Institute and Faculty of Actuaries

Report of the post covid biometric assumption setting working party

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REPORT OF THE POST-COVID BIOMETRIC ASSUMPTION WORKING PARTY

SEPTEMBER 2023

MORTALITY AND LONGEVITY

Executive summary

The COVID-19 pandemic has interrupted business-as-usual approaches to setting and updating mortality and longevity assumptions; it is unclear how to treat data that has emerged since 2020, and it is unclear how the pandemic will impact future mortality improvements. This paper has been produced as a reference for those who are setting biometric assumptions in the aftermath of the pandemic, or indeed those who are tasked with reviewing or approving such assumptions.

We outline three approaches for handling the recent experience:

1. Ignore or down-weight the data
2. Adjust the data
3. Take a driver-based approach to explaining and forecasting the data

We conclude that option 3 should be favoured where it is possible to take this approach, and we demonstrate that even a simple driver-based view of the future can be used to create estimates for impacts of the pandemic relative to a pre-pandemic view. We also show that a driver-based approach can be used to express the difference between a pre-pandemic and post-pandemic basis in a simple way, and demonstrate how this can be used in conjunction with the CMI 2022 model to help to benchmark the impacts of different model parameterisations.

Finally, we review existing research into the drivers of the post-pandemic population experience and conclude that the strain on the NHS and residual COVID-19 are probably the most material drivers of excess mortality relative to pre-pandemic expectations.

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Reliance and limitations

- This paper was produced by the Post-COVID biometric assumption working party. Views expressed are those of the individuals comprising the working party and are not necessarily those of their employers.
- The purpose of the paper is to serve as a reference for those tasks with setting, reviewing, or approving assumptions related to mortality or longevity. The paper offers principles, frameworks, and general guidance. The content of this paper should not be considered as advice or a recommendation. This paper does not aim to calibrate assumptions. It instead raises issues to consider, and highlights possible methodologies
- The analysis presented is applicable at the population level, and we make no distinction between results and approaches for males and females. The focus of this work is UK lives. Users of the paper should apply their own judgement regarding the applicability of the analyses and conclusions to their own portfolio of lives.
- This paper takes account of research and data available to 30th June 2023, except for analyses involving the CMI 2022 model, which were conducted in August 2023.
- Scope: We consider longevity and mortality assumptions in this paper. Similar principles are likely to apply to morbidity, but we have not considered this explicitly as part of this work.
- This work considers best estimate assumptions. Aspects of this paper may be useful in considering implications for the modelling of capital stresses, but we have not considered this explicitly as part of this work.
- Users of the report should form their own view on whether the information it contains is materially complete for the purpose of assessing changes to mortality outcomes that have been precipitated by the pandemic.

1. Introduction

1.1. Background

During the acute phase of the COVID-19 pandemic, the UK experienced waves of excess deaths due to the rapid spread of the SARS-CoV-2 virus and the high infection fatality rate ("IFR"). More than three years on from the first infections, and with infections and deaths now seemingly under control due to vaccinations and population immunity, actuaries must now wrestle with how the pandemic affects biometric assumptions – and in this paper we consider mortality and longevity assumptions. We focus on implications for the methods used in the assumption-setting process, and identification of the changes precipitated by the pandemic, and how the latter should be reflected in assumptions.

1.1.1. A very brief history of the COVID-19 pandemic in the UK

The early phase of the pandemic in the UK was defined by waves of excess deaths punctuated by lockdown measured used to bring infection levels under control. Outside of strict lockdown periods, many restrictions remained in place, such as the requirement to wear masks or isolate after a positive COVID test. As vaccinations were rolled out, restrictions were gradually lifted until on the 24th of February 2022 all remaining legal restrictions were removed [1,2]. Figure 1 shows how COVID-19 deaths evolved throughout the 2020-2022 period, and some key milestones in the fight against the disease.

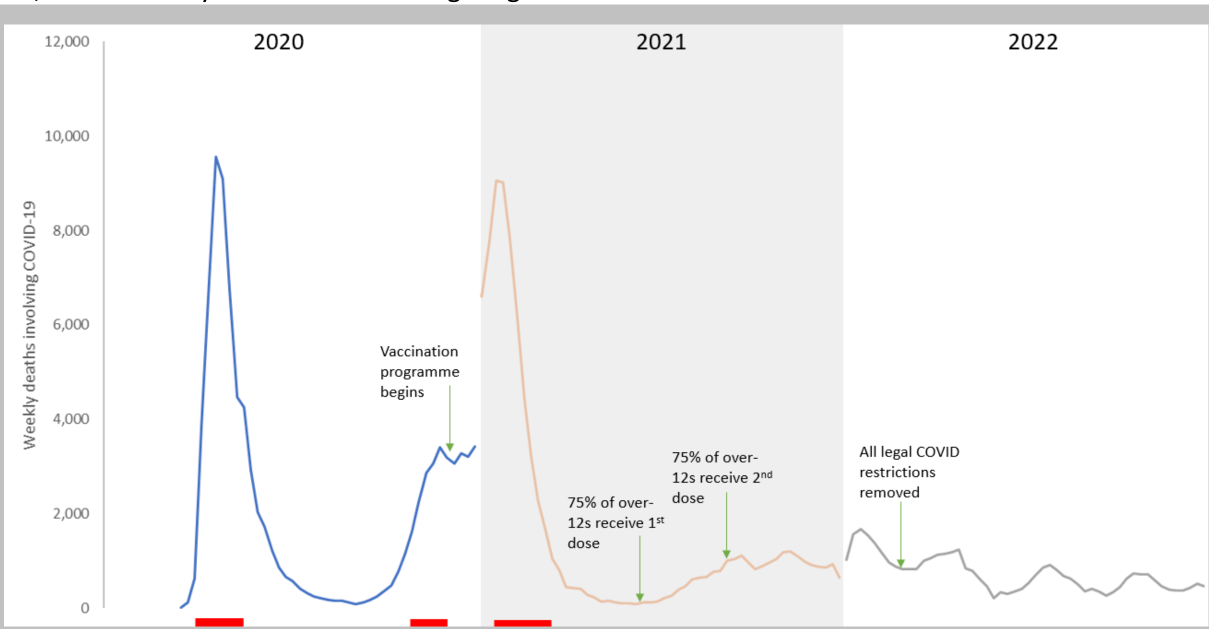

Figure 1. Weekly deaths in the UK involving COVID[3] through 2020-2022.
Red bars indicate periods of national lockdown (the most severe measures put in place)[4], but measures to reduce the spread of the virus were in place from the first lockdown through to the removal of restrictions in February 2022. Vaccination data is taken from the ONS[5].

1.1.2. Deaths attributed to COVID-19: due to or involving?

There are a few methods of estimating the number of deaths that can be attributed to COVID-19:

- During the height of the pandemic, deaths within 28 days of a positive COVID-19 test were used as a proxy for deaths caused by the disease

[1] www.bbc.co.uk (last accessed 31/07/2023)
[2] www.instituteforgovernment.org.uk (last accessed 31/07/2023)
[3] www.ons.gov.uk (last accessed 31/07/2023)
[4] www.instituteforgovernment.org.uk (last accessed 31/07/2023)
[5] www.ons.gov.uk (last accessed 31/07/2023)

- Deaths involving COVID-19 are those where COVID-19 is recorded anywhere on the death certificate (main cause or contributory factor)[6]
- Deaths due to COVID-19 are those where COVID-19 is recorded the main cause of death on the death certificate

Deaths due to COVID-19 are a subset of deaths involving COVID 19 and will therefore always be lower. The CMI mortality monitor uses deaths involving COVID-19 when accounting for COVID-19 deaths in their publication and note that the relationship between deaths involving COVID-19 and excess deaths has varied since the start of the pandemic. During the first wave of the pandemic, excess deaths were more numerous than deaths involving COVID-19, presumably due to under-reporting on death certificates of COVID-19 as a cause. During the second wave, deaths involving COVID-19 were above the number of excess deaths calculated by the CMI, presumably due to over-reporting or a reduction in deaths from other causes (influenza for example). More recently, excess deaths and deaths involving COVID-19 have not tracked as closely as they did during the early period of the pandemic, suggesting that other drivers of excess deaths are becoming dominant.

1.1.3. COVID-19 death statistics

Deaths involving COVID-19 have varied markedly by age; Table 1 shows deaths in England and Wales by age band across 2020-2022, and 2023 YTD.

Table 1. Deaths in England and Wales involving COVID-19

Left: Deaths by year of registration and age-band.

Right: Deaths involving COVID-19 expressed as a percentage of all other (non-COVID-19) deaths registered in the year and age-band.

Age-band	2020	2021	2022	2023 YTD
0-24	54	120	88	20
25-49	1,445	2,452	740	158
50-74	18,940	22,163	7,094	2,144
75+	60,391	51,359	25,218	9,360
Total	80,830	76,094	33,140	11,682

Age-band	2020	2021	2022	2023 YTD
0-24	1.1%	2.2%	1.6%	0.7%
25-49	6.7%	11.4%	3.4%	1.4%
50-74	13.1%	15.7%	4.9%	2.7%
75+	16.7%	15.0%	6.8%	4.5%
Total	15.2%	14.9%	6.1%	3.9%

Note that the absolute and relative number of deaths involving COVID-19 has fallen since 2020/2021 (COVID-19 deaths only started part way through 2020 and so the full-year 2020 figures slightly understate the severity of COVID-19 in that year relative to the other years). Figures are derived from ONS death registration data[7].

Throughout all phases on the pandemic, COVID-19 deaths have been concentrated at the oldest ages both in absolute terms and in terms of uplift to baseline mortality rates. Although mortality rates associated with COVID-19 have fallen markedly since the start of the pandemic, COVID-19 remains a prominent cause of death, particularly at older ages, and so remains one that actuaries should account for when setting biometric assumptions.

1.1.4. Non-COVID excess deaths

The UK has experienced high levels of non-COVID excess deaths since the Summer of 2022. Figure 2 is taken from the CMI's mortality monitor for week 26 of 2023.

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[6] assets.publishing.service.gov.uk (last accessed 31/07/2023)

[7] www.ons.gov.uk (last accessed 31/07/2023). Data taken as at 24 July 2023. The data for 2019-2022 comprise the full ISO year, i.e. all weeks assigned to that year regardless of whether part of the week fell outside of the calendar year. The data for 2023 comprises data to week 26, i.e. from 31st December 2022 to 30th June 2023. We use death registrations (i.e., not occurrences) throughout.

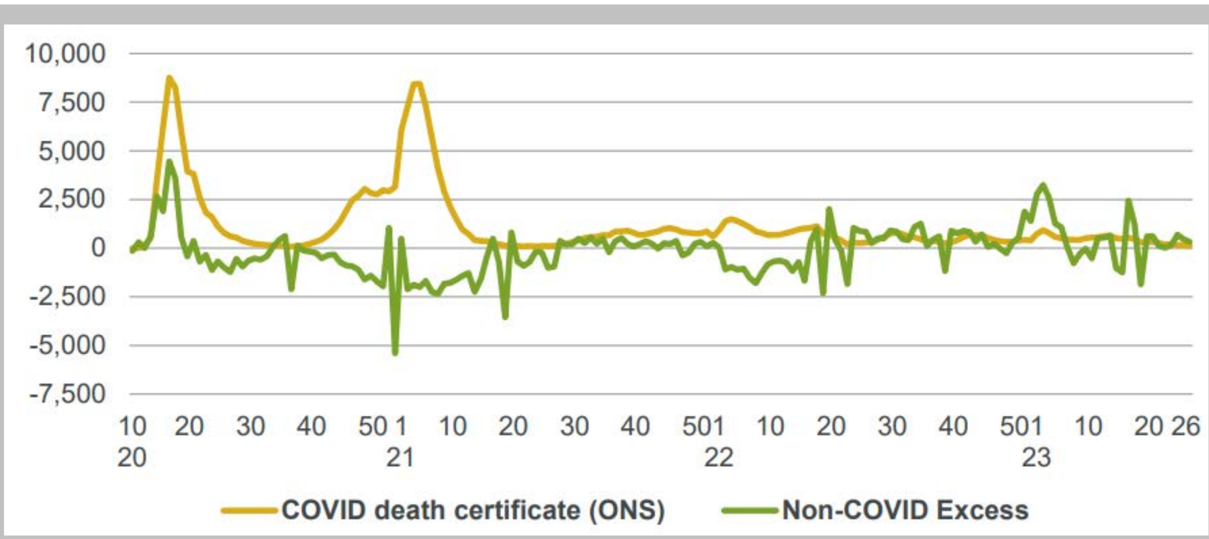

Figure 2. **Non-COVID excess deaths**

This is the difference between observed and expected deaths after subtracting deaths involving COVID-19, over time. Non-COVID excess deaths have been overall positive since the middle of 2022.

The sheer number of deaths in the 2020/2021 spikes obscures the number of recent non-COVID excess deaths to an extent (as does the volatility in registrations around bank-holidays), but the most recent mortality monitor at the time of writing (week 26, 2023) estimates 452 excess deaths in that week of which 129 can be accounted for by COVID-19. This week is reasonably representative of the broader pattern: the CMI also estimates that 2023 YTD excess deaths as at week 26 stand at around 25,000 for England and Wales, which is significantly above the YTD estimate of COVID-19 deaths. For reference, there were approximately 550,000 deaths across England and Wales in 2022 and so each 10,000 excess deaths over the course of a year would be roughly equivalent to 1.8% excess mortality.

Therefore, this is a significant component of all-cause mortality, and in addition to understanding the progression of COVID deaths, setting biometric assumptions also requires a view on the driver(s) of the non-COVID excess deaths that have emerged since the middle of 2022, and a view on how those drivers (and associated deaths) will evolve in the future.

1.1.5. The return of Influenza

Mortality rates at the end of 2022 and beginning of 2023 were impacted by the return of large numbers of influenza deaths, which had been supressed since the start of the pandemic because of measures put in place to control the spread of SARS-CoV-2. The absence and subsequent re-emergence of these deaths and in particular the re-emergence of influenza into a world where SARS-CoV-2 is circulating - poses problems for actuaries who want to make like-for-like comparisons of mortality in different years, and those looking to project mortality rates into the future as SARS-CoV-2 and influenza become coexisting and competing causes of death for the first time.

1.1.6. The cost-of-living crisis

As we emerge from the acute phase of the COVID-19 pandemic, we find ourselves in a very different economic environment to the one we were in before the first COVID-19 deaths were recorded. Challenges emerging directly from the pandemic and associated lockdowns, and other geopolitical changes, have resulted in a high inflation-high-interest environment not seen in the UK in many years. These changes add to the growing list of reasons that pre-pandemic assumptions and assumption-setting processes are unlikely to be appropriate in the immediate future.

1.1.7. Setting mortality and longevity assumptions in 2023

Actuaries looking to understand recent trends in mortality and extrapolate these into the future are burdened by recent data that is difficult to interpret because of the turbulence caused by the COVID-19 pandemic, as well as an uncertain future as we emerge from the pandemic facing excess deaths and a challenging economic environment. We note that setting assumptions pre-pandemic required judgement and for actuaries to be comfortable in dealing with a great deal of uncertainty, but given the unique situation we find ourselves in currently, we believe that reviewing the current state of key drivers of mortality in the UK and offering high-level guidance around setting assumptions in the current environment is a useful exercise. We hope that readers can take additional comfort in their own assumptions by comparing their own processes and considerations to those laid out in this paper.

The paper is structured as follows:

- We describe the assumption-setting process, with separate sections for the process before the COVID-19 pandemic and how this might need to be adapted in current circumstances.
- We demonstrate some of the insights that can be gleaned from using even a very simple driver-based analysis of excess mortality, and show how a driver-based view can be used in conjunction with the CMI 2022 model to help with setting appropriate parameters. The approach can be used to benchmark the relative strengths of any pre- and post-pandemic bases.
- We then explore some of the mortality drivers actuaries should consider when setting assumptions today, including giving our opinions, where appropriate, on the likely materiality of the different factors.

We focus primarily on best-estimate assumptions, but actuaries should also consider how the factors outlined in this paper might impact capital requirements, to the extent that there is some increased uncertainty in the short-term as we emerge from the pandemic.

1.2. Compliance

This paper considers how the outlook for mortality may have changed in light of the coronavirus pandemic. The views in this paper are subjective and any person using this paper should exercise judgement over its suitability and relevance for their purpose. The paper complies with the principles in the Financial Reporting Council's Technical Actuarial Standard "TAS 100: General Actuarial Standards".

1.3. Feedback

Comments are welcome and can be to the chair, Colin Dutkiewicz (colin.dutkiewicz@aon.com).

1.4. Acknowledgements

We thank Richard Willets for sharing his insights as the Working Party were planning this work, and Thomas Honeywell for checking the work presented in Section 4. We thank Steve Bale and Paul Jolly for feedback on an earlier draft of the paper.

This report was produced and reviewed by members of the Working Party, namely:

Craig Armstrong; Laura Benton; David Cartmill; Colin Dutkiewicz (Chair); Jonathan Finn; Oliver Hampson; Ben Johnson; Hai Luc; Paul Malloy; James Malone; Robert Mellows; Richard Montgomery; Jon Palin; Joanne Wells; Nay Wynn

2. Setting biometric assumptions pre-COVID-19

This section summarises the typical pre-COVID assumption-setting process for best-estimate biometric assumptions. In subsequent sections possible changes to this process are discussed.

Assumptions are generally presented as a combination of a base table and improvement rates. The **base assumptions** are usually set with reference to an analysis of the portfolio's own experience, considering the statistical credibility and relevance of the data. If only smaller datasets are available the assumptions may also be supported by the experience on other, similar, datasets and their relative credibility.

For **improvement assumptions** we typically require larger volumes of data to interpret a trend and so population data is often used. Where appropriate, statistical approaches can be used to fit historical improvements and project these into the future, at least in the short term. These short-term improvements often then converge towards a final "long term trend" assumption. This is the approach used by the CMI model, which is commonly used as a means of setting (or at least expressing the strength of) an improvement basis[8].

For more material exposures, improvement assumptions can also be supported by additional analysis into the underlying drivers of historical improvements and how these drivers, and any new ones, might affect improvement rates in the future. Such analysis might include:

- deciding how many years of recent data to use as a credible predictor of short-term trends;
- determining whether factors that impact mortality, such as smoking and obesity or the advent of medical developments, will continue to follow past trends;
- deciding how to incorporate medical opinion on changes to medical practices;
- consideration of new drivers for mortality; and
- deciding how to adjust for portfolio specifics such as socioeconomic group and levels of underwriting.

The established methods for assumption setting often relied on adding one more year of data into an agreed methodology (for instance a 5-year experience analysis for the base table and an agreed trend model). These mechanical approaches were often well established and offered a stable approach year on year. This was reasonable as mortality rates typically progressed steadily according to underlying smooth trends.

We contrast this with the current situation in the next section.

[8] We do not discuss the CMI model in any detail in this paper. Please see CMI Mortality Projections Committee working papers for detailed explanation of the model.

3. Setting biometric assumptions since the onset of COVID

This section sets out some key principles for setting assumptions since the onset of the pandemic. Different approaches will be valid depending on the materiality of the assumption, the credibility of data available and each individual firm's standard approach to base and trend mortality assumption-setting pre-COVID (such as using the most recent 5-year experience window or simply adding a new data point to an existing trend model).

3.1. Limitations of pre-pandemic approaches in current conditions

The spikes in mortality due to COVID-19 in 2020 and 2021 have led to greater volatility in experience data than had been observed in the period leading up to the pandemic. Actuaries are no longer able to assume that recent experience is representative of the short-term future for the purpose of setting either base biometric assumptions or their trends through time. This means that the standard approaches adopted prior to 2020 might no longer give reasonable results.

The predominant approach, certainly for UK mortality, has been to exclude data from 2020 and 2021. The CMI model has placed zero weight on these years and many actuaries have ignored (or at least down-weighted/adjusted) data from this period when setting base assumptions.

The conclusion for 2022 data is less clear. The analysis in this paper suggests that data from 2022 (and emerging 2023) should not be discounted, as the data that is emerging suggest we may be exiting the pandemic into a different mortality (and perhaps improvement) regime than before and so it would be sensible to use as much recent data as possible to glean insights into how this might play out. However, including this in a standard mechanical approach in which the experience window is simply rolled-forward to include 2022 data would be a key judgement, and should only be implemented after relevant analysis has been completed.

3.2. Options for setting assumptions in the presence of COVID-19

We believe three main options have typically been used by firms since the onset of the pandemic:

- Ignore / down-weight data impacted by COVID-19;
- Adjust data impacted by COVID-19; or
- Carry out a bottom-up analysis of the drivers for a more informed view.

There are merits in each of these options depending on the circumstances.

3.2.1. Option 1: Ignore/down-weight data impacted by COVID-19

Under this approach, data from years impacted by COVID-19 is either excluded from the analysis, or included in a diluted form.

Table 2.	Merits of down-weighting Covid affected data
Pro	Exclusion is simple to apply and rationalise for 2020 and 2021
Con	Valuable insights may be lost
Con	Not clear how to treat 2022 and future years' experience. Should this be included and, if so, how should it be weighted relative to a normal year?
Overall	For more material blocks of business, a more detailed approach may be warranted that considers the underlying drivers of current, heavy mortality and how these might be projected. However, a simple weighting approach may be appropriate for smaller portfolios. At a high level, and consolidating the views of the Working Party, the discussion in Section 5 suggests: • Exclusion (or significant down-weighting) of 2020 and 2021 experience continues to be reasonable; and • baseline mortality assumptions based on a down-weighting of the excess mortality experienced in 2022 may give assumptions within a reasonable range for less material blocks of business (for which a more detailed analysis, such as that described in option 3 below, is not warranted). We note the outcome of the CMI Mortality Projections Committee using a 25% weight on 2022 data within the CMI22 model is a decrease in life expectancies relative to pre-pandemic expectations. Our analysis in Section 5 suggests that this is directionally appropriate. As per CMI Mortality Projections Committee guidance, the extent of any changes to life expectancies should be considered in light of the actual portfolio being analysed.

3.2.2. Option 2: Adjust data impacted by COVID-19

Under this approach we use population data to estimate the proportion of deaths in the portfolio that were due to COVID-19 and adjust the data for these[9].

This typically assumes the portfolio impact is the same as on the whole population although adjustments can be made for socio-economic and/or age-specific factors, making use of any portfolio cause of death information that may exist.

Table 3.	Merits of the data adjustment approach
Pro	Insights into other variances in drivers of mortality are retained, in theory.
Pro	Significant changes in mortality will still be apparent.
Con	It is unlikely that COVID-19 related deaths will be accurately captured in the data given the various potential definitions of "a COVID-19 death"
Con	The inaccuracy in the estimated adjustments could obscure or overstate the changes in mortality in other drivers.
Con	Removing COVID-19 deaths from the data implies that this was a very short-lived effect and makes no allowance for the possibility of ongoing COVID deaths impacting mortality in the medium/long term.
Con	While COVID-19 deaths can be removed, this may not capture any indirect effects on other causes of death (e.g. Influenza)
Pro/Con	Other indirect impacts of the pandemic will not be adjusted out, but whether or not they should be retained in the experience depends on a judgement of whether these effects are considered permanent.
Overall	This approach effectively views direct COVID-19 deaths as short-lived but any indirect effects as permanent. This is a relatively crude assumption but may be reasonable for less material portfolios. It may also be the most appropriate methods for portfolios with small or immature volumes of experience data for which some signal around underlying mortality could potentially be drawn.

[9] We focus on adjusting for COVID-19 deaths here. We are aware of alternative methods of removing excess rather than COVID-19 data from the 2020-2022 period. However, these methods are not favoured due to the circularity of the derivation of excess, which means little new information can be inferred. If we derive excess deaths as the difference between actual (say 2022) deaths and some baseline (say 2015-19 average) then remove those excess deaths from 2022 data, we return to the baseline by definition, and so there is no new information over and above that from the 2015-19 average itself.

3.2.3. *Option 3: User a driver-based approach to adjusting assumptions*

This is the most comprehensive option to determine how to adjust assumptions in the aftermath of the pandemic. The following steps can be followed to achieve this “driver-based” approach:

Step 1: Identify the main drivers of why mortality might differ from our view pre-pandemic

Step 2: Quantify, where possible, those drivers including their contribution to 2022 and emerging 2023 excess mortality.

In Section 5 we identify what the Working Party believe to be the key drivers and offer some insights into their quantification and potential projection.

This is not intended to provide an “off the shelf” answer but can help users focus on what are likely to be the most material drivers. Users of this information might wish to enhance this with their own analysis. Section 5 can be summarised into the following grid analysis:

Table 4. Summary of analysis of drivers impact future mortality

Factor	Short (2023 – 2025)	Medium (2026-2030)	Long (2031 +)
Future Spikes in COVID-19	The possibility of future spikes in COVID-19 should be considered in the assessment of capital, but, in our opinion, a reasonable best-estimate of the future trajectory of COVID deaths need not include an allowance for material spikes		
Endemic COVID-19	Mortality remains similar to recent levels	Reductions in disease severity and improvements in treatment likely reduce mortality compared to 2022	
[reduced] Influenza / respiratory deaths	Stabilisation of influenza mortality at similar levels to pre-pandemic, noting some risk of increased severity in the short term. Important to recognise the risk of double-counting the overlap with COVID as a competing cause	Potential for some benefit relative to the short term from mRNA technology developments, and any short-term increases in influenza severity being only temporary.	
Changes to the economic environment	The impact of historical economic downturns has varied in direction and magnitude across different countries, and there is no clear-cut link between the economy and mortality rates. However, analysis of the impact of recent austerity measures in the UK suggests that they might have been a driver of mortality-improvement slowdown post-2011.		
Health service disruption / treatment backlogs	The impact of funding shortage, staff shortage and increased demand etc. are likely to persist in the immediate future. Delays to diagnoses, treatments, and provision of emergency care will continue to have an upward pressure on mortality rates relative to pre-pandemic.	The medium to long term impact is dependent on the NHS hitting their targets on the path to recovery. If successful, we are likely to see a reduction in excess mortality.	
Lost improvements (during the period 2019-2022)	Probably small relative to COVID-19 deaths. Depends on improvements assumed in 2019 basis and the drivers of those improvements, but it seems likely that a significant proportion of these would not have been “lost”.	Likely to have a small impact, possibly immaterial over a longer time-period to the extent that the short-term effect is unlikely to be large, and a proportion of any short term lost improvements can be “won back”	

Forward displacement of deaths	Small magnitude relative to some other drivers mentioned in this paper (healthcare strain for example) but there is potential for some reduction in mortality rates in the short term, particularly for older ages.	While any short-term impact is likely to wear off over time, our simple model suggests that the run-off is relatively slow.
Long COVID	Small increase – the current literature is insufficient but users should keep abreast of newly published literature	Negligible impact
Acute post-COVID-19 sequelae	Material impact on excess deaths, proportional to COVID-19 deaths	Smaller impact, particularly if the endemic steady-state of COVID infections is low
Lifestyle Changes	Small increase to mortality rates – could be more material at younger ages	Small increase – could be more material at younger ages especially if activity and alcohol consumption levels don't revert toward pre-pandemic levels.

Step 3: Consider whether the drivers imply changes that will be temporary or will give rise to longer-term effects, recognising that there is significant judgement involved in this. This can also consider the shape of any adjustment over time (see below). Sensitivity test the assumptions to get a better understanding of the impacts.

Step 4: Consider how to apply this analysis in assumption setting. This could be via an explicit overlay or via existing approaches (e.g. via the application of a certain weight on 2022 data, etc.).

We can appraise the pros and cons of option 3 as follows:

Table 5. Merits of driver-based approach

Pro	Incorporates more insight as to the underlying drivers and so should lead to a better-informed assumption.
Con	More resource intensive which may not be proportionate for less material portfolios; may involve more judgement.
Overall	Some version of this approach is likely to be most appropriate for the more material exposures. Some users may take high-level insight from Section 5 of this paper. Others may carry out a more detailed approach. In either case implementation could be via an explicit overlay to pre-pandemic assumptions (taking due care that there is no double-counting between effects captured in the base table and those captured in the trend). Note that it is possible in principle to take a driver-based view to create base and improvement assumptions in their entirety from the "bottom-up". This would be extremely onerous, however, and we recommend the more pragmatic approach of assigning drivers to changes relative to pre-pandemic expectations.

3.3. Application in assumption setting – considering the shape through time

Any adjustment needs to consider not only the overall magnitude of any assumption change but also its shape through time[10]. We illustrate this in the following table. We assume:

- the unadjusted assumptions to be those used at year end 2019 (i.e. the last full year with no COVID-19 impact);
- "base assumptions" refers to the mortality rate at year end 2022; and
- "improvement rates" refers to any change in the mortality rates from 2023 onwards.

Here an unadjusted base means a year end 2019 mortality rate with 3 years of expected improvement.

[10] In this section we have generally considered the period effects (i.e. shape through time) to be the most significant consideration. However, a development of the approach could justifiably consider any adjustments by age or even cohort if there was sufficient evidence to adjust at this granularity.

Table 6. Possible future mortality shape/trends

Potential shape	YE22 base mortality	Improvements from 2023	Rationale	Comment
Rapid reversion	Pre-COVID view	Pre-COVID view	A quick reversion to the pre-COVID environment. Recognises 2022 was heavy but ignores this experience as a signal for future mortality rates.	Arguably a prudent approach for longevity assumptions based on Section 5 which suggests some adverse impact.
Rapid reversion with improvement drag	Pre-COVID view	Adjusted downward	Assume quick bounce-back of current mortality to pre-COVID-19, but then a longer term drag on improvements	Inconsistent with 2022 and emerging 2023 experience but may be reasonable if rapid reversion is believed and these years are ignored in the setting of base assumptions.
"New normal" here to stay (flat uplift to mortality)	Heavier mortality	Pre-COVID	Assumes short term excess deaths will continue indefinitely – i.e. we have had a step change from our pre-COVID-19 view, but will now see improvement rates in line with YE19 view	These options appear more consistent with 2022 and 2023 emerging experience.
Short-term heavier mortality runs off over time	Heavier mortality	Adjusted upward so that projection blends to pre-COVID-19 rates after n years	Recognises excess deaths in the short term. Also adjusts improvement rates from 2023 onwards to take into account both short term and longer-term impacts of COVID-19, either upward (if we believe the short term adjustment to base table will wear off over time) or downward (if we believe things will deteriorate further).	
Short-term heavier mortality deteriorates over time (uplift to mortality with improvement drag)	Heavier mortality	Adjusted downward		

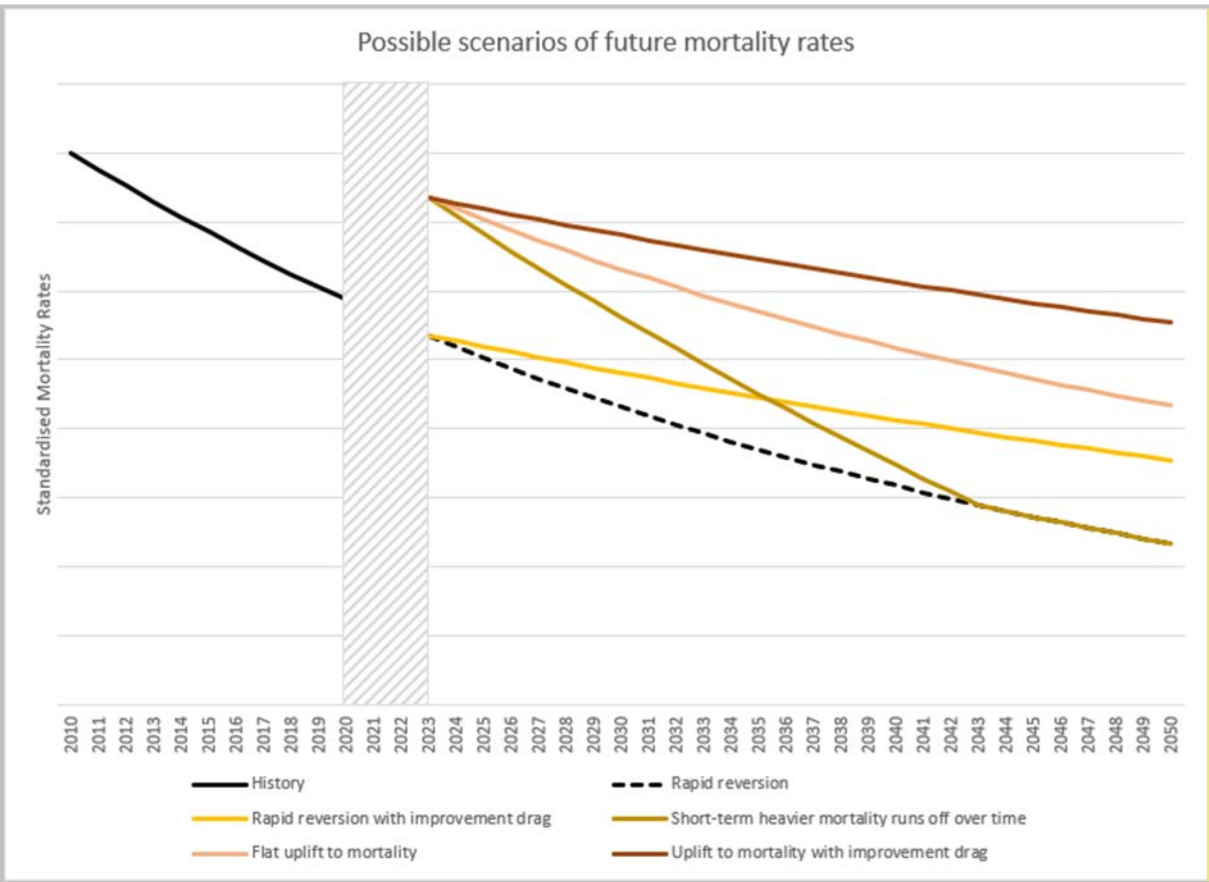

Figure 3. **Potential future mortality rate scenarios**

This is an illustration of some of the potential scenarios for future mortality rates. The solid black line shows an idealised historical standardised mortality rate trajectory, and the shaded area shows the period 2020-2022 (mortality rates not shown for clarity). Future mortality rates may incorporate an increase to base mortality, changes to future improvements, or both. The scenarios shown are not intended to be an exhaustive set of reasonable projections, rather they show a subset of idealised outcomes according to the rationale in Table 6.

We believe that consideration of the likely “shape” of any adjustment can inform whether it is best captured via a change to base table, improvements, or both.

Changes to base mortality can be either explicit overlays or used to validate the use of certain weights on recent experience. For example, this can inform:

- Whether to bring 2022 into the experience window and whether to give it more or less weight than normal;
- Whether to change the investigation period length;
- Whether adjustments made previously (e.g. to remove COVID-19 deaths from previous experience) are reasonable; and
- Whether to make explicit overlays to the base table.
- Whether to make changes to improvements, which could be via the specific parameterisation of the CMI model (or any other model used).

3.4. Concluding guidance for actuaries

Different approaches will be applicable for different portfolios.

Options 1 or 2 are simpler and may be more relevant for less material portfolios where assumptions are typically set using high level judgements rather than with a detailed model of mortality drivers.

Option 3 is likely to be more appropriate for more material exposures. This may apply to firms who already use their own improvement model or carry out more substantial tailoring of the CMI model to reflect analysis of underlying drivers of mortality. For these portfolios our aim is that the Section 5 analysis offers:

- a useful shortlist of the main drivers, including some further focus on what are likely to be the most material of these; and
- an introductory analysis on these drivers with signposting as to what further analysis might be done to inform an assumption.

There are a range of options between these depending on the materiality and appetite for investigating underlying drivers in a driver-based approach.

In the following section we demonstrate a simple application of a driver-based approach to forecasting mortality rates, and show that even a high-level view of how the material drivers will evolve is enough to derive useful insights that can be applied to assumption-setting.

4. Practical application of a driver-based approach

In this section we use a simplified driver-based approach to adjust a pre-pandemic basis and show that useful insights can be gleaned using only high-level views of how drivers of post-pandemic mortality will evolve. The example given will be applicable to longevity business but can be readily adapted to other lines of business and other ages.

4.1. Scenario analyses

A driver-based approach typically involves assigning the current level of excess deaths to different drivers, and then forming a view of how those drivers will evolve in the future. The impact of each driver is applied multiplicatively to a pre-pandemic view of future mortality rates; in the simplest implementation the pre-pandemic baseline remains unchanged in the post-pandemic view, but a more-sophisticated implementation may attempt to capture changes in the baseline either by designating a driver to changes in pre-pandemic expectations or adjusting the baseline explicitly. Section 5 describes the drivers that are likely to be responsible for excess deaths currently.

The most-difficult part of this exercise is taking a view on how the different drivers will evolve over time. A pragmatic approach is to pick some remaining level of excess *x*% (measured relative to a pre-pandemic expectation) that will remain after *n* years, and remain constant thereafter. The effect of the driver changes linearly between the initial year and year *n*. We can simplify the approach even further by treating the initial excess as a single driver, and see what happens to cohort EOL for a range of parameters *x* and *n* (See Figure 4). This simple model of future mortality rates allows us to get a feel for impacts under some reasonable assumptions; we surmise that many actuaries will hold a high-level view of how the material drivers presented in this paper and elsewhere will evolve, and establishing associated "rules of thumb" is a useful part of setting a basis when the future outlook is so uncertain.

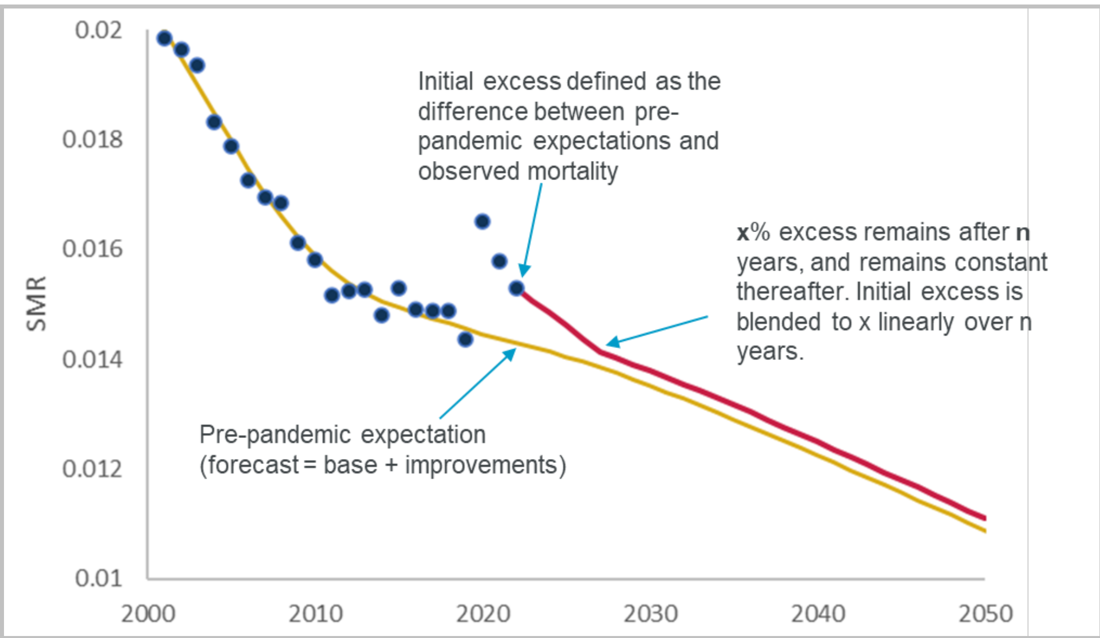

Figure 4. Simple framework for implementing driver-based approach to future mortality
See main text for details. Mortality rates are shown as being standardised by age for simplicity, but in reality adjustments would need to be made for each age.

To illustrate the way in which the framework can be applied, we have created a pre-pandemic expectation of mortality using the CMI 2022 software. We applied zero weight to all years beyond 2019 but otherwise used the core parameters in conjunction with data for males, a long-term-rate of 1.5%, and the S3PMA base table**.**

We have adjusted this baseline using a range of parameters *n* and *x* to illustrate the range of impacts on cohort life expectancy implied by a simple driver-based approach[11] (Figure 5).

	Age	50		
	Baseline EoL	36.46		
	Initial excess	10%		
	Runoff period (**n**) --->			
		5	**10**	**20**
Excess mortality remaining at end of runoff period (**x**)	**0.0%**	-0.02	-0.04	-0.10
	2.5%	-0.23	-0.25	-0.29
	5.0%	-0.44	-0.45	-0.47
	7.5%	-0.64	-0.64	-0.66
	10.0%	-0.83	-0.83	-0.83
	12.5%	-1.03	-1.02	-1.01

	Age	60		
	Baseline EoL	26.65		
	Initial excess	5%		
	Runoff period (**n**) --->			
		5	**10**	**20**
Excess mortality remaining at end of runoff period (**x**)	**0.00%**	-0.01	-0.03	-0.07
	1.25%	-0.11	-0.12	-0.15
	2.50%	-0.20	-0.21	-0.23
	3.75%	-0.30	-0.30	-0.31
	5.00%	-0.39	-0.39	-0.39
	6.25%	-0.48	-0.48	-0.47

	Age	70		
	Baseline EoL	17.49		
	Initial excess	5%		
	Runoff period (**n**) --->			
		5	**10**	**20**
Excess mortality remaining at end of runoff period (**x**)	**0.00%**	-0.02	-0.05	-0.12
	1.25%	-0.10	-0.12	-0.18
	2.50%	-0.18	-0.20	-0.23
	3.75%	-0.26	-0.27	-0.28
	5.00%	-0.34	-0.34	-0.34
	6.25%	-0.41	-0.41	-0.39

	Age	80		
	Baseline EoL	9.76		
	Initial excess	5%		
	Runoff period (**n**) --->			
		5	**10**	**20**
Excess mortality remaining at end of runoff period (**x**)	**0.00%**	-0.04	-0.08	-0.16
	1.25%	-0.09	-0.13	-0.18
	2.50%	-0.15	-0.17	-0.21
	3.75%	-0.21	-0.22	-0.23
	5.00%	-0.26	-0.26	-0.26
	6.25%	-0.31	-0.30	-0.28

Figure 5. Impacts of simple driver-based approach

Impacts of applying the simple driver-based approach to a CMI 2022 forecast for males, with no weight placed on data beyond 2019. Impacts are expressed as changes in cohort life expectancies. Initial excess mortality rates were derived by comparing the model to the population data in 2022 across all ages. Impacts are strongly age-dependent; at younger ages the remaining excess x is more material than the assumption around the runoff period n, as the excess in initially being applied to lower mortality rates (younger ages). At older ages the runoff period becomes more important. Initial excess mortality applies in 2022, and EOLs are as of 2023. EOLs are calculated using the method described in the CMI 2022 working paper.

The results show that for a male aged 50, if the excess decreases linearly over 10 years from 10% in 2022 to 5% in 2032 and then remains at 5%, life expectancy would reduce by 0.45 years from 36.46 (with no excess) to 36.01. Results for other ages and combinations of ***x*** and ***n*** can be read off the tables in the same way.

4.2. A tool for benchmarking bases

The simple driver-based approach can be extended to compare two bases – one from before the pandemic and one from after. To demonstrate this, we create a second mortality forecast from the CMI 2022 model using the same parameterisation except for the application of 25% weight to the data in 2022. We can calculate changes in cohort EOL relative to our first basis, and asses how we would need to parameterise the simple driver-based approach to achieve the same impacts. It is easiest to do this by fixing *n* at some value deemed to be plausible and varying *x*, and here we pick *n* = 10 (Figure 6). The results are shown in Table 7.

[11] Note that we have applied the drivers as if they apply entirely to cohorts, i.e. 5% excess applied to 70-years olds in 2022 running off to 1.25% in some future year will apply to 71-year-olds in 2023, 72-year-olds in 2024, etc. This simplifies the calculation of cohort EOLs, but we note that it would also be reasonable to apply the driver evolution in the period direction. Sophisticated implementations may apportion some of the driver as a period effect and some as a cohort effect, as per an APC(I) model.

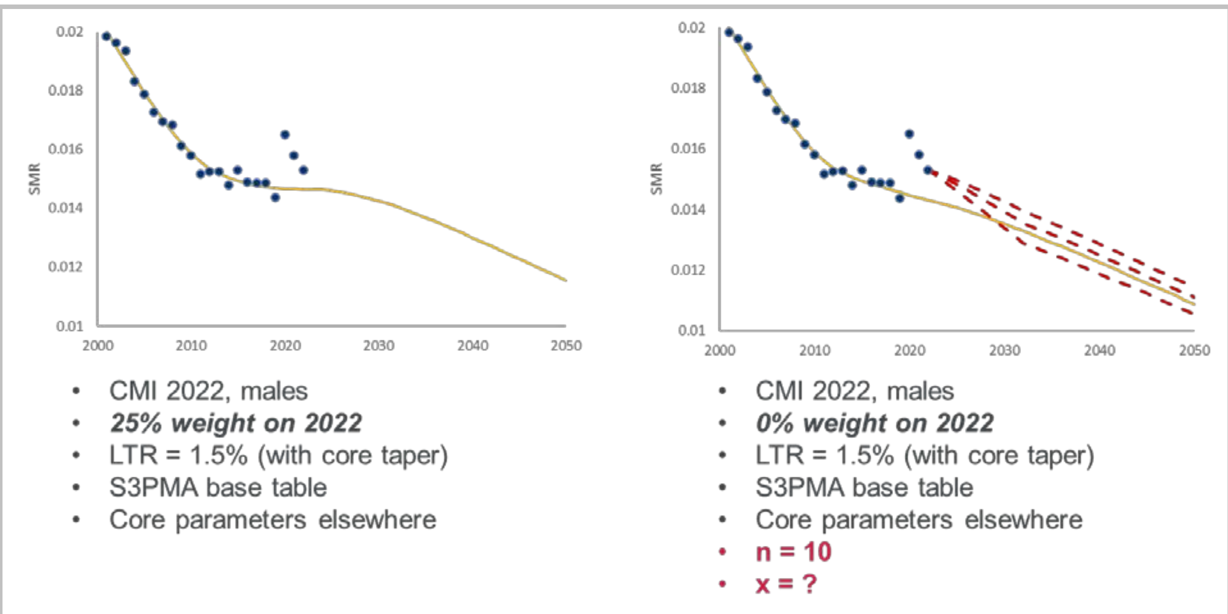

Figure 6. **Post-pandemic versus pre-pandemic forecasts**
Comparison of a post-pandemic forecast (left) to a pre-pandemic forecast with a driver-based approach to projecting excess deaths (right). See text for further details. Mortality rates are shown as being standardised by age for simplicity, but in reality adjustments would need to be made for each age.

Table 7. **Comparison of CMI bases**
Comparison of the CMI bases described in the main text with an equivalent driver-based parameterisation. Under a simple driver-based approach, a significant amount of residual excess must remain in year 10 to achieve the same impact as weighting the 2022 data by 25%. At some ages the residual excess at year 10 must be higher than the initial excess.

Age	cEOL 25 pc weight	cEOL 0 pc weight	Initial 2022 excess	Remaining excess at yr 10
50	35.9	36.5	10.0%	5.9%
60	26.2	26.6	5.0%	5.9%
70	17.1	17.5	5.0%	5.3%
80	9.5	9.8	5.0%	4.1%

The results show that the core parameterisation of the CMI model is consistent with a view that most of the UK-population excess deaths observed in 2022 are here permanently, or may even increase at some ages. Note that this result will be very sensitive to the parameterisation of the model; users that use their own convergence periods, for example, may calculate very different results to those calculated here as the difference between the two bases is predominantly due to differences in short-term improvement rates. We therefore advise users to perform their own calculations using their own pre- and post-pandemic bases rather than assuming the numbers presented here will apply directly to their bases. It is also worth noting that bases can give similar expectations of life despite the forecasted profile of mortality rates being quite different. Forecasts made using the CMI model are constrained to progress smoothly from pre-pandemic trends, with only 25% weight on 2022 data. This means that the forecast does not start from the 2022 level of mortality. The simple driver-based approach produces forecasts that start from 2022 levels of mortality, and so the mortality rates produced by the two methods evolve in a fundamentally different way (Figure 7).

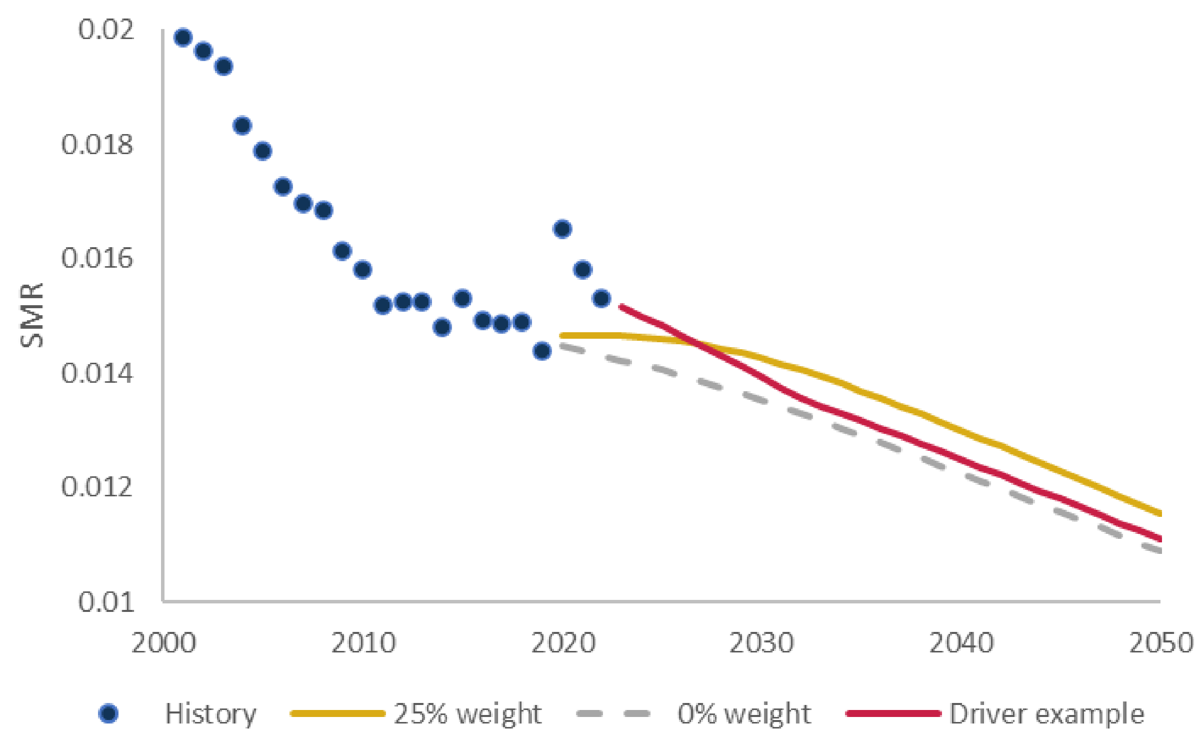

Figure 7. Comparison of forecasts (core CMI 2022 versus driver-based

A comparison of the forecast produced by the core CMI 2022 model (gold) and an arbitrary driver-based projection (red). The driver-based projection starts at 2022 levels of mortality and evolves in a way that is specified relative to a pre-pandemic forecast (grey dashed line). The CMI projection is constrained by adherence to the pre-pandemic data and the core weighting scheme assigns 25% weight to the 2022 data, and so the forecast begins from a level below that of the 2022 data.

We deliberately offer no guidance on how users should parameterise the CMI model, nor do we opine on sensible values for *x* and *n*. The CMI encourages users of the CMI 22 model to consider the impact of the choice of parameterisations, and we suggest that a simple driver-based approach is a useful framework for assessing impacts for reasonableness.

4.3. Conclusion

The uncertainty we face as we emerge from the pandemic requires actuaries to exercise the sound use of judgement based on pragmatic analysis. We believe that even the simplest of driver-based approaches can provide a useful benchmark to be used in conjunction with tried-and-tested techniques from before the pandemic.

5. Drivers of change in the post-pandemic world

This section describes potential drivers of changes to mortality rates relative to pre-pandemic expectations and discusses possible impacts over the short, medium, and long term.

5.1. Further spikes of COVID-19 due to variants

The early phases of the COVID-19 pandemic were punctuated by periods of very high COVID-19 mortality (spikes), separated by lower levels of deaths as government interventions such as lockdowns stemmed the spread of infections. As vaccinations were rolled out and the population gained immunity through infections, the difference between the peaks and troughs of COVID-19 mortality rates became less pronounced, even after all restrictions were lifted. This section explores the likelihood of spikes in SARS-CoV-2 infections and associated spikes in COVID-19 deaths re-emerging in the future.

5.1.1. Variants and immunity: background

The key driver of any future waves of COVID-19 deaths is the balance of population immunity and the nature of any new variants that emerge as being dominant.

5.1.1.1. Variants

COVID-19 is caused by the SARS-CoV-2 virus, which, through mutation and selection, has been observed as several different variants since the first wave of infections in 2020. The original dominant variant in England was the Wild type, and this remained dominant until around December 2020, when the Alpha variant became the prevalent variant. This was followed by Delta in June 2021, and then Omicron around January 2022[12]. As at time of writing, Omicron subvariants XBB and XBB 1.5 are the dominant strains in England[13]. Each variant of SARS-CoV-2 is associated with different properties; Omicron, which has been dominant since January 2022, is the most transmissible variant to date but is less virulent than earlier variants. [14,15]. The emergence of a new variant with a combination of high transmissibility and virulence (severity or harmfulness) could lead to a new wave of COVID-19 deaths.

5.1.1.2. Immunity

SARS-CoV-2 infection no longer carries the same risks of adverse outcomes as it did in the early months of the pandemic, largely due to improved immunity through infections and vaccinations. Briefly, vaccination or prior infection by SARS-CoV-2 prime the immune system to handle future infections more efficiently, and hence reduce the probability of severe illness or death. COVID-19, however, had an annual mortality burden in 2022 that was comparable to that associated with influenza and pneumonia; the ONS data for England and Wales in for the year to December 2022 showed COVID-19 was the sixth leading cause of death in England, at 36.9 deaths per 100,000 people, compared to 33.0 deaths per 100,000 people related to influenza and pneumonia [16] (Although the relative impacts reversed in the YTD data as at May 2023). This means that despite vaccinations and infection-acquired immunity, there is still scope for SARS-CoV-2 infections to cause a material number of deaths. Immunity is likely to wane over time, and new variants could become particularly adept at immune escape.

5.1.1.3. Interplay of variants and immunity

While it's clear that the balance of human immunity and the transmissibility/virulence of the dominant SARS-CoV-2 strain is currently suppressing any significant mortality spikes akin to that seen in the early phases of

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[12] Whitaker et al., Variant-specific symptoms of COVID-19 in a study of 1,542,510 adults in England, 2022. **[#23]**

[13] SARS-CoV-2 variants of concern and variants under investigation in England: technical briefing 52 (April 2023).

[14] Toledo-Roy J.C., Garcia-Pena G.E. Valdes A.M.& Hoeflich A.F. (2023) Agent-based modeling and phylogenetic analysis suggests that COVID-19 will remain a low-severity albeit highly transmissible disease [online]. Available at: doi.org (last accessed 31/07/2023). **[#20]**

[15] Balint et al., Omicron: increased transmissibility and decreased pathogenicity (2022). **[#3]**

[16] Office for National Statistics (2023) Dataset Monthly mortality analysis, England and Wales December 2022 edition [online] Available at: www.ons.gov.uk (last accessed 31/07/2023). Data extracted as at 11/07/23.

the pandemic, there is still a dynamic relationship between these two factors, which we explore in more depth in the next sections.

5.1.2. *Potential for Future Spikes in Excess Deaths Due to COVID-19*

5.1.2.1. *Immunity in the Population*

As previously noted, immunity is commonly gained via a vaccine, or by exposure to the virus. A combination of natural and vaccine-induced immunity (hybrid immunity) is associated with higher levels of protection than either method in isolation. [17,18,19].

An independent report issued on January 27th, 2023, by the Joint Committee on Vaccination and Immunisation (JCVI), estimated the proportion of adults in the UK that had antibodies against SARS-CoV-2 at or above the 179ng/ml level in the week beginning 28th November 2022. This is shown in Table 8. The significance of this level of antibodies is that it has been shown to confer protection against the Delta variant of the virus (although it is still not proven if the same protection is provided against Omicron infections).

Table 8. Antibody prevalence

Proportion of adults by country that had antibodies against SARS-CoV-2 at or above the 179ng/ml level in the week beginning 28th November 2022.

	Percentage above 179 ng/ml
England	97.4%
Northern Ireland	95.9%
Scotland	97.0%
Wales	97.1%

While these figures suggest that immunity levels were very high at the end of 2022, analogy to influenza or the coronaviruses that cause the common cold suggests that immunity is unlikely to reach the point of being absolute or permanent. The remainder of this section describes the drivers of immunity levels, how these might change, and what that might mean for the prospect of future waves.

5.1.2.2. *Vaccination programme*

Recent data from the UK Health Security Agency (UKHSA) indicates that vaccine effectiveness against severe outcomes of COVID-19, such as hospitalisation requiring oxygen or ventilation and admission to intensive care, remain high (approximately 80%) to over 6 months after a booster vaccine. In contrast, vaccine effectiveness against non-severe symptomatic disease caused by the Omicron BA.2 variant wanes to approximately 40% 15 weeks after a booster dose.[20]

At the time of writing, the risk of severe COVID-19 continues to be disproportionately greater in those from older age groups, residents in care homes for older adults, and persons with certain underlying health conditions. The UK vaccination programme appears to be moving to a steady state characterised by an annual

[17] Bobrovitz N. et al (2022) Protective effectiveness of prior SARS-CoV-2 infection and hybrid immunity against Omicron infection and severe disease: a systematic review and meta-regression [online]. Available at: doi.org (last accessed 31/07/2023). **[#6]**

[18] Nordström P., Ballin M. & Nordström A. (2022) Risk of SARS-CoV-2 reinfection and COVID-19 hospitalisation in individuals with natural and hybrid immunity: a retrospective, total population cohort study in Sweden [online] doi.org (last accessed 31/07/2023). **[#16]**

[19] Carazo S., Skowronski D.M., Brisson M., Barkati S., Sauvageau C., Brousseau N., Gilca R., Fafard J., Talbot D., Ouakki M., Gilca V, Carignan A., Deceuninck G., De Wals P. & De Serres G. (2022) Protection against Omicron (B.1.1.529) BA.2 reinfection conferred by primary Omicron BA.1 or pre-Omicron SARS-CoV-2 infection among health-care workers with and without mRNA vaccination: a test-negative case-control study [online]. Available at: doi.org (last accessed 31/07/2023). **[#8]**

[20] Kirsebom F.C.M., Andrews N., Stowe J., Toffa S., Sachdeva R., Gallagher E., Groves N., O'Connell A., Chand M.,Ramsay M. & Bernal J.L. (2022) COVID-19 vaccine effectiveness against the omicron (BA.2) variant in England [online]. doi.org (last accessed 31/07/2023). **[#11]**

booster in autumn for the main target group including all adults age 50+, with an additional booster in spring for the highest risk individuals including adults age 75+ and the immunosuppressed[21].

The most-recent vaccinations at the time of writing were rolled out in Spring 2023, with approximately 3.9 million in the 75+ category receiving their booster in that round, representing approximately 70% of those eligible in that age-band[22]. For comparison, more than 90% of the 75+ age group chose to receive the first dose of the vaccine[23], suggesting that appetite for the vaccination has fallen since the acute phase of the pandemic. Note also that for the initial rounds of vaccinations a much broader range of ages was in scope, and indeed more than 90% of the entire UK population ages 12+ received a first dose of the vaccine[24]. The next round of seasonal vaccinations is scheduled for Autumn 2023[25].

If vaccination trends continue, then those aged under 75 will presumably see a reduction in immunity due to vaccination (although may still retain immunity by other methods). Those aged 75+ may also see a smaller reduction in vaccine-mediated immunity due to the lower uptake rates relative to earlier rounds of vaccinations. Despite vaccination efforts being focussed on ages 75+, this remains the age-group where the majority of COVID-19 deaths occur, suggesting that this age-group is still particularly vulnerable to the virus despite the enhanced efforts to offer protection against it.[26]

5.1.2.3. Immunity through infection

ONS models estimated the proportion of the UK population that had at least one episode of COVID-19 to February 2022.[27] This is the most-up-to-date ONS release at the time of writing, but it is reasonable to expect the figures to be materially higher as at mid-2023.

Table 9. Percentage of population with at least one episode of COVID -19 to February 2022

	Percentage of population with at least one episode of COVID -19
England	70.7%
Northern Ireland	72.2%
Scotland	51.5%
Wales	56.0%

While levels of exposure driven immunity have been quite high, reinfections can occur. For instance, in December 2022, the University of Cambridge Medical Research Council Biostatistics Working Group estimated on average people have experienced over 1.6 infections, though this will differ significantly by age. [28] Since the start of the pandemic many people will have experienced more than one infection indicating that immunity to infection can wear off relatively quickly. There is evidence that reinfection with SARS-CoV-2 can increase mortality risk relative to an initial infection[29].

[21] JCVI statement on the COVID-19 vaccination programme for 2023. Department of Health & Social Care
[22] assets.publishing.service.gov.uk (last accessed 31/07/2023).
[23] www.gov.uk (last accessed 31/07/2023).
[24] www.gov.uk (last accessed 31/07/2023).
[25] www.nhs.uk (last accessed 31/07/2023).
[26] Official Statistics, (2023) Coronavirus (COVID-19) dashboard. Deaths within 28 days of positive test by date of death age demographics [online] Available at: coronavirus.data.gov.uk (last accessed 31/07/2023).
[27] Office for National Statistics, (2022) Coronavirus (COVID-19) Infection Survey technical article: Cumulative incidence of the number of people who have tested positive for COVID-19, UK: 22 April 2022 [online]. Available at: www.ons.gov.uk (last accessed 31/07/2023).
[28] Birrell P., Blake J., van Leeuwen E. & De Angelis D. (2022) COVID-19: nowcast and forecast [online]. www.mrc-bsu.cam.ac.uk (last accessed 31/07/2023). **[#5]**
[29] www.nature.com (last accessed 31/07/2023).

Calvetti et al. 2023 (pre-print)[30] produced a model of infections that takes into account waning immunity in a post-pandemic landscape. They report that the speed with which immunity wears off is the main factor influencing the time between waves of infection. Other factors such as changes to the transmission rate of the virus (due to either mutations or changes to human behaviour) may result in suppression of some waves and give irregular time intervals between consecutive peaks.

Further waves of infections are likely to occur although these could become more difficult to identify as reporting is no longer mandatory. This is likely to contribute to the maintenance of infection-acquired immunity and therefore reduce the likelihood of a severe spike in deaths.

A recent article in Nature supports this conclusion, describing how we're likely to see mini-waves in the future rather than seasonal surges[31].

5.1.2.4. The Virulence and transmissibility of new variants

The virulence of any new emergent variant cannot be reliably predicted but with Omicron being the dominate variant for over a year, it is possible that COVID-19 may be nearing its evolutionary optimum. Toledo-Roy J. C. et al (2023) [32] provide evidence supporting the hypothesis that more virulent variants are unlikely, and that COVID-19 will remain a low-severity although highly transmissible disease. They propose three complementary pieces of evidence.

1. The transmission advantage that Omicron (sub)variants enjoy is in large part because they mostly infect cells in the nose and trachea, compared to previous variants which infected the lungs. This represents an evolutionary advantage for the virus but renders it less virulent compared to earlier variants which had greater capacity for damage in the lungs and induction of pneumonia.
2. The negative link between transmissibility and virulence was modelled illustrating that viruses evolve towards lower virulence.
3. Evidence supports that, (adjusted for the number of individuals infected), Omicron evolution is under stronger selection, reducing the diversity of successful variants. A plausible explanation being that the dominate gene combinations in Omicron are those that make the virus highly transmissible.

Together these observations suggest a plausible future scenario where the severity of COVID-19 remains sufficiently low to avoid future spikes in mortality akin to those seen in 2020 and 2021.

Not all academics agree that evolution towards a less-virulent variant is a foregone conclusion, however. Kun A. et al (2023) [33] for example argue that specific features of COVID-19 mean that a more virulent version of the SARS-CoV-2 virus could emerge as dominant – for example death due to infection does not shorten the infectious period, which means a highly virulent variant would not limit its own chances of spreading.

The long-term dominance of Omicron suggests that the evolution of the virus may be in a state that is difficult to improve upon, albeit there is still some variation in the subtypes of Omicron that become dominant. There is no guarantee that Omicron will remain the dominant variant, however, and there remains some debate over whether a new dominant strain would be more or less virulent than the incumbent Omicron strains.

5.1.3. Conclusion

A major future spike in COVID-19 deaths would require a variant of the virus that could escape population immunity levels and be virulent enough to cause a material risk of death upon infection. While population

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[30] Calvetti D, & Somersalo E. (2023) Post-pandemic modeling of COVID-19: Waning immunity determines recurrence frequency [online]. Available at: www.medrxiv.org (last accessed 31/07/2023). **[#7]**

[31] www.nature.com (last accessed 31/07/2023).

[32] Toledo-Roy J.C., Garcia-Pena G.E. Valdes A.M.& Hoeflich A.F. (2023) Agent-based modeling and phylogenetic analysis suggests that COVID-19 will remain a low-severity albeit highly transmissible disease [online]. Available at: doi.org (last accessed 31/07/2023). **[#20]**

[33] Kun A. Hubai A. Kral A. Mokos J. Mikulecz B Radvabyi A. Do pathogens always evolve to be less virulent? The virulence–transmission trade-off in light of the COVID-19 pandemic [online] Available at www.ncbi.nlm.nih.gov (last accessed 31/07/2023). **[#13]**

immunity via vaccinations seems likely to wane over time, the oldest and most vulnerable are still being vaccinated and the virus continues to circulate with relative low levels of deaths, which should allow for some upkeep of population immunity. The possibility of future spikes in COVID-19 should be considered in the assessment of capital, but, in our opinion, a reasonable best-estimate of the future trajectory of COVID-19 deaths need not include an allowance for material spikes.

Factor	Short (2023 – 2025)	Medium (2026-2030)	Long (2031 +)
Future Spikes in COVID-19	The possibility of future spikes in COVID-19 should be considered in the assessment of capital, but, in our opinion, a reasonable best-estimate of the future trajectory of COVID deaths need not include an allowance for material spikes		

5.2. Endemic COVID-19

Section 5.1 examined the possibility of experiencing future spikes in COVID-19 deaths as were observed early in the pandemic. In this section we discuss how COVID-19 deaths might look in the future excluding any such spikes, and in particular what endemic COVID-19 might look like.

5.2.1. What does it mean for a disease to become endemic?

Epidemiologists say a disease is endemic once its presence in a population has become stable or predictable. Diseases of different severity and infectiousness can be endemic[34]. For example:

- In the UK, the common cold is considered endemic, with mild and somewhat predictable seasonal effects
- In much of sub-Saharan Africa, malaria is endemic, and is responsible for hundreds of thousands of deaths a year[35]

5.2.2. Will COVID-19 become endemic?

Several countries around the world have declared the pandemic phase of COVID-19 is over, and they have started the endemic phase of the disease[36]. Such declarations include a great deal of subjectivity since there is no commonly agreed measure of when a disease has become endemic, and it is difficult to judge in real-time if disease stability has been achieved. Whether or not a disease has become endemic is typically understood only in retrospect.

However, there is broad consensus that COVID-19 will become endemic in the UK, if it hasn't already done so (for example a 2021 survey of 100 immunologists by the journal Nature found 90% of them expected COVID-19 to become endemic[37]).

In this section of the paper, we will treat all future deaths from COVID-19 as deaths arising from "endemic COVID-19", with the exception of COVID-19 deaths coming from any future spikes in mortality of similar magnitude to those of 2020 and 2021 (the risk of which was covered in Section 5.1).

5.2.3. Characteristics of endemic-COVID-19

As highlighted in Section 5.1, research by Toledo-Roy supports the view that Omicron subvariants of COVID-19 will continue to dominate and the disease will tend to reduce in severity[38]. If this is borne out in practice, endemic COVID-19 may look similar to the disease experienced in the UK since the start of 2022, with potential further reductions in severity.

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34 Katzourakis, A. COVID-19: endemic doesn't mean harmless. **[#10]**
35 Klobucista C. When will COVID-19 become endemic? **[#12]**
36 Archi, A. Joe Biden says the COVID-19 pandemic is over. This is what the data tells us. **[#2]**
37 Phillips, N. The coronavirus is here to stay – here's what that means. **[#17]**
38 Toledo-Roy et al. Agent-based modeling and phylogenetic analysis suggests that COVID-19 will remain a low-severity albeit highly transmissible disease. **[#20]**

While a low-severity version of endemic COVID-19 is a plausible outcome, many academics[39] emphasize the uncertainty surrounding how the disease will evolve in future and recognize that future (sub)variants of the disease could include more severe symptoms e.g. blood clots[40].

5.2.4. Impact of immunity and SARS-CoV-2 variants on endemic COVID-19

The dynamics of immunity and virus variants discussed in Section 5.1 in the context of spikes of COVID deaths also apply to endemic COVID-19. Very briefly, vaccine efforts continue for the most vulnerable groups, but are reduced relative to the efforts to roll out the first dose of the vaccine. This means that vaccine-mediated immunity is probably falling across the population, but this is offset by an increase in exposure to a relatively non-virulent version on the virus, which boosts infection-acquired immunity. New strains of the virus might emerge, along with different infectiousness and virulence profiles, and this dynamic between new strains and changing immunity will impact the level of endemic COVID-19 deaths observed in any given year. It is possible that we will see an “acceptable” level of endemic COVID-19 such that if that level is breached then vaccination efforts will be increased in order to bring mortality rates down, but given we have limited experience of living with COVID-19 it is unclear what that level would be.

5.2.5. Impact of treatments on endemic COVID-19

The UK health and social care advisory body NICE lists 7 recommended therapies for treating COVID-19[41] at the time of writing. This range of antiviral drugs, monoclonal antibodies and steroids, all have been shown to help limit the progression of the disease. For example, a recent study in the Lancet showed that early treatment with the antiviral drug combination nirmatrelvir–ritonavir was 80% effective in preventing hospital admission or death in the first 30 days[42].

As the disease moves into the endemic phase, the ongoing availability of effective treatments will be important to limit the number of hospitalisations and deaths from the disease. There is a risk that future (sub)variants of endemic COVID-19 will develop resistance to some of the current antiviral therapies, and mortality rates will increase as a result. However, there is much activity underway to develop new therapeutic treatments for COVID-19, and so there is also the potential for improved outcomes. To give an indication of the pipeline of possible future treatments, the Food & Drug Administration in the US is aware of more than 440 drugs currently in clinical trials with more than 700 further drug development programs in the planning stage[43].

5.2.6. What mortality rate do we expect from endemic COVID-19?

The mortality rate from endemic COVID-19 will depend on a large number of factors including the severity and transmission rate of the (sub)variants that develop over time, the behaviour of the population, and the effectiveness of treatments and vaccine programmes. With so many complex, interacting factors it is difficult to accurately predict the future death rate from endemic COVID-19.

Epidemiological models can be used to help inform discussions on the future mortality rate from COVID-19. However, they typically show a wide range of outcomes, reflecting the large number of uncertain input variables. For example, a 2022 paper by Stoddard et al uses an epidemiological model to show long-term, steady-state endemic COVID-19 deaths in the US of at least 100,000, but with some scenarios showing deaths over half a million[44]. If the disease continues to behave similarly to Omicron, then Stoddard’s model supports the view that endemic COVID-19 deaths in the US could be in the range 100,000-250,000 per year[45]. Adjusting this range for relative population size, would imply endemic COVID-19 deaths in the UK of 20,000-50,000 per

[39] Kun, A et al. Do pathogens always evolve to be less virulent? **[#13]**
[40] Looi, M. How are COVID-19 symptoms changing? **[#15]**
[41] COVID-19 rapid guideline: Managing COVID-19. National Institute for Health and Care Excellence.
[42] Lewnard, J. et al. Effectiveness of nirmatrelvir–ritonavir in preventing hospital admissions and deaths in people with COVID-19. **[#14]**
[43] Coronavirus Treatment Acceleration Program. US Food & Drug Administration
[44] Stoddard et al. Endemicity is not a victory. **[#19]**
[45] Does the COVID-19 “new normal” mean 100,000+ deaths per year? Advisory Board

year, although further adjustments could be considered to take account of differences in population behaviour, age structure, vaccinations and treatments between the two countries. The Stoddard paper is only one example of a study quantifying possible future outcomes, and we encourage readers to consider a range of views on this subject.

While endemic COVID-19 should demonstrate stability and predictability, this does not mean that mortality rates from the disease will be constant. We might expect the number of endemic COVID-19 deaths to have multiple peaks and troughs in any single year[46], and for there to be variation in the number of deaths between years depending on the severity of the prevailing (sub)variants, population behaviour and natural oscillations of the amount of disease within the population.

5.2.7. Mortality rates in the short term (2023-2025)

In the period to 2025 (the "short term"), perhaps the most plausible outcome is a continuation of the status quo. In this scenario, the disease stabilises with low-severity Omicron subvariants continuing to dominate. If there is also stability in population behaviour, vaccination programmes and treatments, then it may be reasonable to anticipate short-term endemic COVID-19 mortality rates similar to those observed in 2022; Table 1 in Section 1.1.3 shows that in 2022 there were 33,140 deaths in the England and Wales where COVID-19 was mentioned on the death certificate.

When setting mortality assumptions using the framework set out in this paper, the key consideration is how the mortality rate of the driver in question has changed compared to a pre-pandemic view. Counting all of the COVID-19 deaths in 2022 as additional deaths would overstate the impact of endemic COVID-19, since multiple causes may be listed on death certificates and some of the deaths would have occurred in the absence of COVID-19 for other reasons. For example, influenza and COVID-19 are competing causes of death, particularly at older ages. See Section 5.3 for more details on the interaction between COVID-19 and influenza.

The default assumption of a continuation of the status quo could turn out to be incorrect in either direction. Actuaries might consider a reduction in the mortality rate from COVID-19 following a further weakening in the severity of the disease, the introduction of more effective treatments, or increased rates of population immunity through disease exposure. An increase in the short-term COVID-19 mortality rate is also possible, for example through a reduction in population immunity as a result of falling vaccination rates, or new variants of COVID-19.

5.2.8. Mortality rates in the medium & long term (2026-)

In the medium to long term, there is a greater range of possible outcomes as there is more time for the disease to progress, behaviours to change and medical breakthroughs to emerge.

Perhaps the most plausible outcome is for mortality rates from endemic COVID-19 to reduce below the short-term rates as a consequence of a weakening in disease virulence and/or further treatments being made available. However, other outcomes are possible and should also be considered when setting assumptions, similar to those discussed in Section 5.2.7 on short-term impacts on mortality rates.

5.2.9. How would different subpopulations be impacted by endemic COVID-19?

Data from 2020 and 2021 show the mortality rate from COVID-19 during the pandemic phase was disproportionately high for males, older populations, those from lower socioeconomic groups, and those living in London[47]. It seems likely that pre-existing morbidity factors played a significant role, but also social and cultural elements may also have had an influence. In particular, London was hit early and hard, being more densely populated and also a travel hub that provided a conduit for the virus.

Data from 2022 show a much more even spread of COVID-19 deaths, especially by region and socioeconomic group. However, COVID-19 continues to impact most heavily on individuals with a weakened immune system,

[46] www.nature.com (Last accessed 23/07/2023).

[47] Excess mortality in England and English regions. Office for Health Improvement and Disparities

and there is also variation in the proportionate impact of COVID-19 by age. Making separate assumptions by age and health status (where known) may therefore be a reasonable approach to take when modelling the impact of endemic COVID-19. Regional variations may be less pronounced, although practical consideration of the conditions that allow viral transmission remain relevant.

5.2.10. Conclusion

Epidemiologists expect COVID-19 will become endemic in the UK if it hasn't already done so. The severity of the endemic disease is uncertain, although a plausible outcome is that Omicron subvariants will continue to dominate and the disease may further reduce in severity. High rates of vaccine compliance in older age-groups, and the prospect of a widening range of COVID-19 treatments both point towards a stabilisation of COVID-19 mortality rates in the short term, and the likelihood for reduced mortality rates in the medium to long term. However, this is not guaranteed, and increased mortality rates are also possible, for example through more severe disease (sub)variants, or falling vaccination rates.

Factor	Short term (2023-25)	Medium Term (2026-30)	Long Term (2031+)
Endemic COVID-19	Mortality remains similar to recent levels	Reductions in disease severity and improvements in treatment likely reduce mortality compared to 2022	

5.3. Reduced respiratory / influenza deaths

A side effect of the government restrictions intended to curb COVID-19 deaths in the early phase of the pandemic was that the measures also reduced deaths due to other respiratory infections such as influenza. This section discusses the consequences of this, and in particular the areas of care required when anticipating what will happen to total deaths when both COVID-19 and influenza and prominent individual causes of death.

5.3.1. Background

Deaths due to respiratory diseases (including influenza and pneumonia) are a material component of all-cause mortality, particularly at older ages, and so are an important driver of annuitant mortality. Deaths are typically seasonal, with a peak in influenza-related deaths anticipated in winter (often mid-January in the UK) and fewer deaths spread across the summer months. Deaths can be attributed directly to respiratory diseases, or deaths can be recorded with a respiratory disease as a contributing factor.

When analysing causes of death, pneumonia is often analysed alongside influenza as it is a common sequela of influenza infections and may be recorded as the cause of death even if it was influenza that led to the pneumonia[48]. In addition to pneumonia, the eventual causes of death that can be linked to an influenza infection are significant: influenza infections are associated with complications of multiple organ systems, including cardiovascular, neurologic, musculoskeletal, ocular, renal, hematologic, and endocrine deaths.[49] Influenza was listed as a primary cause of death for far less than 1% of total deaths in England and Wales (1,000 – 2,000) in 2018 and 2019[50], but estimates of the total burden associated with influenza suggest that a typical figure for annual deaths is likely to be in the range 10,000 – 25,000[51] depending on the severity of the influenza season. It is therefore important not to rely solely on primary cause of death ("deaths due to") statistics when investigating respiratory deaths. Using influenza and pneumonia statistics as a proxy for influenza burden throughout the pandemic may be particularly problematic; pneumonia is a sequela of COVID-19, and so making the assumption that the pre-pandemic relationship between pneumonia and influenza would continue to hold during and after the pandemic could lead to spurious conclusions.

In the remaining part of Section 5.3 we focus on influenza rather than the broader class of respiratory illnesses, due to the COVID-specific considerations associated with influenza.

[48] www.ncbi.nlm.nih.gov (last accessed 31/07/2023).
[49] onlinelibrary.wiley.com (last accessed 31/07/2023).
[50] www.ons.gov.uk (last accessed 31/07/2023).
[51] www.bmj.com (last accessed 31/07/2023).

There are four reasons it is important to consider influenza explicitly when setting future mortality/longevity assumptions:

1. Understanding what has happened during the pandemic and how that might impact conclusions from experience studies
2. Considering the extent to which influenza and COVID-19 will be competing causes of death, and how that might impact total deaths due to both causes
3. Forming a view on whether some pandemic behaviours will persist in future years and mitigate influenza deaths
4. Accounting for the impact of technologies developed in the fight against COVID-19 in the post-pandemic era.

5.3.2. Understanding trends in 2020-2022

Throughout the pandemic influenza deaths have been suppressed, presumably because measures put in place to stop the spread of SARS-CoV-2 have also been effective in stopping the spread of other viruses. In the 2022/2023 winter we saw the re-emergence of influenza for the first time since the start of the pandemic. The degree of the suppression and re-emergence is illustrated in Figure 8[52]

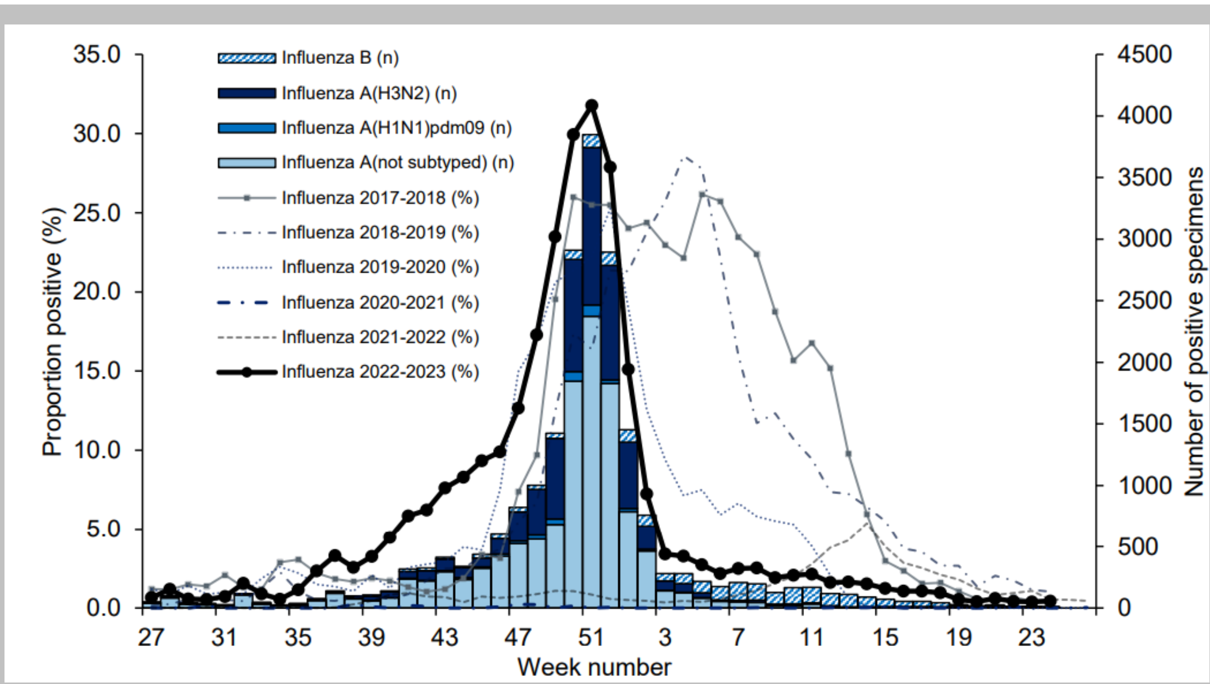

Figure 8. Influenza prevalence by season

Influenza surveillance data shows the suppression of influenza prevalence throughout the 2019-20 to 2021-2022 influenza seasons, with some evidence of a small peak late in the 2021-2022 season. Infections have re-emerged in the 2022-2023 season.

The suppression of influenza deaths during the pandemic will have led to significantly fewer deaths among older lives with all other things held equal, and extrapolating experience from pandemic years without adding influenza deaths back in (for example, taking a simple approach where COVID-19 deaths are removed from the data) would understate future deaths.

There are three key considerations to make when deciding on how to interpret and extrapolate from influenza trends during the COVID-19 pandemic:

1. The extent to which influenza deaths during the pandemic would have been displaced by COVID-19 deaths or overlap with other causes

[52] www.gov.uk (last accessed 31/07/2023).

2. Uncertainty around the future of influenza seasons, including their timing and severity
3. The disruption in the seasonal variation of deaths that the absence of an influenza season has caused through 2020-2022

The first point is very closely related to the considerations that need to be made when forecasting influenza deaths into a future where COVID-19 is a competing risk of death, and as such will be covered in more detail in Section 5.3.3.

The second point requires consideration of potentially reduced influenza immunity in the population due to suppression of the virus during the pandemic, and changes in the dynamics of circulating influenza strains.[53,54] Briefly, a reduction in population immunity might lead to more-severe influenza seasons in the short term, but in addition the impact of COVID-19 suppression also disrupting the dynamics of influenza infections could have a compounding effect on the severity of influenza seasons. This arises due to the lack of competition between influenza strains during the pandemic period (as spread between geographic regions has been supressed) meaning a greater diversity of strains may be circulating globally, making it harder to develop vaccines targeting the right antigens. The disruption in influenza seasons during the pandemic has also led to changes in their timing as they start to re-emerge; in South America for example there was a summer influenza outbreak in 2021 between waves of COVID-19. Altered timing of influenza seasons has a knock-on-effect for interpreting excess deaths, but also for coordinating the global response to influenza, which typically relies on synchronization between influenza outbreaks in the Northern and Southern hemispheres. Over time, it seems reasonable that these short-term impacts would blend back towards their pre-pandemic steady states; the peak of the 2022/23 influenza season in England was only a few weeks earlier than was typical pre-2020, for example.

The third point is critical to interpreting the level of excess deaths reported at high frequency –for example in weekly ONS releases. Excess deaths are calculated relative to a baseline, which corresponds to the expectation of deaths for the given time period. If refreshes are more frequent than annually, then the seasonal profile of deaths needs to be accounted for when setting the baseline expectation, and more deaths will be expected during the typical influenza season than in summer.

If the seasonal trend component of the expected deaths calculation is no longer appropriate for what is being observed empirically, the measure of excess will be misleading. For example, in the absence of an influenza season, there will be considerable negative excess deaths during the time period where influenza was expected in the baseline. Over time, however, to the extent that some of those that might otherwise have died of influenza in winter months begin to die at other times of the year, this could contribute to an observation of excess deaths in summer with no apparent driver. In the short term, the extent to which this happens will depend on the extent to which influenza deaths are accelerated deaths – i.e. deaths that would have happened due to some underlying cause over the duration of the year anyway due to frail members of the population being susceptible to a number of competing causes of death. It seems reasonable to assume that some proportion of the influenza deaths will be accelerated, particularly at the older ages; a population study in the Netherlands suggested that by not including competing risks when estimating the burden of influenza the years-of-life-lost due to the disease at ages 80+ could be overstated by around 80%[55], but the impact is reduced at younger ages due to the reduction in competing risks.

5.3.3. *Competing risks in projections*

The 2022/2023 winter in the UK suggested that we will be living with both COVID-19 and influenza in circulation in the coming years. It seems reasonable to assume that the endemic COVID-19 and reestablishment of influenza-related deaths from before the pandemic will not be additive, however, as they will be competing causes of death (particularly at older ages).

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[53] www.ncbi.nlm.nih.gov (last accessed 31/07/2023).
[54] www.ncbi.nlm.nih.gov (last accessed 31/07/2023).
[55] academic.oup.com (last accessed 31/07/2023).

Figure 9 shows the relationship between influenza, COVID-19, and other causes of death before, during, and after the pandemic. Not every COVID-19 death will be a new or excess death relative to pre-pandemic expectations, particularly over the time-horizon of at least a year (such that the seasonal considerations mentioned earlier are less relevant). COVID-19 is a new cause of death relative to pre-pandemic expectations, however, and so directionally it can only be responsible for additional deaths. Forming a view on the degree of overlap between COVID-19 deaths and existing causes is an important aspect of assessing the future burden of COVID-19. We have not been able to quantify the displacement of influenza (or influenza accelerated deaths) by COVID-19 during the pandemic, and so judgement will be important when deciding on how many deaths the re-emergence of influenza will be responsible for now that it is in the presence of the competing risk of COVID-19.

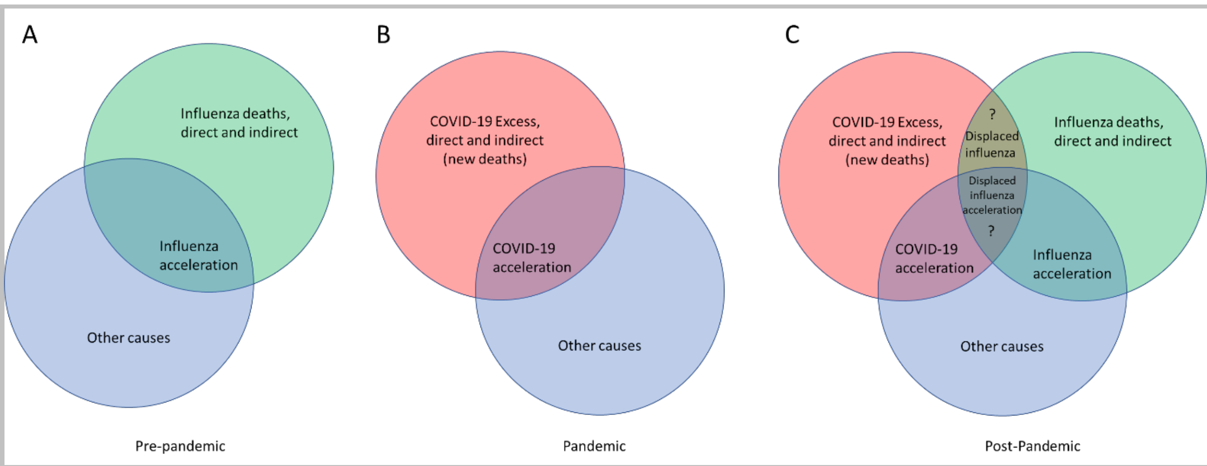

Figure 9. Cause of death interactions

Interactions between competing causes of death in the pre-pandemic, pandemic, and post-pandemic world. **A** Pre pandemic, influenza coexisted with other causes of deaths with some overlap in the deaths accounting for competing risks (accelerated deaths) – i.e. those who would have died in the year from either influenza or something else and so removing influenza as a cause of death would not have saved those lives. **B** During the pandemic, influenza was supressed and so the influenza deaths were removed (or at least greatly supressed). Those accelerated by influenza remained, albeit the deaths would occur at a later date. COVID-19 is added as a new cause, and overlaps with other causes in the same was as influenza did, although not necessarily to the same extent. **C** In the post-pandemic world, influenza, COVID-19 and other causes of death coexist. All of the three categories compete as risks, including competition between all three causes simultaneously. When analysing deaths between 2020-2022, we need to consider the addition of COVID-19 as a cause of death and its overlap with other causes, but also the removal of influenza and how it overlapped with other causes. As we move into the post-pandemic era, we should anticipate influenza deaths re-emerging but should consider how these deaths overlap with deaths that would have occurred anyway from COVID-19 or another cause even in the absence of influenza. Note that the sizes of the circles are set equal for illustrative purposes only.

The emergence of COVID-19-related deaths post mid-2021 has not shown an obvious seasonal profile, and instead appears to ebb-and-flow in small waves throughout the year. If this continues into the future, i.e. COVID-19 does not become seasonal (or indeed if it does become seasonal but out of sync with influenza) then the degree of competition between the two causes of death may be relatively small and the total number of deaths will be more akin to the sum of pre-pandemic influenza and estimated endemic levels of COVID-19 deaths. If COVID-19 deaths become more seasonal in the same way as influenza then there may be more offsetting between the two causes of death[56].

[56] There is perhaps also an asynchronous element to their competition in that both causes of death are prevalent amongst the most-vulnerable and COVID-19 deaths throughout the year might reduce the pool of vulnerable survivors that would be the most susceptible for the next influenza season (and the influenza season reduces the pool of susceptible people for COVID-19 deaths throughout the year).

The deaths associated with the 2022/2023 influenza season appear to have been broadly in line with typical pre-pandemic levels[57], and COVID-19 deaths continued throughout and beyond the influenza season, which might (tentatively) suggest the degree of overlap between the two kinds of death might be small in practice. We need to observe more influenza seasons before making firm conclusions, however.

5.3.4. Pandemic-related mitigations

The absence of influenza seasons throughout the pandemic suggests that strategies used during the pandemic are successful in supressing the spread of influenza, however the 2022/2023 influenza season suggests that long-term suppression due to behaviours is unlikely. It's implausible we will see lockdowns put in place for the purpose of supressing influenza, and the less invasive strategies such as mask wearing and vigilant hand-washing have either not persisted as habits in the UK or are not effective enough in isolation to mitigate the spread of influenza. The pandemic did, however, spark rapid development of mRNA vaccines, and understanding how this technology might impact mortality in the coming years is important for projecting future mortality rates.

5.3.4.1. Advances in vaccine technology

In a highly-cited pre-pandemic review of mRNA vaccines, the authors cite high potency, capacity for rapid development and the potential for low-cost manufacture, as key benefits of the technology[58]. The rapid development of COVID-19 vaccines during the pandemic showcased the real-world advantages of mRNA vaccines[59] and fuelled interest in how they might prove beneficial in a post-pandemic world.

5.3.4.2. Mitigation against influenza

mRNA vaccines have applications beyond COVID-19 and have a use case for targeting other circulating viruses, such as influenza. The UK already offers vaccines against influenza, and so it's useful to understand why switching to mRNA vaccines might offer advantages over the traditional vaccine approaches used today. In a review of mRNA technologies for influenza vaccines[60], the authors cite antigen design, productions volumes/efficiency, and technological drawbacks of current production techniques as a key limitation of the current (i.e. not based on mRNA) approach to producing influenza vaccines, and explain that vaccine delivery may be too late, or that vaccine efficacy may be low because of these factors. It is also possible for a vaccine to be mis-matched against the dominant strain in a given season, and so for vaccine efficiency to be particularly low. Vaccines based on mRNA technology have the potential to overcome these limitations:

- The manufacturing process is not limited to growing viruses in eggs, allowing greater speed of deployment, flexibility and efficiency
- The proteins encoded by the mRNA are made by the cells of the recipient, and so are probably a closer match to the parts of the virus the proteins are mimicking (no issues with the protein going off in storage, and the protein is being made under the same conditions as the virus it is trying to mimic, for example)
- mRNA approaches allow a broader range of antigens to be delivered in a single dose, which may improve the immune response

Hurdles remain in realising these benefits in humans, but recent studies have shown mRNA vaccination approaches to offer mice protection against a range of influenza strains[61]. Actuaries will need to make judgements around the speed at which these vaccines can be developed and approved for human use, and the improved protection they will offer beyond existing vaccines when setting future mortality rates.

[57] www.gov.uk (last accessed 31/07/2023).
[58] www.nature.com (last accessed 31/07/2023).
[59] www.nature.com (last accessed 31/07/2023).
[60] www.pnas.org (last accessed 31/07/2023).
[61] www.pnas.org (last accessed 31/07/2023).

5.3.4.3. *Mitigation against cancers*

mRNA vaccines have been touted as a weapon in the fight against cancer. Briefly, the vaccines prime the host immune system to kill cancer cells in the same way as it would kill infected cells. A recent review in The Lancet[62] highlighted a number of clinical trials that are currently underway, but cautioned that results from early clinical trials have shown only modest indications of clinical efficacy. Key challenges include: the ability to identify tumour-specific mutations and translating those to effective mRNA vaccines; rapid, large-scale, and safe production of mRNA vaccines; and identifying the best method of administering the vaccines. The authors also suggest that mRNA cancer vaccines will be most effective when tumours are caught at an early phase, or when used in combination with other therapies. The path to tangible mortality improvements looks longer for mRNA vaccines for cancer than it does for influenza, but the technology continues to develop rapidly, and initiatives such as the UK/BioNTech collaboration[63] aim to accelerate the pace of progress.

5.3.5. *Conclusion*

Experience studies of the 2020-2022 period will not include as many Influenza deaths as other years due to the suppression of circulating viruses by anti-COVID-19 measures in place during this time. This will have an impact on how these studies should be interpreted, and how any future experience including influenza can be compared to the 2020-2022 period. Mortality projections should include both influenza and COVID-19 as causes of death, and account for the fact they are competing risks (and that the way in which they compete could be more closely coupled than – say – heart disease and cancer). Data emerging from the 2022/23 influenza season suggests (tentatively) that neither influenza nor COVID-19 was materially supressed as a cause of death during or after this period, but more influenza seasons will need to be observed before firm conclusions around the interaction of the two can be drawn. Medical advances borne from developing the COVID-19 vaccine may prove effective in reducing influenza deaths in the medium term and might find clinical applications in areas such as anti-cancer therapeutics in the longer term.

Factor	Short term (2023-25)	Medium Term (2026-30)	Long Term (2031+)
[reduced] Influenza / respiratory deaths	Stabilisation of influenza mortality at similar levels to pre-pandemic, noting some risk of increased severity in the short term. Important to recognise the risk of double-counting the overlap with COVID as a competing cause	Potential for some benefit relative to the short term from mRNA technology developments, and any short-term increases in influenza severity being only temporary.	

5.4. ***Changes to the economic environment***

Economic conditions in 2023 are very different to those immediately before the first COVID-19 infections. In this section we explore changes to the economy and what changes (if any) insurers might wish to consider making to their biometric assumptions as a result of this.

5.4.1. *Changes to the UK economy*

The UK economy has undergone changes that have been either a direct consequence of the COVID-19 pandemic, or have precipitated in the aftermath of the acute phase of the pandemic. Teasing out pandemic impacts from other changes to the global political environment such as the UK leaving the European Union, and the war in Ukraine is difficult due to overlaps in timings. In this section we give a high-level overview of the key themes associated with the current economic issues faced by the UK.

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[62] www.thelancet.com (last accessed 31/07/2023).
[63] www.bbc.co.uk (last accessed 31/07/2023).

5.4.1.1. Lockdown-induced recession

Lockdowns – periods in which travel and socialising was severely restricted – were a key pillar in the UK government's response to restricting the spread of COVID-19 infections and reducing the associated mortality rates[64]. The knock-on effect was a sharp decline in GDP, as the lockdown restrictions restricted economic activity (Figure 10).

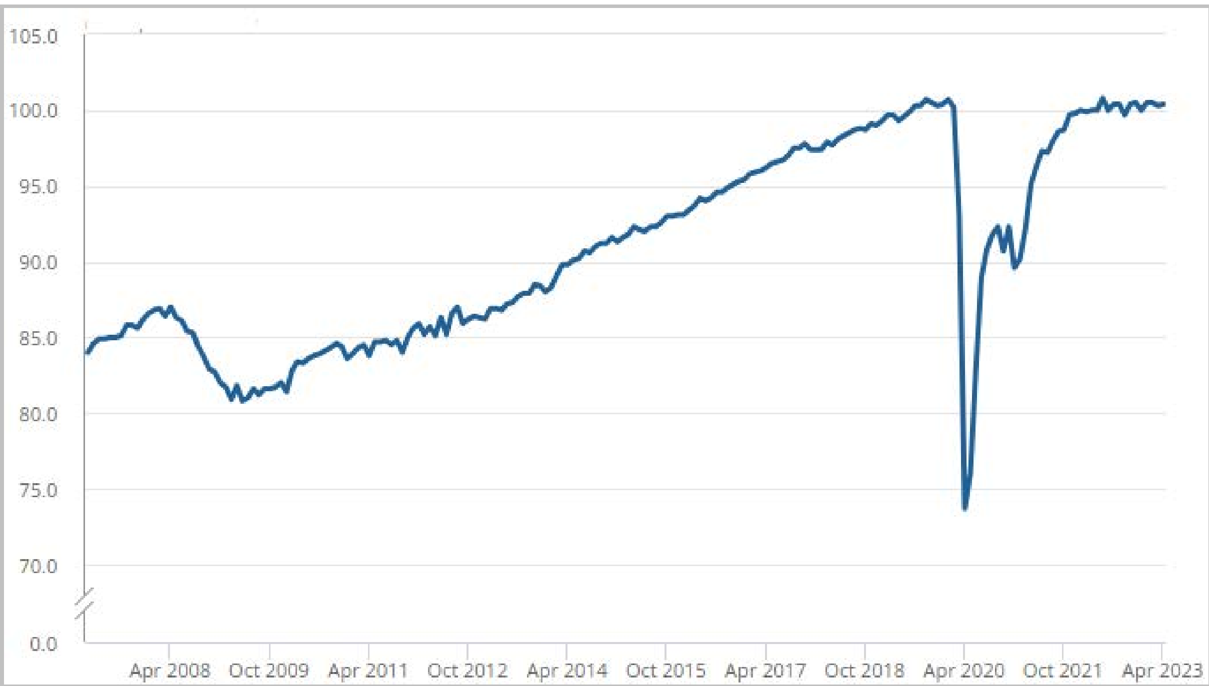

Figure 10. UK GDP index

Normalised to 100 in 2019[65]. Lockdowns implemented from early 2020 led to an acute drop of around 25%, before recovering to approximately pre-pandemic levels between 2022-2023.

GDP levels have recovered to approximately pre-pandemic levels, but GDP has been growing from around 2009-2019 and so the stagnation of growth represents a reduction in GDP relative to what might have been extrapolated from pre-pandemic trends.

The Department of Health and Social Care, ONS, GAD, and Home Office produced a joint paper in July 2020 (i.e. in the midst of the acute phase of the pandemic) outlining estimates of the direct and indirect impacts of COVID-19 on excess deaths and morbidity, including the impact of lockdown-induced recession[66]. The paper estimated that over the medium term (2-5 years, i.e. 2022-2025) we should expect around 18,000 excess deaths, largely due to cardiovascular diseases, which the authors calculate assuming a 4 percentage point increase in unemployment and an estimate of the relationship between unemployment and cardiovascular deaths. Although the rise in unemployment in the UK has been below 4 percentage points (see below), sources such as the OHID excess mortality dashboard tool[67] show that recent excess deaths have been weighted towards cardiovascular causes – much more so than, say, cancers – but interpretation of the cause of this is muddied by adverse cardiovascular outcomes also being a sequela of COVID-19 infections[68]. In the long term (5-45 years, or 2025-2065) it is suggested that we could expect a small number of further excess deaths for younger people entering the labour market at an inopportune time (approximately 15,000 spread over the entire time period, so small on a per annum basis).

[64] gds.blog.gov.uk (last accessed 31/07/2023).
[65] www.ons.gov.uk (last accessed 31/07/2023).
[66] assets.publishing.service.gov.uk (last accessed 31/07/2023).
[67] www.gov.uk (last accessed 31/07/2023).
[68] Raisi-Estabragh et al, Cardiovascular disease and mortality sequelae of COVID-19 in the UK Biobank, 2003 **[#18]**

5.4.1.2. Increased public sector net borrowing

In 2020/21, the Government spent more than it raised from receipts mainly due to the pandemic, leading to a budget deficit. The deficit reached a peacetime record in 2020/21 of 15% of GDP, largely for two reasons[69]:

1. The Government provided support to public services, households and businesses during the pandemic, which cost around £315 billion;
2. Less economic activity meant tax revenues fell

The extent to which the impact of this deficit is felt by the general public depends on government philosophy – but if there is political will to reduce the deficit then we may see a reduction in spending on public services like the NHS, or on provision of financial relief for the most vulnerable during the cost of living crisis. In addition, high interest rates mean it costs the government more money to service the debt and to borrow, so there is added pressure reduce future borrowing (or increase tax).

5.4.1.3. Changes to employment rates and economic activity

During the first year of the Covid-19 pandemic there was a significant increase in the unemployment rates for both men and women[70]. From the start of 2021, unemployment rates have since returned to similar and slightly lower levels than those seen before the pandemic. Compared to 2019, we also observe higher levels of economic activity, particularly amongst men, where economic inactivity indicates persons who are unemployed and not available for or seeking work (Figure 11).

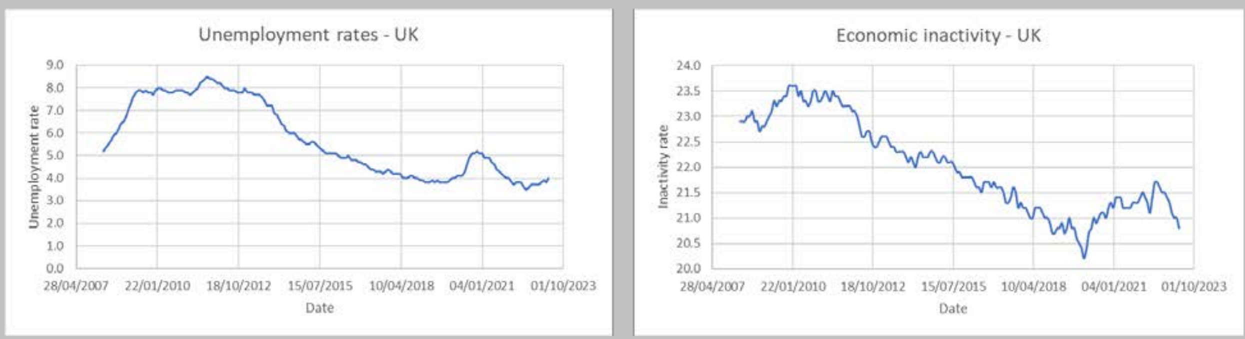

Figure 11. Unemployment and economic activity

Unemployment and economic activity rates increased during the acute phase of the pandemic, but have returned to approximately pre-pandemic levels more recently.

Increases in economic inactivity were driven by younger age groups early in the pandemic, but more-recently the 50-64 age-group has comprised the majority of the increase in inactivity relative to pre-pandemic levels (Figure 12).

[69] commonslibrary.parliament.uk (last accessed 31/07/2023).
[70] www.ons.gov.uk (last accessed 31/07/2023).

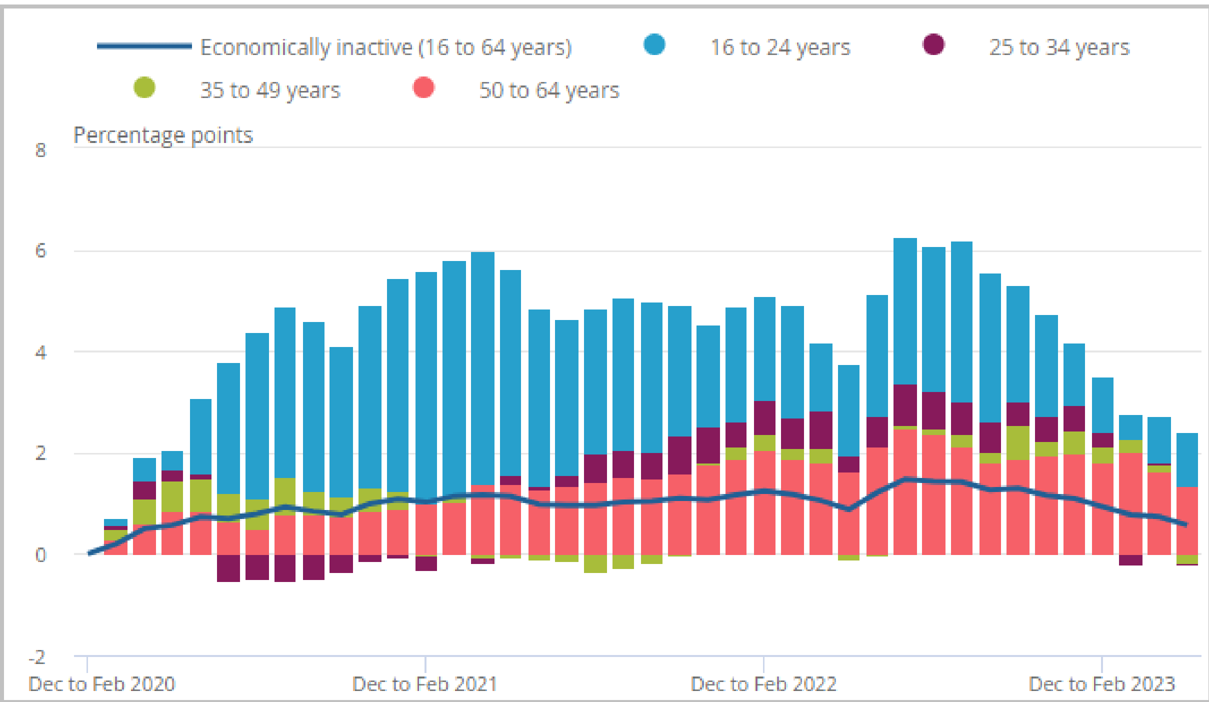

Figure 12. **Economic activity by age band**
Economic inactivity by age-band relative to 2019 levels. Early in the pandemic younger ages were responsible for most of the increase in inactivity (blue bars), but more recently the 50-64 age group has comprised most of the increase (pink bars).

Recent research by the Institute of Fiscal Studies suggests that around half of the 50-70 year-olds that left the workforce in 2020-2021 ended up in relative poverty[71], but that those that left the workforce in the following year (2021-2022) have similar living standards and wellbeing to pre-pandemic cohorts. This suggests that older workers that left the workforce early in the pandemic may have been forced to do so because of disruptions to the labour market or because of health concerns, but those leaving later may have done so from a position of comfort.

5.4.1.4. Inflation rates and interest rates – the cost-of-living crisis

At the time of writing, the UK is experiencing inflation and interest rates at levels that haven't been seen since the early 1990's. The Bank of England base rate is 5% and the inflation (according to the CPI – consumer price index) stands at 8.7%. The Bank of England uses interest-rate rises as a tool to reduce inflation, and is tasked with keeping inflation in line with a target rate of 2%, which is set by the government[72].

High inflation rates mean rising prices, which put pressure on household finances. Wages may increase to keep pace with inflation, but this additional money can drive up inflation even further, again placing pressure on household finances. Interest rates are increased to bring down inflation, as it reduces demand for goods through two mechanisms:

1. Interest rates affect consumers. Those servicing debts such as mortgages will see repayments rise if they are on a variable rate of repayment, or are on a fixed rate that expires and needs to be renewed. Higher rates also encourage saving rather than spending. These effects reduce the money available to spend on other goods and services.
2. Projects become more expensive to finance, which restricts business activity and growth. The corresponding reduction in economic output can lead to job losses or reduction in pay/hours worked and hence a reduction in demand for goods and services.

[71] ifs.org.uk (last accessed 31/07/2023).
[72] www.bankofengland.co.uk (last accessed 31/07/2023).

The cause of the high inflation experienced by the UK is still a matter of debate, and commentators note that inflation rates in the U.S.A and Eurozone have been tamed more quickly than in the UK[73]. Key culprits for the high levels of inflation appear to be our relatively high dependence on gas in our energy mix (gas prices rose dramatically during 2021/2022 and remain high relative to pre-pandemic levels), shrinkage of the workforce, and the immediate aftermath of leaving the European Union. The UK is also impacted by factors common to all countries, such as the increase in food prices resulting from the disruption of the supply of agricultural products from Ukraine due to the war with Russia[74].

5.4.2. Is there a link between the economy and mortality rates?

It is tempting to assume that adverse economic conditions such as recessions would lead to increases to population mortality rates; wealthier individuals typically live longer than those that are less wealthy, and economic slowdown is typically associated with a decrease in wealth and prosperity for individuals. However, the academic literature suggests that the link between the economy and mortality is complex and not fully understood[75]. In the U.S.A. for example, mortality rates increased as unemployment rates fell during the 1970s and 1980s, but this relationship weakened and even disappeared beyond 2000. In Europe the same effect remained strong even throughout the 2008 recession, but in low-income countries the relationship appears to be reversed (mortality rates rise when unemployment rises). There is also variation in how recessions have impacted mortality inequalities in the past (i.e. the difference in mortality rates between the most and least affluent in society), albeit the general rule seems to be that economic recession increase mortality inequalities.

In the UK, austerity measures were introduced in the June 2010 budget, which in practical terms meant an increase in taxation and a fall in public spending[76]. Population mortality improvements fell sharply shortly after austerity measures were put in place[77], and austerity measures have frequently been blamed for excess deaths in this period[78,79]. It is notoriously difficult to reliably pick out changes in mortality trends until several years after they have occurred, but it does appear that there was a slowdown in mortality improvements from 2011 and that this persisted until the start of the COVID era.

There have been attempts to quantify the relationship between healthcare spending in the UK and mortality improvements. For example, analysis in the November 2020 IFOA longevity bulletin Kenneth McIvor noted the results of a regression analysis that suggested each 1% additional funding received by the NHS might give rise to a 0.4% decrease in mortality rates, coming through over the subsequent 10 years[80].

Actuaries may already have established their view on this relationship prior to the pandemic and these could be updated to reflect the current circumstances. However, it is difficult to pin down cause and effect in systems as complex as the economy and the NHS, and so even if we conclude that austerity was a contributor to the slowdown in mortality improvements, the profile of the current economic environment in the UK is very different to that which was in place at the start of the austerity period and care must be taken when drawing analogies between the two periods.

5.4.3. Conclusion

The UK is emerging from the acute phase of the COVID-19 pandemic into a world with a number of economic challenges, that have cumulated in a high interest and high inflation environment. It seems inevitable that a broad cross-section of society will be placed under financial pressure in the coming months and years, however

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[73] blogs.deloitte.co.uk (last accessed 31/07/2023).
[74] www.bis.org. (last accessed 31/07/2023).
[75] Benach et al. What do we know about the impact of economic recessions on mortality inequalities? A critical review. 2022. **[#4]**
[76] assets.publishing.service.gov.uk (last accessed 31/07/2023).
[77] www.theactuary.com (last accessed 31/07/2023).
[78] Watkins et al. Effects of health and social care spending constraints on mortality in England: a time trend analysis, 2017 **[#21]**
[79] www.ippr.org (last accessed 31/07/2023).
[80] www.actuaries.org.uk (last accessed 31/07/2023).

it is unclear how this might impact future mortality rates, if at all. Whilst there may be a link, we advise caution in buying into narratives that link the state of the economy to future mortality rates, whether they be simple or complex or sophisticated; and instead suggest scanning for emerging themes such as changes in relative mortality rates between the most- and least-well-off. This may seem at odds with links between household finances and tangible outcomes like the ability to buy food and heat homes, but the academic literature suggests that the relationship between the economy and mortality is not straightforward and has changed over time[81]. We also caution that money itself does not buy a longer life, rather it is more likely to relate to lifestyle, leisure pursuits, stress levels and other second-order effects that are correlated with wealth. Finally, it is important to not double count any anticipated impacts from the economic outlook – for example, a reduction in health spending could sit as an anticipated healthcare impact or an economic impact, but not both.

Factor	Short term (2023-25)	Medium Term (2026-30)	Long Term (2031+)
Economic changes	The impact of historical economic downturns has varied in direction and magnitude across different countries, and there is no clear-cut link between the economy and mortality rates. However, some studies have suggested that austerity measures in the UK have been a driver of mortality improvement slowdown post-2011.		

5.5. *Health Service disruption*

This section discusses the impact of health service disruption and treatment backlogs on mortality rates and gives an indication to how these might change over the short, medium and long term. It considers the impact on various dimensions where possible, e.g. by gender, age, geography and socioeconomic group.

Figure 13 summarises some of the ways in which the COVID-19 pandemic has disrupted the NHS in the UK. The rest of this section explores the key themes from the figure, and the implications for insurers as they set mortality and longevity assumptions.

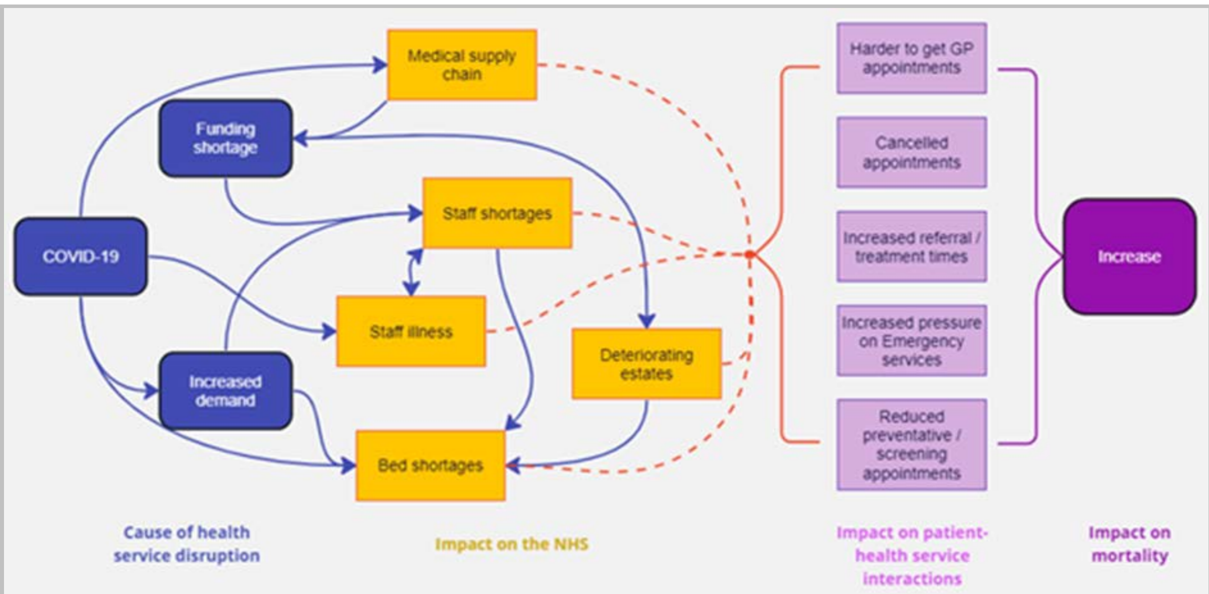

Figure 13. **Dynamics of NHS disruption**
Some of the key dynamics of the disruption of the NHS during and after the COVID-19 pandemic.

5.5.1. *Cause of Health Service Disruption*

Section 5.4.2 outlined some of the links between the austerity measures imposed in June 2010, and subsequent reductions in mortality improvements observed in the population – and how this may have been manifested through falls in NHS funding. These funding challenges are compounded by the increasing needs

[81] www.sciencedirect.com (last accessed 31/07/2023).

of an ageing and growing population and have been further exacerbated by the pressures of the COVID-19 pandemic.

Pressure on the NHS has further manifested as staff shortages and strikes across all areas[82], deteriorating estates[83], bed shortages[84], and medical supply challenges[85]. Health services were forced to cope with the influx of COVID-19 patients during the height of the pandemic, and some patients with urgent healthcare needs avoided seeking help during the pandemic for reasons including not wanting to waste the time of healthcare professionals and worrying about catching COVID-19[86]. To the extent that some of these patients are returning later may be contributing to the current backlog.

5.5.2. Waiting times and missing referrals

The factors highlighted above have a direct impact on the interactions between patients and the healthcare services. Staff shortages and fewer beds ultimately impact hospitals' ability to provide timely care and remain a major factor in the growing backlogs and waiting times which have been further compounded by the challenges from COVID-19. The latest figures published by the BMA[87] for December 2022 show:

- around 7.2 million people waiting for treatment (as per Figure 14) – this represents a sharp increase to pre-pandemic levels and trends
- 3.1 million of these patients waiting over 18 weeks
- 0.4 million of these patients have been waiting over a year for treatment - which is around 240 times the number of people waiting over a year in December 2019
- a median waiting time for treatment of 14.4 weeks - significantly higher than the median wait of 8.3 weeks in December 2019

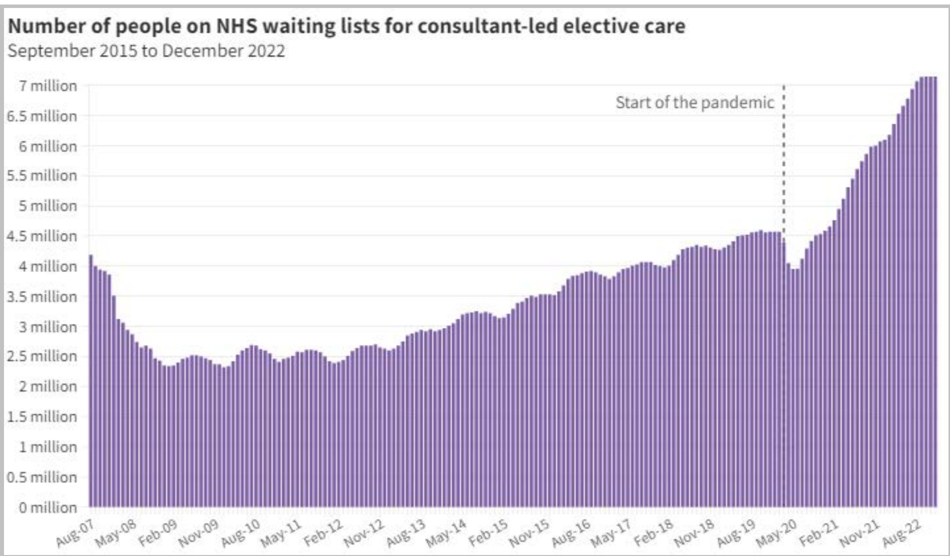

Figure 14. NHS waiting lists
Number of people on NHS waiting list for consultant-led elective care Sept 2015-Dec 2022

The Nuffield Trust 'Cancer waiting times' article[88] published in February 2023, notes the percentage of patients with suspected cancer being seen by a specialist within two weeks has fallen from around 95% between 2009

[82] BMA, Pressures in General Practice Data Analysis www.bma.org.uk (last accessed 31/07/2023).
[83] NHS Digital, Estate Returns Information Collection 2021/2022 digital.nhs.uk (last accessed 31/07/2023).
[84] Source: NHS England data, Bed Availability and Occupancy, www.england.nhs.uk (last accessed 31/07/2023).
[85] Source: The Times, Additional cost to the Department of Health of concession prices on NHS concessions, www.thetimes.co.uk (last accessed 31/07/2023).
[86] bmjopen.bmj.com (last accessed 31/07/2023).
[87] Source: BMA, NHS Backlog Data Analysis www.bma.org.uk (last accessed 31/07/2023).
[88] Source: Nuffield Trust, Cancer waiting times www.nuffieldtrust.org.uk (last accessed 31/07/2023).

and 2014 to just 75% in Q2 2022/23. The wait time for cancer treatment following the decision to treat has also fallen from around 98% of people being treated within one month to 90% over the same period.

Missing referrals

In the early stages of the COVID-19 pandemic the NHS saw a reduction in referrals and diagnoses in cancers, heart attacks and strokes. However, the Department of Health and Social Care paper[89] notes that they do not expect all the missing referrals to return. The reasons given include:

- Some health issues resolve themselves
- Some patients seek private healthcare or secondary care
- Changes in GP's ways of working, e.g. increased or better usage of Referrals Assessment Service (RAS), which could help GPs better manage patients in primary care triage and avoid unnecessary referrals.
- COVID-19 leading to death of individuals

The British Heart Foundation 'Tipping Point' report[90] notes that the missing referrals for patients mean lost opportunities to manage the risk factors for cardiovascular diseases, noting in particular a steep decline in hypertension management; 89% of patients diagnosed with hypertension had their blood pressure checked in March 2020, dropping to 64% by March 2021. This has partially recovered to 78% in March 2022 (the latest Tipping Point report at the time of writing) but is still not at the pre-pandemic levels. The report estimates that the reduction in control of hypertension could lead to 11,190 additional heart attacks and 16,702 additional strokes over a three-year period. A Lancet Oncology paper study published in 2020[91], estimated substantial increases in the number of avoidable cancer deaths in England are to be expected as a result of diagnostic delays due to the COVID-19 pandemic in the UK. For four tumour types (breast, colorectal, lung and oesophageal) the findings correspond to 3291–3621 additional deaths across the scenarios within 5 years. A collaboration between GAD, DHSC, ONS, and the Home Office estimated that delays to elective care because of the pandemic could lead to around 12500 excess deaths over a 5-year period[92].

5.5.3. Emergency care performance

There has been a marked increase in both A&E waiting times and ambulance response times relative to immediately pre-pandemic. Figure 15 shows how waiting times have progressed since the start of 2019. Ambulance response times increased sharply between the start of 2021 and the end of 2022, but fell at the beginning on 2023 (albeit remaining above the target time of 18 minutes for Category 2 calls).

The proportion of A&E attendances dealt with in under 4 hours fell from the start of 2021, reaching a low towards the end of 2022. This metric also showed some signs of improvement in early 2023, albeit still below the performance levels seen in 2019. We note that the extended timeseries data shows that the A&E wait metric has been deteriorating since at least 2010. Analysis carried out by the Emergency Medical Journal suggests waiting more than 6 to 8 hours in A&E increases the 30-day standardised mortality ratio by 8%[93]. We surmise that additional time waiting time due to ambulance delays would have a similar impact. Research by Lane Clark & Peacock[94] estimates that more than 400 additional deaths a week (between Sept 2022 to Feb 2023) could be due to long delays in accessing emergency care. Not all these deaths could be typically defined as excess deaths but could all be considered 'avoidable'.

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[89] Source: Gov.UK, Direct and indirect health impacts of COVID-19 in England: emerging Omicron impacts published Aug 2022 www.gov.uk (last accessed 31/07/2023).
[90] Source: British Heart Foundation, Tipping Point www.bhf.org.uk (last accessed 31/07/2023).
[91] www.thelancet.com (last accessed 31/07/2023).
[92] assets.publishing.service.gov.uk (last accessed 31/07/2023).
[93] Source: Emergency Medical Journal, Association between delays to patient admission from the emergency department and all-cause 30-day mortality emj.bmj.com (last accessed 31/07/2023).
[94] Source: Wait watchers, Published in The Actuary May 2023, www.theactuary.com (last accessed 31/07/2023).

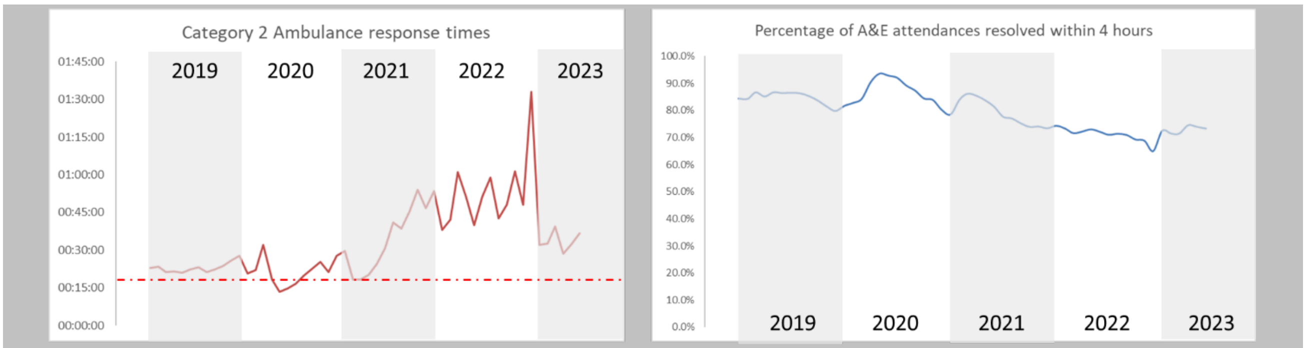

Figure 15. **Ambulance and A&E times**
Left: category 2 (emergency) average ambulance response times vs the target of 18 minutes since the start of 2019[95].
Right: The percentage of A&E attendances resolved within 4 hours from arrival to admission, transfer, or discharge[96].

A key driver of the delays in providing emergency treatment is delays in discharging those that are clinically ready to leave hospital[97]. In December 2022 an average of 13,440 patients a day remained in hospital despite no longer meeting the criteria to stay. In addition to the knock-on effects this has on the ability to get people out of A&E and admitted to hospital, delays in leaving hospital can lead to poorer outcomes for those forced to stay and contribute to a loss of independence.

5.5.4. The road to recovery

At the time of writing, a few initiatives are underway to help relieve the pressure on the NHS.

1. The NHS has published a delivery plan for recovering urgent and emergency care services[98], comprising 5 key areas: increasing capacity, growing the workforce, speeding up discharge from hospitals, expanding new services in the community, and helping people access the right care first time
2. The Prime Minister has published a long-term workforce plan with an emphasis on training more staff, retaining existing staff, and reforming the way staff work[99]
3. There is an NHS delivery plan for tackling the COVID-19 backlog of elective care, which outlines plans to increase capacity, prioritise treatment, transform the way in which elective care is provided, and provision of better information and support for patients[100].

Analysis by the Institute of Fiscal Studies in February 2023 concluded that progress against the plan to tackle the elective care backlog has been mixed[101]. The Long-term workforce plan has targets in place for 2031, and the plan for recovering urgent and emergency care services has a short-term target of 76% of patients spending less than 4 hours in A&E by March 2024 (i.e. below pre-pandemic levels and the pre-pandemic target of 100%). It seems likely that the issues faced by the NHS are complex, and hence will take time to resolve. It would be unreasonable to expect any excess deaths attributed to NHS strain today to run-off over a short period of time.

5.5.5. Deaths at home

Analysis of the OHID dashboard tool for excess mortality in England[102] shows a material increase in deaths that have occurred at home, which have consistently run into many hundreds each week (Figure 16).

[95] Ambulance quality indicators – AmbSYS time series to June 2023 www.england.nhs.uk (last accessed 31/07/2023).
[96] Monthly AE timeseries June 2023 www.england.nhs.uk (last accessed 31/07/2023).
[97] commonslibrary.parliament.uk (last accessed 31/07/2023)
[98] Department of Health and Social Care and NHS England, Delivery Plan report: www.england.nhs.uk (last accessed 31/07/2023)
[99] www.gov.uk (last accessed 31/07/2023).
[100] www.england.nhs.uk (last accessed 31/07/2023).
[101] ifs.org.uk (last accessed 31/07/2023).
[102] www.gov.uk (last accessed 31/07/2023).

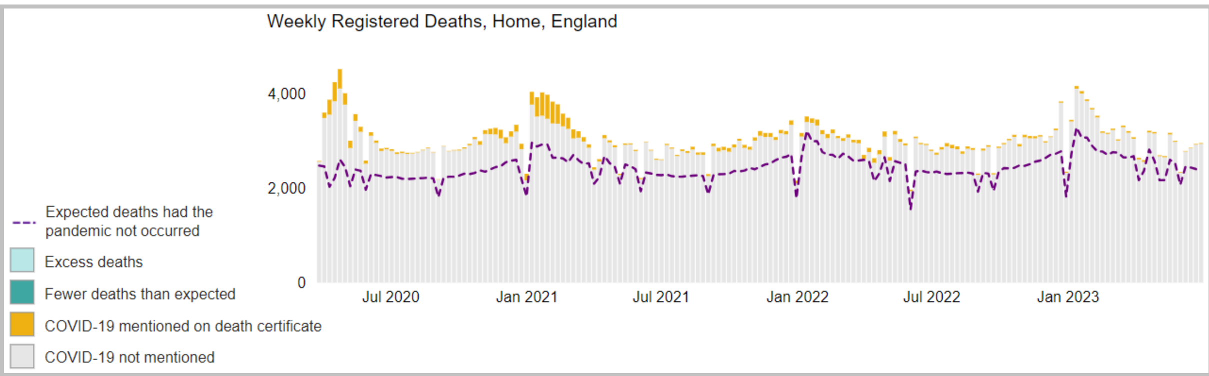

Figure 16. Deaths at home

Deaths at home since the beginning of the COVID-19 pandemic, including pre-pandemic expectations according to OHID calculations. There has been a consistently high level of non-COVID-19 excess deaths in at home.

Excess deaths in hospital settings have been positive and negative at different points throughout the pandemic, but the consistency of the positive excess deaths at home is striking. It is unclear why so many deaths are occurring in the home setting[103,104,105] but we caution against concluding that because the additional deaths are at home then this must be inconsistent with the narrative of an NHS that is under strain. This is because there are a number of other mechanisms by which we would see this, including the inability or unwillingness of patients to engage with the healthcare system and extreme ambulance and A&E waiting times. We note that since June 2022 there have been material excess deaths in hospitals as well as at home; presumably, those dying at home would have died in a hospital setting before the pandemic, and all other things being equal deaths in hospital should be materially reduced if people are dying elsewhere.

5.5.6. Conclusion

To summarise, the healthcare system is complex with many overlapping and interlinked factors in play. COVID-19 has intensified the pressure on an NHS that may already have been growing in the run-up to the pandemic, and has precipitated issues such as staffing shortages, discharge delays, and growing waiting lists for elective surgery. There are plans in place to fix the biggest issues facing the NHS, but it is a large and complex entity so the impact of any positive changes will likely only be felt over a long period rather than in the short-term.

<table>
<tr><th>Factor</th><th>Short term (2023-25)</th><th>Medium Term (2026-30)</th><th>Long Term (2031+)</th></tr>
<tr><td>Health service disruption / treatment backlogs</td><td>The impact of funding shortage, staff shortage and increased demand etc. are likely to persist in the immediate future. Delays to diagnoses, treatments, and provision of emergency care will continue to have an upward pressure on mortality rates.</td><td colspan="2">The medium to long term impact is dependent on the NHS hitting their targets on the path to recovery. If successful, it would be reasonable to assume a reduction in excess mortality.</td></tr>
</table>

5.6. Lost improvements

This section considers whether any of the underlying drivers of mortality improvement (that pre-dated COVID and might have been continuing to take effect in the background since 2020) have been disrupted.

[103] hansard.parliament.uk (last accessed 31/07/2023).
[104] www.kingsfund.org.uk (last accessed 31/07/2023).
[105] www.nuffieldtrust.org.uk (last accessed 31/07/2023).

5.6.1. *The impact on any excess death measure*

The extent to which excess deaths were experienced in the period 2020-2022 (i.e. in the past, but after the introduction of COVID) and will continue to be experienced in 2023+ depends on our chosen baseline – i.e. our expectations of future deaths as set immediately before we began experiencing COVID deaths. An insurer with expectations at that time of rapid future improvements from 2019 will calculate a higher level of excess deaths for 2022 (say) than one with a more-pessimistic view of the future, because the baseline differs. In general, despite periods of accelerating or slowing rates of historical improvements, in the run-up to COVID-19, most actuaries were assuming that improvements would continue to some degree into the future, with the rates of future improvement estimated using models (such as the APCI model produced by the CMI), and expert judgement. This suggests that when measuring the excess (e.g. in 2022) some improvements should be taken into account.

In 2019, a typical insurer will have assumed that mortality rates in 2020+ will have each been lower than the year before. Because of this, in order to get a full grasp on drivers of future mortality rates we not only need to think about <u>new</u> drivers of deaths (such as those related to COVID-19 as a disease, and those that might be a consequence of sub-optimal healthcare provision), but also whether our anticipated improvements from pre-pandemic have been disrupted. Put differently, in a scenario where we could immediately cure COVID-19, restore NHS performance to 2019 levels, and generally undo the negative effects of the pandemic such that we end up with mortality rates that are the same as in 2019 – we would still end up with excess deaths because we anticipated being in a state where mortality rates are **lower** than pre-pandemic values by 2022. The distinction between this section and others in this paper is that here we focus on these "lost improvements" i.e. what we anticipated happening but might not have got, whereas other sections look describe the new drivers of mortality we're experiencing since the beginning of the pandemic. Figure 17 illustrates this.

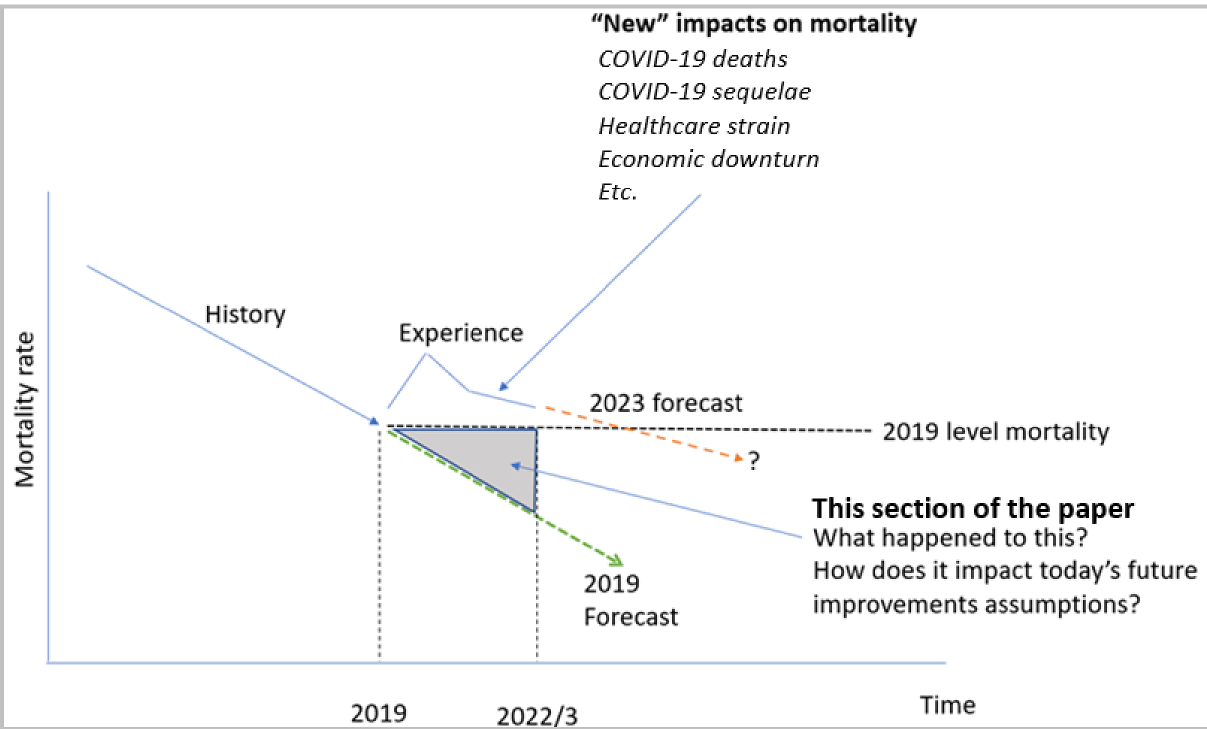

Figure 17. A simplified view of the considerations discussed in this section.
In 2019, actuaries would have produced forecasts for future mortality (green dashed line) based on historical trends. Experience in the period 2020-2023 can be split into two parts: things that have changed relative to 2019 (experience above the black dashed line in the figure), and things that have changed relative to 2019 expectations (grey shaded area below the dashed line). Both components are important for forming a view of future improvements from 2023 (orange line), and it is the latter "lost improvements" that are discussed in this section. The reality is more complex than the figure implies (there will be some drivers of better-than-anticipated mortality that evolved through the 2020-2022/3 period, for example), but having this simple model in mind is helpful in thinking through the components of excess deaths and how they might evolve in the future.

Recognise that this is impossible to detect from the data

As part of assessing the extent that lost improvements should inform assumptions going forwards, we need to consider whether any potential impacts are likely to be material, and whether they are short-term or long-term. If we assume a simple mortality improvement basis of 1% pa at all ages and in all years, it's clear that the extent to which we would be able to detect a deviation from our assumed trend in the short term is quite limited for at least two reasons:

1. COVID-19 deaths have been materially higher than 1%, and there is enough uncertainty around the recording of COVID-19 deaths (particularly in the first wave) and deaths due to sequelae of COVID-19 that, trying to tease out whether lost improvements were a driver of recent mortality from data alone would not be possible
2. Mortality rates are noisy even in times when underlying improvement trends are relatively calm, and to estimate improvements we need multiple years of data and smoothing/modelling methods to tease out signal from noise. These methods are not applicable when there has been a discontinuity in mortality progression, as has been the case with the COVID-19 pandemic

Over the longer term, the impact could increase to the extent that any missed improvements accumulate, however it seems likely that the picture then starts to become muddied by the emergence of new drivers of excess deaths (just how precise can we be in attributing excess deaths to A&E waiting times vs not having realised incremental gains in medical technology?), and the potential for us to see a catch-up effect where improvements were actually delayed rather than "lost".

5.6.2. *Proposed approach*

Because of the imprecise nature of teasing out any impact of lost improvements from the plethora of other drivers of mortality, we recommend taking a pragmatic and high-level view on how anticipated improvements might have been disrupted. The following checklist covers off the main considerations:

Step 1: Identify drivers of anticipated trends

- In broad terms, what was expected to underpin anticipated improvements? Was it medical advances? Improvements in air quality? Economic growth? Or lifestyle changes such as smoking cessation?
- Think about the extent to which these drivers are a consequence of what is happening here and now (period effects) vs those that have been build up over many years (cohort effects).

The accumulated impact of prior improved medical treatment is unlikely to be significantly affected. An average 65-year-old in 2010 receiving the benefit of latest developments in the treatment of circulatory diseases, for example, is likely to arrive as a 75-year-old in 2020 in a healthier state than the average 75-year-old in 2010. If they survive Covid-19 without dying or developing long-Covid, then in 2023 they arrive as a 78-year-old in who is likely to be healthier than the average 78-year-old was in 2020. It seems unlikely that the degree of improvement in that regard would be materially impacted by the pandemic.

On the other hand, the pandemic has interrupted medical care and research that we might have anticipated improving and leading to more saved lives. Many would-be patients have been unable to obtain appointments or commence treatment for life threatening diseases (see also Section 5.5), and advanced therapies might have been delayed in being brought into general usage. These “here-and now” impacts can be linked explicitly to pandemic disruptions.

In reality this kind of exercise is difficult, but having some rough view of where improvements were likely to have come from is a useful tool in thinking about what might have changed and so whether any improvements have been “lost”. There should be multiple drivers identified in practice, with some proportion of the total anticipated improvement attributed to each.

Step 2: Surmise how robust each of the drivers might have been to the pandemic

The outcome of this analysis, and therefore the view on whether “lost improvements” is likely to be material, will be very much a function of the reader’s view on these drivers. Questions that might be considered when approaching this are:

- If you identified medical advances as a material driver of anticipated improvements, how might lock-downs, social distancing and hence reduced lab time have impacted that?
- Might working from home and reduced transport have improved air quality temporarily? Lockdowns reduced GDP relative to expectation – what impact might that have had? (see also Sections 5.4 and 5.5)
- How did personal behaviours change during lockdowns (smoking, alcohol, exercise etc.) and would we expect a material longer term effect from this?

Period effects are likely to be more sensitive to pandemic-driven disruptions as they represent effects at a single point in time, whereas cohort effects are likely to be more persistent because they represent the accumulation of multiple factors over the lifetimes of individuals.

Step 3: Use the attribution of short-term improvements and impacts to estimate a short-term trend deviation

- Alter the effect attributed to each driver according to pandemic impacts and recombine to give an adjusted short-term trend. The difference between this and the original trend can be used to derive short-term excess deaths (e.g. in 2022) due to lost improvements.

Step 4: Form a view on how readily the improvements can be “won back”

For example, lost lab time is unlikely to be made up quickly and so perhaps medical research improvements are lost forever as breakthroughs are pushed back relative to pre-pandemic expectations. Some breakthroughs may be accelerated (see for example vaccine technologies driven by mRNA research, discussed in Section 5.3) – but because the subset of all medical research that has been accelerated by COVID-19 is probably small, it's sensible to deal with these as separate items that might drive mortality improvements beyond what was anticipated in the in the future.

Setbacks for other drivers might not be as difficult to "win back" as lost research. For example, if rolling out existing treatments/drugs to a wider population was identified as a driver of improvements – presumably that can be done very quickly in a post-pandemic world, albeit at a later date than anticipated.

Step 5: Blend the impact of lost-short-term improvements into the long-term

A simple approach is preferred here, as anything complex is likely to be spuriously precise. Recovering some proportion of the lost short-term improvements smoothly over some medium/long-term time-horizon is likely to be a sensible approach, reflecting that only a proportion will be "won back".

Step 6: Avoid double-counting

Double-counting the impacts of lost improvements could come in two forms:

1. Including future mortality uplifts due to lost improvements **and** as a new driver of excess deaths
   - For example, if we identify NHS strain as a driver of excess deaths and we anticipated NHS improvements in our 2019 basis, we need to separate out the impacts of NHS performance not improving as expected, and the impact of NHS strain deteriorating since 2019.
2. Identifying a driver of improved future mortality that was ***already implicit*** in the pre-pandemic improvement basis
   - For example, we might identify mRNA technology as something that reduces future influenza and cancer deaths. If we held the view in 2019 that cancer and influenza death rates would improve in the coming years, we must have assumed there was some driver of that. Whenever a new breakthrough is announced we need to take a view on whether it is beyond what must have needed to have happened to maintain the anticipated pace of improvements.

5.6.3. *Conclusion*

Factor	Short term (2023-25)	Medium Term (2026-30)	Long Term (2031+)
Lost improvements	Probably small relative to COVID-19 deaths. Depends on improvements assumed in 2019 basis and the drivers of those improvements, but it seems likely that a significant proportion of these would not have been "lost".	Likely to have a small impact, possibly immaterial over a longer time-period to the extent that the short-term effect is unlikely to be large, and a proportion of any short term lost improvements can be "won back"	

5.7. *Forward displacement of deaths (health selection)*

It has been suggested that higher than expected mortality in one period might lead to lower than expected mortality in the next period - "mortality displacement", see for example the IFOA pandemic mortality monitor for week 34 of 2021[106]. We investigate this using a deliberately simple approach to get a rough idea of the possible impact of this effect during the pandemic.

5.7.1. *A simple model of mortality displacement*

Suppose:

[106] www.actuaries.org.uk (last accessed 31/07/2023).

- We have a group of people with an average life expectancy of L years;
- A shock event occurs that instantly kills a proportion s of them; and
- The shock event has no impact on the life expectancy of the remainder.

What can we say about the life expectancy of the remainder?

Write L_D for the prior life expectancy, before the shock event, of those that died, and L_R for the prior life expectancy of those that remain.

Then the prior life expectancy for the entire group prior to the shock (L) is the weighted average of those who died and survived:

$$L = s \times L_D + (1 - s) \times L_R \quad (1)$$

and rearranging this gives

$$L_R = (L - s \times L_D) \div (1 - s) \quad (2)$$

This shows that to estimate the life expectancy of those remaining, we need to estimate the life expectancy of those who died.

We can use the relationship in step **2** to make some simple general observations - for example, if we have $L = 10$ and $s = 1\%$:

- If $L_D = L = 10$, then $L_R = 10$ also. More generally, if the life expectancy of those who died was no different to the group as a whole then the life expectancy of those who remain is also no different. We only see a change if there is "health selection" with those dying having different characteristics to those remaining.
- An upper bound on L_R is given by taking $L_D = 0$. In this case, $L_R = 10.1$, so a 1% mortality shock leads to at most a 1% increase in the life expectancy of survivors.

5.7.2. An estimate of forward displacement in England & Wales in 2020

We have estimated the impact of the COVID mortality shock in 2020 on life expectancy using ONS data[107] for England & Wales and focussing on ages 65 and above.

We apply the model above to each age and gender separately. We estimate L based on mortality rates for 2019 and estimate s based on the increase in mortality rate between 2019 and 2020 (averaging each mortality rate over five years of age to smooth out some of the volatility of the crude rates)

We have considered two approaches to L_D.

- Setting $L_D = 0$ gives an upper bound for the increase in life expectancy as above.
- A more realistic estimate based on analysis by Matthew Edwards[108] of the COVID-19 ARG. He suggested a mortality ratio "of the order of 130%" for the Died group relative to the population so we have scaled population mortality rates in 2019 by 130% to estimate prior life expectancy for those who died. This was corroborated by later research[109], but we note that a figure for the general population may not be appropriate for an insurance portfolio.

Table 10 shows the results. Here the "best estimate" refers to the more realistic estimate above. Although we applied the model to individual ages, we have shown results for the 65+ age group, weighted by population in 2019 to act as a rough proxy for a pensioner or annuitant portfolio.

[107] www.ons.gov.uk (last accessed 31/07/2023).
[108] covidactuaries.org (last accessed 31/07/2023).
[109] www.opensafely.org (last accessed 31/07/2023).

Table 10. Impact on life expectancy, ages 65+
Impact of health selection on life expectancy for England & Wales in 2020

Gender	Type	Life expectancy Overall (L)	Died (L_D)	Remain (L_R)	Increase Absolute ($L_R - L$)	Relative ($L_R - L)/L$
Male	Upper bound	12.307	0.000	12.359	0.052	0.43%
Male	**Best estimate**	**12.307**	**10.788**	**12.314**	**0.008**	**0.06%**
Female	Upper bound	13.351	0.000	13.388	0.037	0.27%
Female	**Best estimate**	**13.351**	**11.857**	**13.356**	**0.005**	**0.04%**

The table shows that the best estimate for the increase in life expectancy due to health selection for a portfolio aged 65+ is around 0.05% for both males and females. However, the "Increase" in Table 10 varies significantly by age, as shown in Table 11.

Table 11. Impact on life expectancy by age
Impact of health selection on life expectancy for England & Wales in 2020 - best estimate by age

	Absolute increase ($L_R - L$)		Relative increase ($L_R - L)/L$	
Age	Male	Female	Male	Female
65	0.003	0.001	0.02%	0.01%
75	0.006	0.003	0.05%	0.02%
85	0.016	0.009	0.26%	0.14%
95	0.025	0.020	0.97%	0.69%

5.7.3. *How long might this survivorship bias last?*

We have tested the persistence of the impact under the simple model as follows, by cohort:

- Project the total cohort from 2019, using the same mortality assumptions as above;
- Project the part of the cohort that died in 2020. e.g. for males aged 85, we estimate that an extra 1.49% of the population died (10.87% mortality in 2020 compared to 9.38% in 2019). We keep track of how many of these would have been expected to have survived to later years in the absence of COVID based on their mortality (with the 130% mortality ratio);
- Calculate the remaining population and its life expectancy based on the difference between the total population and those who died.

Whilst the increases in life expectancy are modest under this model, we find that they do persist for a long time:

- For males initially aged 85, the relative increase is 0.26% initially (as in the tables above). Projecting this forwards, we find that it persists for some time, being above 0.20% until 2029.
- For males initially aged 65, the relative increase is 0.02% initially and persists for decades. It is still 0.02% in 2049.

5.7.4. *Notes and caveats*

It's worth reiterating that a key assumption of the model is that the pandemic has no impact on the life expectancy of those who do not die. This is an unrealistic assumption, but we make it here as other factors, such as adverse health implications including long COVID, are being considered separately.

The level of forward displacement, and also the speed of its run-off over time, is sensitive to the choice of the mortality ratio (i.e. the 130% in our example). Higher ratios will lead to more survivorship bias and a slightly faster run-off. Also, if an age-dependent mortality ratio is applied (for example if the same initial life expectancy difference is represented by 160% at younger ages tapering down towards 100% at older ages, instead of a flat 130%) then this also leads to faster run-off of the survivorship bias effect, all else equal.

The analysis in this section only looks at the impact of excess mortality in 2020. The impact will be bigger if we also include excess in subsequent years.

We have assumed a single figure for the life expectancy of those who died. The disproportionately high number of care home deaths in the first wave may have led to a greater survivorship bias for that wave due to the shorter life expectancy of those in care homes, but this would have run off more quickly.

5.7.5. Conclusion

The simple modelling approach described here allows us to probe a plausible range of outcomes for the increase in life expectancy we might expect to see given the COVID-19 pandemic caused deaths among the most vulnerable to a greater extent than it did amongst the fittest members of the population. A reasonable set of assumptions gives rise to very modest increases in life expectancy for survivors relative to the pre-pandemic population, albeit one that is relatively persistent. This increase is estimated needs to be interpreted in conjunction with the other drivers of mortality described in this paper, and relies on simplifying assumptions such as the life expectancy of survivors not being impacted by the pandemic.

Factor	Short term (2023-25)	Medium Term (2026-30)	Long Term (2031+)
Forward displacement of deaths	Small magnitude relative to some other drivers mentioned in this paper (healthcare strain for example) but there is potential for some reduction in mortality rates in the short term, particularly for older ages.	While any short-term impact is likely to wear off over time, our simple model suggests that the run-off is relatively slow.	

5.8. Adverse health implications of COVID-19 infections and the pandemic in the medium-to-long term

In this section we discuss the main drivers of change in future mortality as a result of:

- behaviour change following lockdowns and the pandemic more generally, and
- the longer-term impacts of having previously been infected with COVID-19.

5.8.1. Long COVID

Most individuals make a full recovery from a COVID-19 infection within a few days or weeks their first symptoms. However, some continue to suffer from symptoms over a longer period[110]. The ongoing health issues that individuals experience after recovering from the immediate, acute COVID-19 symptoms are often collectively referred to as 'Long-COVID'. Long-COVID can manifest itself as wide-ranging adverse outcomes across numerous organ systems and may lead to lifelong disabilities among a some of those with the illness[111]. It is not clear what the long-term implications for mortality rates are for this group given the limited time since first COVID-19 infections occurred.

5.8.2. Acute post-COVID sequelae

We make a distinction between Long COVID and acute post-COVID sequelae: Long COVID describes the illness that persists for many months or years after contracting COVID-19, whereas acute post-COVID sequelae apply to the drivers of heightened mortality in the period immediately following a COVID-19 infection, but after the initial COVID-19 symptoms have abated and the infection is generally deemed to have been cleared.

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[110] www.nhs.uk (last accessed 31/07/2023).

[111] Davis et al. Long COVID: major findings, mechanisms and recommendations, 2023 **[#9]**

A study in the UK using Biobank data tracked the mortality rates of a cohort of patients who had been infected with COVID-19 between 16 March 2020 and 30 November 2020 (n =7,139) against a cohort of participants who weren't infected (n = 71,296).[112] The study found that patients in the 'post-acute' phase of a COVID-19 infection exhibited significantly higher mortality rates over an 18-month period compared to the uninfected cohort [HR: 5.0 (95% CI: 4.3–5.8)].

A US study[113] tracked 13,638 patients to analyse 12-month mortality risk for those who suffered from severe COVID-19 (defined as severe if hospitalized within the first 30 days of their initial positive test) and those with mild COVID-19 (not hospitalized) from 01/01/2020 until 30/06/2020 versus those who weren't infected. The paper notes "The 12-month adjusted all-cause mortality risk was significantly higher for patients with severe COVID-19 compared to both COVID-19 negative patients (HR 2.50; 95% CI 2.02, 3.09) and mild COVID-19 patients (HR 1.87; 95% CI 1.28, 2.74). The vast majority of deaths (79.5%) were for causes other than respiratory or cardiovascular conditions." However as 79.5% of deaths were for 'other' causes it's difficult to ascertain whether the aftermath of having COVID contributed to their increased mortality risk or whether prior comorbidities are what caused them to develop more severe COVID-19 in the first place.

A large study of US veterans considered this effect for vaccinated groups as well as non-vaccinated, and found that there was heightened mortality over a 6 month period even for vaccinated groups: "At 6 months after infection, we show that, beyond the first 30 days of illness, compared to contemporary controls, people with [breakthrough infection i.e. from vaccinated status] exhibited a higher risk of death (hazard ratio (HR) = 1.75, 95% confidence interval (CI): 1.59, 1.93) and incident post-acute sequelae (HR = 1.50, 95% CI: 1.46, 1.54), including cardiovascular, coagulation and hematologic, gastrointestinal, kidney, mental health, metabolic, musculoskeletal and neurologic disorders." This corroborates the findings from the studies above that mortality rates are high in the time period immediately following the acute phase of a COVID-19 infection, and that this also applies for vaccinated individuals. It also presents a comparison of vaccinated and unvaccinated and concludes that vaccination confers some protection against adverse outcomes in this post-acute period[114].

These studies consider periods of up to 18 months and so it is not possible to say how long the heightened risk will last, but it remains possible that it persists to the longer term.

5.8.3. Lifestyle changes

In order to minimise the risk of catching and spreading COVID the population generally took both a personal choice to socialise less whilst government-enforced lockdowns meant that many daily activities also became illegal. This included the closure of sporting facilities, which had substantial impacts on the population level of physical activity. Figure 18 illustrates the impact on average daily step counts by region as measured from smartphone tracking of over 1.2 million users[115]:

[112] academic.oup.com (last accessed 31/07/2023).
[113] www.frontiersin.org (last accessed 31/07/2023).
[114] Al-Aly et al., Long COVID after breakthrough SARS-CoV-2 infection, 2022 **[#1]**
[115] www.thelancet.com (last accessed 31/07/2023).

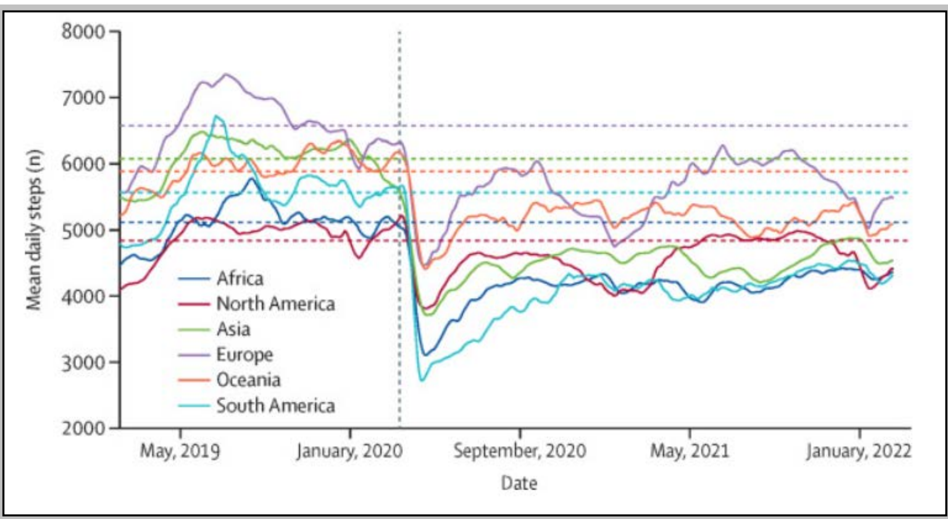

Figure 18. Changes in daily step counts since the COVID-19 pandemic began.

Although we don't have data specifically for the UK, we see that worldwide activity levels (using steps as a proxy) haven't recovered to pre-pandemic levels with European steps still 14% lower than the baseline. To the extent that this reflects a new, lower, normal in the level of physical activity undertaken by individuals it could suggest some more persistent increase to the associated mortality and morbidity risks.

A small study by Docherty *et al.*[116] showed that over 70s increased their activity levels and reported improved physical health during lockdown. However, their mental wellbeing significantly declined in many regards: depression, stress, confusion, anxiety and memory failure. The impact of this on future mortality is therefore uncertain.

A further behavioural change arising from the pandemic included the widespread adoption of risk reduction measures including:

- Working from home
- Mask wearing
- Improved hygiene, such as the use of antibacterial handwash

Society now has a better understanding of the benefits of the latter two measures, which may lead to an increased number of individuals adopting these behaviours more regularly, by choice, whenever they believe there to be increased levels of community illness. However, we have already seen significant reductions in these practices, which could be expected to continue to slowly decline as peoples' memory of the pandemic fades.

Working from home remains prominent in Great Britain, with approximately 40% of workers saying they had worked from home in the last seven day period around the end of 2022.[117] This compares to between 27% and 30% of workers in 2019. The impact of this shift to more home working on mortality is unclear, as is whether it will persist. No clear link between home working and mental wellbeing was found in a recent meta analysis[118].

Alcohol consumption increased significantly during the pandemic and high-risk drinking has remained above pre-pandemic levels in 2023 (Figure 19)[119]:

[116] www.ncbi.nlm.nih.gov (last accessed 31/07/2023). The Effects of COVID-19 Lockdown on Health and Psychosocial Functioning in Older Adults Aged 70 and Over

[117] www.ons.gov.uk (last accessed 31/07/2023).

[118] Wels et al. Home working and social and mental wellbeing at different stages of the COVID-19 pandemic in the UK: Evidence from 7 longitudinal population surveys, 2023 **[#22]**

[119] www.alcoholinengland.info (last accessed 31/07/2023).

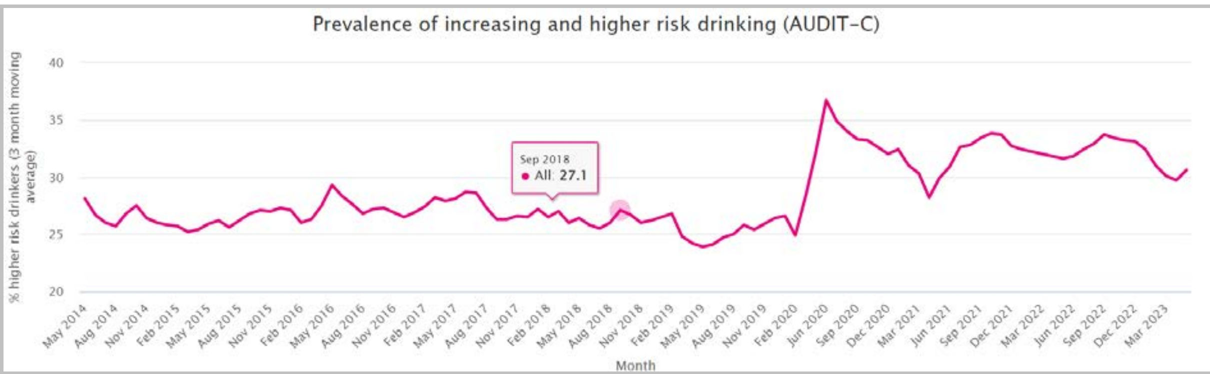

Figure 19. Changes in levels of higher-risk drinking
According to the Alcohol in England Alcohol use disorders identification test consumption (AUDIT-C)

If this consumption continues in the long term there could be an additional 9,914 premature deaths by 2035[120]. Whilst a significant total, if spread over many years this represents a less than 0.1% increase in deaths. However, it is worth nothing that liver disease is the second most common cause of years of life lost in England among working age people and premature deaths (under age 75) from alcohol-related liver disease has increased 23% between 2011 and 2020[121]. Therefore, the step-increase in alcohol consumption could potentially bring a material impact at younger ages.

5.8.4. Conclusion

Factor	Short (2023-2025)	Medium (2025-2030)	Long (2031+)
Long COVID	Small increase in mortality is possible– the current literature is insufficient but users should keep abreast of newly published literature	Negligible impact	Negligible impact
Acute post-COVID-19 sequelae	Material impact on excess deaths; probably reasonable to assume this is proportional to COVID-19 deaths (potentially with a lag as they come through in the subsequent period)	Smaller impact, particularly if the endemic steady-state of COVID infections is low	
Lifestyle Changes	Small increase – could be more material at younger ages	Small increase – could be more material at younger ages especially if activity and alcohol consumption levels don't revert toward pre-pandemic levels.	

[120] www.sheffield.ac.uk (last accessed 31/07/2023).
[121] www.thelancet.com (last accessed 31/07/2023).

6. Conclusions

The COVID-19 pandemic has heightened the need for judgement when setting mortality and longevity assumptions. We believe that adopting a driver-based approach to understanding current mortality experience is an important part of the actuarial toolkit, and that even a simple driver-based model can be used to:

- Yield important practical insights into the evolution of excess mortality, and the materiality of assumptions related to this
- Help users of the CMI 2022 model sharpen their views on what comprises a reasonable projection of mortality rates, and hence inform the parameterisation of the model
- Allow users to benchmark changes between pre-pandemic and post-pandemic bases in a simple and readily interpretable way

A review of existing research into likely drivers of post-pandemic excess mortality has suggested that pressure on the NHS and residual COVID (and its sequelae) are likely to be the major drivers of post-pandemic excess, and it would be reasonable for offices with limited time and resources to focus efforts on forming a view on these drivers. The mortality landscape is complex and ever evolving, however, and actuaries should remain vigilant in responding to emerging research and analysis, and the mortality trends that emerge as we collect more post-pandemic data.

References

1. Al-Aly et al., Long COVID after breakthrough SARS-CoV-2 infection, 2022
2. Archi, A. Joe Biden says the COVID-19 pandemic is over. This is what the data tells us.
3. Balint et al., Omicron: increased transmissibility and decreased pathogenicity (2022).
4. Benach et al. What do we know about the impact of economic recessions on mortality inequalities? A critical review. 2022.
5. Birrell P., Blake J., van Leeuwen E. & De Angelis D. (2022) COVID-19: nowcast and forecast [online]. www.mrc-bsu.cam.ac.uk (last accessed 31/07/2023).
6. Bobrovitz N. et al (2022) Protective effectiveness of prior SARS-CoV-2 infection and hybrid immunity against Omicron infection and severe disease: a systematic review and meta-regression [online]. Available at: doi.org (last accessed 31/07/2023).
7. Calvetti D, & Somersalo E. (2023) Post-pandemic modeling of COVID-19: Waning immunity determines recurrence frequency [online]. Available at: www.medrxiv.org (last accessed 31/07/2023).
8. Carazo S., Skowronski D.M., Brisson M., Barkati S., Sauvageau C., Brousseau N., Gilca R., Fafard J., Talbot D., Ouakki M., Gilca V, Carignan A., Deceuninck G., De Wals P. & De Serres G. (2022) Protection against Omicron (B.1.1.529) BA.2 reinfection conferred by primary Omicron BA.1 or pre-Omicron SARS-CoV-2 infection among health-care workers with and without mRNA vaccination: a test-negative case-control study [online]. Available at: doi.org (last accessed 31/07/2023).
9. Davis et al. Long COVID: major findings, mechanisms and recommendations, 2023
10. Katzourakis, A. COVID-19: endemic doesn't mean harmless.
11. Kirsebom F.C.M., Andrews N., Stowe J., Toffa S., Sachdeva R., Gallagher E., Groves N., O'Connell A., Chand M.,Ramsay M. & Bernal J.L. (2022) COVID-19 vaccine effectiveness against the omicron (BA.2) variant in England [online]. doi.org (last accessed 31/07/2023).
12. Klobucista C. When will COVID-19 become endemic?
13. Kun A. Hubai A. Kral A. Mokos J. Mikulecz B Radvabyi A. Do pathogens always evolve to be less virulent? The virulence–transmission trade-off in light of the COVID-19 pandemic [online] Available at www.ncbi.nlm.nih.gov (last accessed 31/07/2023).
14. Lewnard, J. et al. Effectiveness of nirmatrelvir–ritonavir in preventing hospital admissions and deaths in people with COVID-19.
15. Looi, M. How are COVID-19 symptoms changing?
16. Nordström P., Ballin M. & Nordström A. (2022) Risk of SARS-CoV-2 reinfection and COVID-19 hospitalisation in individuals with natural and hybrid immunity: a retrospective, total population cohort study in Sweden [online] doi.org (last accessed 31/07/2023).
17. Phillips, N. The coronavirus is here to stay – here's what that means.
18. Raisi-Estabragh et al, Cardiovascular disease and mortality sequelae of COVID-19 in the UK Biobank, 2003
19. Stoddard et al. Endemicity is not a victory.
20. Toledo-Roy J.C., Garcia-Pena G.E. Valdes A.M.& Hoeflich A.F. (2023) Agent-based modeling and phylogenetic analysis suggests that COVID-19 will remain a low-severity albeit highly transmissible disease [online]. Available at: doi.org (last accessed 31/07/2023).
21. Watkins et al. Effects of health and social care spending constraints on mortality in England: a time trend analysis, 2017
22. Wels et al. Home working and social and mental wellbeing at different stages of the COVID-19 pandemic in the UK: Evidence from 7 longitudinal population surveys, 2023
23. Whitaker et al., Variant-specific symptoms of COVID-19 in a study of 1,542,510 adults in England, 2022.

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