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ACTUARIAL SCIENCE

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INTERNSHIP REPORT

The Impact of Covid-19 on Mortality Assumptions when Valuing UK Defined Benefit Pension Schemes

Shadri Andre Butcher

October 2021

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ABSTRACT

Year 2020 has been an unexpected year, due to the emergence of the coronavirus, Covid-19. This virus caused a rise in number of deaths in many countries including the UK. Currently, the pandemic is still causing excess deaths in 2021, but less than what was experienced in 2020 and this may be due to effective vaccines that started being administered towards the end of 2020. Nevertheless, there is great uncertainty in how future mortality may be impacted and hence various views on this impact have resulted. Consequently, setting accurate mortality assumptions for pension valuations can become even more difficult. In this report, mortality data on England and Wales is studied as this is the data used to calibrate the popular mortality projections model, the CMI model, used in many UK pension valuations. The CMI_2019 and CMI_2020 models are used to test how the extended parameters may be adjusted, considering three differing views on the future mortality impact of Covid-19, as well as the resulting impact on liabilities of a pension scheme when these adjustments are made.

The results show that in-line with the view that the pandemic will not impact future mortality, upgrading to the CMI_2020 model with a core value of 0% for the w_{2020} parameter causes an approximate 0.16% fall in liabilities. If Covid-19 is believed to have a negative impact on future mortality instead, then an upgrade to the CMI_2020 model with a non-zero weight on the w_{2020} parameter, a lower LTR in the 2019 model or a lower A parameter value in either the 2019 or 2020 model could be used, resulting in a reduction of liabilities. Of these responses, the greatest fall in liabilities of 3.72% occurred when an upgrade to the 2020 model using full weight on the w_{2020} parameter was used. On the other hand, if the virus is believed to have a positive impact on future mortality, a higher LTR parameter could be used or higher A parameter in either the 2019 or 2020 model causing an increase in liabilities. The highest increase in liabilities was 2.22% which resulted when a LTR of 2.00% was used instead of 1.50%.

Keywords: Pension Schemes, Covid-19, Pandemic, Mortality Impact, Mortality Projections.

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CONTENTS

LIST OF GRAPHS

LIST OF TABLES

1. INTRODUCTION

The novel coronavirus has affected the world in numerous ways and in varying scales. Two notable impacts being the many lives that have been lost and the pressure that has been placed on economies world-wide (United Nations, 2020). Thankfully, the production of effective vaccines has emerged to counteract the virus but the full extent of the impact of Covid-19 remains unknown.

Pensions are one of the sectors that have been affected by this unforeseen virus, as Covid-19 has taken the lives of numerous persons, especially the elderly. According to the provisional data provided by (ONS, 2021a) on monthly deaths from March 2020 to June 2021, the average age of persons who died in England and Wales, with Covid-19 as the underlying cause of death, was 80 years. Since most elderly people are receiving some type of pension, which is usually paid at least until they die, a pension scheme's payment obligations are expected to decrease, *ceteris paribus*. However, whether this positive effect on liabilities due to the increased mortality is material, depends largely on the length of time it takes for countries to fully recover from the impact of the virus. This recovery not only entails the health aspect but also the economic aspect, since economic hardships have also been shown to be related to higher mortality rates (Doerr & Hofmann, 2020).

It is necessary for pension valuers of defined benefit schemes to calculate how long members are expected to survive, as this directly impacts the total liability of the schemes and hence the schemes´ funding positions (Government Actuary´s Department, 2020). As many persons´ livelihoods depend, or will depend, on pension benefits, it is paramount for pension schemes to accurately estimate their liabilities as much as possible and ensure that they will be able to cover these liabilities. Therefore, much care is taken to assess the different factors that can affect these payment obligations, including the changing mortality rates due to the pandemic. At first glance, mortality rates in 2020 have spiked beyond anyone's expectations, causing a decrease in life expectancy. For example, if we compare years 2019 and 2020, we see that the life expectancy measured from birth in England fell by 1 year (from 83.7 to 82.7 years) for women and by 1.3 years (80 to 78.7 years) for men (Raleigh, 2021). A slight fall in life expectancy has also occurred for 65-year-olds, with females now expected to live one week less and males expected to live four weeks less based on latest model of the Continuous Mortality Investigation (Seekings, 2021). However, given mortality rates have not remained constant in the past and given that the 2020 mortality experience was far from that of any normal year, it may be unlikely that this lower life expectancy will materialise. Also, any short-term liability impacts due to the virus are expected to be small for most schemes and maybe overshadowed by indirect, long-term mortality impacts and the impacts of shifts in the financial markets (Caine, 2020a). This is because the virus mainly impacts the elderly and cuts short their pension payments by a few years relative to the future payments to surviving members which stay unaffected (Caine, 2020a). Payments to the surviving members, who would represent a greater proportion of pension scheme members, may however be affected if post-pandemic mortality rates continue to be different to what we would expect if the pandemic did not occur (Caine, 2020a).

The pandemic has also disrupted financial markets causing losses in assets used to cover pension plan liabilities (Preppernau, 2020 & Knox, 2020) and a rise in unemployment, which negatively impacts pension contributions (Knox, 2020). These losses in assets can upset short-term reductions in liabilities and result in lower funding positions for pension schemes. Nevertheless, there is still much uncertainty surrounding future mortality and it is too soon to know if the recent mortality spike will affect the downward trend in projected mortality rates in the longer-term (Kyriakou, 2021).

Within the pensions field, uncertainty is common-place as various assumptions must be made about the future, to calculate pension annuities. Pension actuaries must consider mortality very carefully, as it translates to how long the scheme is expected to pay pension benefits. This falls under the ´mortality assumptions´ of the pension scheme and usually includes a base mortality table and mortality improvements assumptions. The base mortality table is grounded on the past experience of a specified population with whom the pension scheme members are believed to share a similar mortality, usually with slight adjustments to the base table. On the other hand, mortality improvements focus on how mortality is expected to develop in the future, and this involves a substantial amount of judgement.

According again to data provided by (ONS, 2021b) on weekly deaths in England and Wales, from 28 December 2019 to 3 September 2021, an unusual number of deaths have occurred in years 2020 and 2021 so far, with approximately 75,618 excess deaths in year 2020 and 31,444 excess deaths in 2021, up until 3 September. Due to these unexpected deaths, many of which would have been related to the pandemic, and the great uncertainty about Covid´s future impact on mortality, setting mortality assumptions for pension schemes becomes even more challenging in these times. As pension valuations depend greatly on projections of mortality and expected improvements, the longer-term effects of the virus on future mortality rates can be of great concern.

Actuarial valuations in the UK are required by law at least once every three years, according to Section 224 of the Pensions Act 2004,[1] and many pension schemes will be doing their valuations this year, amid the pandemic. Despite this being a very uncertain period to make accurate assumptions about future mortality, these assumptions must still be formed to value pension liabilities. Setting mortality improvement assumptions during the pandemic will thus require a greater deal of judgement since the current, as well as the possible future, impact of Covid-19, will need to be considered.

As judgement is involved, trustees and actuaries will aim to form a well-reasoned opinion about the expected impact of the virus on the mortality of their pension scheme members. Thus, differing views are likely to emerge, which can lead to various responses to future mortality improvement assumptions. There are three main views that have emerged about the possible impact of the virus on future mortality rates.

The first is that the mortality experienced in 2020 was one-of-a-kind and may only be a short-term spike (Daneel & Palin, 2021), thus this experience may not affect the longer-term mortality rates and hence mortality improvements in the future. Contrary to this, some believe

[1] **Pensions Act 2004 - Section 224: Actuarial valuations and reports**

(1) The trustees or managers must obtain actuarial valuations—

(a) at intervals of not more than one year or, if they obtain actuarial reports for the intervening years, at intervals of not more than three years, and

(b) in such circumstances and on such other occasions as may be prescribed.

that there are more interrelated impacts of Covid-19 that might indeed affect future mortality rates, forming the other two viewpoints.

The second view is that it is also reasonable to expect mortality to continue being high (just not as high as the 2020 experience). This is due to the negative effects of the virus which can remain, including the economic depression (Caine, 2020b; Aon, 2020a; Palin, 2021), possible after-effects of survivors of the virus (American Academy of Actuaries, 2020; Palin, 2021) and the consequences of delayed treatment of other ailments during the pandemic (Caine, 2020b).

On the other hand, it is also believed that the pandemic can cause mortality rates to fall in the future, due to a healthier surviving population (Caine, 2020b; American Academy of Actuaries, 2020) and increased investments in healthcare (Aon, 2020a), forming the third view.

Based on these three different viewpoints, the mortality assumptions of a pension scheme will either be left as it is or updated to reflect the possible impact of the virus, either positive or negative. Despite knowing some of the various views and possibilities of the mortality impact of the virus, it is impossible to know the actual outcome and each of the three outcomes could easily come to past. Also, we do not know what the overall impact will be if both the positive and negative long-term impacts interplay.

Nevertheless, assumptions must be made, and the calculated pension liabilities along with the funding position of pension schemes will either rise or fall, based on the position taken on the impact of the pandemic and the related change in mortality assumptions.

Due to the uncertainty of the impact of Covid-19 on mortality and the resulting greater uncertainty in setting mortality assumptions during this pandemic, this topic was chosen to be investigated. In the next chapter, an introduction on mortality rates and mortality improvements is given, as well as an overview of how mortality has developed in England and Wales and how the 2020 mortality experience differs to that of previous years. The third chapter focuses on the three different views of the impact of the virus on future mortality and how mortality assumptions can change to allow for these views. It also introduces the CMI_2020 model, which will be used as the mortality projections model to consider how mortality assumptions may change in-line with the three views on Covid´s future mortality impact, and the expected effect on liabilities when these changes are made. In the fourth chapter a practical exercise is conducted, to test the various changes in mortality assumptions given in chapter three and the resulting impact on liabilities. Finally, the last chapter concludes based on the results obtained.

This project was completed as part of a five-month internship at the Lisbon Service Center (LSC) department of Willis Towers Watson (WTW). The internship involved one full month of training which covered the basics of the work done at the LSC and the various tasks that are done to complete a valuation for a UK pension scheme. In the following four months, the training was put to practice by working on valuation projects for different pension schemes. Within this internship, the necessary knowledge about UK pension schemes and how to value pension liabilities using the company´s internal software was learnt. For the practical exercise of this internship project, the company provided dummy data due to confidentiality regulations and this data, along with the CMI_2019 and CMI_2020 model, was used for the analysis done in the fourth chapter.

2. MORTALITY RATES AND MORTALITY IMPROVEMENTS

2.1 Introduction to mortality rates

Mortality rates represent the probability of a person of age x dying within the next year (i.e before he/she reaches age $x + 1$) and the actuarial notation usually used is q_x. If the person did not die within the year, then the only other option is that he/she has survived. Therefore, the probability of a person of age x surviving the next year is equal to $1 - q_x$. The actuarial notation used to represent this survival probability is p_x.

As pensions are mainly paid to retired persons until they die, which is uncertain in time, estimates must be used based on past and current experiences and on expectations on how mortality rates will develop in the future. These estimates come in the form of mortality rates, which give the probability of a person dying, hence allowing us to calculate how many years a person of any age is expected to live for and translates to how long a company is expected to pay a pension to a retiree.

Lower mortality rates imply that persons are living longer and therefore pensions are expected to be paid also for a longer period, increasing pension liabilities, *ceteris paribus*. Conversely, as already explained, higher mortality rates cause pension liabilities to decrease, *ceteris paribus*, as persons will be expected to have a shorter lifetime to receive their respective pension amounts. Consequently, mortality rates are one of the key components used in the demographic assumptions that are set to value a pension scheme.

2.2 Comparing mortality rates

To analyze deaths over time, one can compare the total annual number of deaths for a particular year with that of previous years. However, this does not take into consideration the growth in the population along time. With more people, more deaths are expected to occur. Thus, to consider a change in population size when comparing mortality rates, one can use the crude mortality rate which is the number of deaths per a fixed number of persons (e.g 100,000 persons) in the population (Statistics Canada, 2017). Consequently, the populations being analyzed will essentially have a constant size to do a better comparison.

Another characteristic is that the age distribution in populations also changes with time, and persons of different ages have different mortality rates, with the overall trend being persons of higher ages having higher mortality rates.

To consider this effect for comparison purposes, mortality rates can also be standardized based on age. This guarantees that differences in annual deaths are not a result of differences in the populations´ age distribution (CDC, n.d.).

For example, consider Table 1 below which gives data for Canada´s estimated population size and the number of cancer deaths in 2000 and 2011, provided by Statistics Canada (2017).

Table 1: Cancer deaths and population estimates, Canada, 2000 and 2011

Age Group	Characteristic	2000	2011
0-39 years	Estimate of population	17,068,876	17,191,850
	Number of deaths	1,345	1,004
	Crude rate	7.9	5.8
40 years and over	Estimate of population	13,616,854	17,150,930
	Number of deaths	61,325	71,472
	Crude rate	450.4	416.7
Total all ages	Estimate of population	30,685,730	34,342,780
	Number of deaths	62,672	72,476
	Crude rate	204.2	211.0

Source: *Statistics Canada:* https://www.statcan.gc.ca/eng/dai/btd/asr

If the total number of deaths are compared, we notice a clear increase from 62,672 deaths in year 2000 to 72,476 deaths in year 2011 (9804 extra deaths). However, the total population size has also increased from 30,685,730 to 34,342,780 between the eleven years.

To account for this, the crude rates can be calculated for the two years using Equation 1 (Božikov, Zaletel-Kragelj & Bardehle, 2010):

$$CDR_{(spec.group)} = \frac{N_{deaths\ (spec.group)}}{N_{pop\ (spec.group)}} * 100{,}000 \qquad (1)$$

where $CDR_{(spec.group)}$ is the crude death rate in a specific population group, $N_{deaths\ (spec.group)}$ is the number of deaths in a specific population group and $N_{pop\ (spec.group)}$ is number of population in a specific population group.

By using Equation (1) and the specific population group as the total population, we get the total crude death rates of 204.2 for year 2000 and 211.0 for year 2011. This means that in year 2000, approximately 204 persons have died for every 100,000 persons in the population and in year 2011, approximately 211 persons have died per 100,000 persons in the population (Statistics Canada, 2017). Hence, there is an increase in crude mortality rates which is in-line with the increase in the total number of deaths in 2011. However, as seen in Table 1, the population of both age groups have increased with a 0.72% increase in the "0-39 years" age group and 26% increase in the "40 years and over" age group. Therefore, the more significant change in the age structure has been the increase in the number of persons aged 40 years and over, the age group which has a higher mortality rate (Statistics Canada, 2017).

To account for this change in the age distribution, the rates were standardized using the 1991 population, where 61.6% of Canadians were under 40 years and 38.4% were 40 years or over (Statistics Canada, 2017). To calculate the age-standardized mortality rates (ASMR), the direct method of standardization was used, by multiplying the crude death rates for each age-group (age-specific rates) by the respective proportions of the 1991 population (Standard population) and summing afterwards. More generally, Equation (2) below, taken from "The Registrar General's Statistical Revies of England & Wales for the Year 1934", as cited in Chiang (1979), is used for the direct method of standardization.

$$D.M.D.R. = \sum_i M_{ui} \times \frac{P_{si}}{P_s} \qquad (2)$$

where D.M.D.R is the Direct Method Death Rate, i is the number of age-groups, M_{ui} is the age-specific death rate for age interval $(x_{i,}x_{i+1})$, P_{si} is the standard population in age-group i and P_s is the total standard population.

Note that the D.M.D.R. is a weighted average calculation, where the death rates by age-group, M_{ui}, of a specific population, are weighted by the proportions of the standard population, $\frac{P_{si}}{P_s}$ (Chiang, 1979).

As we are taking the same standard population for both 2000 and 2011, the age-distribution used will also be the same and hence the result is age-standardized. Applying Equation (1) to calculate the age-specific rates, where the specific population groups are those in the two age groups, we obtain the crude rates for both age-groups (age-specific rates) given in Table 1. Then using Equation (2) we find:

$ASMR_{2000}$ = (7.9 x 61.6%) + (450.4 x 38.4%) = 177.8

$ASMR_{2011}$ = (5.8 x 61.6%) + (416.7 x 38.4%) = 163.6

Consequently, when the direct method is used, for year 2000 there is an ASMR of 177.8 deaths per 100,000 Standard population and for year 2011 there is an ASMR of 163.6 deaths per 100,000 Standard population. Notice that even though there is an increase in the total crude rate, when the changing age-structure is accounted for, there is a decrease in age-standardized mortality rates.

2.3 Mortality improvements

According to the Continuous Mortality Investigation (see Section 3.5), a mortality improvement is the reduction in mortality rates between two years and the term "improvements" is used because of the usual downward trend in mortality (IFoA, 2021a). If mortality rates decrease there is a positive improvement but if mortality rates increase the result is a negative improvement (IFoA, 2021a). If there is no change in mortality then the improvement is zero (Rischatsch, Pain, Ryan & Chiu, 2018).

The annual mortality improvement can be calculated as in Equation (3) (Rischatsch, Pain, Ryan & Chiu, 2018).

$$MI = 1 - \frac{m_t}{m_{t-1}} \tag{3}$$

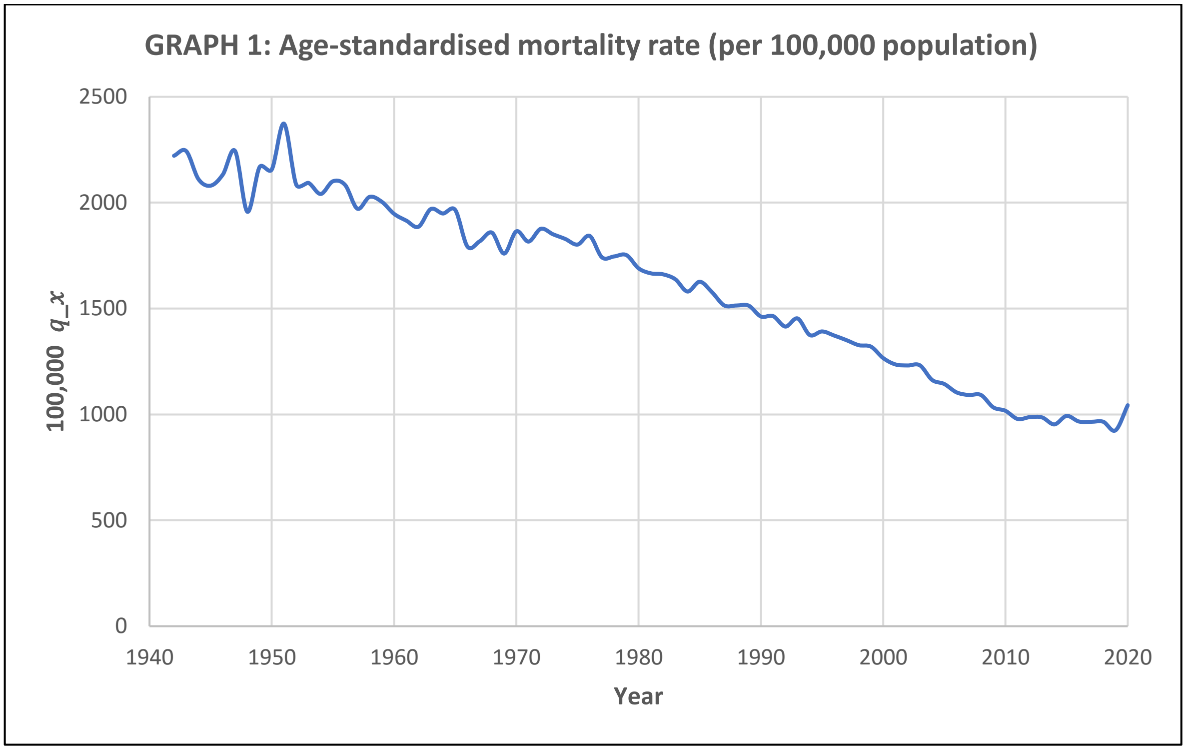
where MI is Mortality improvement and m_t is the Mortality rate at time *t*.

For example, if the data given in Table 1 was actually for two successive years, using the total crude rates we would have a mortality rate of 0.002042 (=204.2/100,000) in the first year and 0.00211 (=211.0/100,000) in the following year. Thus, the annual mortality improvement would be -3.33% (=1 - 0.00211/0.002042), i.e. a negative improvement due to the increase in mortality rate between the two years.

2.4 Mortality in England and Wales

2.4.1 Age-standardized mortality rates along time

Using the provisional data[2] provided by the Office of National Statistics on age-standardized mortality rates for the England and Wales populations (ONS, 2021d), Graph 1 below was plotted.



Source:
https://www.ons.gov.uk/peoplepopulationandcommunity/birthsdeathsandmarriages/deaths/adhocs/12735annualdeathsandmortalityrates1938to2020provisional

Based on Graph 1, mortality rates have been very unstable between 1942 and 1952 with high peaks in mortality in 1947 and 1951. This instability was partly due to high death rates during WWII (ONS, 2015), which began in 1939 and ended in 1945, and due to the 1951 influenza

[2] As stated by ONS (2021d):

These rates are standardized to the 2013 European Standard Population, expressed per 100,000 population; they allow comparisons between populations with different age structures, including between males and females and over time. Note: Figures for 2020 are provisional. Finalised figures will be produced in summer 2021 and can be found as part of the *Deaths registered in England and Wales* *release."*

epidemic (A/H1N1), which caused an unusual increase in deaths in England (Viboud, Tam, Fleming, Miller, & Simonsen, 2006).

In the next 20 years, between 1952 and 1972, there has been moderate spikes in mortality rates causing moderate variance in the rates. Afterwards, post-1972 rates have been steadily decreasing with a few small spikes. Yet, from 2011 until 2019, decreases occurred at a slower rate. Finally, due to the coronavirus pandemic, year 2020 is shown to have a relatively large spike in mortality rate, when compared to the other spikes between 1972 and 2019, inclusive.

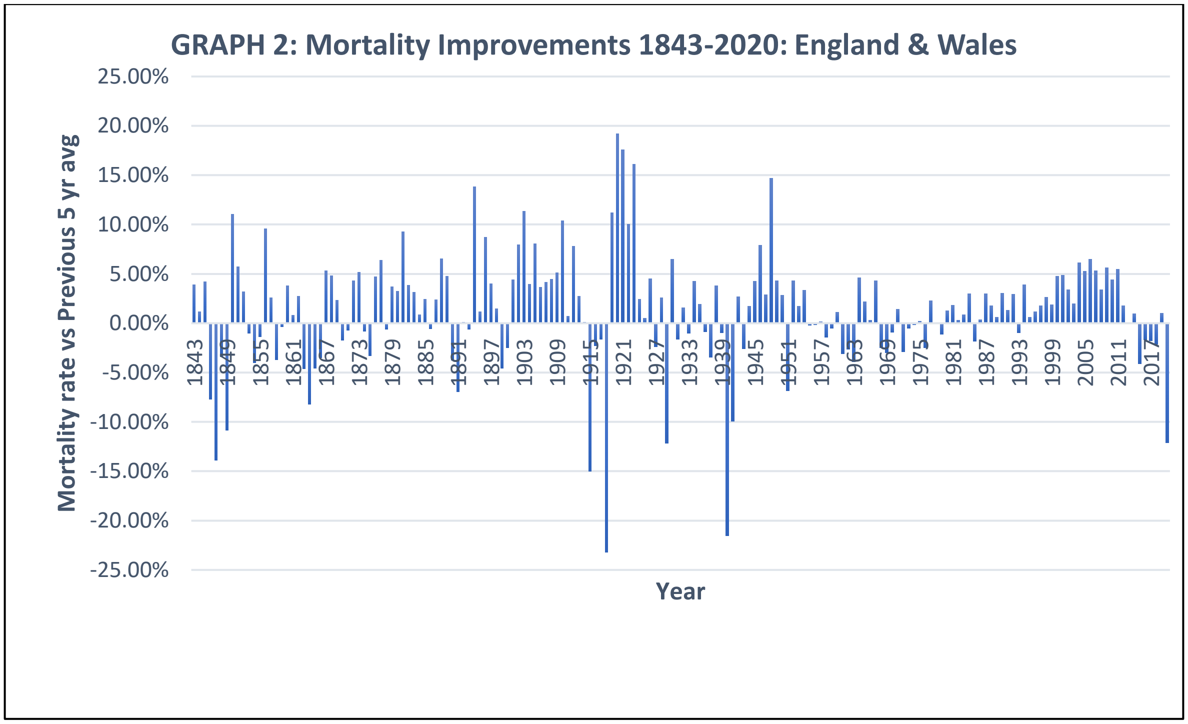
Overall, mortality rates are shown to be trending downwards throughout time. According to Raleigh (2021), this trend is at first largely due to improvements in nutrition, hygiene, housing, sanitation, control of infectious diseases and other public health measures. These caused life expectancy to increase from 40.2 years and 42.3 years for males and females born in 1841, respectively, to 56 years and 59 years for males and females born in 1920, respectively (Raleigh, 2021).

Following the same source, subsequent decreases in mortality rates were due to immunizations for children, universal health care, medical advances in treating cardiovascular disease and cancer, and due to a reduction in smoking. In England, by 2019, a newborn was expected to live 80 years (males) and 83.7 (females). In the past decade, however, the improvements in life expectancy have reduced when compared to those in the previous decades, and this can also be seen in Figure 1 above: between 2011 and 2019, the graph appears relatively flat. Then, due to the pandemic, life expectancy fell greatly in 2020, to 78.7 years for males and 82.7 years for females, the likes of which has not been witnessed since World War II, overshadowing the slowdown between 2011 and 2019 (Raleigh, 2021).

Hence, this 2020 experience is shown to be a very unusual experience but based on the behavior of mortality rates after previous spikes, it appears that the overall downward trend almost always continues even after huge spikes in mortality. This goes in favor with the conjecture that the increased mortality due to Covid may just be a short-term mortality spike. However, the slowdown in the downward trend in mortality after 2011 coupled with this unusual 2020 mortality experience could also warrant the possibility of a shift in the long-term trend.

2.4.2 Mortality improvements along time

To get a greater sense of the development of mortality improvements, the crude mortality rates were used as this data provided by the ONS has a larger time span (1838 to 2020). Mortality improvements were calculated by comparing the mortality rate for each year starting from 1843 to 2020 with the average mortality rate of the previous five years. If the mortality rate at year *t* is lower than the average mortality rates from the previous five years (years *t*-5 to year *t*-1), then the mortality improvement is positive, otherwise it is negative.



Source:https://www.ons.gov.uk/peoplepopulationandcommunity/birthsdeathsandmarriages/deaths/adhocs/12735annualdeathsandmortalityrates1938to2020provisional

Based on Graph 2, since 1843, there have been mainly positive mortality improvements, i.e. for a large proportion of the years, mortality has decreased in comparison to the previous five-year average. Then in the past decade the slowdown in mortality improvements is observed with slight positive improvements in year 2012, a very small negative improvement in 2013 and a positive improvement in 2014, followed by greater negative improvements up until 2018. In 2019 there is a slight positive improvement and then in 2020 there is a great fall in mortality improvement by 12.13%, unparalleled to any other since 1941 (9.96%). The prior experience between 2011 and 2019 could have hinted towards expecting a negative mortality improvement in 2020, but not to the extent that was observed.

2.4.3 The 2020 & 2021 mortality experience

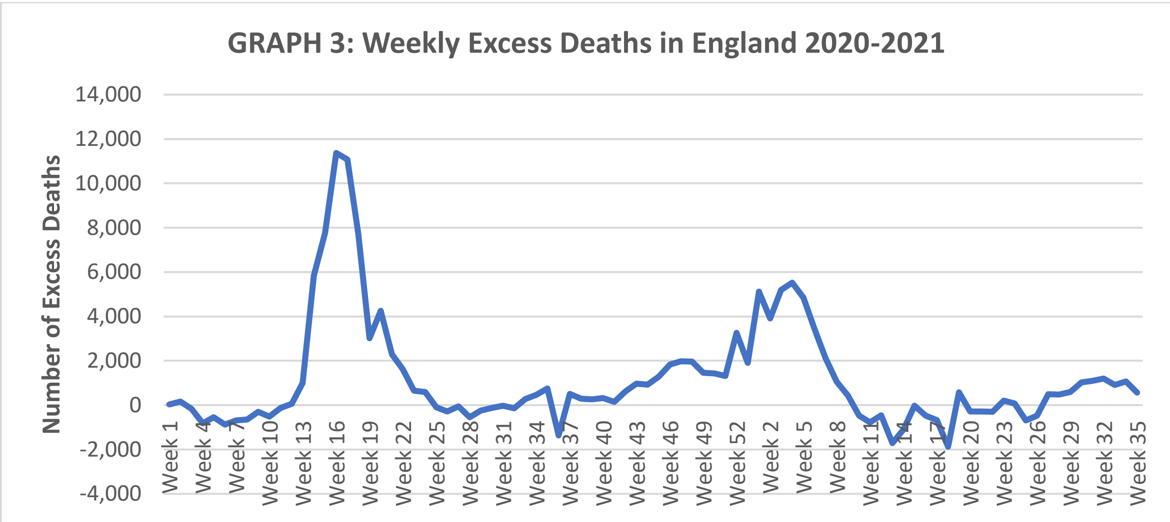
Regardless of the clear increase in mortality rates and decrease in mortality improvements in 2020, it is difficult to know the true contribution of deaths due to the coronavirus pandemic and what the effect will be on pension schemes. On 26 January 2021, the UK had 100,000 deaths registered as due to COVID-19, however, these were defined as deaths within four weeks of a positive COVID-19 test (Caine, 2021a). This definition would not capture the exact number of deaths due to the virus, since it depends on whether a Covid test was taken. Hence, in cases where the deceased did not take a Covid test but had the virus, this definition would be underestimating Covid deaths. This underestimation is more likely to have occurred when there were little tests being made (Caine, 2021a).

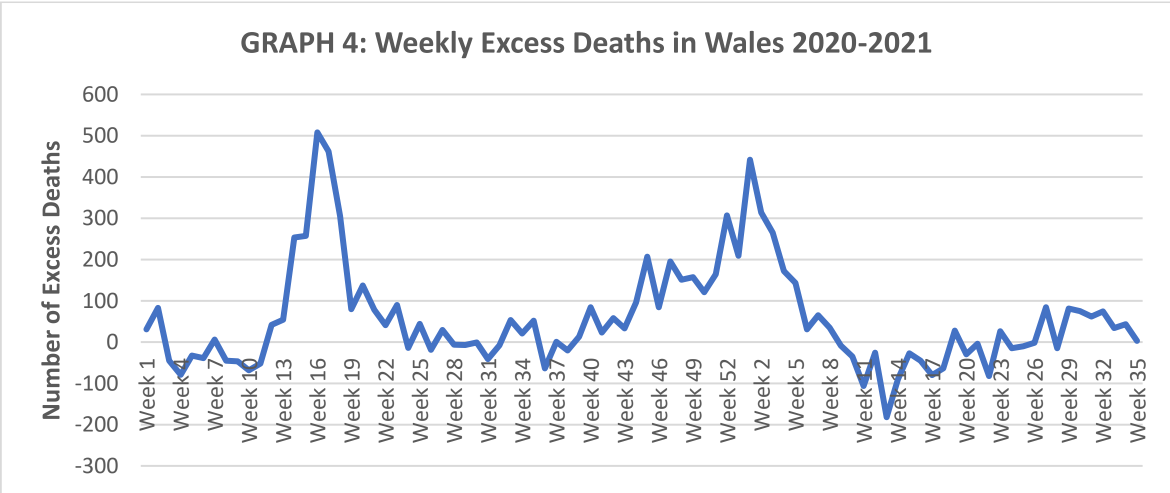
On the other hand, the impact of the virus could also be overestimated, as Covid mainly affects older persons and those with pre-existing conditions who might have died otherwise, although it is sad indeed (Caine, 2021a). In these cases, Covid-19 would have just been one of the co-morbidities leading up to death, but it has been customary for deaths from epidemics to replace deaths from pathological causes (Armstrong, 2021).

To give an example of this, Armstrong (2021) states "A patient might have heart disease and be on a trajectory towards heart failure and death, but if an epidemic disease suddenly intervened to bring that death forward then the epidemic disease was the cause of death" (p. 1620). There are also the indirect effects of the virus on other causes of death, for example, restrictions may have increased number of suicides but could also have decreased road traffic deaths (Aburto, Kashyap, Schöley, *et al*., 2021). Hence, the recorded number of deaths due to Covid and its impact on mortality can be debatable when using the numbers recorded on death certificates.

To therefore get a more accurate idea of the impact of COVID-19, one can use excess deaths, which is taking the number of deaths that was observed during the pandemic and compare it to the expected number of deaths if the virus did not occur (baseline level) (Aburto, Kashyap, Schöley, et al., 2021; Caine, 2021a). Using this, the Continuous Mortality Investigation (CMI) estimated approximately 60,000 excess deaths by June 2020 while 40,000 were documented by the Government, and by 29 January 2021, the CMI had calculated 99,000 excess deaths versus 104,000 recorded by the Government and 126,000 registered as COVID-19 deaths on the death certificates (Caine, 2021a).

Despite these differences, thousands of excess deaths have occurred due to the pandemic. Taking the weekly registered deaths up until September 3, 2021 that are provided by the ONS and comparing with the pre-pandemic five-year average deaths (years 2015-2019), we can calculate the weekly excess deaths (ONS, 2021b) as shown in Graphs 3 & 4. In this case the previous five-year average deaths would be the expected deaths which are subtracted from the actual deaths to obtain the excess deaths.





Source:https://www.ons.gov.uk/peoplepopulationandcommunity/birthsdeathsandmarriages/deaths/bulletins/deathsregisteredweeklyinenglandandwalesprovisional/3september2021

Based on Graphs 3 and 4 we see that the shape of the graphs is reasonably similar between England and Wales, with both countries showing the greatest number of excess deaths within the first wave of the virus. This first wave was estimated to be between March 2020 and May 2020 (ONS, 2021c) which spans week 12 to week 22 approximately. The highest peak is shown to be in week 16 with 11,370 and 508 excess deaths in England and Wales, respectively.

Excess deaths are shown to have also occurred from week 38 in 2020 to week 9 in 2021.The highest number of excess deaths in this second period being 5,522 in week 3 of 2021 for England and 442 excess deaths in the first week of 2021 for Wales. Note that the second wave of Covid-19 was estimated to be between September 2020 and April 2021 and it involved a new variant of the virus, the Alpha variant, appearing in December 2020 (ONS, 2021c). This could explain the excess deaths observed between week 38 in 2020 and week 9 in 2021 and the highest peaks in the second wave period being at the end of 2020 and the beginning of 2021.

The most recent wave is the third wave, which is due to the highly contagious Delta variant (Kleczkowski, 2021) and the relieving of most lockdown restrictions in the UK (Jones, 2021).

However, despite the increased number of Covid cases, vaccinations have diminished the number of deaths within this wave and as many as 100,000 deaths are estimated to have been avoided since the beginning of the rollout of vaccines (Jones, 2021). This can be seen in Graphs 3 and 4 as the peaks of excess deaths over the three wave periods have decreased. Summing up all the weekly excess deaths in the data provided by ONS (2021b) gives a total of 75,618 excess deaths for England and Wales combined, in 2020, and 31,444 excess deaths in 2021, up until 3 September 2021. Hence the pandemic´s negative impact on mortality is still being witnessed in 2021, albeit less than the 2020 mortality experience.

There is still so much uncertainty surrounding the pandemic and the various measures undertaken to combat the virus that no one knows if excess deaths will go towards zero (baseline mortality) (Aburto, Kashyap, Schöley, *et al*., 2021). Even though vaccines have been effective, the protective antibodies which fight against the virus have been declining rapidly after vaccination (The Guardian, 2021). Consequently, researchers are worried that if this reduction in antibodies continue, vaccines will be less helpful against the virus than expected (The Guardian, 2021). This, along with the possibility of new variants of the virus emerging could cause further breakouts and more deaths (Kleczkowski, 2021).

On the other hand, future mortality in the short-term can also be less than expected, as some deaths in 2020 would have occurred in the following few years if the pandemic did not occur (Aon, 2020b). Essentially this means that the pandemic brought forward some deaths in time, possibly leaving the years in which these persons were supposed to die with a lower number of deaths to be observed.

Amid this uncertainty, well-reasoned perspectives must be formed about how mortality is expected to develop in the future and how to incorporate these ideas in the assumptions when valuing pension liabilities. If mortality rates fall back to the general trend, then this would imply that the virus just caused a short-term fluctuation, but if the rates follow a different trend in future years, then this would suggest a structural break. Distinguishing between the two is very important for pension schemes, especially since longevity risk is difficult to diversify (Rischatsch, Pain, Ryan & Chiu, 2018). This is due to the possibility that everyone or at least all persons of a certain cohort will live longer, which cannot be reduced by pooling the risk over many individuals (Rischatsch, Pain, Ryan & Chiu, 2018). However, it is too soon to know if the unusually high mortality rates in 2020 and 2021 so far, will have a long-term effect on future mortality rates (Kyriakou, 2021).

3. VIEWS ON THE FUTURE MORTALITY IMPACT OF COVID-19 AND THE CMI MODEL

3.1 View 1: The pandemic will not impact future mortality

One could consider that Covid-19 will just be a short-term spike in mortality and thus will not affect future mortality rates in the longer-term. Also, even though it is uncertain, the positive impacts (see Section 3.3) and negative impacts (see Section 3.2) of the virus could even cancel out each other to some extent (Caine, 2020b). Hence, resulting in no change or a very small change in future mortality rates.

According to data provided by the government, it is too soon to determine if the recent 2020 mortality spike will affect the downward trend in projected mortality rates in the longer-term (Kyriakou, 2021). Consistent with this opinion, many CMI users believe that the 2020 mortality experience is one of a kind and most likely an unwise guide to future mortality improvements (Daneel & Palin, 2021). Including the 2020 data as normal would greatly contort projections (Gaches, Murray & Scott, 2021) causing more than 10 months decrease in the life expectancy for a 65-year-old female and almost 15 months fall for 65-year-old males when compared to the CMI 2019 model life expectancies (Daneel & Palin, 2021). This decrease is believed to be unreasonable for just one-year extra data and thus the model was adjusted to reduce the impact of the 2020 mortality experience (Daneel & Palin, 2021). Hence, based on this line of thought, mortality assumptions for pension schemes would not change significantly and the mortality experience in 2020 may be ignored to some extent.

3.2 View 2: The Pandemic will negatively impact future mortality

One can also consider the link between financial depressions and higher mortality rates. The economic downturn due to Covid-19 may cause a reduction in overall health and wellbeing of individuals and burden the supply of healthcare (Caine, 2020b), causing a fall in life expectancy (Aon, 2020a). Consequently, a further stagnation in future mortality improvements could result, like what has been witnessed within the last decade after the global financial crisis in 2008 (Palin, 2021). Also, due to the focus on the pandemic, other conditions and ailments for thousands of persons in the UK were treated later than usual which could lead to unknown consequences in the future for the survivors (Caine, 2020b).

It is also possible that persons who were infected by the virus could experience a negative impact on their health that remains after surviving it (American Academy of Actuaries, 2020), for example, because of decreased lung capacity (Palin, 2021). This could mean that higher mortality rates may carry on in the future, but most likely at a lower level than that experienced within the pandemic (American Academy of Actuaries, 2020). Hence, within this line of thinking, actuaries and trustees could be motivated to consider that mortality improvements may decrease in the future and that the impact of the virus might not just be a short-term impact.

3.3 View 3: The pandemic will positively impact future mortality

On the other hand, there is the possibility that the virus has a positive impact on future mortality rates due to the measures and healthier habits adopted to control the spread of the disease. This includes, but is not limited to, the increased awareness of infection risks which could decrease deaths from the annual flu in the future (Caine, 2020b). For example, more careful handwashing and mask-wearing can reduce the spread of other illnesses now and even new ones in the future (American Academy of Actuaries, 2020).

Furthermore, persons started eating healthier, exercising more regularly, and using less motor vehicles during the pandemic (Caine, 2020b). If these habits are maintained and less workers are required to go to work physically in the future, the resulting healthier environment (due to less air pollution from the commute to work) and healthier lifestyles could positively impact future mortality (Caine, 2020b).

The surviving population is also likely to consist of less frail individuals as the virus has taken the lives of many elderly people and those who already had health issues, which could result in a decrease in mortality rates in the coming years (American Academy of Actuaries, 2020). In addition, Covid-19 caused a greater focus on healthcare and tragically showed the close link between healthcare and the economy (Deloitte, 2021a). It has reinforced the need for strong health systems and the advantages of long-term investments in health (WHO, 2021). Hence, the virus could cause a growth of spending on health and social care in the future as well as increase the UK´s resilience to future pandemics (Aon, 2020a).

These viewpoints on the possible positive impacts of Covid-19 on future mortality can lead to mortality improvements being expected to increase at a greater rate in the future and thus mortality assumptions may change to comply with this view.

3.4 How these three perspectives will affect mortality assumptions

These three scenarios can lead to three different responses when setting mortality assumptions, during and after this pandemic. The first view could lead assumption setters to continue using their pre-pandemic mortality assumptions. This would be a wait-and-see approach and it would mean that little consideration to the 2020 mortality experience and Covid´s impact will be taken, at least until more time passes (Gaches, Murray & Scott, 2021). If the mortality impact of the virus lingers and more reason appears to change, then the mortality assumptions can be adjusted at the next valuation in three years.

If pension valuers are of the second view and expect mortality to increase (albeit at lower rates than the 2020 experience) then the mortality assumptions in use will be adapted to apply a lower rate of mortality improvements.

If the third view is taken, then the opposite would be applied, and the assumptions will have higher rate of improvements meaning that the pension members will be expected to live even longer.

Of the last two views, the latter provides a more prudent response, since it is better to overestimate longevity when calculating pension liabilities as opposed to underestimating it and running the risk of insolvency. However, one must also note that pricing annuities to ensure readiness for all mortality possibilities in the future can be unreasonably costly but changing mortality assumptions too quickly can also stretch balance sheets when more data on mortality is available, causing changes to expected liabilities (Rischatsch, *et al.*, 2018).

3.5 The Continuous Mortality Investigation

The Continuous Mortality Investigation (CMI)[3] produces decrement tables covering mortality and sickness for UK life insurers and pension funds (IFoA, 2021b). Their work is focused on the mortality of people covered by annuities, assurances, income protection products and self-administered pension schemes (SAPS) (IFoA, 2021c). Based on data on experiences provided by UK life assurance companies and actuarial consultancies, they investigate mortality and morbidity to create respective tables (IFoA, 2021c). CMI also looks forward, by estimating how mortality will develop in the future and creating projections (IFoA, 2021c). Many UK pension schemes use the CMI mortality projections model to estimate longevity and hence the total pension annuities expected to be paid to members and their dependents.

3.6 CMI 2020 model

Each year the CMI produces an updated version of their mortality projections model with the latest being the 2020 version, CMI_2020. The written form for model versions prior to 2020 is (CMI, 2021a):

$$\text{CMI\_year\_G\_(LTR\% \_ A\% \_ } S_k\text{)} \tag{4}$$

where year is the version of the model, G is gender, LTR is the long-term rate of improvement, A is the initial addition to improvements and S_k is the smoothing parameter.

The 2020 model version is given a similar form but with a new weighting parameter, W_{2020}, which allows users to choose how much weight is placed on the 2020 mortality experience. Hence the 2020 CMI model is given in the following form (CMI, 2021a):

$$\text{CMI\_2020\_G\_(LTR\% \_ A\% \_ } S_k \text{ \_ } W_{2020}\text{\%)} \tag{5}$$

[3] https://www.actuaries.org.uk/learn-and-develop/continuous-mortality-investigation

The model has default values for each of the parameters except the LTR which the CMI believes model users should form their own judgement for this rate. The CMI_2020 default values are: A = 0% ; S_k= 7 ; W_{2020} = 0%. When the default values are being used, the written form of the model is simplified to just show the non-default values (CMI, 2021a).

An extensive process involving model fitting using an age-period-cohort improvement model and various equations are used to estimate the final mortality improvements in the CMI 2020 model and prior models (see CMI (2021b) for further details). The process involves calculating mortality improvements for the age-period and cohort elements separately and then summing these in the end (CMI, 2021b). For illustrative purposes we will only show the age-period formula for the "m-style"[4] improvements.

For the t-step ahead projection for the age-period component (CMI, 2021b),

when $0 \leq t \leq T_x^{AP}$:

$$MI_{x,Y_{max}+t}^{AP*} = L_x^{AP} + \left(MI_{x,Y_{max}}^{AP*} - L_x^{AP}\right)\left(1 - 3\left(\frac{t}{T_x^{AP}}\right)^2 + 2\left(\frac{t}{T_x^{AP}}\right)^3\right) + D_x^{AP} t \left(1 - \frac{t}{T_x^{AP}}\right)^2 ; \tag{6}$$

when $t > T_x^{AP}$:

$$MI_{x,Y_{max}+t}^{AP*} = L_x^{AP} \tag{7}$$

where $MI_{x,Y_{max}}^{AP*}$ is the initial rate of mortality improvement for age x, L_x^{AP} is the long-term rate for age x (see Equation 8), T_x^{AP} is the convergence period for age x, which must be greater than zero (see Table 2 below for the core values) and D_x^{AP} is the direction of travel for age x with a core value of 0 for all ages.

Note that there is no core value for the L_x^{AP} parameter in the CMI models and model users must at least provide a single value, LTR, for the long-term rate and then this value is used for L_x^{AP} (CMI, 2021b).

[4] The CMI 2020 model first calculates "m-style" improvements then converts them to "q-style" improvements. see CMI (2021b)

$$L_x^{AP} = \begin{cases} \text{LTR}, & x \leq 85 \\ \text{LTR}\left(\frac{110 - x}{25}\right), & 86 \leq x \leq 109 \\ 0, & x \geq 110 \end{cases} \quad (8)$$

Table 2: Core model assumptions for the age-period convergence period (T_x^{AP}), based on age in Y_{max}

Age (x) in Y_{max}	Age-period (T_x^{AP})
20-49	10
50-60	x - 40
61-79	20
80-94	100 - x
95-105	5
106-109	5
110 and older	5

Source: CMI_2020 methods paper https://www.actuaries.org.uk/learn-and- develop/continuous-mortality-investigation/cmi-working-papers/mortality-projections/cmi-working-paper-147

Using Equations 6 and 7, for ages between 61 and 79 inclusive and assuming similar assumptions as in CMI (2020): the core value assumptions for the direction of travel and convergence period (i.e $D_x^{AP} = 0$; $T_x^{AP} = 20$); initial mortality improvement of 0.50% (i.e $MI_{x,Y_{max}}^{AP*}$= 0.50%). For an LTR of 1.50% we get Equations 9 & 10. Note that $L_x^{AP} = LTR$ as the age range is below 86 year (see Equation 8).

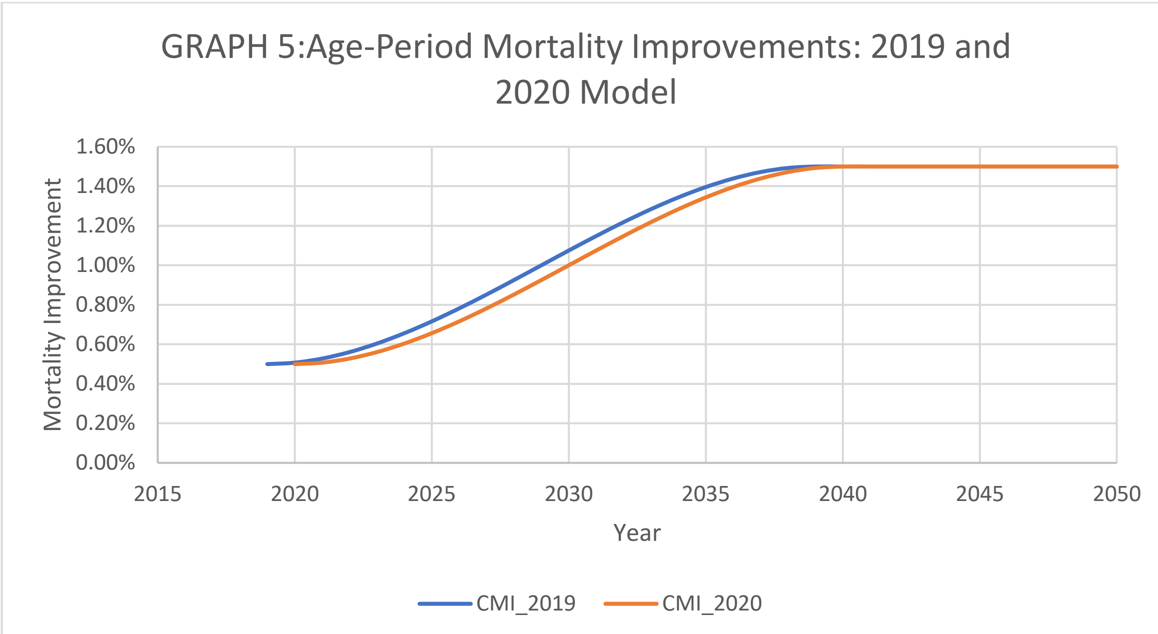
when $0 \leq t \leq 20$:

$$MI_{x,Y_{max}+t}^{AP*} = 1.50\% + (0.50\% - 1.50\%)\left(1 - 3\left(\frac{t}{20}\right)^2 + 2\left(\frac{t}{20}\right)^3\right) \quad (9)$$

and when $t > 20$:

$$MI_{x,Y_{max}+t}^{AP*} = 1.50\% \quad (10)$$

Plotting this for the 2019 and 2020 model we have:



Based on Graph 5 we see that mortality improvements start out at 0.50% for both models however it starts at 2019 for the CMI_2019 model and 2020 for the CMI_2020 model. As the convergence period is 20 years, mortality improvements converge to 1.50% in year 2039 for the CMI_2019 model and in year 2040 for the CMI_2020 model. Hence, we see that when the initial mortality improvement $MI_{x,Y_{max}+t}^{AP*}$ is less than the assumed long-term mortality improvement (which is expected in most cases), the graph is positive. Therefore, as the same mortality projections formula is used in both models, when the same parameter assumptions are used, the shape of the graph remains the same and the graph just shifts one year to the right. This results in lower mortality improvements and hence lower life expectancies in the CMI_2020 model even when 0% weight is place on the 2020 data in comparison to the CMI_2019 model. Note that this approach can be done for the cohort mortality improvements and the combined mortality improvements will show a similar result.

3.7 The three views on Covid´s future mortality impact and the CMI model: effects on liabilities of schemes

3.7.1 View 1

View 1 is: "The Pandemic will not impact future mortality". Out of the various approaches for mortality assumptions listed by Gaches, Murray & Scott (2021), two of them are in line with this opinion. The first is to continue using a pre-2020 CMI model with the same parametrization. This response ignores the 2020 experience and may be used while the longer-term impacts of the pandemic on mortality are analysed (Gaches, Murray & Scott, 2021). Caine (2021b) believes that this is a likely response due to the unusually high mortality in 2020 (and even in 2021 so far). Also note that updating from the CMI_2019 model to CMI_2020 essentially provides no new data if the core value of 0% is used for the weight on the 2020 data (except the change from estimated 2019 data with actual ONS data) and the change would be small (CMI, 2020). Therefore, assumption setters who believe that Covid-19 will not affect future mortality rates, or that the resulting impact will be very small, will most likely choose to maintain their previous version of the CMI model, disregarding the high mortality experience in 2020 and 2021. If all other things remain equal, including the scheme profile, the liabilities of the scheme will also remain unchanged compared to the liabilities of the original pre-2020 model.

The second response is for the mortality assumptions to be upgraded to the CMI_2020 model, but the core value of 0% maintained for the weight on the 2020 mortality experience (w_{2020}). This is similar to the first response as it does not consider the 2020 data for future mortality expectations, but it allows for the 2020 experience delaying the change to higher long-term improvements by a year (Gaches, Murray & Scott, 2021). According to these authors, short term improvements are usually low in conjunction with the low mortality improvements experienced in the previous decade and long-term improvements are higher, but there is a slow-down in the change to greater improvements by one year, due to the CMI mortality projections model pushing the long-term out by another year for each new version. This was also shown previously in Graph 5.

Thus, even when zero weight is placed on the 2020 experience, the CMI-2020 model still projects a reduced life expectancy mainly due to this change from short-term to long-term improvements. More specifically, using zero weight in the CMI_2020 model, as in line with the default assumptions, causes life expectancy for a 65-year-old male to reduce by about four weeks and by one week for a 65-year-old female, when compared to using the 2019 version. Thus, there is an approximate 0.1% to 0.3% fall in liabilities. For further details, see (Gaches, Murray & Scott, 2021; XPS Pensions Group, 2021; Deloitte, 2021b),

We can then conclude that liabilities are expected to decrease slightly, if assumption setters upgrade to the CMI_2020 model with zero weight on the 2020 mortality experience, but the extent of this decrease will depend on which version they are upgrading from. This is because the 2020 CMI model creates expectancies of life that are significantly lower than any pre-2018 CMI model, but closer to that of the 2018 and 2019 models (Deloitte, 2021b). Based on the analysis done by Deloitte (2021b), the 2020 model produces a 0.3% higher female life expectancy at age 65 than the 2018 model, but a 0.1% lower life expectancy for 65-year-old males. Therefore, the liability impact of upgrading from the 2018 model will depend on the pension scheme´s gender profile (with more female members relating to a higher chance of increased liabilities while a greater proportion of male members will cause a greater chance of liabilities falling).

Following Deloitte (2021b), the 2020 model produces slightly lower life expectancies (0.1% for 65-year-old females and 0.3% for 65-year-old males) than the 2019 model. Mortality in 2019 was less than any in the previous decade, resulting in an approximate one month increase in life expectancy when using the 2019 model over the 2018 model. Comparing with life expectancies of pre-2018 models, however, shows a more significant change: 1.8% and 2.5% decrease in life expectancies at age 65 for females and males, respectively, if we upgrade from the 2017 model to the 2020 model; 2.4% and 3.3% decrease for females and males if the upgrade is from the 2016 model.

3.7.2 View 2

View 2 is: "The Pandemic may negatively impact future mortality". According to Gaches, Murray & Scott (2021), another response in mortality assumptions could be to upgrade to the CMI_2020 model but use a non-zero weight on the 2020 mortality experience parameter (W_{2020}). This would be in line with the view that the Covid_19 virus will continue to impact mortality for some years after 2020 and thus affect the trend in mortality.

As the 2020 mortality experience involved greater deaths than usual, placing more weight on this experience would mean that these higher death rates are expected to feed through more to the following years, which agrees with the second viewpoint. Upgrading to use the CMI_2020 model in mortality assumptions will cause a higher decrease in liabilities when more weight is placed on the 2020 mortality experience parameter (W_{2020}). An approximate decrease of 1.5% to 3.5% in liabilities is expected for most schemes that place a reasonable weight on the mortality experienced in 2020 which could lead to a 25% fall in deficit for a scheme with a funding level of 90% (XPS Pensions Group, 2021).

Gaches, Murray & Scott (2021) also states that one could consider decreasing the long-term rate of improvement parameter (*LRT*), this would mean that the future long-term improvements are expected to be less than originally expected. According to Deloitte (2021b), this parameter depends on your opinion on future improvements, including medical developments, the impact of worsening environmental situation on physical and mental wellbeing, and the state of the economy after the pandemic. Usually, an LTR of 1.25% or 1.5% is used, with a 0.5% decrease in the parameter causing an approximate 1.5% decrease in liabilities (Deloitte, 2021b).

According to Gaches, Murray & Scott (2021), one could also upgrade to the CMI_2020 model and adjust the *A* parameter or adjust this parameter in a previous model version. The *A* parameter reflects the contrast between the actual data from the pension scheme and the ONS data, with an increase in the parameter causing immediate future and past-year improvements to rise, as well as life expectancies (Deloitte, 2021b). If a lower rate is chosen for this parameter, then this would be in line with View 2, as it would imply lower developments in the near future, due to the pandemic. A decrease in this parameter can cause an approximate decrease of 2.0% and 1.5% in liabilities for males and females, respectively (Deloitte, 2021b). It must be noted that even though pension scheme members are expected to have higher improvements, CMI has shown that this difference is not very significant (Deloitte, 2021b).

3.7.3 View 3

View 3 is: "The Pandemic may positively impact future mortality". The response to the CMI model assumptions supporting this viewpoint would be the opposite of what can be used for View 2 above and the opposite effect on liabilities is expected. That is, in conjunction with View 3, one can increase the LRT parameter value or use a higher value for the A parameter in the CMI_2020 model or a prior version. The effect is expected to be higher life expectancies and a change in liabilities like those listed for View 2, but instead of a decrease in liabilities, it will now be an increase.

4. PRACTICAL EXERCISE

4.1 The data

Dummy data for "Pension Scheme ABC" was provided by WTW to perform the calculations and test the impacts to liabilities in-line with the changing mortality projections model. The effective date of the valuation is 31 March 2021. A short summary of the data is given below in Table 3. Actives represent the persons who are currently working and contributing to the pension scheme. Deferreds are the members who have stopped contributing to the scheme but are not due to receive their pension yet. Retirees are the members of the scheme who are currently receiving their pension and the spouses and children are the dependants of the members who contributed to the scheme. Usually, pension starts to be paid to dependants (spouses and children) when the original member dies.

Table 3: Data Summary for Pension Scheme ABC

Status	**Number of members**	**Average Age (nearest)**	**Total Annual Salary/ Pension (£)**
Actives	212	56	8,912,004.12
Deferreds	519	54	1,584,401.28
Retirees	383	73	1,591,978.01
Spouses	52	75	118,592.08
Children	1	18	1,763.64

Using the provided data in WTW´s internal software along with the economic and demographic assumptions in the Appendix, the liabilities for each status were calculated and then summed to present the total liability of Pension Scheme ABC. In line with the three views on the impact of Covid-19 on future mortality, the possible changes in mortality assumptions listed in Section 3.7 were tested to see the effects on the liabilities of the scheme. The base model chosen to do comparisons with was CMI_2019_(LTR1.50%_A0.25%)[5] which is the CMI 2019 projections model with a long-term rate of improvement (LTR) of

[5] Note that for simplicity the Gender term is not written but the model specific to each gender is used.

1.50%, initial addition to improvements (A) of 0.25% and core value of 7 for the smoothing parameter (S_k). The value of S_k is not shown because when a core value[6] is used for a parameter (other than the LTR parameter), the parameter and its value do not appear in the written form of the model. In our case, as the base model uses the core value for S_k this parameter is not written. Using the base model CMI_2019_(LTR1.50%_A0.25%) in the current valuation yields a total past service liability of £164,674,090 for Pension Scheme ABC. For simplicity, and since it is a usual practice in these sorts of exercises, the asset value for the scheme was chosen to be equal to this liability, so that the original funding position is 100% (the total assets cover the total liabilities exactly). The base model will form the basis for the sensitivity tests that will be presented in the following sections.

4.2 Results when View 1 is adopted

View 1: The pandemic will not impact future mortality.

Response 1: Continue using the same model that was used at the last valuation.

This response is the same as the base model run and hence there is no impact on liabilities.

Response 2: Upgrade to the CMI_2020 model but use the core value of 0% for the w_{2020} parameter.

Following this response, the CMI_2020_(LTR1.50%_A0.25%) model was chosen and resulted in a 0.16% decrease in the total past service liability to £164,409,892. This decrease is in-line with the expected 0.1% to 0.3% fall in liabilities as stated by Deloitte (2021b) for schemes which update to the CMI 2020 model with a core value of 0% for the w_{2020} parameter. Due to this decrease in liabilities for ABC, the funding position increased to 100.16%. Hence the scheme in now expected to be in a slightly better position to cover its liabilities, under this new mortality assumption.

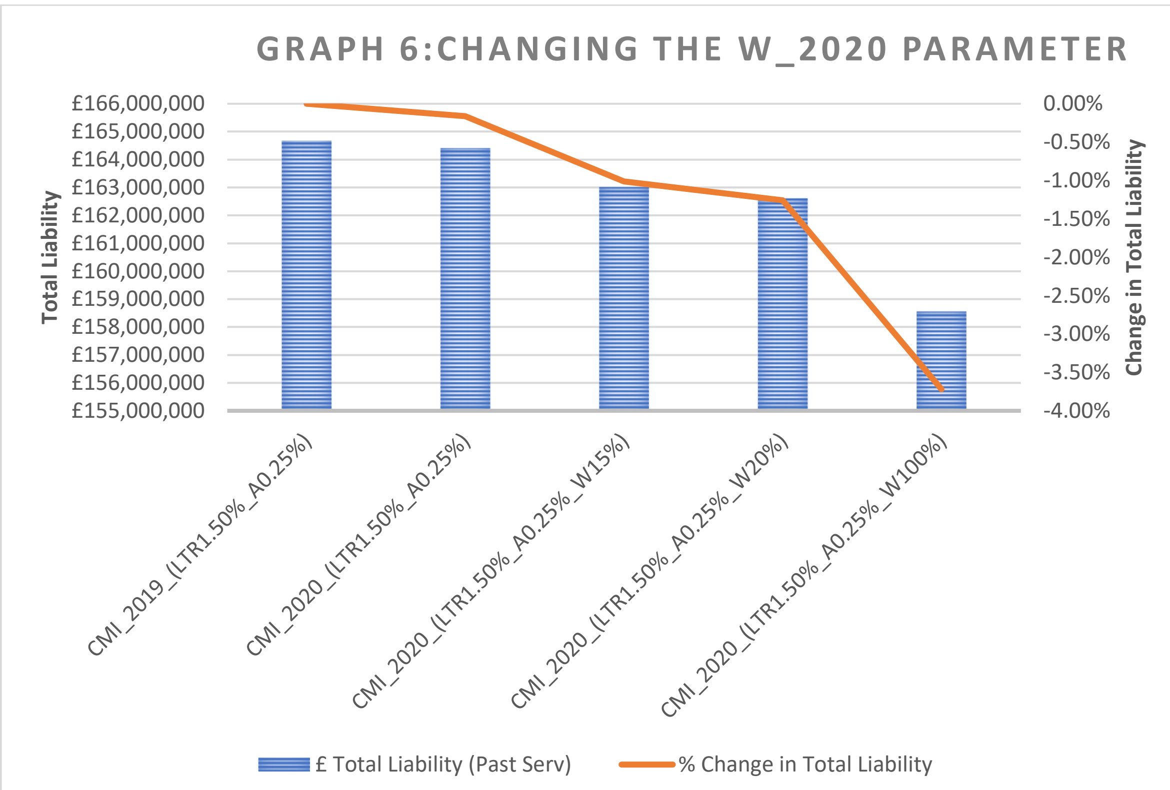
[6] Core values: A = 0%; $S_k = 7$; $W_{2020} = 0\%$

4.3 Results when View 2 is adopted

View 2: The pandemic will negatively impact future mortality.

Response 1: Upgrade to the 2020 model but do not use the core value of 0% for the w_{2020} parameter.

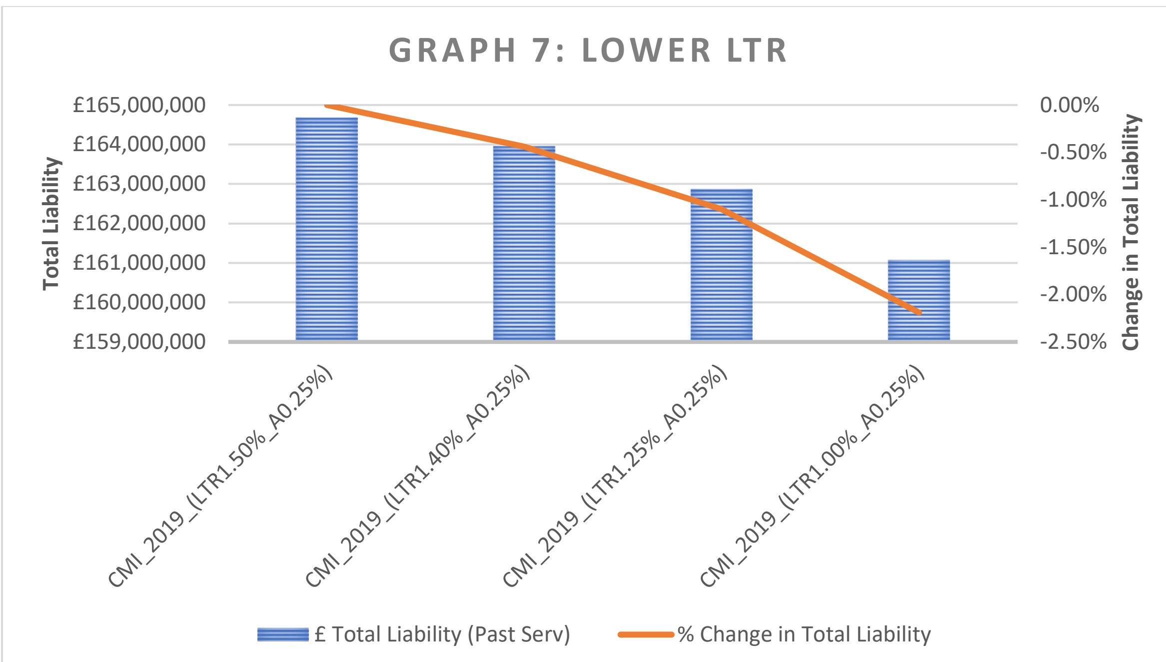
For this response, the weights 15%, 20% and 100% were used for the w_{2020} parameter in the CMI 2020 model along with the same LTR value of 1.50%, 0.25% for the A parameter and the core value of 7 for S_k. The effects of upgrading to these models are shown below in Graph 6, where the percentage change in liability is measured against the base model CMI_2019_(LTR1.50%_A0.25%).



As expected, adding more weight to the w_{2020} parameter causes liabilities to decrease more. If assumption setters of ABC Pension Scheme are more conservative about the negative impact of Covid-19, they may adopt smaller weights such as 15% and 20% for the w_{2020} parameter in the CMI 2020 model, which results in a fall in liabilities of 1.01% and 1.26%, respectively. On the extreme end, if full weight is placed on the 2020 mortality data (i.e. 100% used for the w_{2020} parameter) then there is a 3.72% decrease in liabilities. These results are reasonably in conjunction with the 1.5 to 3.5% decrease that XPS Pension Group (2021) expects for a scheme that places a reasonable weight on the parameter.

Response 2: Continue using the CMI 2019 model but with a lower LTR

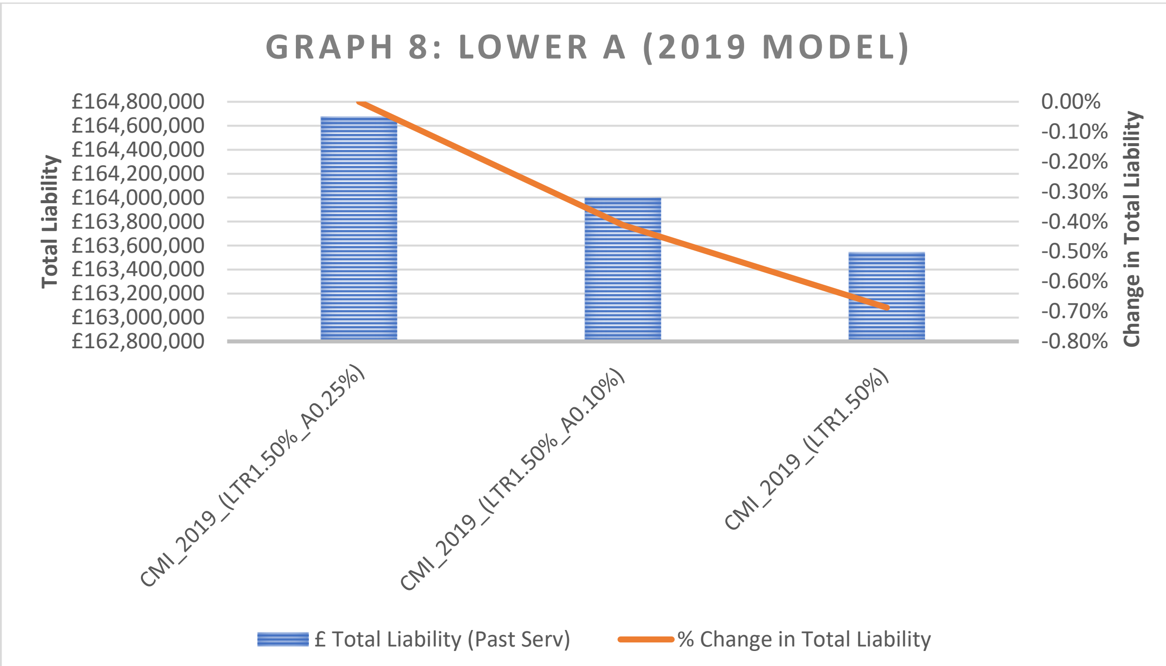
For ABC, the original LTR used is 1.50% in the 2019 CMI model. Hence, to test this response, LTRs of 1.40%, 1.25% and 1.00% were used in the CMI 2019 model with the same A parameter value of 0.25% and core value of 7 for S_k. The results are shown below in Graph 7:



Based on Graph 7, we see that the liabilities decrease from £164,674,090 to £163,948,530 (0.44% decrease) if an LTR of 1.40% is now used, a decrease to £162,864,103 (1.10% decrease) if an LTR of 1.25% is used and a 2.19% decrease to £161,068,285 if an LTR of 1.00% is used. This decrease of 2.19% in liabilities is greater than the expected 1.50% decrease, if the LTR changes by 0.5%, as indicated by Deloitte (2021b). In ABC Pension Scheme´s case it appears that for every 0.10% decrease in the LTR, liabilities decrease by an approximate 0.44% and hence a change of 0.50% in the parameter is expected to result in an approximate 2.20% ($= 0.44\% \times 5$) liability decrease, *ceteris paribus*.

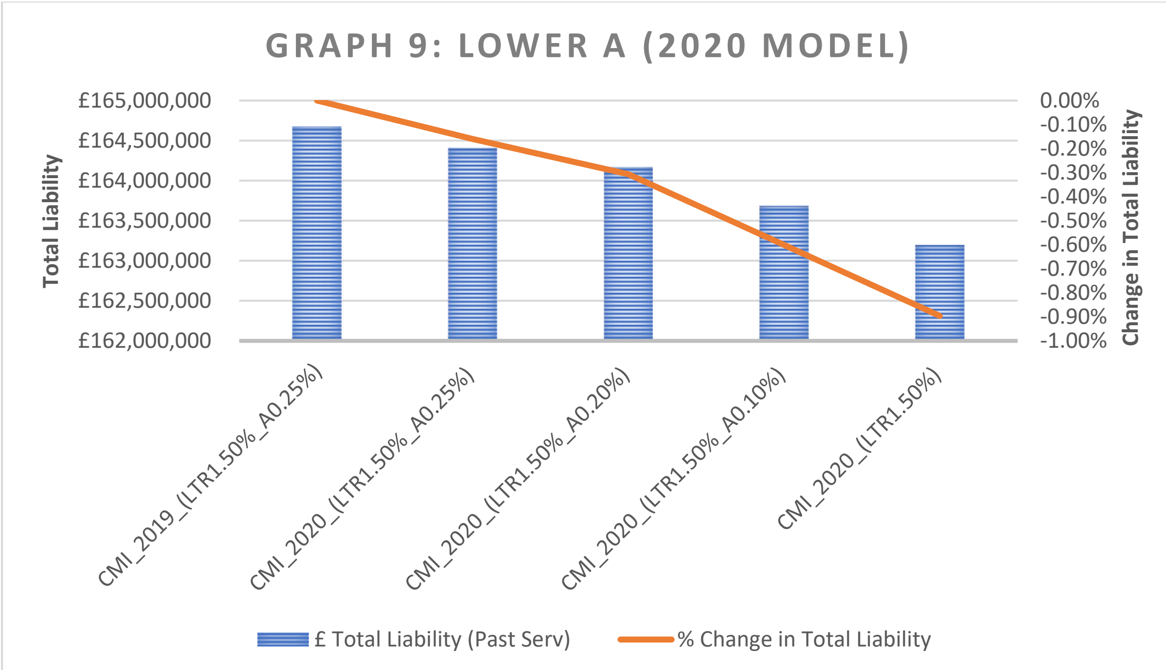
Response 3: Use a lower A parameter value in either the 2019 or 2020 model

The original rate used for the A parameter is 0.25% in the 2019 model. To test the sensitivity to this parameter, lower values of 0.10% and 0% (core value) were used in the 2019 CMI model, while maintaining the LTR parameter as 1.50% and the core value 7 for S_k. The results are shown below in Graph 8.

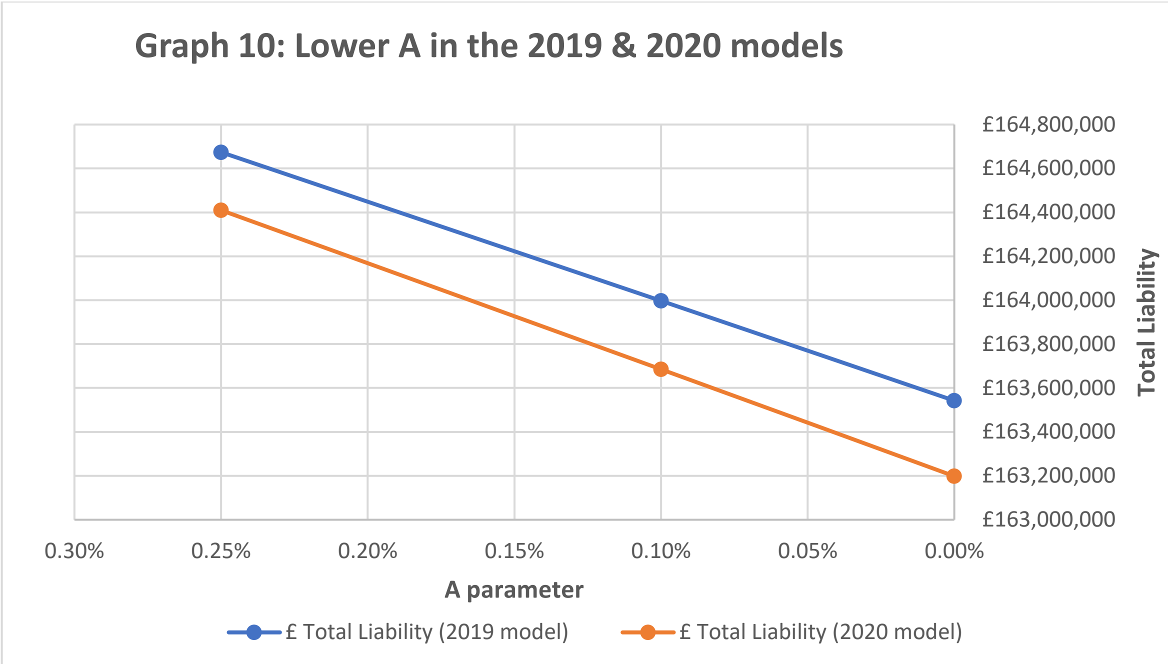


Based on the graph we see that by decreasing the A parameter in the 2019 model there is also a decrease in the total past service liabilities. Results show a 0.41% fall in liabilities if 0.10% is used for the A parameter, and 0.69% fall in liabilities, if the chosen value is 0%. This causes the funding position of the scheme to increase slightly to 100.41% and 100.69%, respectively.

Upgrading to the 2020 model with a lower A parameter was also tested (see Graph 9 below), while retaining the LTR value of 1.50% and the core values 7 and 0% for S_k and W_{2020} parameters, respectively.



As shown in Graph 9, when an upgrade to the CMI 2020 model is used together with an A parameter value smaller than the original 0.25%, then the liabilities decrease more. There appears to be an approximate 30% fall in liabilities for every 10% decrease in the A parameter, close to what was witnessed when changing A in the 2019 model in the previous Graph. Recall that the upgrade to the CMI 2020 model with the A parameter remaining at 0.25% caused liabilities to fall by 0.16% when compared to the liabilities of the base model. Now when the A parameter decreases in the 2020 model from 0.25% to 0.20% (0.05% decrease in the A parameter) the decrease in total liabilities of ABC Pension Scheme changes from 0.16% to 0.31%, a further decrease of 0.15% ($= 0.05/0.10 \times 30\%$). Moreover, when A decreases to 0.10% or 0% the liabilities of the scheme decrease by 0.60% and 0.90%, respectively, when compared to liabilities of the base model.



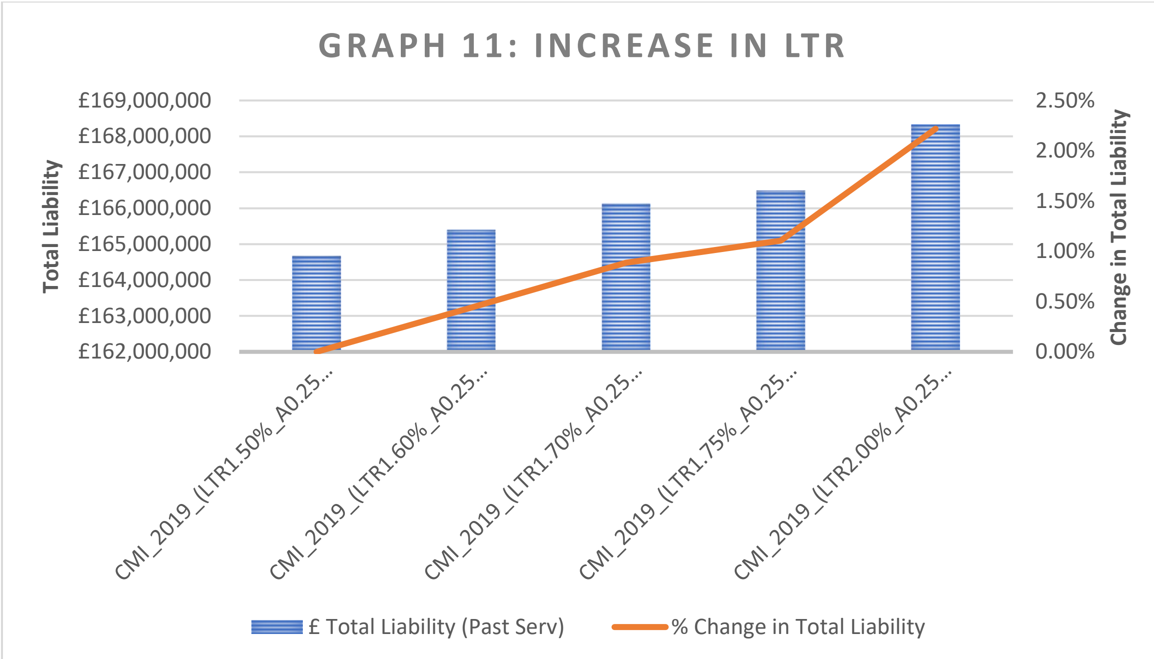
As expected, the effect of upgrading to the CMI 2020 model causes a decrease in liabilities when compared to the 2019 model. This difference is maintained when a lower value for the A parameter is used (see Graph 10). Furthermore, the difference in liabilities between the 2019 and 2020 models seem to widen slightly, as A is decreased.

4.4 Results when View 3 is adopted

View 3: The pandemic may positively impact future mortality.

Response 1: Continue using the CMI 2019 model but with a higher LTR

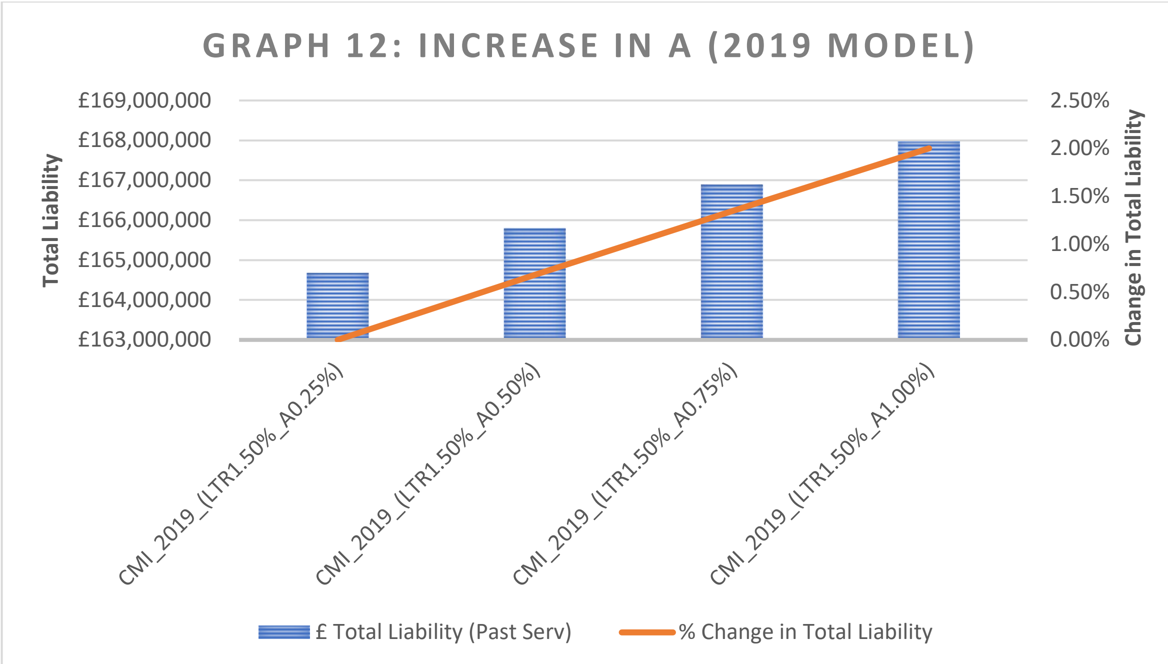
To test this possibility, higher LTR values of 1.60%, 1.70%, 1.75% and 2.00% were used in the CMI 2019 model with the original A parameter of 0.25% and core value of 7 for S_k (see Graph 11 below).



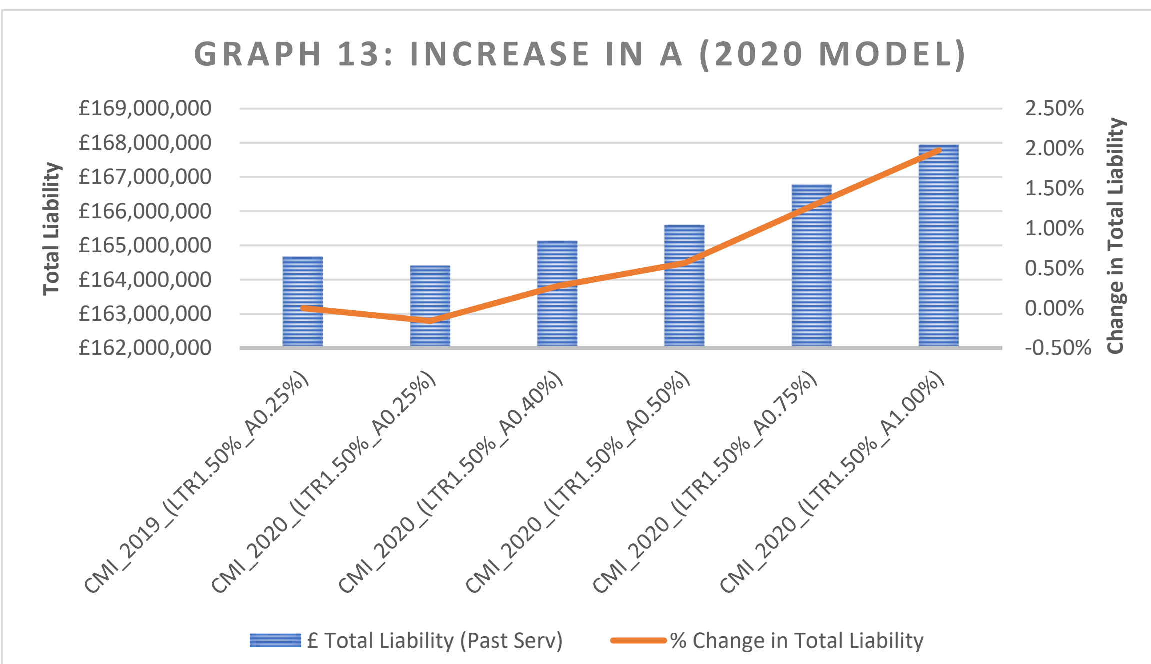
As expected, an increase in the LTR parameter value leads to an increase in the total liabilities of ABC Pension Scheme. Each 0.10% increase in the LTR results in an approximate 0.44% increase in liabilities of the scheme. If the assumption setter for ABC is less conservative about the positive long-term impact of Covid-19 on mortality, they may tend towards using slightly higher LTR values such as 1.60% or 1.70%. This would result in a respective 0.44% or 0.88% rise in liabilities. On the other hand, if they are more conservative, higher values such as 1.75% or 2.00% may be implemented, resulting in larger increases of 1.11% or 2.22% in the scheme´s liabilities.

Response 2: Use a higher A parameter value in either the 2019 or 2020 model

To analyze this response, the A parameter was increased while holding the other parameters fixed in the 2019 model (LTR=1.50% & S_k = 7). The results in Graph 12 show that an increase in the A parameter to 0.50%, 0.75% and 1.00% relates to ABC´s liabilities rising by 0.68%, 1.34% and 2.00%, respectively. Hence an approximate 0.67% increase in liabilities is expected for each 0.25% increase in the A parameter, when comparing with the liability of the base model. This ties up closely to the 0.69% decrease in liabilities experienced when the A parameter decreases by 0.25%.

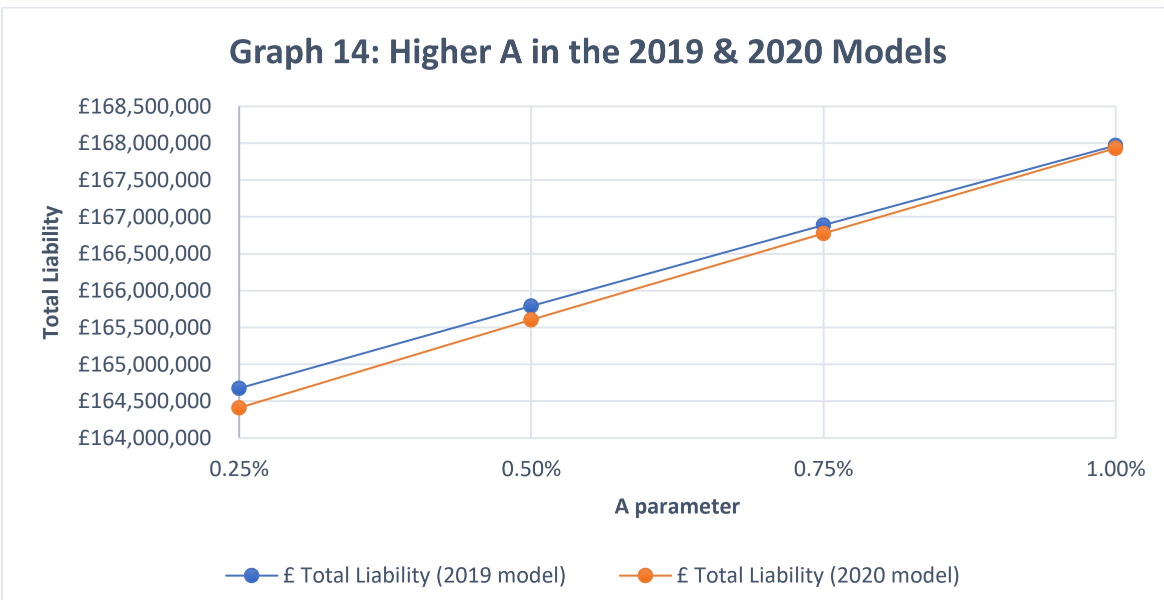


The impact of increasing the A parameter value in the 2020 CMI model was also tested while holding the LTR fixed at 1.50% and using the core values of 7 and 0% for S_k and W_{2020} (see Graph 13 below). Higher A values of 0.40%, 0.50%, 0.75% and 1.00% were used for this analysis.



According to the results, an upgrade to the 2020 model using the same A value of 0.25% relates to a fall in liabilities compared to the liabilities of the base 2019 model, as previously stated. However, when a higher A value is used in the 2020 model *ceteris paribus,* the total liabilities increase. They increase to £165,127,874 (0.28% increase), if an A value of 0.40% is used, and to £165,602,858 (0.56% increase), if the A value is increased to 0.50%. If higher values such as 0.75% or 1.00% are used, then the liabilities of the scheme will increase to £166,777,202 (1.28% increase) or £167,933,109 (1.98% increase), respectively.

Based on Graph 14 below, the upgrade to the 2020 model with the same A parameter value of 0.25% results in a slight decrease in liabilities. The 2020 model continues to produce lower liabilities than the 2019 model when the A value is increased at least until 1.00%. However, as A increases, the difference in liabilities of the two models diminishes. The difference starts out at £264,198 (0.16% of the liability of the 2019 model) for the initial A value of 0.25% and decreases to just £35,297 (0.02% of the liability of the 2019 model) when 1.00% is used as the A value.



5. CONCLUSION

The novel Coronavirus has affected many countries worldwide, including the United Kingdom, in causing a higher number of deaths than expected. Due to the various ways that deaths from Covid-19 can be recorded, excess deaths have been used as the more reliable measure to determine the mortality impact of the pandemic. However different estimates have still emerged between the CMI, government and death certificate records. Nevertheless, amidst these differences, thousands of excess deaths have been estimated.

Based on the data for England and Wales that was provided by the Office of National Statistics (ONS), we see a mortality spike in 2020 that is relatively large when compared to any other spike after 1972. This 2020 mortality experience caused a negative mortality improvement of approximately 12.13% when compared to the average mortality of the previous five years, a fall that has not been witnessed since 1941. Hence the impact of the virus on past mortality is undeniable. However, the full extent of Covid-19´s impact remains unknown.

Pension valuations involve a great deal of assumptions, particularly mortality assumptions, as pensions are mainly paid until the death of members of pension schemes or their spouses. Consequently, to value the pension liabilities of a scheme, the future lifetime of individuals must be estimated. Due to the pandemic causing an unusual increase in the number of deaths and the uncertainty about its impact in the future, setting mortality assumptions for pension schemes can become more challenging. Trustees and actuaries will have to form well-reasoned views about the expected impact of the virus on the mortality of their pension scheme members. Three main views have emerged about such impact.

The first view is that *the pandemic will not impact future mortality.* It results from how unusual the 2020 mortality experience was and thus Covid-19´s impact may just be a short-term spike in mortality, not affecting the longer-term mortality. The Age-Standardized mortality rates (ASMRs) for England and Wales also show various spikes in mortality but the long-term trend is almost always persisting, which could also support this view. In line with this view, mortality assumption setters could continue using their Pre-2020 CMI model for projections or upgrade to the CMI-2020 model using the core value of 0% for the weight placed on the 2020 data. For ABC Pension Scheme, following the second approach resulted in a 0.16% decrease in liabilities which was in conjunction with the 0.1% to 0.3% decrease as suggested by Deloitte (2021).

The second view is that *the pandemic will negatively impact future mortality.* Covid-19 has caused a burden on the economy and on healthcare, which could feed into the longer-term, reducing life expectancies. The focus on the disease led to delays in treatment of other conditions and persons who contracted but survived the virus could experience diminished health in the future. In line with this view, trustees and actuaries setting mortality assumptions may choose to upgrade to use the CMI_2020 model with a non-zero weight for the W_{2020} parameter, resulting in a 1.01% or 1.26% fall in liabilities if lower weights like 15% or 20% are used. If full weight is placed for the parameter, then a 3.72% decrease in liabilities resulted. One can also use a lower rate for the LTR parameter which in ABC Pension Scheme´s case resulted in a 0.44% to 2.19% fall in liabilities (if a lower LTR between 1.40% and 1.00% was used as opposed to the original LTR of 1.50%). Using a lower A parameter in either the CMI_2019 or CMI_2020 model was also considered as a reasonable approach. Due to the upgrade to CMI_2020 model causing an initial fall in liabilities, the decrease in the A parameter in the 2020 model resulted in lower liabilities than when the A parameter was decreased in the 2019 model. Using a lower A value of 0.10% or 0.00% (core value) resulted in a respective 0.41% and 0.69% decrease in liabilities, when using the 2019 model, and a respective 0.60% and 0.90% fall, if the 2020 model was used. Recall that LTR is the long-term rate of improvement, A is the initial addition to improvements and W_{2020} is the weight placed on the 2020 mortality experience.

The third view is that *the pandemic will positively impact future mortality.* Healthier habits and greater awareness on infection risks, a healthier environment due to less air pollution and healthier lifestyles could positively impact future mortality. Moreover, as the virus mainly takes the lives of older persons, or persons who had prior ailments, there can be a decrease in mortality, since the surviving population is healthier. It is also possible that resilience to future pandemics has become stronger. This view could lead CMI model users to consider using their original pre-2020 model but increasing the LTR. This approach was shown to result in a 0.44% to 2.22% increase in ABC Pension scheme´s liabilities, if the original LTR of 1.50% was raised to a value between 1.60% and 2.00%, inclusive. Also, a higher A parameter value could be used as another approach, either in the Pre-2020 model or in the 2020 model. For ABC Pension Scheme this response resulted in a 0.68% to 2.00% increase in liabilities, if a higher A value from 0.50% to 1.00% was chosen in the 2019 model (the original A value is 0.25%). If the 2020 model is used, increasing the A value from 0.25% to a value between 0.50% and 1.00% resulted in 0.56% to 1.98% increase in liabilities.

These are just some of the approaches that could be used based on the three views on the impact of Covid-19. From these approaches we see that liabilities of the pension scheme will either decrease or increase based on the view taken. The highest increase in liabilities results if an LTR of 2.00% is used in the 2019 model (i.e CMI_2019_(LTR2.00%_A0.25%)), which causes liabilities to increase by 2.22%. The biggest decrease in liabilities results if there is an upgrade to the CMI_2020 model with full weight on the 2020 mortality experience, which results in a 3.72% fall in liabilities. From the first view, only a slight change in liabilities is expected and this would be more of a wait-and-see approach, while more data is collected on the mortality impact of the virus. For the second view and third view, assumption setters may be more conservative and adjust the parameters slightly. The most prudent option would be to take on the third view of Covid-19 positively impacting long-term mortality as it is better to overestimate longevity.

This internship at WTW exposed me to the Pensions field within the UK, providing knowledge about how defined benefit pension schemes are valued. Throughout the internship I learnt new tasks that are necessary for a pension scheme valuation, including checking the data provided by administrators to ensure that it is reasonable and calculating liabilities using the provided economic and demographic assumptions. I also learnt how to do experience analysis where we would test what happened versus what was expected based on the provided assumptions. For example, based on mortality assumptions we determine how many deaths were expected and compare it to the number of deaths that occurred within the valuation period along with the impact on liabilities. Furthermore, we learnt how to do sensitivity testing for the calculated liabilities based on changing assumptions (including mortality improvement assumptions). Hence, this internship provided the means to apply some of the concepts learnt within the master´s program as well as develop on that knowledge. Also, studying this research topic helped in understanding what to expect for the sensitivity tests when mortality assumptions are adjusted.

In this report, the full scope of responses to the mortality impact of Covid were not covered. The impact of Covid-19 has been different across ages, gender and geographical location. Hence, further research in how these differences could impact future mortality and hence mortality projection assumptions could also be investigated. Also, the results used in this report depends on the base model that is chosen. Therefore, one could also consider the impact on liabilities when other Pre-2020 models are used as the base model e.g CMI_2018 model. One could also consider how other parameters in the CMI models may be adjusted (e.g S_k) in conjunction with views on Covid´s future mortality impact. Furthermore, when setting mortality assumptions for pension schemes, the focus is on the scheme´s mortality. Consequently, with real data one could compare the mortality of the scheme before the pandemic with mortality during (and after) the pandemic to get a better sense of Covid´s impact on the specific scheme´s members. This would provide added insight for which assumptions to use for the projections model. To conclude, if survivors of the virus are shown to experience an increased mortality in the future, pension schemes could consider gathering data on whether their members contracted Covid or not and use different mortality assumptions between these members.

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APPENDIX:

Economic and Demographic Assumptions

Table 4: Economic basis

Name	Description	Long Term Increase
RATE	Valuation discount rate	1.95%
SALESC	Rate of escalation in salaries	3.13%
S148	Rate of increase in UK Section 148 orders	3.13%
GMPFIXEDRATE	UK GMP fixed rate revaluation	4.50%
RPI	Rate of inflation (RPI)	2.47%
CPI	Rate of inflation (CPI)	1.71%
RPI_0_2.5	Rate of RPI inflation, 0% floor, 2.5% cap	2.13%
RPI_0_5	Rate of RPI inflation, 0% floor, 5% cap	2.47%
GMP_0	UK GMP increases at 0%	0%
GMP_CPI_0_3	UK GMP increases at rate of CPI inflation, 0% floor, 3% cap	1.71%
CPI_MAX5	Rate of CPI inflation, 5.0% cap, no floor	1.71%
CPI_MAX2.5	Rate of CPI inflation, 2.5% cap, no floor	1.69%
BSPINC	Basic State Pension increases	1.71%

Table 5: Demographic basis 1

Actives				
Description	Sex	Element	Rating	Multiplier
Voluntary age retirement rates	Male Female	N/A N/A	N/A N/A	N/A N/A
Impaired health retirement rates	Male Female	N/A N/A	N/A N/A	N/A N/A
Withdrawal rates	Male Female	LTPHEAVY LTPHEAVY	0 0	1 1
Death rates	Male Female	S1NMA S1NFA	0 0	1 1
Salary Scale	Male Female	N/A N/A	N/A N/A	

Table 6: Demographic basis 2

Description	Sex	Element	Rating	Multiplier
Proportion married	Male Female	0.9 0.8	0 0	
Age difference	Male Female	3 -3	0 0	
Assumed retirement age for proportion married calculations	Male Female	65 65		
Deferred benefit payment age	Male Female	65 65		

Table 7: Male Mortality Assumptions

Males		
Base mortality:		
Base table: S3NMA	Age rating: 0	Multiplier: 1
Mortality improvement allowance:		
Single set of improvements		
Table reference details:		
Table type: Year of use	Effective date	Final age rating: 0
Improvements:		
Improvement: CMI_2019_M_(1_50%_A0_25%)		Start year: 2013

Table 8: Female Mortality Assumptions

Females		
Base mortality		
Base table: S3NFA	Age rating: 0	Multiplier: 1
Mortality improvement allowance:		
Single set of improvements		
Table reference details:		
Table type: Year of use	Effective date	Final age rating: 0
Improvements:		
Improvement: CMI_2019_F_(1_50%_A0_25%)		Start year: 2013