decline of global period life expectancy by 1.6 years between 2019 and 2020, according to the Global Burden of Disease.[2] The global pandemic stopped the ever-improving mortality trajectory and left a massive dent in the curve.

Fast forward to 2024, COVID-19 cases have declined, and the mortality rate has decreased compared to the 2020/2021 period (Figure 2), making it look like our lives are finally back to normal.

How should the life and health insurance industry interpret this incident to the future mortality prediction? Whilst considerable research has been devoted to the interpretation of post-pandemic mortality trends (SOA[3], CMI[4], AG[5]), the approach to using recent data for setting base mortality assumptions is less clear. Many actuarial institutes are choosing to ignore the experience of the pandemic.[6] But is that a wise approach? How long can mortality data over the pandemic continue to be ignored?

This article discusses the basic principles of longevity pricing, the impact of COVID-19 on the longevity curve, and how to adapt to this unusual disruption in order to reflect more realistic assumptions in the future.

Figure 2: Excess mortality during the Coronavirus pandemic



Source: Human Mortality Database (2024) Excess mortality during the Coronavirus pandemic (COVID-19) - Our World in Data

Longevity Pricing 101: Setting Base Mortality and Mortality Improvements

In order to properly price and manage longevity risk, an insurer must have a view of both the current level of mortality (= base mortality) and how that level will change over time (= mortality trend).

One approach to setting base mortality assumptions involves starting with past mortality experience, at a portfolio level if large enough or at an industry level.

Ideally, if the scheme has rich enough mortality experience data, rates can be graduated directly from the experience. However, this is rarely the case. A more common approach is to compare the observed past scheme mortality experience ("actuals") verses a standard industry table ("expecteds") to set the base mortality level and shape of mortality by age. Such comparisons are called mortality experience analyses.

Base mortality and mortality trends go hand in hand. Generally when conducting an experience analysis, multiple years of data are analyzed to smooth out any volatility in the mortality experience. When multiple years of data are used, it is important to take the past mortality trend into account. This ensures signals from an experience analysis of actual mortality vs expects are not misinterpreted. Generally, pricing a Pension Risk Transfer (PRT) deal will require five years of mortality experience at a minimum for experience analysis results to be credible.

So how does the industry set mortality trends? Here we look to mortality improvement models. These can be stochastic or deterministic in nature and are usually calibrated to national population data.

Generally, data-driven improvement models will fit a trend to past mortality data, then project that trend forward into the future, with a carefully calibrated parameter setting which allows for how much the past may be repeated into the future.

As the mortality improvement models are fitted to past data, they conveniently provide a smoothed view of past mortality improvement. Examples of these models include the CMI (Continuous Mortality Investigation) model in the UK or the MIM (Mortality Improvement Model) in the US*. It is then natural for actuaries to use this smoothed past mortality trend to account for historical mortality improvement when setting base mortality rates.

This approach worked well prior to the pandemic, as the latest years of mortality experience can be used to ensure the resulting base mortality rates are as up-to-date as possible. But now the situation has changed due to the pandemic, requiring us to examine if we need to make any adjustments.

**Note: The MIM and CMI models are examples of data-driven models, which extrapolate the past into the future. An alternative approach is to use a driver-based model, which uses a more judgement-driven approach, considering the past and future drivers of mortality trends and therefore how mortality trends might evolve in the future.*

To manage longevity risk, SCOR has developed and used such models to understand how medical advances and changes in behaviour and the environment will impact mortality rates and future longevity. This approach goes beyond the traditional method of predicting future trends through extrapolation of historical data, enabling us to offer better value protection for our clients and their customers through a more comprehensive understanding of the risks involved.

The Elephant in the Room

Now let's talk about the "elephant in the room", the issue that is troubling everyone in the post-COVID era insurance industry – the status quo models do not work anymore following the pandemic.

The onset of COVID-19 caused the industry to rethink how mortality improvements should be considered when setting base mortality assumptions. Since 2020, the world experienced exceptional years of elevated mortality, far out of line with expectations prior to the COVID-19 pandemic, as shown in Figure 3.

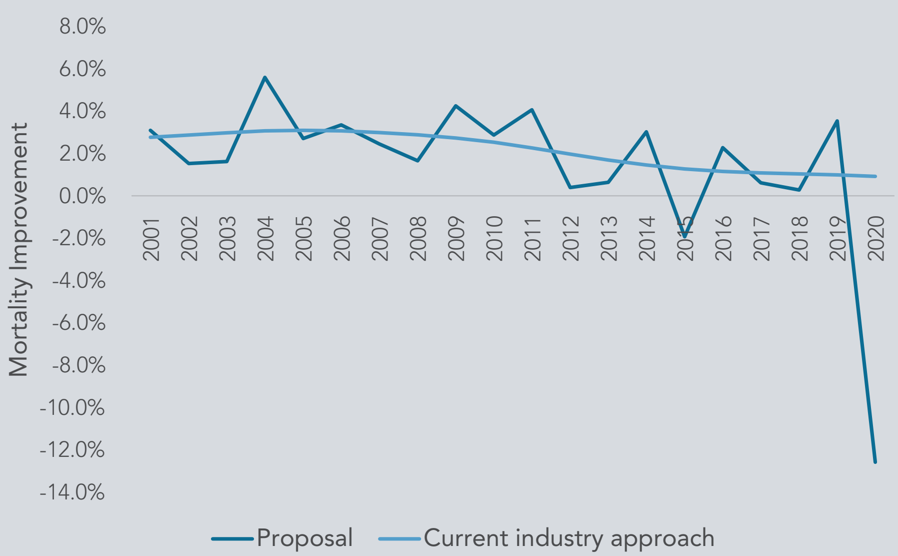
Since this was an extraordinary period of time, it would be incorrect to simply conduct an annual experience update, and thereby include these extraordinary years in our expectations on future mortality without some modification. The "smoothed past trends" models could not adapt fast enough, meaning that the experience result would be an overestimate of the true level of mortality in the mortality base assumptions.

One potential solution could be simply to exclude post-pandemic data altogether. However, ignoring valuable information that could have a substantial actual impact on the mortality curve would not be ideal either.

An alternative solution could be to allow for the pandemic years in the past trend model with some (lower) credibility or weighting to those data points. UK's Continuous Mortality Investigation (CMI) has done this in their more recent models, with their latest version (CMI_2023) applying 15% weight to 2022 and 2023 data when smoothing through past improvement rates. The issue with this approach is that the weights are very much subjective, and there will still be substantial variation in the actual experience over 2020-21 vs. expected using this basis.

Considering the above issues with alternative solutions, one could choose to stay with the smoothed pre-pandemic trend model and add on excess terms for the pandemic years. However, this method is not perfect either, as it runs the risk of adding complexity to the model.

Figure 3: Observed Annual Mortality Improvement



Source: SCOR internal data based on CMI Model

A More Elegant Solution

Let us explore a more elegant solution to this problem. "Elegance" might sound unusual in the insurance field, but it is a sought-after commodity in the field of scientific research. In this context, "an elegant solution" refers to a scientific or mathematical approach that addresses a problem in a simple yet extremely effective manner.

What does "elegance" entail in this context? A great example is when early astronomers in the sixth to fourth century BC[7] first came up with their models of the universe. Early models of the universe assumed the planets followed circular motions around the Earth. However, this model had a serious problem: the observations did not fit the data. In particular, certain planets appeared to move backward in relation to their expected orbits.

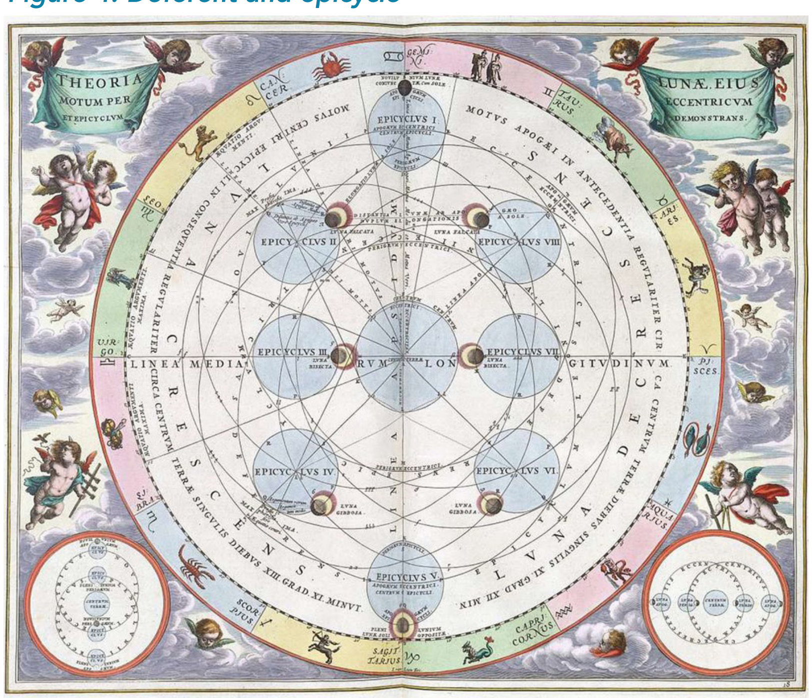
Epicycles were introduced to correct the issue of the model. The hypothesis became that planets moved in circles, moving on another bigger circle. The model got a bit more complicated but appeared to explain the data better.

Various attempts to simplify the model were made in the subsequent centuries. In the early 16th century, Copernicus attempted to improve the model by assuming that the planets rotated around the sun not the Earth. However, epicycles were still needed to explain the observed motions of the planets.

Then, in the early 17th century, Johannas Kepler produced an elegant – simple yet highly effective – solution: the orbit of the planets is an *ellipse,* not a circle. This considerably simplified the models, removing the need for epicycles altogether.

This concept of elegance can be equated to the statistical concept of parsimony, which means that a model should strike the right balance between simplicity and accuracy of fit. A simpler model is preferred over the more complex one, if the more complex model doesn't greatly improve the fit.

Figure 4: Deferent and epicycle



Source: Cellarius Harmonia Macrocosmica

So, how does this concept apply to the industry approach to past improvements?

Previously, plotting a smoothed trend through past mortality rates might have been considered to be the parsimonious option. They were conveniently generated by the future trend model, and they fitted the past data well.

But this traditional approach was challenged during COVID-19. Figure 5 shows the age-standardised annual observed mortality rates for males in the UK between 2000 and 2023, showing the smoothed approach to past improvement fits the data well enough up to the onset of the pandemic in 2020.

After experiencing extremely high mortality rates in 2020 and 2021 as shown by the red circle in Figure 5, the main question was how to allow for the escalation in mortality and whether traditional mechanisms are the most appropriate method to use. Actuaries considered either ignoring the data altogether or proposing "fixes" to their original models, which involved implementing temporary adjustments from 2020 onwards to accommodate the unusual levels of mortality.

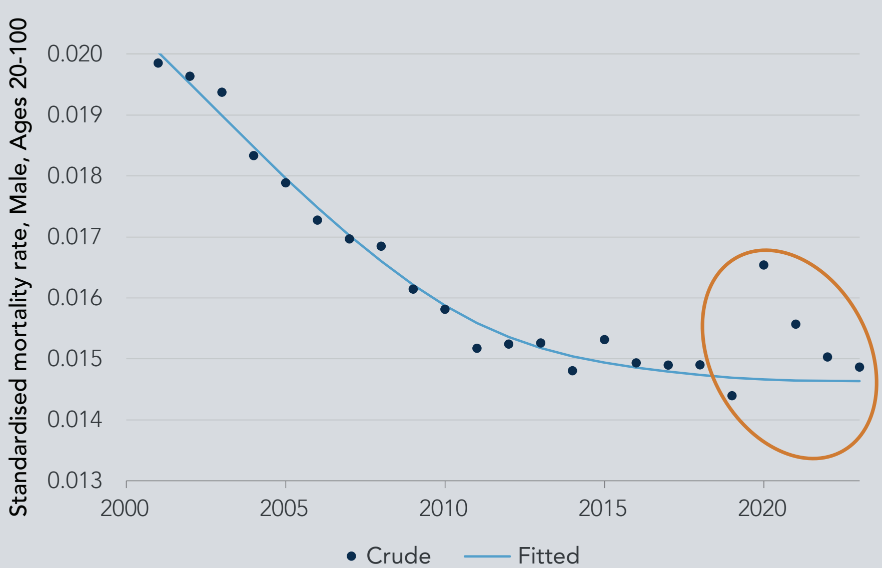
However, we have a more elegant solution to this problem – not to smooth through past improvements.

The past mortality trends are inherently not smooth, fluctuating from year to year, influenced by the annual flu seasons and the recent COVID-19 waves. These were actual occurrences, so why should we smooth them out?

Keeping the past improvements unsmoothed is a more elegant and therefore better solution. This approach captures abnormal years of experience data as the basis for expected historic mortality. If the national population experienced a heavy flu/COVID season, it is reasonable to expect a subset of the population such as a defined benefit pension scheme will also experience higher mortality.

The advantage of this methodology is that it captures unusual historic years explicitly so every past year can be used for experience analysis and allows for trends as they happen. This approach is not restricted to the pandemic. Even before the pandemic there were outlier years which the smoothed trend did not capture. An example is

Figure 5: Observed and fitted UK mortality rates up to 2023 under the CMI 2023 model.



Source: CMI_2023

UK mortality in 2015, as seen in Figure 5, where there were more deaths than expected due to the flu vaccine being much less effective in that year[8].

By allowing for this observed volatility in the past improvements basis, we can achieve actual over expected (A/E) ratios closer to 100% when analyzing the experience by calendar year, as illustrated in the hypothetical example in Figure 6 In this example, using a smoothed approach would lead to a significant underpricing of a longevity deal.

However, there are challenges to this approach. One would need to be careful if the scheme being priced had a different geographical spread to the national population, as the mortality experience for the scheme during the pandemic years may differ due to this. This is a particular issue for larger countries such as the US, as shown in the next section.

Additionally, one needs to use caution if using a standard industry-based mortality table such as the SAPS tables in the UK or the PRI-2012 tables in the US. These tables were constructed using a smoothed past improvement basis, so an adjustment is required to use these tables on an unsmooth past improvement basis. We explore both these challenges in the next section.

Figure 6: Illustration of A/E Impact of Using Unsmoothed Past Improvements

	y1	y2	y3	y4	y5	Total
Actual deaths	990	1010	995	1150	980	5125
Expected deaths (smoothed imps)	1000	1000	1000	1000	1000	5000
A/E	99%	101%	100%	115%	98%	103%

	y1	y2	y3	y4	y5	Total
Actual deaths	990	1010	995	1150	980	5125
Expected deaths (unsmoothed imps)	992	1007	991	1154	984	5128
A/E	99.8%	100.3%	100.4%	99.7%	99.6%	99.9%

Source: SCOR Internal

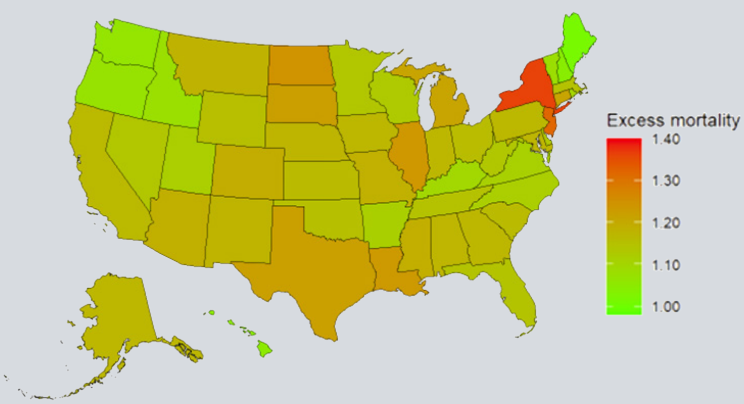
Cautionary Points in the Suggested Approach

1. Geographical Application

When considering the suggested method, it's important to exercise caution as the COVID-19 pandemic waves may have had differing impacts depending on each geographical area. For example, Figure 7 shows the U.S. example, where New York was hit hard by the first wave, causing significantly greater excess mortality in 2020 in this state vs the rest of the country.

Also, one needs to take into consideration that pension schemes that are not geographically diverse will have COVID experience that may differ from that of the entire country. To overcome this, SCOR proposes a solution based on the experience in COVID years for smaller geographical areas of the country in question, as illustrated in Figure 8. The geographical mix of the scheme could then be used to derive the scheme-specific deviation in mortality over the COVID years from the recent trend over non-COVID years. This could then be compared to the national population average deviation to derive a suitable scheme adjustment.

Figure 7: Excess Mortality in the US by state in 2020 - males



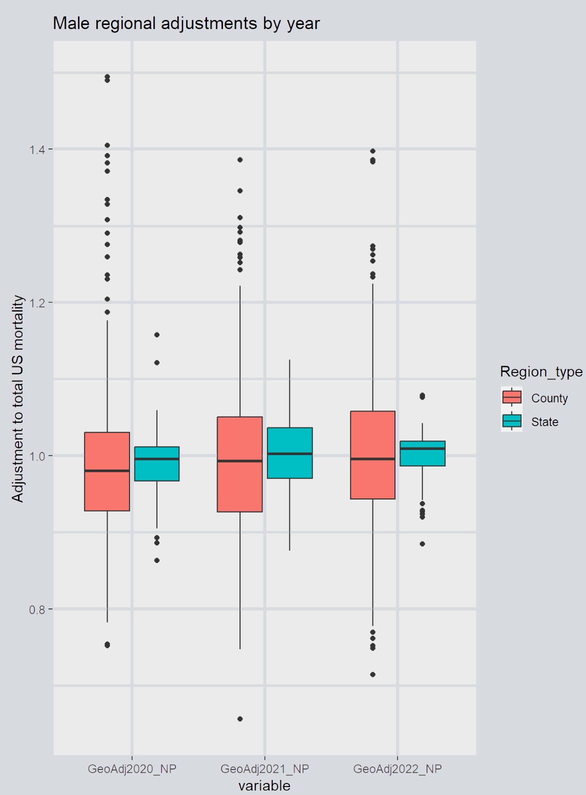
Source: SCOR calculations based on CDC data

2. Adjusting industry tables

When using the method of unsmoothing past improvements on the longevity assessment, suitable adjustments need to be made to the base mortality tables to account for the use of smoothed past improvements in the graduation of those curves.

For example, in the CMI SAPS S4 tables where mortality experience over 2014-2019 was used, an adjustment was made to the exposures for each calendar year to remove the impact of mortality improvements from experience and adjust rates to a common date of 1 January 2017 (details of which can be found in appendix 6 of CMI working paper 181).

Figure 8: Geographical Adjustments for the US Pandemic Years, Males



Source: SCOR Internal

This adjustment was made using the core parameterization of the CMI_2017 model, which produces smoothed past improvement. Had the CMI used unsmoothed past improvement in their exposure adjustment, they would have arrived at a different graduated mortality rate. Consequently, industry base tables need to be adjusted by the longevity actuary to account for this discrepancy if unsmoothed past improvements are used.

3. Starting point for the projection

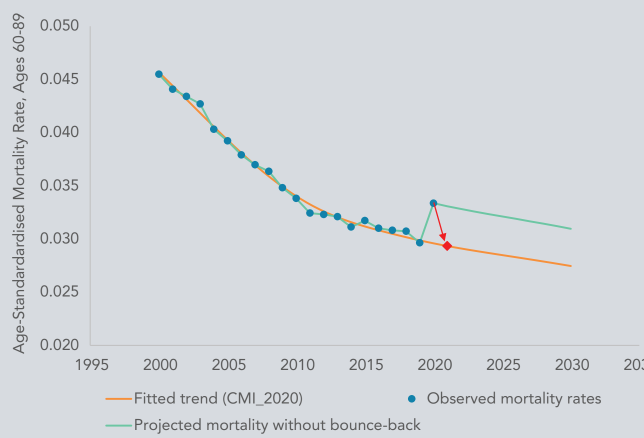
The last cautionary point with this approach is that if the final observed improvement data point is outside normal trends, the improvement in the first year of projection would need to be forced to "bounce back" to the trend.

An extreme example of this was at the start of the pandemic, as illustrated in Figure 9, when the 2020 mortality experience was well outside normal trends.

By removing periodical smoothing, we don't have a sensible starting point for the projection. Without adjusting the projection, unusual results will be locked in for all future years. This can be overcome by defining a prior view of a mortality trend and deriving the improvement rate required in the first year of the projection to ensure that the first year of projected mortality reverts near to the final observed actual mortality rate (prior to the anomaly year).

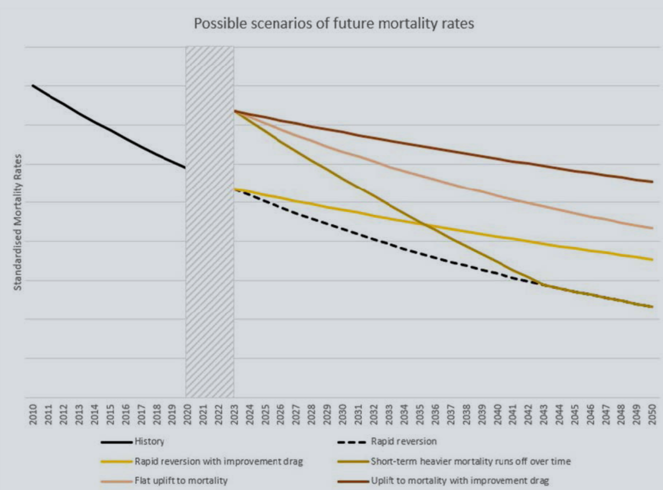
In an extraordinary case such as COVID-19, the longevity actuary may wish to implement an alternate reversion to the underlying prior view of the current mortality level to allow for the run-off of excess mortality over time towards an endemic view, such as some of the scenarios shown in Figure 10. Whilst this is not the topic of discussion in this paper, actuaries may wish to refer to the extensive work of the CMI Post-COVID Biometric Assumption Working Party, in which SCOR experts participated, which is available here.

Figure 9: Illustration of First Year of Projected Mortality Reverting to Trend



Source: ONS data and CMI_2020 core model projection

Figure 10: Potential future mortality scenarios (output of the CMI Post-COVID Biometric Assumption Working Party Report)



Conclusion

The COVID-19 pandemic posed a significant challenge in setting base mortality rates. However, excluding valuable mortality experience data over the pandemic is not viable in the long-term.

Using unsmoothed past improvements is an elegant solution - one would need to adjust the improvement rate in the first year of the projection to get back to trend, and base mortality tables would need to be adjusted to avoid double counting. Allowance can also be made for geographic biases to the impacts of COVID-19 based on scheme geography. This achieves a sensible perspective of future mortality improvements without ignoring valuable information in the pandemic years.

Sources

1. Pension Risk Transfer Market Update (mercer.com)
2. https://www.thelancet.com/journals/lancet/article/PIIS0140-6736(24)00476-8/fulltext
3. COVID-19 and the Short-Term Impact on Future U.S. Mortality | SOA
4. CMI Working Paper 189 | Institute and Faculty of Actuaries
5. Projections Life Table AG2024 (actuarieelgenootschap.nl)
6. CMI Working Paper 181 | Institute and Faculty of Actuaries
7. Cosmic Engine: Early Models of the Universe (csiro.au)
8. Why a rise in deaths in 2015 highlights the importance of flu vaccination – UK Health Security Agency (blog.gov.uk)

Author:

Roshan Tajapra
Head of Longevity Research

Please feel free to visit us at scor.com

SCOR SE
5 avenue Kléber - 75795 PARIS Cedex 16
France

SCOR
The Art & Science of Risk

October 2024