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Aging and Retirement

RPEC 2024 Mortality Improvement Update

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AUTHOR Society of Actuaries Research Institute
Retirement Plans Experience Committee

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Section 1: Executive Summary

This report presents an analysis of recent population mortality experience compiled by the Retirement Plans Experience Committee (RPEC or the Committee) of the Society of Actuaries Research Institute (SOA), with respect to the development of mortality improvement assumptions for measuring obligations of retirement programs in the United States (U.S.). Each year from 2015 through 2021, RPEC released an update to Mortality Improvement Scale MP-2014 (SOA 2014) that incorporated the latest available historical mortality data. These scales were produced by the RPEC_2014 model which, in 2021, was incorporated into the MIM-2021 model (SOA 2023b). The most recent scale released by RPEC is MP-2021 (SOA 2021), reflecting mortality data through 2019.

The COVID-19 pandemic—which began in 2020—led to a sharp increase in mortality rates. These mortality rates have declined significantly since the onset of the pandemic, but emerging data reflecting U.S. mortality through June of 2024 suggests that there is still a small amount of excess mortality for the 65+ population—around 2.5%, according to RPEC's updated analysis.

Since the publication of our 2023 report, RPEC has made some changes to our analysis of excess mortality. These changes, which are detailed in Subsection 3.2, include a change in data source for underlying population counts, the introduction of age standardization of excess mortality when summarized by age band, and redefinition of expected mortality as 2019 mortality levels projected using the MP-2021 improvement scale.

While the worst effects of the pandemic on mortality have subsided, there is not yet sufficient post-pandemic data upon which to develop an updated MP scale. Therefore, RPEC will not release a new scale in 2024. We have included in the next section of this report a discussion of the potential timing of the release of the next MP scale.

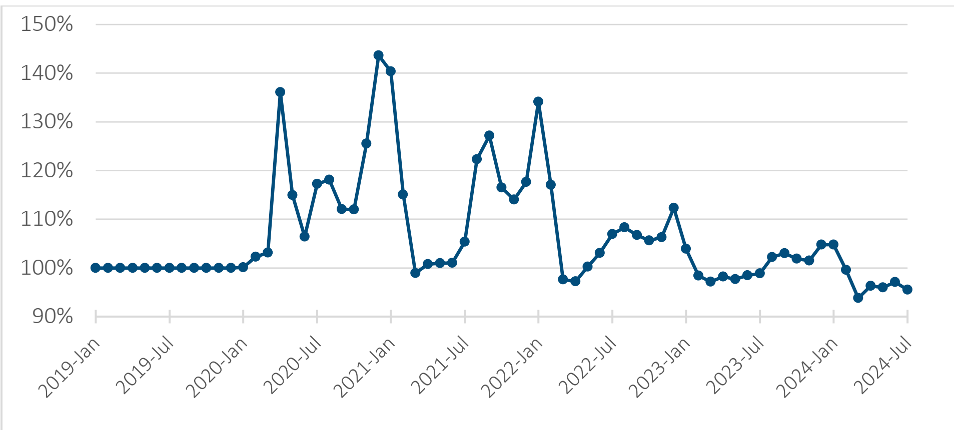
Section 2: Potential Timing of Release of an Updated MP-Scale

RPEC released the most recent version of its MP mortality improvement scale in October 2021. That scale reflected data from the 2021 Old-Age and Survivors Insurance and Federal Disability Insurance (OASDI) Trustees' Report (Trustees Report) through 2016. Additional data for 2017 through 2019 were taken from the Centers for Disease Control and Prevention (CDC), the U.S. Census Bureau, and the Centers for Medicare and Medicaid Services (CMS).

In the late winter / early spring of 2020, the COVID-19 pandemic began to exert a material impact on U.S. mortality experience. As shown in Figure 1, spikes in mortality persisted through early 2022 driving up the overall average excess mortality for the year; however, similar spikes did not occur in 2023. These increases in mortality distort the underlying data described in the first paragraph of this section which RPEC has historically used to create the MP Scales.

Figure 1

Monthly Death Rate for the 65+ Population, as % of the Corresponding Monthly Death Rate in 2019



The results in Figure 1 are age-standardized to remove noise caused by year-to-year changes in the population's age structure. The Technical Appendix provides a detailed description of the age-standardization process.

2023 mortality data will become available from CMS during 2025. While the data shown later in this report continue to show a somewhat gradual reduction in excess mortality, RPEC may deem the 2023 data to be reasonable for use in its traditional mortality improvement analysis. However, as described in the MP-2021 report, the production of the MP improvement scale utilizes Order 3 Whitaker Henderson Graduation which smooths information across multiple years. Furthermore, to mitigate edge effects, the scale development process utilizes a two-year step back which reduces the impact of the most recent two years of data on the resulting improvement scale. Because of these factors, RPEC would not expect to produce an updated scale in 2025 with its traditional methods using only a single year of additional, post-pandemic data.

RPEC will evaluate the 2023 data, once available, and will consider whether alternative methods[1] of incorporating a single year of additional information could generate a meaningful update to the MP-2021 scale. Nonetheless, it is possible that RPEC could determine the best course would be to wait for three to

[1] Such alternative methods might include assigning zero weight to the pandemic years of data and applying the current graduation processes. Another possibility might be to fill the years 2020 through 2022, inclusive, with expected mortality data based on the MP-2021 analysis and then perform the graduation while including the new 2023 data.

five years of post-pandemic data prior to issuing an updated improvement scale. At the long end of that range, the data for 2027 would not be available from CMS until 2029, with the likely result being an updated MP scale reflecting our traditional methods in the fall of that year.

Section 3: Recent U.S. Mortality Trends

This section of the report provides RPEC's analysis of recent U.S. mortality experience, with a focus on excess mortality and how it has abated over time. While the results are presented in a similar manner to prior years' reports, RPEC has made some significant changes this past year in how we determine excess mortality. These changes, which are discussed in Subsection 3.2 below, had a noticeable impact on the results.

3.1 DATA SOURCES

As the starting point for developing each MP scale, RPEC uses Medicare death and exposure data for ages 65 and above, and death data from the Centers for Disease Control (CDC) for ages below 65. CDC data is also available for ages 65 and above, but the Medicare data offers the advantage of death counts and exposure counts that originate from individual records, thereby ensuring strong internal consistency between the numerators and denominators that are used to compute death rates. In contrast, when using CDC death counts to compute death rates, exposure must be estimated. Possible sources for exposure data include estimates of the U.S. resident population produced by the Census Bureau and the Social Security Administration's (SSA) estimates of the Social Security Area population (which is a slightly broader population definition compared to that used by the Census Bureau).

The Census Bureau conducts a full census every 10 years, and also generates both intercensal and postcensal population estimates, which together provide a complete set of historical population estimates by year, sex, and age. However, these estimates are imperfect, affected by both overcount and undercount errors. In addition, the 2020 Census took place during the pandemic, increasing the challenge of obtaining accurate measurements. Consequently, the Census Bureau has not yet released its final set of 2010-to-2020 population estimates (but is likely to do so before the end of 2024), and, in addition, adjustments to the 2021-to-2023 estimates are a possibility.

While Medicare data offers the advantage of robust estimates for both exposure and death counts, it has a time lag of about two years: as of October 2024, the most recently available Medicare death and exposure data is from 2022. In contrast, provisional CDC death counts are available with a time lag of merely one week. Recent CDC data is incomplete (i.e., some recent deaths have not yet been reported), but data that is three months and older is typically over 99% complete for the older age groups. Thus, relative to Medicare data, CDC data offers the advantage of timeliness.

Because timeliness is essential for the assessment of recent mortality trends, RPEC uses CDC death count data for this purpose. To compute crude death rates, CDC death counts (by sex and single-age) were divided by general population estimates (by sex and single-age) produced by the SSA. The SSA develops its population estimates (SSA 2024b) using the Census Bureau's estimates as a starting point. The Technical Appendix provides our rationale for using the SSA's population estimates as opposed to the Census Bureau's estimates.

3.2 CHANGES TO OUR APPROACH FOR ANALYZING MORTALTY TRENDS

Each year since 2021, RPEC's MP reports have contained our analysis of the emerging effects of the COVID-19 pandemic on U.S. population mortality. Central to this analysis is a comparison of actual to expected deaths by age group, yielding a measure of excess mortality that we have tracked since the onset of the pandemic. In last year's report, we mentioned some adjustments that were made to the data and methodology used in our analysis. Those adjustments were to account for the fact that the CDC death counts were reported on a monthly rather than weekly basis, and to update the underlying population data to incorporate the 2020 census information (USC 2020).

This year, RPEC has continued to refine its methodology and source data in an attempt to yield results that we believe may be more informative to pension and OPEB valuation actuaries. These changes are as follows:

Change in source data for underlying census counts

One challenge we have faced in our analysis was obtaining a reliable data source for the underlying population counts. These counts are essential to developing mortality rates from the CDC death counts. While our analysis last year was updated to reflect the 2020 census information, we did not have a definitive source of population counts by age in the years leading up to 2020 or beyond 2020. As mentioned in last year's report, the population counts used by RPEC for 2011-2019 were recast by linearly interpolating between the 2010 and 2020 censuses. The resulting annual incremental change was also used to project the 2020 population counts beyond 2020.

One issue caused by this methodology was that the actual-to-expected (A/E) ratios for the 75-84 age group were much higher than for other age groups in 2022 and 2023. The oldest cohorts of the Baby Boomers were beginning to age into the 75-84 age group in 2022, yet the linear extrapolation of the 2020 census counts did not capture this and therefore understated the population counts, resulting in overstated "actual" death rates.

As mentioned in Subsection 3.1, our analysis now reflects population estimates produced by the Social Security Administration (SSA 2024b). These estimates provide population counts by single age and gender for each year considered in our analysis, and more accurately capture the aging of the Baby Boomer generation which caused the A/E nuance noted above.

Tracking death and population counts by each individual age

The previous methodology used by RPEC only looked at death and population counts by age band. Under the revised methodology, and enabled by the new data source for population counts, RPEC's analysis uses information for each individual age rather than grouped by age band.

Change in determination of "expected" deaths to incorporate MP-2021

Under the previous methodology, expected deaths were determined by computing the mortality trend for each age group over the five-year period from 2015 through 2019 and extending that trend through the period under study, adjusting for seasonality. In determining the mortality trend, mortality rates were calculated for each year by dividing the number of deaths for each gender and age range by the estimated population counts. Under the revised methodology, mortality rates were determined by age and gender using death and population counts in 2019, establishing a base pre-COVID mortality table. Expected deaths were then determined for 2020 through 2024 by projecting this base mortality table using MP-2021.

We believe this method of determining expected deaths should yield results that are more directly informative to pension actuaries that use MP-2021, as changes in expected mortality from the 2019 base year mirror the assumed changes in mortality from a pension or OPEB valuation that uses MP-2021.

Note RPEC also tested the post-2019 A/E ratios using other years as the base mortality table, including 2012, and found very little difference in the resulting A/E ratios.

Age standardization applied when grouping results across an age range
As mentioned above, RPEC now collects death and population counts at each individual age. This data is then aggregated across a group of ages when analyzing A/E ratios for that age group. For purposes of calculating actual and expected deaths for an age group, RPEC has found that shifts in the underlying age-specific population counts over time can skew the reported A/E ratios if the counts are not standardized by age. To eliminate this effect and standardize the results, the death rate for each individual age is weighted according to its relative size within the overall age group in the 2019 base year.

This skewing of the results without age standardization may not be readily apparent to most actuaries. To help actuaries better understand the need for age standardization when grouping results across an age range, we have provided additional details and an example in Subsection 6.2 of this report.

It is worth noting that of the changes made to the data and methodology used to determine the A/E ratios listed above, the age standardization had the greatest effect. For example, the overall A/E ratio for the 65+ population in 2023 using the above data and methodology was approximately 102.8%. Without age standardization, the A/E ratio was approximately 99.5%.

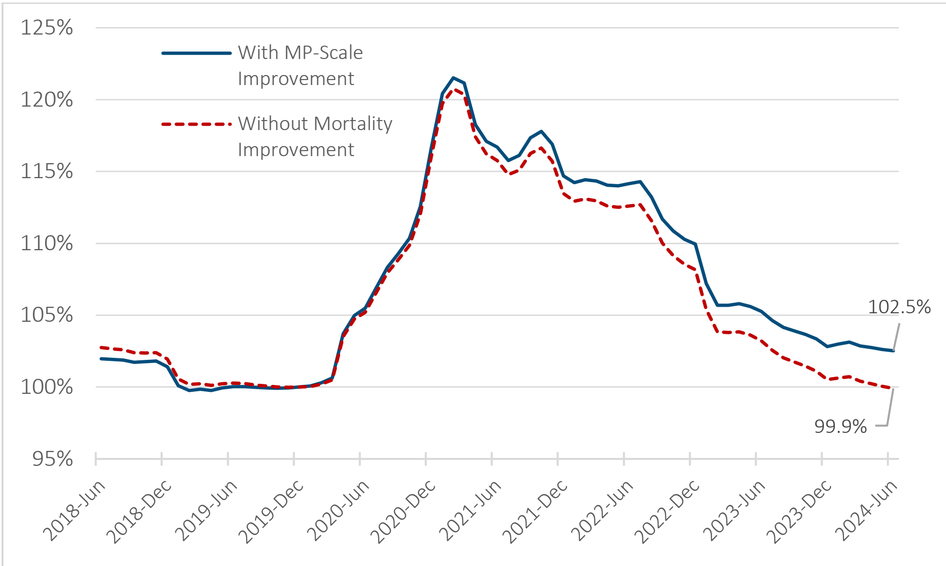
3.3 RESULTS FOR THE 65+ POPULATION

Using CDC death count data and SSA general population estimates, RPEC analyzed recent mortality experience for the 65+ population, producing the actual-to-expected (A/E) death ratios shown in Figures 2 and 3. Each value in these figures reflects the trailing 12-months of data, compared against the corresponding data from 2019. For example, the result for June 2024 reflects data from July 2023 through June 2024, compared against January-to-December data from 2019. Results are age-standardized to eliminate noise related to shifts in the population age structure, as explained in the Technical Appendix.

Two sets of historical A/E values are presented in Figures 2 and 3. The red dashed line shows values computed using 2019 data to compute expected deaths, without any adjustment for expected mortality improvement. In contrast, for the solid blue line, expected deaths were adjusted to reflect mortality improvement anticipated by the MP-2021 projection scale. To compute expected deaths in 2023, for example, 2019 data was adjusted using MP-2021 to reflect expected improvement from 2019 through 2023. The results in the blue line provide insight into how recent mortality experience has unfolded relative to the MP-2021 scale.

The results in Figures 2 and 3 (and in subsequent exhibits) should be viewed as estimates that are subject to uncertainty. Uncertainty arises primarily from inherent difficulties in estimating general population counts by age and sex. The 2020 Census took place during the pandemic, increasing the challenge of obtaining accurate measurements. Not only has the pandemic affected the reliability of population estimates for recent years, but it has contributed to a delay in the release of final population estimates for the 2010 to 2020 period, which are subject to revision based on data from the 2020 Census. The Census Bureau intends to release final 2010-to-2020 population estimates sometime before the end of 2024. The analysis in this report, therefore, is based on population estimates that are provisional as opposed to final.

Figure 2
Ratio of Actual to Expected Deaths for Trailing 12-Month Periods, for the 65+ Population

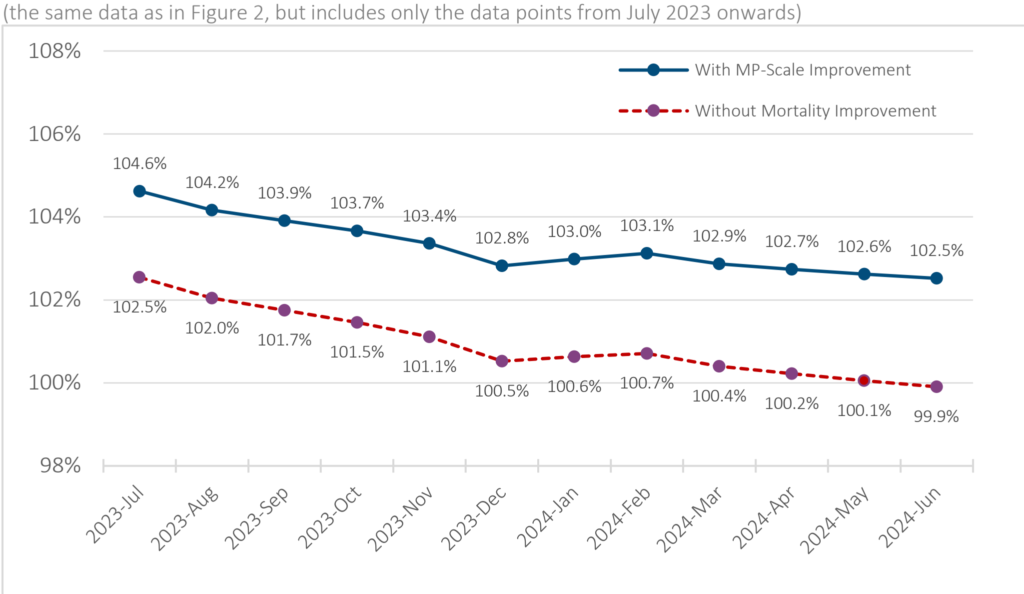


Actual deaths for the 65+ population have fallen close to the number expected using 2019 mortality rates but are 2.5% greater than the level anticipated using the MP-2021 scale applied to 2019 data.

The estimate of 2.5% excess mortality reflects data for the 12-month period from July 2023 to June 2024.

The dashed red line uses expected values computed directly from 2019 data, without adjustment based on the MP-2021 scale. The solid blue line also uses 2019 data to compute expected deaths but adjusts the deaths to reflect mortality improvement implied by the MP-2021 scale.

Figure 3
Ratio of Actual to Expected Deaths for Trailing 12-Month Periods, for the 65+ Population
(the same data as in Figure 2, but includes only the data points from July 2023 onwards)



3.4 RESULTS BY GENDER AND 10-YEAR AGE GROUP

The results in Figures 2 and 3 reflect the aggregate mortality experience of all cohorts above age 65, for males and females combined. To provide greater detail, Tables 1 and 2 below decompose the data into female and male and break the results into 10-year age groups similar to what we have provided in past reports. In addition, data for the working-age population is presented. Like the results in Figures 2 and 3, the results in Tables 1 and 2 are age-standardized to eliminate noise associated with shifts in age composition.

Table 1 uses 2019 data for expected deaths, identical to the approach used for the dash red lines in Figures 2 and 3. Table 2 also uses 2019 data as the basis for computing expectations, but adjusts the data to reflect the mortality trends implied by the MP-2021 scale, identical to the approach used for the solid blue lines in Figures 2 and 3.

Roughly speaking, across the period from 2019 to 2024, the MP-2021 scale has negative rates of improvement for ages below 50, and positive rates of improvement for ages above 50. This causes the values in Table 2 to be greater than the corresponding values in Table 1 for ages 55+ and has the opposite effect for lower ages. For example, the 2023 A/E value for males in the 35-to-44 age group is 123.9% in Table 1, but only 111.7% in Table 2. Conversely, the 2023 A/E value for males in the 75-to-84 age group is 102.5% in Table 2, but only 99.3% in Table 1.

Table 1

Ratios of Actual to Expected Deaths, Using 2019 Data (without improvement) to Compute Expectations

	Females				Males			
Age	2021	2022	2023	July 2023 to June 2024	2021	2022	2023	July 2023 to June 2024
15-24	129.7%	119.1%	111.1%	104.6%	128.5%	117.3%	111.5%	103.6%
25-34	135.9%	121.5%	108.5%	102.2%	139.8%	126.6%	114.9%	106.8%
35-44	142.3%	123.5%	113.5%	109.5%	148.5%	132.2%	123.9%	118.6%
45-54	133.1%	113.9%	102.8%	101.2%	140.6%	119.5%	109.1%	106.1%
55-64	125.1%	110.9%	100.6%	98.9%	127.6%	111.4%	101.5%	99.1%
65-74	118.0%	108.4%	100.2%	99.6%	119.6%	109.0%	100.7%	99.9%
75-84	114.1%	108.2%	100.2%	99.4%	116.4%	108.7%	99.3%	98.3%
85+	107.7%	107.8%	101.9%	101.8%	109.3%	107.0%	100.2%	99.5%
20 to 64	129.7%	113.9%	103.3%	100.9%	134.2%	117.3%	107.4%	103.8%
55+	113.5%	108.4%	101.0%	100.4%	117.4%	108.8%	100.3%	99.2%
65+	111.9%	108.1%	101.0%	100.6%	115.1%	108.2%	100.0%	99.2%

Table 2

Ratios of Actual to Expected Deaths, Using 2019 and the MP-2021 Scale to Compute Expectations

	Females				Males			
Age	2021	2022	2023	July 2023 to June 2024	2021	2022	2023	July 2023 to June 2024
15-24	127.0%	115.8%	107.7%	101.3%	126.3%	114.7%	108.9%	101.3%
25-34	130.0%	114.6%	101.4%	95.4%	133.6%	119.2%	107.3%	99.5%
35-44	137.2%	117.3%	106.7%	102.5%	139.5%	121.3%	111.7%	106.2%
45-54	135.2%	116.4%	105.8%	104.4%	140.1%	118.9%	108.3%	105.2%
55-64	125.4%	111.8%	102.1%	100.9%	128.1%	112.4%	103.1%	101.1%
65-74	119.8%	110.8%	103.0%	102.8%	120.3%	110.0%	102.0%	101.5%
75-84	116.0%	111.0%	103.8%	103.4%	118.2%	111.3%	102.5%	101.9%
85+	108.3%	108.9%	103.3%	103.5%	110.3%	108.5%	102.1%	101.6%
20 to 64	129.4%	113.7%	103.5%	101.4%	132.7%	115.7%	105.8%	102.4%
55+	114.7%	110.2%	103.2%	103.0%	118.5%	110.4%	102.4%	101.6%
65+	113.2%	109.9%	103.4%	103.3%	116.3%	110.0%	102.2%	101.7%

Section 4: Potential Mortality Loads for Improvement Scale Development

We are aware that some actuaries and plan sponsors would like somehow to reflect the potential lingering effects of the COVID-19 pandemic in an adjusted mortality assumption. It continues to be our opinion that it would not be appropriate to publish an MP scale reflecting a COVID adjustment, given the uncertainty regarding the effects of the pandemic on future mortality levels. However, we also continue to believe that an actuary could reasonably use the information in this report and other sources to develop their own "COVID-adjusted" mortality improvement scale reflecting their opinion and their clients' opinions on the potential future effects. Subsection 4.1 of last year's report (SOA 2023) listed some of those other sources of information.

As reported in Subsections 3.3 and 3.4, the A/E ratios for the 65+ population have decreased over the years since the onset of the pandemic, and were around 102.8% for 2023, and 102.5% for the 12-month period ending in June of 2024. Some actuaries may be of the opinion that the excess mortality from the pandemic in the U.S. has reached its ultimate level. That is to say, the current excess mortality of 2.5% will remain in the long term, and we have experienced a permanent shift in mortality levels relative to what we would have expected them to be projecting 2019 mortality levels using MP-2021.

To implement such an assumption through an adjusted MP-2021 scale, an actuary could make this adjustment using the MIM model by adding a 2.5% load for ages 65 and older for males and females in the 2025+ columns in Tab 1, Step 5 of the model. Alternatively, the actuary could enter the gender-specific excess mortality amounts of 1.7% male and 3.3% female.

In deciding whether to make this or other COVID-related adjustments to a mortality improvement scale, actuaries should consider the following:

- The data used by RPEC in our analysis is for the broader U.S. population. There may be regional differences in excess mortality in recent years like there were in 2020 and 2021, but RPEC did not perform an analysis to study these differences. That being said, the regional variances observed throughout 2020 and 2021 in the U.S. may have dissipated over time as fewer people are maintaining their vaccinations and more people have developed some sort of resistance arising from previous COVID infections.

- Excess mortality for a specific pension population may be somewhat different than it is for the broader U.S. population. Anecdotally, members of RPEC have observed excess mortality levels vary significantly from one pension population to another, and generally have not been as severe as for the general U.S. population.

- The A/E results reported in Subsections 3.3 and 3.4 reflect a base mortality table set in 2019, with similar results for earlier base tables. If an experience study has been performed for a specific pension plan to set a base mortality table using post-2019 mortality experience, the A/E results may not be applicable to the extent there was already some excess mortality reflected in the plan's experience study.

Section 5: Other Sources of Information

5.1 SOCIAL SECURITY ADMINISTRATION APPROACH TO REFLECTING PANDEMIC MORTALITY

The 2024 Trustees Report (SSA 2024) contains information regarding the mortality impact of COVID-19 and the projection of future effects used by the SSA in its modeling for the system. Note that this material is focused on the broader U.S. population, and post-65 is specifically reflective of people enrolled in the Social Security system as recorded by Medicare.

A high-level description of the COVID-19-related mortality impact reflected in the 2024 Trustees Report states, "Actual mortality data are now available for all age groups for calendar years 2020 through 2022. To account for the continuing effects of the pandemic in calendar years 2023 and 2024, adjustment factors are applied to the probabilities of death that would have been projected in the absence of the pandemic. Based on preliminary data available at the time assumptions for this report were set, these adjustment factors are somewhat higher for all age groups for 2023 compared to the factors used for last year's report. The factors assumed for 2024 are also above the factors used for last year's report. As in last year's report, projected death rates for years after 2024 are assumed to be unchanged from the levels that would have been projected in the absence of the pandemic" (SSA 2024, from ***Demographic Data and Assumptions***, page 79). Additionally, "The table below shows the multiplicative factors that were applied to the probabilities of death that would have been projected in the absence of the pandemic. Factors for 2020 through 2022 are not necessary, as actual data are available" (SSA 2024, page 86).

Table 3
SSA MULTIPLICATIVE FACTORS APPLIED TO PROBABILITIES OF DEATH (SSA 2024)

Year	Age 0	Ages 1-14	Ages 15-64	Ages 65-84	Ages 85+
2023	1.01	1.22	1.08	1.06	1.04
2024	1.00	1.06	1.02	1.02	1.01

The report also notes, "Actual death rates for 2022 exceeded those projected in the 2023 report. Factors for 2023 are based on partial, provisional data through July and assumptions about the remainder of the year."

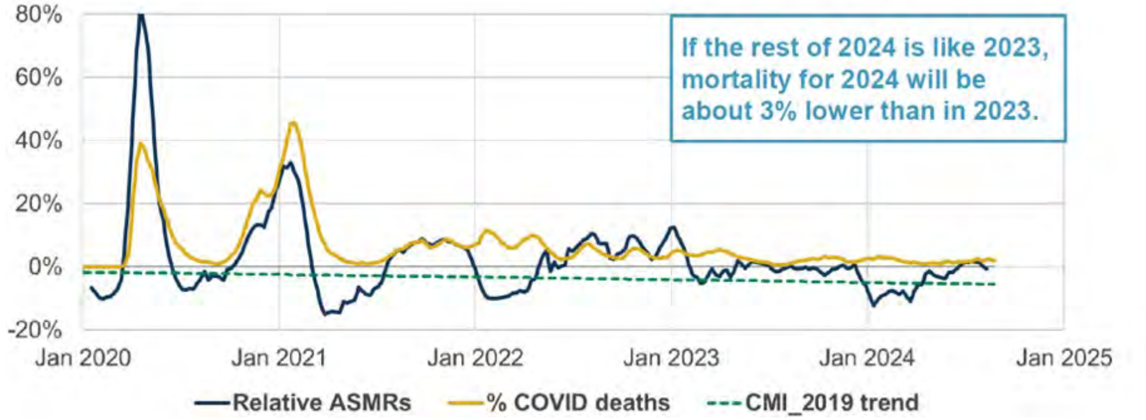
Mortality rates for 2025 and beyond contain no loads. Age 65 cohort life expectancies for 2025 under Intermediate assumptions show 19.3 years for males and 21.9 years for females (SSA 2024, page 101). These are the same as provided in the 2023 Trustees Report.

5.2 APPROACHES IN OTHER COUNTRIES TO REFLECTING PANDEMIC MORTALITY

United Kingdom

Covid-related deaths in the UK have continued to decline since the onset of the pandemic, with 2024 mortality levels for England and Wales showing a 3% decrease over 2023 levels through August. Figure 4, shown below, is taken from a September 16, 2024 presentation by Cobus Daneel, who is chairman of the UK's Continuous Mortality Improvement (CMI) Mortality Projections Committee, and shows information on weekly mortality rates in England and Wales to August of 2024. Note that "ASMR" in the below figure stands for "age-standardized mortality rate."

Figure 4
Smoothed (five-week average) ASMRs Relative to the 2025-2019 Average



Source: a September 16, 2024 presentation by Cobus Daneel, who is chairman of the UK's Continuous Mortality Improvement (CMI) Mortality Projections Committee.

In April of 2024, the CMI released a new version of their Mortality Projections Model, CMI_2023, which incorporates mortality experience thru 2023. In the Core model, 0% weight was given to 2020 and 2021 mortality experience, and 15% weight was given to 2022 and 2023 experience. The previous version, CMI_2022, reflected in the Core model 0% weight for 2020 and 2021 and 25% weight for 2022. The Core parameters in CMI_2023 produce similar but slightly lower life expectancies than those produced under the CMI_2022 Core parameters. The Core model parameters are often used by Scheme actuaries in pension valuations.

The CMI also announced that they will be considering different approaches to reflecting post-pandemic mortality experience in the Core settings for CMI_2024, due in part to the observation that if 2024 mortality experience continues to evidence a 3% decrease over 2023 mortality levels, assigning a 20% weight to 2022-2024 experience would produce an increase in projected mortality relative to the Core settings in CMI_2023, a somewhat counter-intuitive result. One approach under consideration is the "overlay" approach, under which post-pandemic mortality rates would include an adjustment for excess pandemic mortality which decays over time, with the user determining how long that decay takes. This is similar to the "COVID load" concept discussed in recent SOA MP reports.

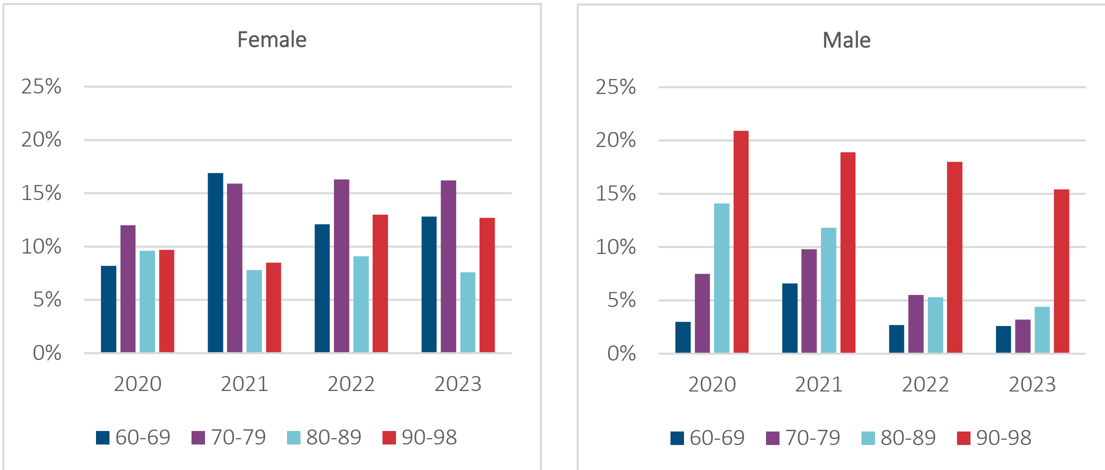
The CMI also conducted another annual survey of UK insurers and reinsurers on their use of the CMI Mortality Projections Model. Of the respondents who indicated that they intend to use a version of the model with weight parameters assigned to post-pandemic experience periods, all of them indicated their intent to use either the Core parameters or weights less than the Core parameters. Using lower weights than the Core parameters produces higher life expectancies in CMI_2023.

While there is no formal survey to support this view, it is RPEC's understanding that, in general, pension scheme actuaries in the UK are more inclined to reflect some elevated levels of mortality due to COVID in their assumptions than insurers or reinsurers.

The Netherlands

In the Netherlands, excess mortality has continued into 2022 and 2023, with higher excess mortality for females than for males. The charts provided below in Figure 5 display female and male excess mortality since the onset of the pandemic for different age groups. The percentages refer to the excess mortality death counts expressed as a percentage of total expected deaths. The information shown in these charts are from an analysis performed by the Committee Mortality Research of the Dutch Actuarial Association and provided to RPEC.

Figure 5
Netherlands: Excess Mortality by Year, Sex, and Age Group



The Dutch Royal Actuarial Association publishes a Projections Life Table every two years. This table is used by nearly all insurance companies and pension funds for pricing and reserving. The latest table, AG2024, was published in September of 2024 and reflects the addition of 2022 and 2023 mortality experience since the prior table AG2022. Both tables base the long-term mortality projection upon aggregated data through 2019 among EU countries assessed as having similar levels of prosperity. Both tables also reflect an adjustment to short-term projected mortality based upon post-pandemic mortality experience in the Netherlands.

AG2022 based this short-term excess mortality adjustment upon experience from 2020 and 2021. It was assumed that the initial excess mortality would reduce by 50% annually thereafter. However, the 2022 and 2023 mortality experience in the Netherlands evidenced higher levels of excess mortality than predicted in the AG2022 table. As a result, the AG2024 table assumes that the initial excess mortality will reduce by 25% annually. As a result of this updated table, pension liabilities are estimated to decrease by approximately 0.1% for males and 0.2% for females, with higher reductions for older populations.

Section 6: Technical Appendix

6.1 SELECTION OF POPULATION DATASET

To compute crude death rates for the analysis presented in this report, CDC death counts were divided by general population estimates produced by the Social Security Administration (SSA) for its 2024 Trustees Report (SSA 2024). The SSA's population estimates, in turn, were developed from Census data.

Rather than using the SSA's population estimates, RPEC could have used population data downloaded directly from the Census Bureau. Indeed, RPEC gave the Census data careful consideration. Across time, the size of a cohort (of individuals of the same age) will change due to deaths, immigration, and emigration. Immigration and emigration occur primarily within the working-age population; consequently, at older ages, a cohort's size should decline across time in tandem with the number of deaths. For age cohorts older than 65 as of 2018 (i.e., cohorts born in 1953 and earlier), RPEC examined the relationship between deaths and population counts. Focusing on the period between 2018 and 2023, RPEC found a somewhat weak relationship between the running total of CDC deaths and the cumulative decline in Census counts. In contrast, examination of the SSA population data revealed a relatively strong relationship with CDC death counts. Therefore, RPEC elected to use the SSA population counts (SSA 2024b) for this analysis.

The Census Bureau has not yet released its final estimates for population counts for the 2010 to 2020 period. The Census Bureau is expected to release these estimates before the end of 2024. The revised population estimates may exhibit a stronger relationship with CDC death counts.

It is beyond the scope of this report to consider the possible reasons that the SSA population data out-performs the currently available Census data with respect to consistency with CDC death counts for ages 65+. Readers seeking more information about the SSA data may refer to page 97 of the SSA's Trustees Report (SSA 2024), which describes the methodology for deriving population counts.

Note that an asymmetry exists between the geographical area covered by CDC death data and the area covered by the SSA population counts. The CDC data captures U.S. residents of the 50 states and the District of Columbia (DC), while the SSA data has broader coverage. In addition to the 50 states and DC, the SSA data captures the following population segments: civilian residents of Puerto Rico, the Virgin Islands, Guam, American Samoa, and the Northern Mariana Islands; Federal civilian employees and persons in the U.S. Armed Forces abroad and their dependents; non-citizens living abroad who are insured for Social Security benefits; and all other U.S. citizens abroad. As a result of this broader definition, the SSA's population estimate for July 1, 2023 is 342 million, while the Census estimate is 335 million (for the 50 states and DC). This asymmetry is material with respect to computing mortality rates, but the objective of this report is to examine mortality trends rather than to quantify mortality rates. Trends are unlikely to be affected by the asymmetry.

6.2 AGE STANDARDIZATION

The A/E results presented in Section 3 are calculated across broad age groups. For example, the results in Figures 1 and 2 reflect data for ages 65 and above. Shifts in a population's age structure can influence the aggregate death rate computed across an age group. In general, if the average age shifts upwards (downwards) across time, this will tend to increase (decrease) the aggregate death rate, even if age-specific mortality rates remain unchanged. This makes it difficult to interpret trends in unstandardized death rates.

Suppose, for a hypothetical data set, that the unstandardized death rate for females of age 60-to-64 is 1.00% in year one of a mortality study, and 0.98% in year five. Without more information, it cannot be determined if the 2% decrease in the aggregate death rate is due to (1) a downward shift in age-specific mortality rates, (2) a downward shift in the age distribution, or (3) a combination of these two effects. This issue is illustrated using fictional data in Tables 4 and 5. In Table 4, age-specific mortality rates decrease by 2%, leading to a 2% decline in the aggregate mortality rate. In Table 5, age-specific mortality rates are constant across time, but shifts in the population's age structure lead to a 2% decline in the aggregate mortality rate.

Table 4

Downward Shift in Age-Specific Death Rates Leads to 2% Decrease in Aggregate Death Rate

Age	1 Year 1 Exposure	2 Year 1 Deaths	3 Year 1 D / E	4 Year 5 Exposure	5 Year 5 Deaths	6 Year 5 D / E	6 / 3 Mort Ratio
60	100,000	789	0.789%	100,000	773	0.773%	98.0%
61	99,000	875	0.884%	99,000	857	0.866%	98.0%
62	98,010	970	0.990%	98,010	951	0.970%	98.0%
63	97,030	1,076	1.108%	97,030	1,054	1.086%	98.0%
64	96,060	1,193	1.242%	96,060	1,169	1.217%	98.0%
Total	490,100	4,902	1.000%	490,100	4,804	0.980%	**98.0%**

Table 5

Shift in Age Composition Leads to a 2% Decrease in the Aggregate Death Rate

Age	1 Year 1 Exposure	2 Year 1 Deaths	3 Year 1 D / E	4 Year 5 Exposure	5 Year 5 Deaths	6 Year 5 D / E	6 / 3 Mort Ratio
60	100,000	789	0.789%	140,000	1,105	0.789%	100.0%
61	99,000	875	0.884%	126,700	1,120	0.884%	100.0%
62	98,010	970	0.990%	114,664	1,135	0.990%	100.0%
63	97,030	1,076	1.108%	103,770	1,150	1.108%	100.0%
64	96,060	1,193	1.242%	93,912	1,166	1.242%	100.0%
Total	490,100	4,902	1.000%	579,046	5,675	0.980%	**98.0%**

To neutralize the effects of changes in the population's age structure, the results presented in this report are age standardized. Age-standardized results are easy to interpret because the effects of changes in age structure are eliminated. If a standardized death rate increases (decreases) across time, this implies that age-specific death rates also increased (decreased).

For this report, age standardization was accomplished using 2019 population counts as weights. In effect, this "freezes" the population's age structure at 2019 levels. Aggregate death rates are computed as the weighted average of age-specific death rates, using weights derived from 2019 population counts. For example, to compute the age-standardized death rate in 2023 for ages 60 to 69, the following calculation is performed:

$$\left(\sum_{x=60}^{69} \frac{\text{Deaths(x)}_{2023}}{\text{Population(x)}_{2023}} * \text{Population(x)}_{2019}\right) \div \sum_{x=60}^{69} \text{Population(x)}_{2019}$$

Revisiting the situation depicted above in Table 5, this methodology of age standardization would use the year one exposure counts by age in computing the weighted-average death rate for the 60-64 age band in year five. Since the year five death rates are the same as year one death rates for each age, the resulting age-standardized, weighted-average death rate for the 60-64 age band would be the same 1.000% as in year one, and therefore the mortality ratio in the rightmost column would be 100%. This illustrates how age standardization resolves the skewing of death rates when there are shifts in the age composition of a group over time.

For presentational simplicity, the prior equation shows death and population data in annual time units. In fact, the underlying death data is monthly rather than annual, and the calculation process is adjusted accordingly. The population data consists of mid-year (July 1) estimates; to calculate estimates for other calendar months, population at each age was assumed to vary linearly across the period between each of the mid-year estimates. Monthly death and population data facilitates calculations for rolling 12-month periods that straddle adjacent calendar years—for example, the period from July 2023 to June 2024.

6.3 EXPECTED DEATH RATES

The A/E values presented in Sections 3.3 and 3.4 are determined as the ratio of two age-standardized death rates. The numerator (the actual death rate) is calculated as described in Section 6.2. The denominator (the expected death rate) is calculated using 2019 death count data, since 2019 was chosen as the base year for RPEC's A/E analysis. Because 2019 data is also used for age standardization, the expected death rate calculation in any given year reduces to the following, as illustrated for the age group running from 60 to 69:

$$\sum_{x=60}^{69} \text{Deaths}(x)_{2019} \div \sum_{x=60}^{69} \text{Population}(x)_{2019}$$

The fact that the resulting expected death rate for any given year is the same as in 2019 makes sense, since without a mortality improvement assumption the expected mortality is constant. To determine expected death rates that include mortality improvement implied by the MP-2021 scale, the calculation of the expected mortality rate in year *y* is modified as follows:

$$\sum_{x=60}^{69} \text{Mort Improve Factor}(x, y) * \text{Deaths}(x)_{2019} \div \sum_{x=60}^{69} \text{Population}(x)_{2019}$$

The mortality improvement factor varies by age and target year, reflecting cumulative MP-2021 improvement from 2019 to the target year *y* that is captured in the numerator of the A/E calculation. For example, if the actual period is January-to-December 2023, then the mortality improvement factor will reflect cumulative MP-scale improvement across the 2019-to-2023 period. A factor of 95% indicates cumulative mortality improvement of 5%, or a 5% reduction in the mortality rate.

To calculate the expected death rate for a 12-month period that straddles adjacent calendar years, the calculation is similar, except the summation in the numerator is broken into monthly time units, reflecting death and population data for specific months. Because the calculation spans two calendar years, the mortality improvement factor must be adjusted accordingly. For example, for the 12-month period from July 2023 to June 2024, death data for July through December of 2019 is adjusted to reflect 2019-to-2023 improvement (based on MP-2021), while death data for January through June of 2019 is adjusted to reflect 2019-to-2024 improvement.

To generate sex-specific results, the calculations described in Sections 6.2 and 6.3 are performed separately for males and females. To generate combined results for males and females, the calculations loop across both sexes.

Section 7: Reliance and Limitations

The information in this report has been developed from data from other sources and has been presented for the purpose of valuing U.S. pension and other post-employment benefit obligations. No assessment has been made concerning the applicability of the information to other purposes.

Section 8: Acknowledgments

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RPEC members (members of the Mortality Improvement Subcommittee are denoted with an asterisk) are:

David L. Driscoll, FSA, MAAA, EA, FCA, Committee chairperson
Brent A. Banister, FSA, MAAA, EA, FCA*
James G. Berberian, ASA, EA, MAAA, FCA*
Ben Blakeslee, FSA, MAAA*
Robert A. Blough, FSA, MAAA, EA, FCA
James Chakan, FSA, EA*
Douglas J. Fiddler, ASA, MAAA, EA, FCA
Timothy J. Geddes, FSA, EA, MAAA, FCA*
Martin W. Hill, FSA, MAAA, FCA, Mortality Improvement Subcommittee chairperson*
Piotr Krekora, ASA, MAAA, FCA, EA*
Adrienne Ostroff Lieberthal
Sergey Peters, ASA, EA*
Irina Pogrebivskyi, FSA
John R. Popiolek, FSA, MAAA, EA
Scott F. Porter, FSA, MAAA, EA
Michael P. Quercia, ASA, MAAA
Mitchell Rubenstein, ASA
Graham A. Schmidt, ASA, MAAA, FCA, EA
Mark Spong, FSA, CERA, MAAA*
Larry Stern, FSA*
Matthew A. Strom, FSA, MAAA, EA
Elizabeth A. Wiley, FSA, MAAA, EA, FCA
Eva Sau Ying Yum, FSA, FCIA, EA, MAAA
Paul B. Zeisler, ASA, EA, MAAA

At the SOA:

- Patrick D. Nolan, FSA, MAAA, Senior Experience Studies Actuary
- Patrick Wiese, ASA, Lead Modeling Researcher

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Society of Actuaries Research Institute
8770 W Bryn Mawr Ave, Suite 1000
Chicago Illinois 60631
www.SOA.org