SOA Research INSTITUTE

Mortality and Longevity

Aging and Retirement

Mortality Improvement Scale MP-2021

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Mortality Improvement Scale MP-2021

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CONTENTS

Section 1: Executive Summary

This report presents Scale MP-2021, the latest iteration of the mortality improvement scales developed annually by the Retirement Plans Experience Committee (RPEC, or "the Committee") of the Society of Actuaries (SOA). Scale MP-2021 is based on the same underlying methodology used to develop Scale MP-2020 (SOA 2020). This report reflects one additional year of historical population data for 2019.

The Scale MP-2021 mortality improvement rates can be found on the SOA website at the following link: https://www.soa.org/resources/experience-studies/2021/mortality-improvement-scale-mp-2021/.

The Scale MP-2021 mortality improvement rates presented in this report are slightly higher than the corresponding Scale MP-2020 rates. Table 1.1 of deferred-to-62 annuity values shows that, starting with Pri-2012 base mortality rates, most 2021 pension obligations calculated using Scale MP-2021 (with a discount rate of 4.0%) are anticipated to be 0.2% to 0.4% higher relative to their Scale MP-2020 counterparts. Section 4 illustrates that the annuity factor changes using other base mortality tables are similar.

Table 1.1

MONTHLY DEFERRED-TO-62 ANNUITY-DUE VALUES AT 4.0% AS OF JAN. 1, 2021
PRI-2012 PROJECTED GENERATIONALLY

	Age	MP-2020	MP-2021	% Change
Females	25	3.7302	3.7396	*0.25%*
	35	5.4301	5.4447	*0.27%*
	45	7.9156	7.9383	*0.29%*
	55	11.5776	11.6099	*0.28%*
	65	14.2154	14.2572	*0.29%*
	75	10.2131	10.2580	*0.44%*
	85	6.1713	6.1979	*0.43%*
	95	3.3468	3.3605	*0.41%*
Males	25	3.5013	3.5054	*0.12%*
	35	5.0957	5.1011	*0.11%*
	45	7.4306	7.4405	*0.13%*
	55	10.8782	10.8960	*0.16%*
	65	13.3508	13.3798	*0.22%*
	75	9.4200	9.4558	*0.38%*
	85	5.4691	5.4867	*0.32%*
	95	2.8823	2.8883	*0.21%*

In 2021, the SOA released a new mortality improvement model, MIM-2021, which is discussed further in Sections 2 and 3. MIM-2021 is based on the same concepts underpinning the RPEC_2014 model with additional enhancements for cross-practice use. Both the RPEC_2014 (order-3 graduation upon which MP-2021 is based) and RPEC_O2 (smoother order-2 graduation) approaches are available within the MIM-2021 Application Tool. The MIM-2021 Application Tool replaces the RPEC_2014 and RPEC_O2 implementation tools that have been released alongside past iterations of RPEC's MP scales. RPEC plans to produce the MP scales using the MIM-2021 Application Tool going forward.

As discussed in Section 5, the MP-2021 projection scale is based upon historical mortality information through 2019 that does not reflect the COVID-19 pandemic. Due to the uncertainty about the near- and long-term effects of COVID-19, no adjustments to Scale MP-2021 have been made for the pandemic. However, an interface has been included in the MIM-2021 Application Tool to allow practitioners to adjust projection scales for COVID-19.

RPEC believes that Scale MP-2021 produces a reasonable mortality improvement assumption for measuring obligations for most retirement programs in the United States within the context of the "assumption universe" as described in Actuarial Standard of Practice (ASOP) No. 35 (ASB 2020). However, RPEC also believes that other mortality improvement scales, including those created with an assumption set different from that selected by RPEC, could fall within the ASOP No. 35 assumption universe. It is the responsibility of the actuary to determine which mortality improvement assumption is appropriate to use for a given purpose.

Section 2: Data Sources, Underlying Model, and Recent U.S. Mortality Experience

2.1 Data Sources

The historical mortality information published by the Social Security Administration (SSA) in conjunction with the 2021 Old-Age and Survivors Insurance and Federal Disability Insurance (OASDI) Trustees' Report included rates that are smoothed across ages for each individual year through calendar year 2018 (SSA 2021). The data for calendar years 1950 through 2016 used in the MP-2021 study were taken directly from these SSA-published mortality rates. Rates for 2017 through 2019 were calculated using the most recent data developed by the Centers for Disease Control and Prevention (CDC), the U.S. Census Bureau and the Centers for Medicare and Medicaid Services (CMS). The process used to develop the 2017 through 2019 rates follows the SSA's graduation methodology. See Appendix B for additional information.

2.2 Committee-Selected Assumptions

Scale MP-2021 was constructed using the same model infrastructure and committee-selected assumption set used to develop Scale MP-2020. The specific committee-selected assumptions used are as follows:

- Long-term rate of mortality improvement: flat 1.35% rate to age 62, decreasing linearly to 1.10% at age 80, further decreasing linearly to 0.40% at age 95, and then decreasing linearly to 0.00% at age 115
- Horizontal convergence period (along fixed ages): 10 years
- Diagonal convergence period (along fixed year-of-birth cohorts): 20 years
- Horizontal/diagonal blending percentages: 50%/50%
- Initial slope constraint: 0
- Historical data: SSA probabilities of death, smoothed with order-3 Whittaker-Henderson graduation

Applying a two-year step-back[1] from 2019 (the most recent year of mortality data), along with a 20-year diagonal convergence period, results in Scale MP-2021 long-term rates that are fully attained in calendar year 2037.

2.3 The MIM-2021 Mortality Improvement Model

In 2021, the SOA released MIM-2021 (SOA 2021), a new mortality improvement model that is a single structure for actuarial practitioners across different practice areas to create mortality improvement projections. An initial version of MIM-2021 was released in April 2021, and an updated model is being released concurrently with this report. MIM-2021 utilizes the same concepts underpinning the RPEC_2014 model (used to create past MP scales), but with enhanced capabilities to allow for projections that may be applicable to a variety of actuarial practice areas. Similar to past iterations of the RPEC_2014 model, the MIM-2021 Application Tool has a feature that allows practitioners to load the parameters that produce Scale MP-2021.

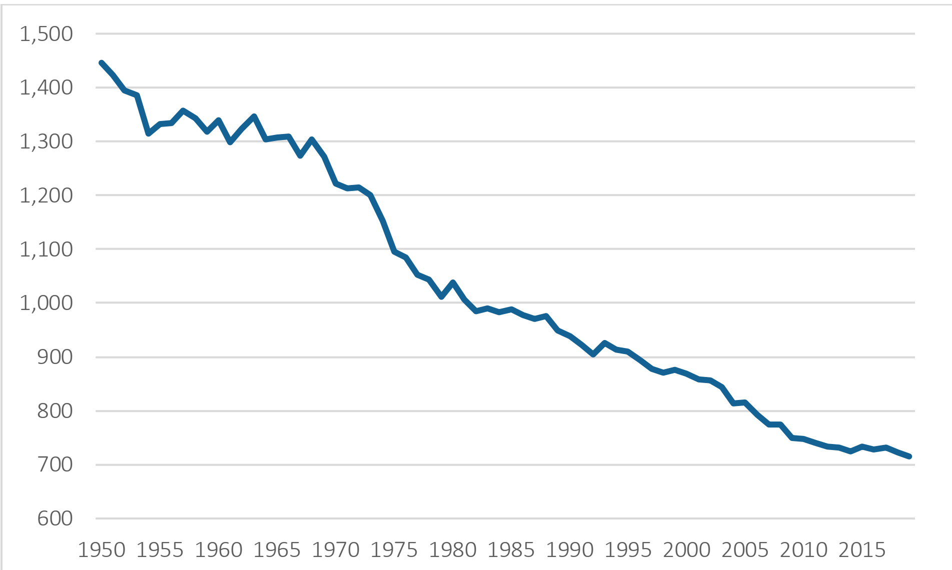
[1] See the Scale MP-2014 Report (SOA 2014) for more information.

MIM-2021 reflects historical mortality data through calendar year 2019. As with all versions of the RPEC_2014 model, historical rates in MIM-2021 were calculated using a two-dimensional Whittaker-Henderson graduation of the natural logarithm of U.S. population mortality rates with smoothness components based on the sum of the squares of third finite differences.

2.4 Recent U.S. Population Mortality Experience

The age-adjusted mortality rate for 2019 was 715.2 (per 100,000), a decrease of 1.2% from the 723.6 rate for 2018 (NCHS 2021a, NVSS 2021). Figure 2.1 shows the total (males and females combined) age-adjusted mortality rates in the United States for calendar years 1950 through 2019.

Figure 2.1
U.S. AGE-ADJUSTED MORTALITY RATES PER 100,000, CALENDAR YEARS 1950–2019



Mortality rates in calendar year 2019 were lower for seven out of the 10 leading causes of death in the United States, which included the two leading causes of death—heart disease (–1.3%) and cancer (–1.9%). Mortality rates increased by 2.7% for unintentional injuries (the third-leading cause of death), and the remaining two causes did not change significantly (Kochanek, Xu and Arias 2021). Based on the CDC's age-adjusted death rates (NCHS 2021a; NVSS 2021), the age-adjusted mortality improvement rate averaged approximately 0.5% per year over the period 2010 to 2019, compared to an average of approximately 1.5% per year from 2000 through 2009.

Preliminary analysis by the National Vital Statistics System (NVSS 2021) indicates that the average age-adjusted death rate in the United States (per 100,000 of population) was 830.5 for 2020, which was 16.1% higher than the corresponding value of 715.2 for 2019. It should be noted that this preliminary information for calendar year 2020 was not reflected in any of the mortality improvement scales presented in this report.

These mortality improvement statistics illustrate age-adjusted mortality improvement rates for the U.S. population as a whole. The trends of mortality improvement vary significantly by gender and age group.

Section 3: Considerations for Use of the MIM-2021 Application Tool

3.1 Data Sources

Since the release of Scale MP-2014, RPEC has relied upon releases of historical data supplied by the SSA as described in subsection 2.1. The MIM-2021 Application Tool allows for selection of alternative historical datasets to use for mortality improvement projections, with the intent of allowing practitioners in various areas the latitude to choose which one they deem most appropriate for their specific purpose. For these alternative datasets, deaths are taken from the National Vital Statistics System of the National Center for Health Statistics (NCHS) and exposures are taken from the Census Bureau. For the duration of this report, the NCHS deaths, Census Bureau exposures and the resultant mortality rates will be collectively referred to as "NCHS data."

A key reason for the inclusion of the NCHS data in the model is the ability to stratify the NCHS data into socioeconomic deciles using geographical indicators, as described in subsection 2.2 of the MIM-2021 report. This allows users to not only produce mortality improvement scales based on the aggregate NCHS data, but particular socioeconomic deciles (or blends thereof) that might be applicable to a particular population. This level of granularity is not currently available in the SSA dataset.

Since the release of the original RPEC_2014 model, RPEC has elected to use the SSA historical mortality data rather than the NCHS data due to the SSA's use of data from CMS for ages 65 and above. RPEC continues to utilize the SSA historical mortality data for its MP scales for the following reasons:

- All people covered by Medicare and Medicaid are required to verify their ages, and for this reason, RPEC has considered the CMS data to be more reliable for ages 65 and older, which are especially relevant for pension valuations.
- The NCHS data relies upon deaths from the National Vital Statistics System and exposure counts from the Census Bureau, which means that the NCHS mortality rates in MIM-2021 are based on data from two different sources. In contrast, CMS exposures and deaths for ages 65 and older in the SSA data come from the same source, which the Committee believes is important when assessing year-over-year mortality improvement.
- The annual population counts published by the Census Bureau are estimates based on the 2010 census. Post-censal estimates for 2011–19 are derived from the 2010 census using birth and mortality statistics from NCHS and international migration rates by sex and age for each year. When the 2020 census information is published, the Census Bureau will re-estimate population counts for 2011–19. In contrast, the exposure counts from CMS are based on the number of people enrolled in Medicare[2] and are not estimates.
- The NCHS and SSA mortality rates for ages 65 and older appeared to be quite close in 2010 but have increasingly diverged over the course of the decade, with the rates based on the NCHS data decreasing substantially relative to the SSA data, as shown in Figures 3.1 to 3.3.[3] A similar divergence was noted by SSA over the course of the 2000–09 decade until the 2010 census resulted in true-ups of the Census Bureau population counts for 2001 through 2009 that brought the two sets of mortality rates closer in line. Due to this precedent, RPEC anticipates that

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[2] Above age 70, SSA uses the population enrolled in Medicare that is also receiving a Social Security or Railroad Retirement Board benefit. However, due to the increasing number of people delaying commencement of Social Security benefits, below age 70, SSA uses all individuals enrolled in Medicare.

[3] Figures 3.1 to 3.3 show how the mortality rates change over the course of the decade for females; the pattern for males is similar.

forthcoming intercensal adjustments to Census Bureau population estimates for 2011–19 may noticeably change NCHS mortality rates from those implied by the data currently available.

Figure 3.1
SSA AND NCHS FEMALE MORTALITY RATES BY AGE FOR 2010

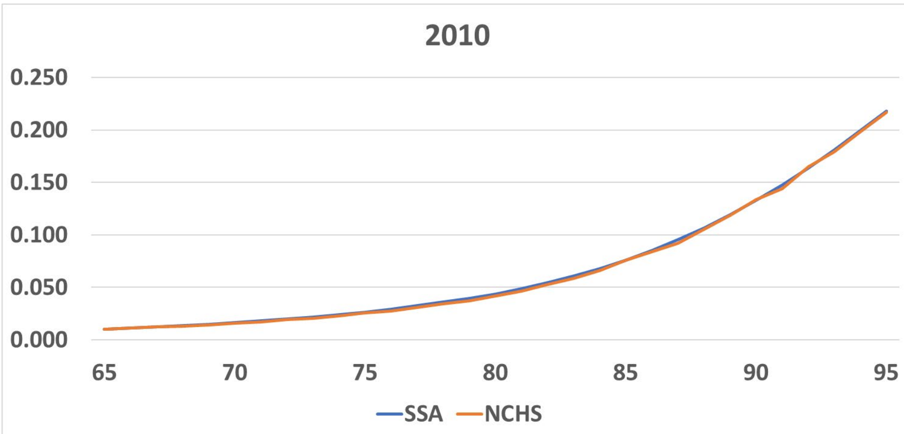


Figure 3.2
SSA AND NCHS FEMALE MORTALITY RATES BY AGE FOR 2015

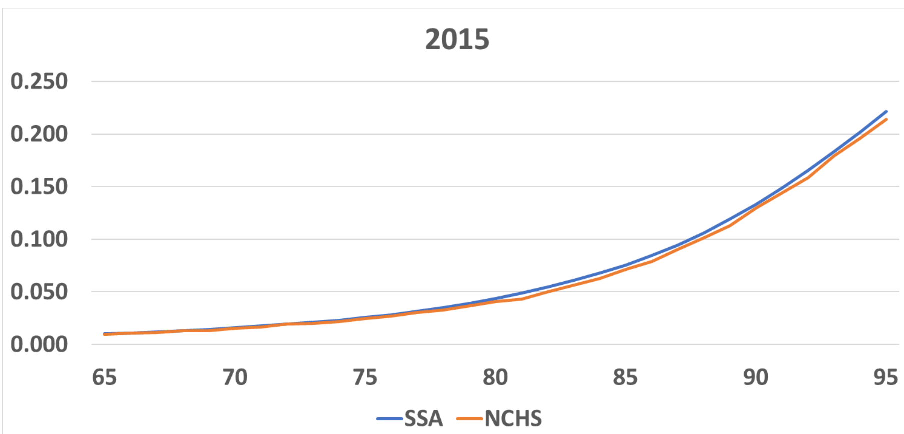
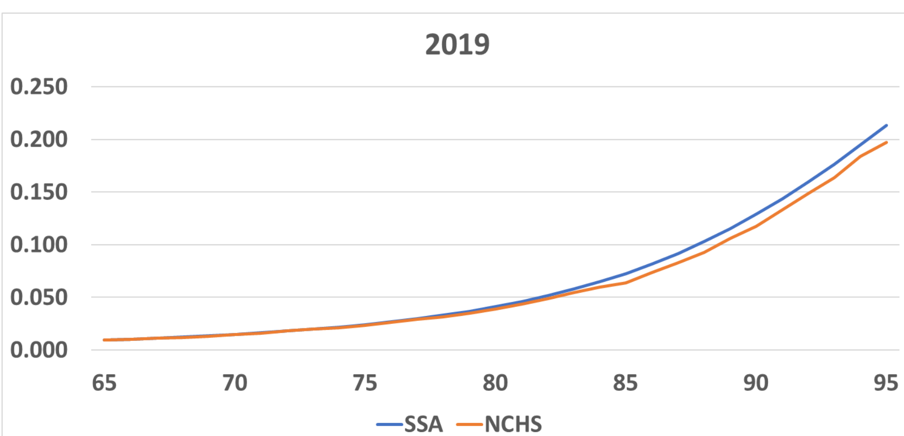


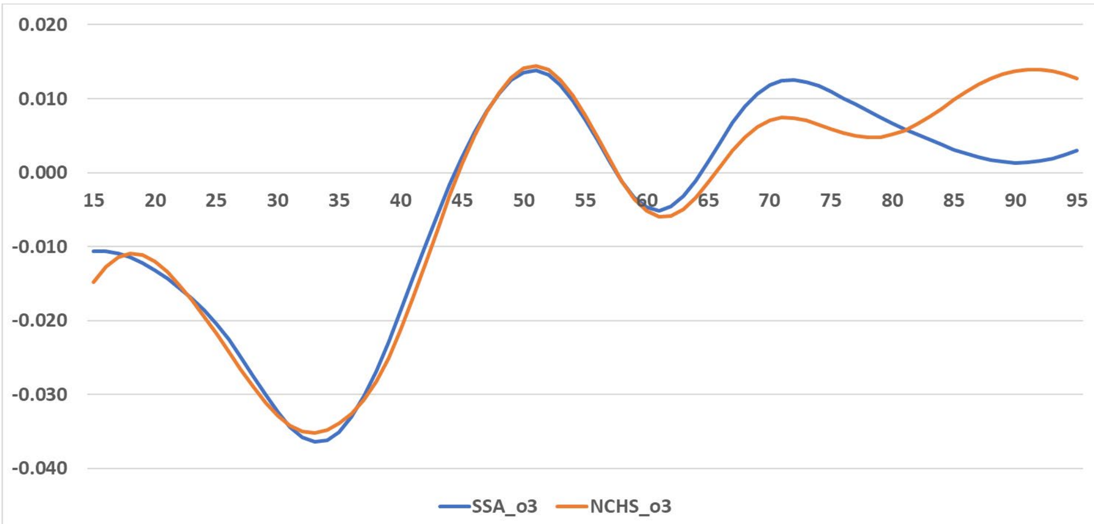
Figure 3.3
SSA AND NCHS FEMALE MORTALITY RATES BY AGE FOR 2019



Along with the MIM-2021 Application Tool, the SOA has released an accompanying MIM-2021 Data Analysis Tool that allows users to plot and compare different historical mortality rates and improvement rates between the datasets available in the MIM-2021 Application Tool, including socioeconomic deciles and quintiles. This Data Analysis Tool can be of particular help in allowing practitioners to analyze how the NCHS data compare to the SSA data underpinning Scale MP-2021. Figure 3.4 shows the NCHS and SSA improvement rates for females for the most recent five years of data, which are the most important historical years for determining the interpolating cubic polynomials for Scale MP-2021.[4]

Figure 3.4

SSA AND NCHS ANNUALIZED GEOMETRIC RATE OF MORTALITY IMPROVEMENT, FEMALES, 2015–2019



The datasets differ in their methods of smoothing mortality rates within calendar years, but the greatest differences in improvement rates are observed above age 65, where the two datasets are based on different sources. A recent University of Michigan Retirement Research Center research paper concluded that differences in the raw exposures and deaths used, rather than differences in the smoothing methodologies, are primarily responsible for the deviation in mortality rates between the two sources (Barbieri 2018). This conclusion is consistent with the observations above showing a divergence in mortality rates over the course of the 2010–19 decade, which may be due to decreasing accuracy of Census Bureau population estimates as more years have elapsed since the 2010 census.

Table 3.1 shows how Pri-2012 annuity factors differ between using the SSA data used to construct Scale MP-2021 and the NCHS historical data with all of the other committee-selected assumptions. The NCHS data produces higher annuity factors, particularly at the oldest ages. This outcome is a result of NCHS mortality rates decreasing by more than SSA mortality rates over the course of the last decade, as illustrated by Figures 3.1 to 3.3.

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[4] 2017 is the final year of historical (rather than projected) improvement rates in Scale MP-2021, which is the "jumping off" point for cubic polynomial interpolation described in subsection 3.2. 2015–19 is selected as a five-year period centered around 2017.

Table 3.1

MONTHLY DEFERRED-TO-62 ANNUITY-DUE VALUES AT 4.0% AS OF JAN. 1, 2021
PRI-2012 PROJECTED GENERATIONALLY

	Age	SSA (MP-2021)	NCHS Data	% Change
Females	25	3.7396	3.7547	*0.40%*
	35	5.4447	5.4649	*0.37%*
	45	7.9383	7.9650	*0.34%*
	55	11.6099	11.6441	*0.29%*
	65	14.2572	14.3030	*0.32%*
	75	10.2580	10.3940	*1.33%*
	85	6.1979	6.5061	*4.97%*
	95	3.3605	3.5577	*5.87%*
Males	25	3.5054	3.5183	*0.37%*
	35	5.1011	5.1173	*0.32%*
	45	7.4405	7.4601	*0.26%*
	55	10.8960	10.9168	*0.19%*
	65	13.3798	13.4029	*0.17%*
	75	9.4558	9.5909	*1.43%*
	85	5.4867	5.8245	*6.16%*
	95	2.8883	3.1188	*7.98%*

3.2 Additional New Features of MIM-2021 Application Tool

As mentioned in subsection 2.3, MIM-2021 includes the capability to load the committee-selected assumptions and historical SSA dataset used to produce Scale MP-2021. In addition to the assumptions familiar to users of past iterations of the RPEC_2014 model, MIM-2021 includes some new options for users to further customize their projection. First, MIM-2021 introduces the concept of user-defined "intermediate-term" rates of improvement, which are reached at user-specified future years and held constant for a user-specified period before grading linearly to the assumed long-term rates of improvement. Scale MP-2021 does not utilize intermediate-term rates.

Second, past versions of the RPEC-2014 model have relied upon the mortality improvement rates determined from the most recent two years of historical mortality data (after accounting for the two-year step-back referenced in subsection 2.2) and the slope of mortality improvement rates determined from the most recent two years of mortality improvement rates. These two figures have defined the "jumping off" point for the cubic polynomials used for interpolation across the convergence period. The MIM-2021 Application Tool allows the user to base these jumping-off values off of different historical periods than the most recent two years. The initial improvement rates and slopes can also be manually overridden by age.

A third new feature is the ability for users to enter their own adjustments to mortality due to COVID-19. This is described in more detail in subsection 5.2 of this report.

3.3 Relationships Between Socioeconomic Subsets of NCHS Data and Mortality Improvement

Should a practitioner choose to model mortality improvement using historical data of an assumed higher or lower socioeconomic level, the MIM-2021 Application Tool allows the functionality to do that. However, the use of NCHS socioeconomic quintiles and deciles will reduce the size of the underlying dataset and may introduce additional volatility into year-over-year annuity factors produced from improvement scales developed using MIM-2021. Practitioners should also be aware that while populations of higher socioeconomic status have generally exhibited lower mortality than populations of lower socioeconomic status, higher socioeconomic status has not always been indicative of higher mortality improvement across all combinations of age, sex and time period. For some of these combinations, mortality improvement has been higher for people of lower socioeconomic status.

The MIM-2021 Data Analysis Tool allows users to plot and compare how different socioeconomic deciles and quintiles compare to the aggregated national data. Figures 3.5 and 3.6 show the annualized geometric rate of improvement for NCHS quintiles and deciles from 1982 through 2019 for females. The lowest socioeconomic group is represented by “q1” in Figure 3.5 and “d1” in Figure 3.6. Though there are exceptions, the higher socioeconomic groups experienced greater mortality improvement than lower socioeconomic groups during this time period.

Figure 3.5

ANNUALIZED GEOMETRIC RATE OF MORTALITY IMPROVEMENT BY NCHS QUINTILES, FEMALES, 1982–2019

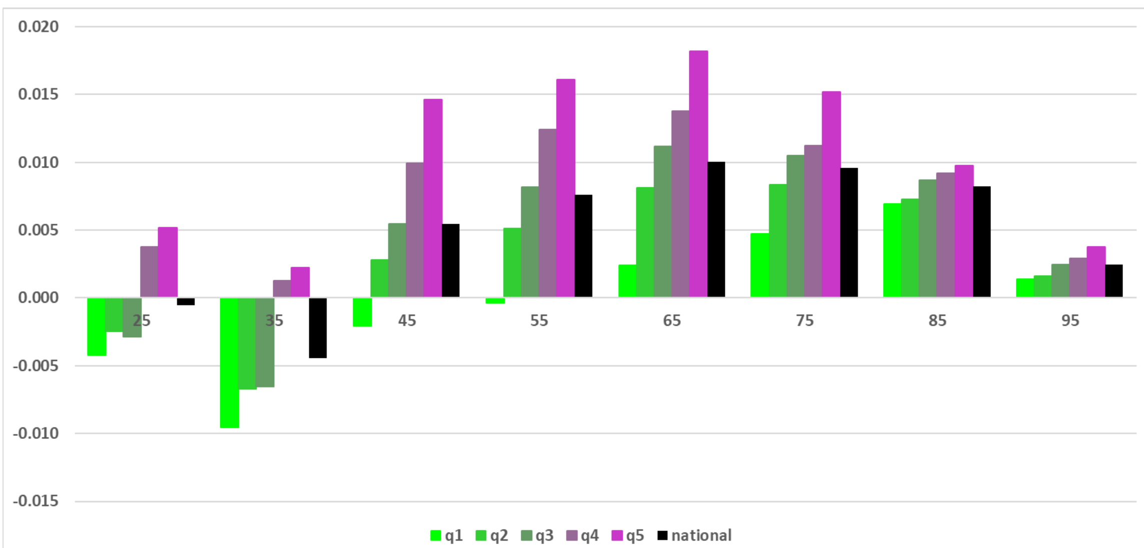
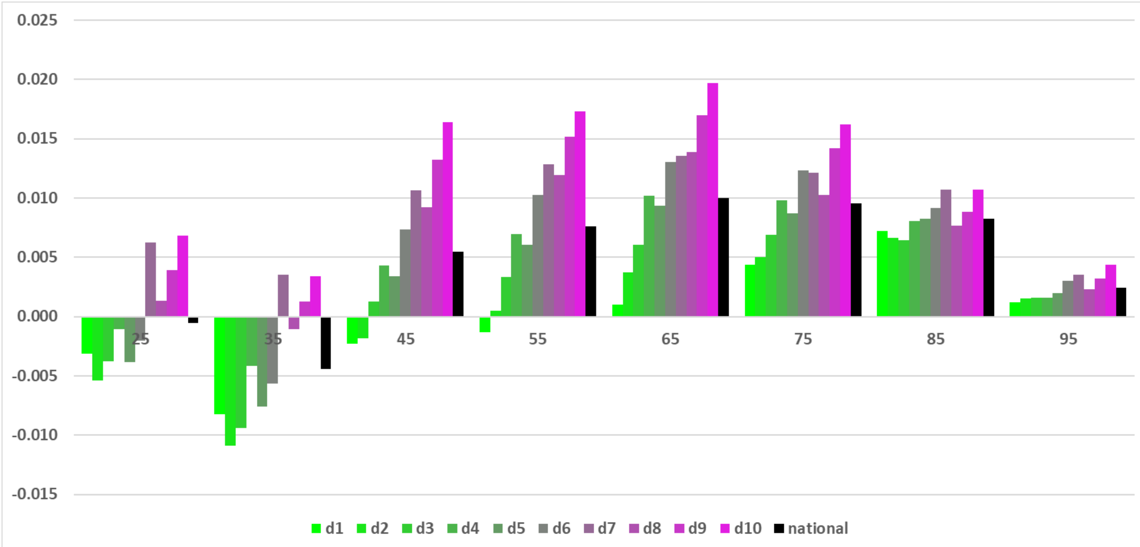


Figure 3.6

ANNUALIZED GEOMETRIC RATE OF MORTALITY IMPROVEMENT BY NCHS DECILES, FEMALES, 1982–2019



Practitioners familiar with the RPEC_2014 model will recall that the future projection of mortality improvement relies upon the most recent two years of historical improvement data, which are influenced most prominently by the most recent years of historical mortality data. Figures 3.7 and 3.8 display the same information as the above Figures 3.2 and 3.3 but include only years 2010–19. It can be seen that in the most recent decade, the relationship between NCHS income groups and mortality improvement is not consistent across ages.

Figure 3.7

ANNUALIZED GEOMETRIC RATE OF MORTALITY IMPROVEMENT BY NCHS QUINTILES, FEMALES, 2010–19

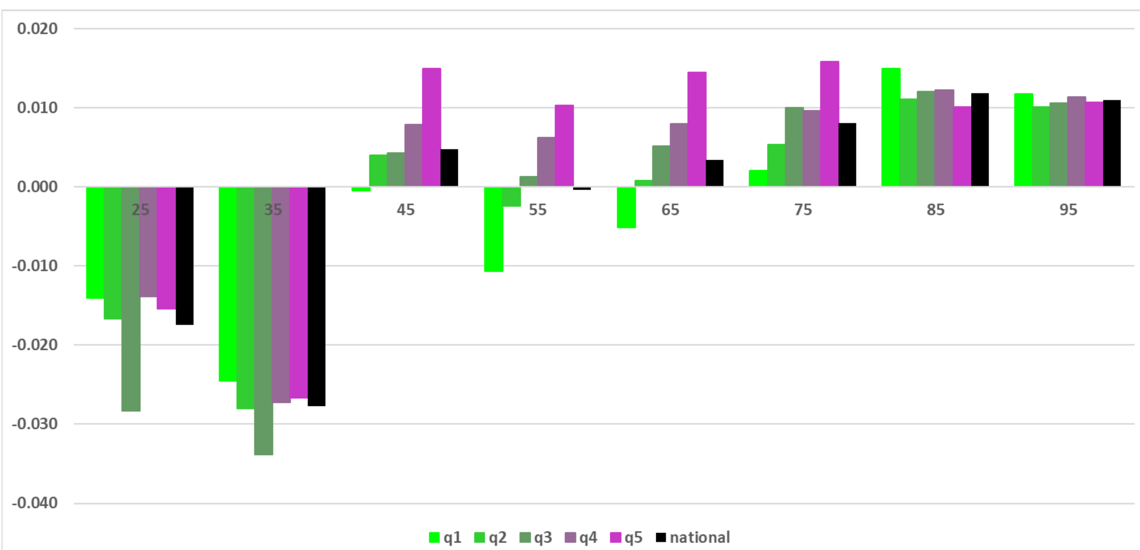
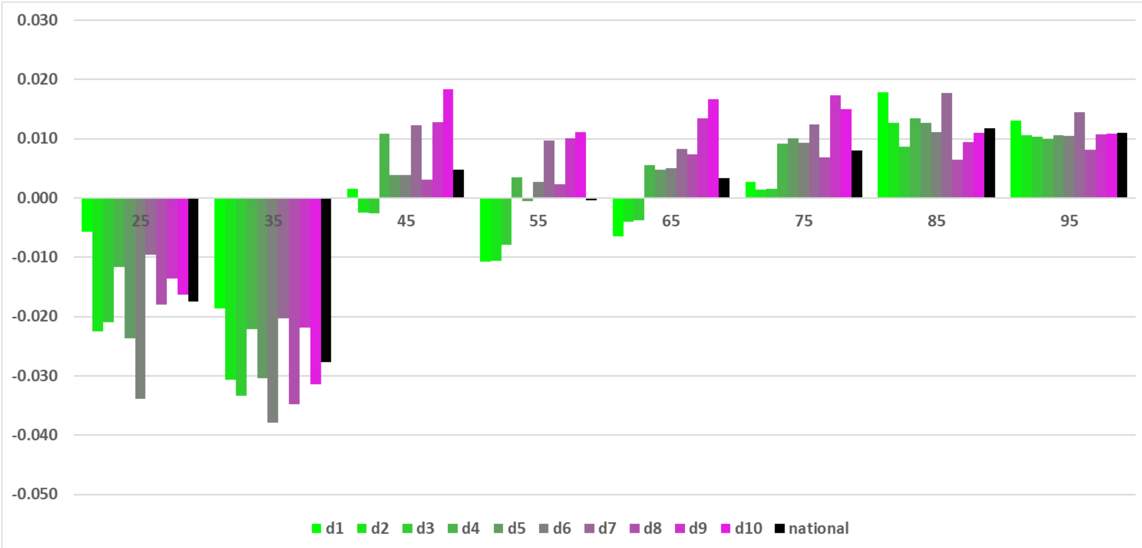


Figure 3.8

ANNUALIZED GEOMETRIC RATE OF MORTALITY IMPROVEMENT BY NCHS DECILES, FEMALES, 2010–19



Users of the MIM-2021 Application Tool considering use of socioeconomic subsets of the NCHS data for mortality improvement projections are encouraged to make use of the MIM-2021 Data Analysis Tool to understand how relationships between NCHS socioeconomic categories and mortality improvement have evolved over time. Practitioners should carefully review how selection of different NCHS socioeconomic categories will influence mortality improvement projections and be aware of the year-over-year volatility that this might introduce.

Another consideration regarding use of socioeconomic subsets of the NCHS data is the forthcoming incorporation of the 2020 census into the estimates for the Census Bureau's 2011–19 population counts. The mortality rates for 2011–19 will be adjusted, which could potentially significantly change the observed levels of improvement over the past decade. The change may disproportionately affect certain socioeconomic strata.

3.4 Setting the Long-Term Rate of Improvement Using Historical Data

The MIM-2021 Application Tool includes an optional feature that allows users to set intermediate- and long-term rates of mortality improvement by computing these values from historical information. Section 5 of the MP-2020 report (SOA 2020) details the process by which RPEC chose its new long-term rate of improvement. Table 3.2 (taken from the Scale MP-2020 report) shows that the long-term rate computed by age group can vary based on the start and end years chosen for the historical data. Practitioners choosing to use this feature should be aware of how changing these input years can influence the results.

Table 3.2
BEST-FIT ANNUAL MORTALITY IMPROVEMENT FOR SELECT 10-YEAR AGE BANDS

Time Period	Age 55-64	Age 65-74	Age 75-84	Age 85-94
1940–2017	1.29%	1.19%	1.08%	0.75%
1950–2017	1.33%	1.24%	1.09%	0.71%
1960–2017	1.45%	1.36%	1.13%	0.73%
1970–2017	1.48%	1.43%	1.09%	0.53%
1980–2017	1.39%	1.52%	1.09%	0.40%
1940–1980	0.99%	0.94%	1.06%	0.87%
1950–1990	1.13%	0.99%	1.09%	0.97%
1960–2000	1.48%	1.18%	1.12%	0.94%
1970–2010	1.63%	1.38%	1.05%	0.49%

RPEC ultimately based its selected long-term rate of improvement on data from the 1950–2017 time period. For purposes of computing the long-term rate of improvement from historical data, the MIM-2021 Application Tool includes historical data back to 1982. Table 3.2 indicates that for the age 65–74 band, improvement rates were higher for 1980–2017 than all other periods studied and, for the age 85–94 band, improvement rates were lower for 1980-2017 than all other periods studied. Use of the longest historical time period available in the MIM-2021 model for setting long-term rates of improvement may therefore produce outlier estimates for some ages.

Section 4: Impact of Scale MP-2021

4.1 Comparison of 2021 Annuity Values

Table 4.1 presents a comparison of monthly deferred-to-62 annuity-due values using various SOA mortality tables, all calculated generationally as of 2021 (“Generational @ 2021”) using Scale MP-2021. These annuity values were computed using the following specifications:

- Employee rates for ages below 62 and retiree rates for ages 62 and older
- A discount rate of 4.0%

In Table 4.1, and each of the subsequent tables in this Section that uses Pri-2012 as a base table, the “total dataset” version of Pri-2012 is used.

Table 4.1

MONTHLY DEFERRED-TO-62 ANNUITY-DUE VALUES AT 4.0% AS OF JAN. 1, 2021
SOA MORTALITY TABLES PROJECTED WITH SCALE MP-2021

	Age	Pri-2012	PubG-2010	PubT-2010	PubS-2010
Females	25	3.7396	3.8619	3.9668	3.7751
	35	5.4447	5.6344	5.8008	5.5051
	45	7.9383	8.2332	8.4937	8.0399
	55	11.6099	12.0626	12.4669	11.7611
	65	14.2572	14.8292	15.3823	14.3860
	75	10.2580	10.8035	11.3082	10.4194
	85	6.1979	6.5413	6.9038	6.3985
	95	3.3605	3.4906	3.5410	3.4824
Males	25	3.5054	3.5975	3.7703	3.5898
	35	5.1011	5.2327	5.4982	5.2282
	45	7.4405	7.6390	8.0373	7.6295
	55	10.8960	11.2077	11.8012	11.1658
	65	13.3798	13.7508	14.5022	13.5934
	75	9.4558	9.7528	10.3734	9.5214
	85	5.4867	5.7372	6.0951	5.5277
	95	2.8883	3.0685	3.0990	3.0159

Table 4.2 shows how these annuity factors compare to those calculated using Scale MP-2020. The values in the tables indicate that, generally, updating from Scale MP-2020 to Scale MP-2021 will result in an increase in benefit obligations between 0.2% and 0.4%. This impact is relatively consistent for all the base tables shown.

Table 4.2

IMPACT OF UPDATING FROM SCALE MP-2020 TO MP-2021 USING VARIOUS BASE MORTALITY TABLES
COMPARISON OF MONTHLY DEFERRED-TO-62 ANNUITY-DUE VALUES AT 4.0% AS OF JAN. 1, 2021

	Age	Pri-2012	PubG-2010	PubT-2010	PubS-2010
Females	25	0.25%	0.20%	0.18%	0.23%
	35	0.27%	0.22%	0.19%	0.24%
	45	0.29%	0.23%	0.20%	0.26%
	55	0.28%	0.23%	0.20%	0.25%
	65	0.29%	0.25%	0.21%	0.28%
	75	0.44%	0.38%	0.34%	0.41%
	85	0.43%	0.39%	0.36%	0.40%
	95	0.41%	0.40%	0.39%	0.40%
Males	25	0.12%	0.09%	0.08%	0.10%
	35	0.11%	0.08%	0.08%	0.09%
	45	0.13%	0.11%	0.10%	0.12%
	55	0.16%	0.14%	0.12%	0.14%
	65	0.22%	0.19%	0.16%	0.19%
	75	0.38%	0.35%	0.30%	0.36%
	85	0.32%	0.31%	0.28%	0.32%
	95	0.21%	0.21%	0.20%	0.21%

For comparison purposes, versions of Tables 4.1 and 4.2 with factors computed using a discount rate of 7.0% can be found in Appendix E.

4.2 Comparison of 2021 Cohort Life Expectancies

Table 4.3 presents a comparison of 2021 cohort life expectancy values at the indicated ages, calculated assuming:

- Base mortality rates equal to headcount-weighted Pri.H-2012 employee rates for ages below 62 and headcount-weighted Pri.H-2012 retiree rates for ages 62 and older
- Mortality projection starting in 2012 using Scale MP-2020 for the first column of life expectancies and using Scale MP-2021 for the second column

Table 4.3
COHORT LIFE EXPECTANCIES AS OF JAN. 1, 2021
PRI.H-2012 PROJECTED GENERATIONALLY

	Age	MP-2020	MP-2021	% Change
Females	25	63.34	63.46	*0.19%*
	35	52.75	52.87	*0.23%*
	45	42.24	42.35	*0.26%*
	55	31.81	31.92	*0.35%*
	65	22.13	22.22	*0.41%*
	75	13.86	13.94	*0.58%*
	85	7.44	7.48	*0.54%*
	95	3.70	3.72	*0.54%*
Males	25	60.00	60.06	*0.10%*
	35	49.54	49.58	*0.08%*
	45	39.19	39.24	*0.13%*
	55	28.89	28.95	*0.21%*
	65	19.52	19.59	*0.36%*
	75	11.99	12.05	*0.50%*
	85	6.26	6.28	*0.32%*
	95	3.12	3.13	*0.32%*

4.3 Alternative Order-2 Model

Scale MP-2021 and its predecessors have been based on historical U.S. population mortality rates that have been graduated with a two-dimensional “order-3” Whittaker-Henderson method. In this context, order-3 refers to the degree of the finite difference operators used in the smoothness components of the two-dimensional Whittaker-Henderson objective function.

In 2018, RPEC began producing an alternative version of the RPEC_2014 model, denoted the RPEC_O2 model, that uses order-2 rather than order-3 Whittaker-Henderson graduation. This change in finite difference operators produces a generally smoother two-dimensional surface of mortality improvement rates. RPEC’s research has indicated that, relative to the order-3 model, the order-2 model tends to yield greater year-over-year stability in pension liability calculations. However, the order-2 model will be less sensitive to emerging changes in U.S. mortality patterns and generally produces a weaker fit when compared to ungraduated historical mortality improvement rates.

For purposes of this report, “O2-2020” is used to designate the scale produced using the order-2 model released in October 2020 and the committee-selected assumption set in effect for Scale MP-2020. “O2-

2021" is used to designate the corresponding order-2 scale produced this year using the committee-selected assumption set for Scale MP-2021. Table 4.4 shows a comparison of annuity values produced by the O2-2020 and O2-2021 scales as of Jan. 1, 2021, using Pri-2012 as a base table and a discount rate of 4.0%.

Table 4.4

MONTHLY DEFERRED-TO-62 ANNUITY-DUE VALUES AT 4.0% AS OF JAN. 1, 2021
PRI-2012 PROJECTED GENERATIONALLY

	Age	O2-2020	O2-2021	% Change
Females	25	3.7546	3.7549	*0.01%*
	35	5.4663	5.4671	*0.01%*
	45	7.9680	7.9700	*0.03%*
	55	11.6600	11.6627	*0.02%*
	65	14.3149	14.3188	*0.03%*
	75	10.3492	10.3558	*0.06%*
	85	6.2887	6.2908	*0.03%*
	95	3.3609	3.3624	*0.04%*
Males	25	3.5401	3.5342	*-0.17%*
	35	5.1515	5.1428	*-0.17%*
	45	7.5064	7.4957	*-0.14%*
	55	10.9906	10.9785	*-0.11%*
	65	13.4942	13.4836	*-0.08%*
	75	9.5825	9.5786	*-0.04%*
	85	5.6225	5.6200	*-0.04%*
	95	2.9171	2.9195	*0.08%*

The differences in annuity values when updating from O2-2020 to O2-2021 are smaller than the corresponding differences for MP-2020 and MP-2021. Table 4.4 shows a slight decrease for most male annuity factors (except for age 95) and very small increases for female annuity factors.

Table 4.5 shows a comparison of the annuity values produced by the O2-2021 scale and the MP-2021 scale using Pri-2012 as the base table. Scale MP-2021 produces lower annuity values. It is worth noting, however, that the spread between the annuity factors resulting from the two scales has narrowed compared to those produced using the 2020 versions of each model (see SOA 2020, Table 4.6).

Table 4.5

MONTHLY DEFERRED-TO-62 ANNUITY-DUE VALUES AT 4.0% AS OF JAN. 1, 2021
PRI-2012 PROJECTED GENERATIONALLY

	Age	MP-2021	O2-2021	% Change
Females	25	3.7396	3.7549	*0.41%*
	35	5.4447	5.4671	*0.41%*
	45	7.9383	7.9700	*0.40%*
	55	11.6099	11.6627	*0.45%*
	65	14.2572	14.3188	*0.43%*
	75	10.2580	10.3558	*0.95%*
	85	6.1979	6.2908	*1.50%*
	95	3.3605	3.3624	*0.06%*
Males	25	3.5054	3.5342	*0.82%*
	35	5.1011	5.1428	*0.82%*
	45	7.4405	7.4957	*0.74%*
	55	10.8960	10.9785	*0.76%*
	65	13.3798	13.4836	*0.78%*
	75	9.4558	9.5786	*1.30%*
	85	5.4867	5.6200	*2.43%*
	95	2.8883	2.9195	*1.08%*

4.4 History of Impact of Updates to Scale MP-2014

Scale MP-2021 is the seventh annual update to Scale MP-2014 that has been produced by the SOA. Table 4.6 shows the history of year-over-year changes in annuity factors by age and gender for each of these annual updates. These percentages reflect all changes made each year, including data updates as well as any changes to the model parameters or committee selected assumptions. These percentage changes were computed on the following basis:

- Employee rates for ages below 62 and retiree rates for ages 62 and older[5]
- A discount rate of 4%
- RP-2006 as the base table for MP-2015 through MP-2018 and Pri-2012 as the base table for MP-2019 through MP-2021

Table 4.6
HISTORY OF YEAR-OVER-YEAR CHANGE TO ANNUITY FACTORS FROM UPDATES TO SCALE MP-2014

	Age	MP-2015	MP-2016	MP-2017	MP-2018	MP-2019	MP-2020	MP-2021
Females	25	-1.4%	-1.3%	-0.7%	-0.4%	-0.4%	-0.4%	0.3%
	35	-1.4%	-1.4%	-0.7%	-0.4%	-0.3%	-0.3%	0.3%
	45	-1.5%	-1.5%	-0.7%	-0.4%	-0.3%	-0.4%	0.3%
	55	-1.5%	-1.5%	-0.7%	-0.3%	-0.3%	-0.4%	0.3%
	65	-1.7%	-1.3%	-0.6%	-0.2%	-0.3%	-0.5%	0.3%
	75	-3.0%	-1.8%	-1.0%	-0.3%	-0.5%	-0.8%	0.4%
	85	-4.5%	-3.2%	-1.5%	-0.2%	-0.8%	-1.0%	0.4%
Males	25	-0.9%	-1.7%	-0.9%	-0.7%	-0.6%	-0.2%	0.1%
	35	-1.0%	-1.8%	-0.8%	-0.7%	-0.5%	-0.3%	0.1%
	45	-1.1%	-1.7%	-0.8%	-0.6%	-0.4%	-0.3%	0.1%
	55	-1.2%	-1.6%	-0.8%	-0.5%	-0.3%	-0.5%	0.2%
	65	-1.4%	-1.5%	-0.7%	-0.4%	-0.2%	-0.6%	0.2%
	75	-2.7%	-1.7%	-1.0%	-0.3%	-0.6%	-0.8%	0.4%
	85	-3.4%	-2.9%	-1.4%	-0.3%	-1.0%	-1.0%	0.3%

Table 4.6 indicates MP-2021 creates the first increase in annuity values due to an annual update to Scale MP-2014.

Scale MP-2014 included historical mortality data through calendar year 2009. As can be seen in the heat maps in Appendix A, mortality improvement for retirement-aged individuals was relatively high during the 2000–2009 decade. Since then, there has generally been a trend of lower mortality improvement, including negative improvement for some age groups in certain years.

[5] For RP-2006, healthy annuitant rates were used for ages 62 and older.

Some annual updates included more than just adding one additional year of historical data. In particular:

- The effects shown for Scale MP-2015 were due to the addition of two new years of historical data for 2010 and 2011.
- Scale MP-2016 added three new years of historical mortality information (2012−14), as well as some changes to the committee-selected assumption set.[6]
- The effects shown for Scale MP-2020 primarily reflect a change in the committee-selected long-term rate of mortality improvement; see subsection 4.1 of the Scale MP-2020 report (SOA 2020).

[6] Scale MP-2016 also introduced two changes to the committee-selected assumption set. First, the length of the age-period (horizontal) convergence period used to transition from near-term improvement rates to the long-term improvement rates was shortened from 20 years to 10 years. Second, the initial slope for the cubic polynomials used to transition from near-term improvement rates to the long-term improvement rates was fixed at zero. Previous iterations of the scale based the slope on the most recent two years of historical data, constrained to +/−0.003.

Section 5: Considerations Related to COVID-19

5.1 Mortality Experience in the United States during the COVID-19 Pandemic

COVID-19 has greatly affected mortality rates in the United States since March 2020. The pandemic continues to exert significant impact on population mortality through the date of this report's authorship. The impact of COVID-19 on mortality rates, however, has not been evenly dispersed by geography, race, gender, or socio-economic level. The excess death rates have also varied substantially from period to period with pronounced peaks and less-elevated valleys.

The SOA has conducted extensive research into the impact of the pandemic on mortality rates. This research includes an analysis of population mortality data (Leavitt 2021). This analysis, updated in May 2021, calculates excess mortality rates by age and gender.[7] Table 5.1 shows the actual-to-expected (A/E) mortality ratios from that analysis.

Table 5.1
EXCESS MORTALITY RATES FOR THE 40 WEEKS MARCH 22, 2020 THROUGH DEC. 26, 2020

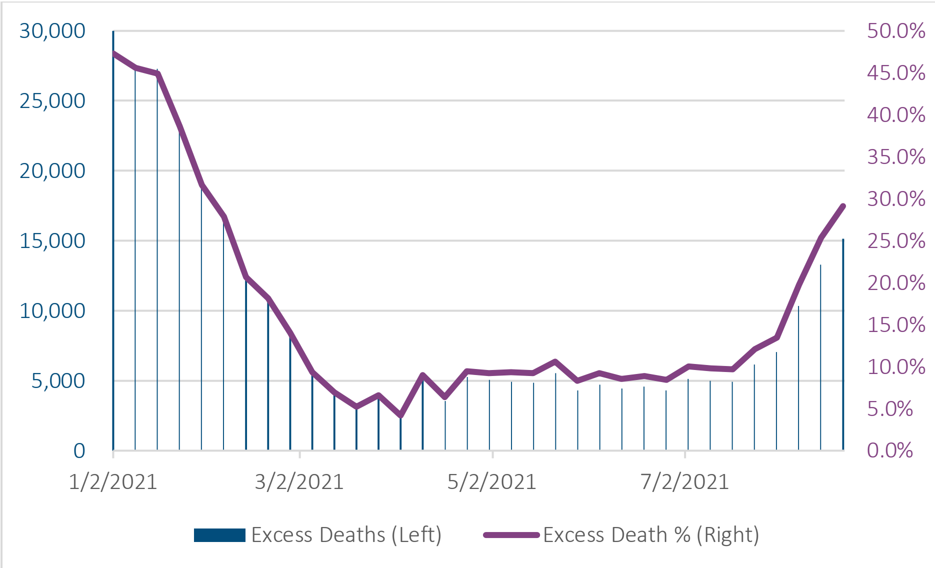
	Females			Males		
Age	Total A/E	COVID-19	Exc. COVID-19	Total A/E	COVID-19	Exc. COVID-19
15–24	119.0%	3.6%	115.4%	125.3%	2.1%	123.2%
25–34	118.7%	6.3%	112.4%	122.5%	4.7%	117.9%
35–44	124.0%	9.4%	114.6%	128.9%	10.1%	118.8%
45–54	122.8%	12.7%	110.2%	128.7%	15.8%	112.9%
55–64	116.4%	13.7%	102.6%	121.2%	15.9%	105.3%
65–74	120.4%	16.6%	103.9%	122.8%	19.2%	103.7%
75–84	121.2%	17.7%	103.5%	123.5%	20.8%	102.7%
>84	119.5%	17.0%	102.5%	119.4%	18.9%	100.4%
All ages	119.7%	16.0%	103.7%	122.3%	17.5%	104.8%

The data compiled in the Leavitt paper showcase that mortality rates were higher than expected among nearly all age groups. While rates ascribed to COVID-19 were materially higher in those over age 65, excess mortality of more than 15% was present for both males and females and all age groups above age 15. Males, overall, exhibited higher excess mortality and a higher rate of death from COVID-19.

Significant excess mortality has continued into 2021. Figure 5.1 shows weekly excess deaths for 2021 through Aug. 21. The rate of excess deaths in January and February peaked at more than 45%. During the spring/early summer, the excess death rate moderated significantly as the roll out of vaccines protected many of the most vulnerable groups. Nonetheless, due to incomplete inoculation rates and the advance of the delta variant, excess deaths increased significantly during late July and approached 30% by the week ended Aug. 21.

[7] Excess mortality rates are determined as the percentage increase in observed mortality over expectations. These expectations were developed using trends for mortality rates and population counts by sex and age.

Figure 5.1
2021 WEEKLY EXCESS DEATHS AND EXCESS MORTALITY RATES THROUGH AUG. 21



Based on data available from the CDC, in many states the first six months experienced greater excess death rates than the full year of 2020 (NCHS 2021b). For the 34-week period through Aug. 21, 2021, excess deaths in the U.S. were approximately 16.8%, which compares to 16.2% for all of 2020. More recent data from the CDC for the month of September shows a moderation in excess death rates; however, recent weeks' data is less complete and, consequently, the degree to which the recent wave has ebbed remains uncertain.

5.2 COVID-19, Scale MP-2021 and the MIM-2021 Projection Model

As stated in subsection 2.1, the MP-2021 projection scale is based upon historical mortality information through calendar year 2019, before the COVID-19 pandemic. Accordingly, MP-2021 does not reflect any historical or potential future effects of COVID-19.

The Committee discussed at length whether to include COVID-19 effects in the standard MP-2021 scale. Currently there remains a good deal of uncertainty within the actuarial community and more broadly about the near and long-term effects of COVID-19. The degree to which vaccines and treatments will be able to control the pandemic long term has yet to be determined, and the frequency and severity of future variant strains is unknown. It is also uncertain how COVID-19 infections may affect a person's health long term.

Accordingly, the Committee decided that it would be best if the effects, if any, of COVID-19 on future mortality improvement for a particular pension population were an assumption chosen by individual practitioners. To facilitate this, the MIM-2021 Application Tool includes a COVID-19 adjustment section so that users could more easily incorporate their COVID-19 adjustments into a projection scale. The COVID-19 adjustment section of the MIM-2021 Application Tool can be found in "Step 4b" of the input section on the "1. model" tab.

The COVID-19 adjustment section is set up such that users can enter specific loads on mortality for each year 2020 through 2024 and separately for 2025 and beyond (if a long-term COVID-19 adjustment is desired). These adjustments can be defined differently for each combination of age and sex. Amounts entered into this section for 2020 through 2024 will be reflected in the resulting projection scale as a percentage load on mortality only for the year listed and will be automatically reversed out in the subsequent year unless mortality loads are also entered for the subsequent year. Blank cells will be interpreted by the MIM-2021 Application Tool as a 0% load.

For instance, if users wanted to load 2020 mortality levels for males and females for all ages by 18%, load 2021 mortality levels by 10% and apply no load for all subsequent years, they would enter 18% for all ages under the 2020 column and 10% for all ages under the 2021 column. In this example, the improvement rates for 2022 in the resulting scale would include an adjustment to reset 2022 mortality projections to what they would have been had the COVID-19 adjustment section been left blank.

Additional, detailed examples of how to use the COVID-19 adjustment section of the MIM-2021 Application Tool are provided in Appendix D.

Section 6: Online Tools

The SOA has made available the following resources that users may find helpful:

- Scale MP-2021 rates can be downloaded in an Excel format here: *https://www.soa.org/resources/experience-studies/2021/mortality-improvement-scale-mp-2021/*.
- The MIM-2021 Application Tool can be used to reconstruct Scale MP-2021 or construct alternative mortality improvement scales using the MIM-2021 framework. The MIM-2021 Data Analysis Tool can be used to analyze the historical datasets included in the MIM-2021 Application Tool. These tools can be downloaded here: *https://www.soa.org/resources/research-reports/2021/mortality-improvement-model/*.

Section 7: Reliance and Limitations

Mortality Improvement Scale MP-2021 has been developed from U.S. population data for the purpose of valuing U.S. pension and other post-employment benefit (OPEB) obligations. No assessment has been made concerning the applicability of the scale to other purposes.

Section 8: Acknowledgements

The Society of Actuaries would like to thank the Retirement Plans Experience Committee, and especially the Mortality Improvement Subcommittee, for their support, guidance, direction and feedback throughout the project.

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Appendix A: Heat Maps

The next two pages compare the MP-2021 and O2-2021 gender-specific heat maps for calendar years 1951 through 2039.[8] Because of the continued use of a two-year step-back in both sets of rates, 2017 is the final year of graduated historical data included explicitly and 2018 is the first year of the projected rates. The vertical dashed white lines on the heat maps distinguish between the historical and projected rates, and the thin vertical gray lines indicate the 2021 rates.

[8] The ultimate rates are achieved in 2037; two additional years are shown to illustrate that the rates level off.

Figure A.1
SCALE MP-2021 HEAT MAP, FEMALES

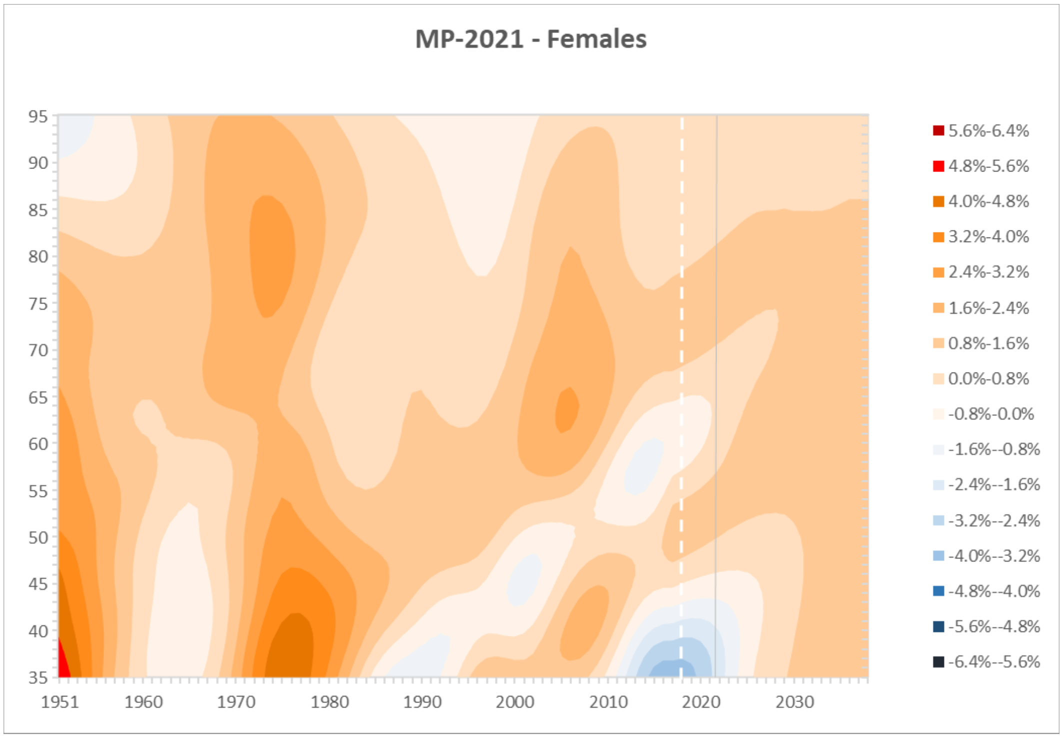


Figure A.2
SCALE MP-2021 HEAT MAP, MALES

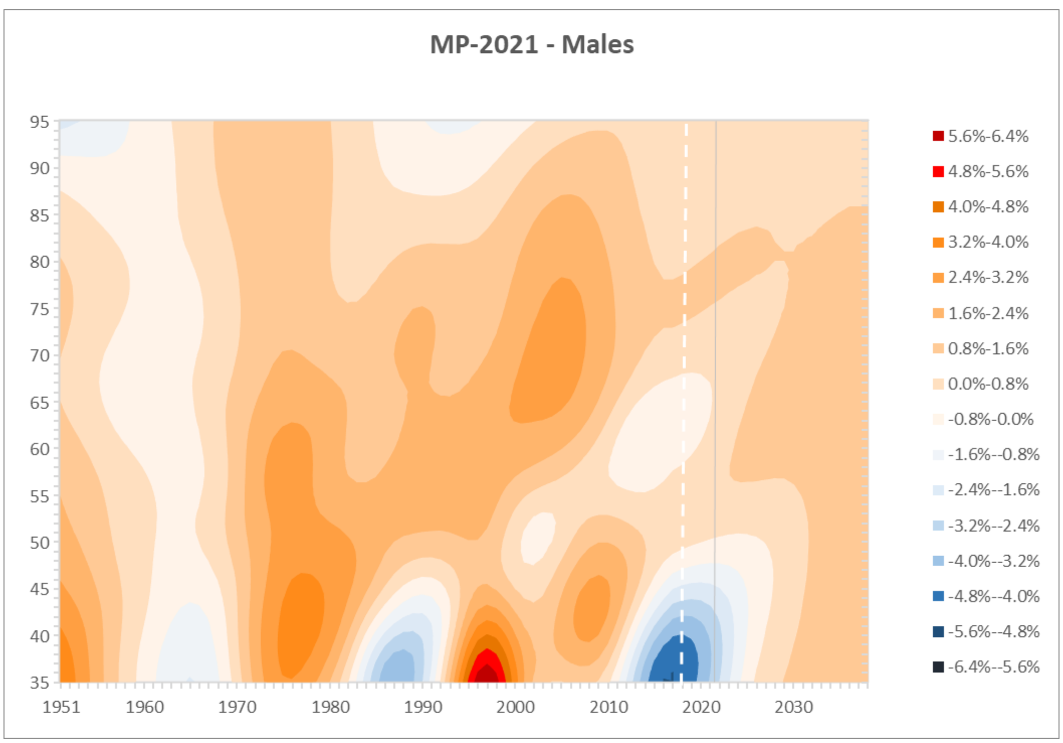


Figure A.3

SCALE O2-2021 HEAT MAP, FEMALES

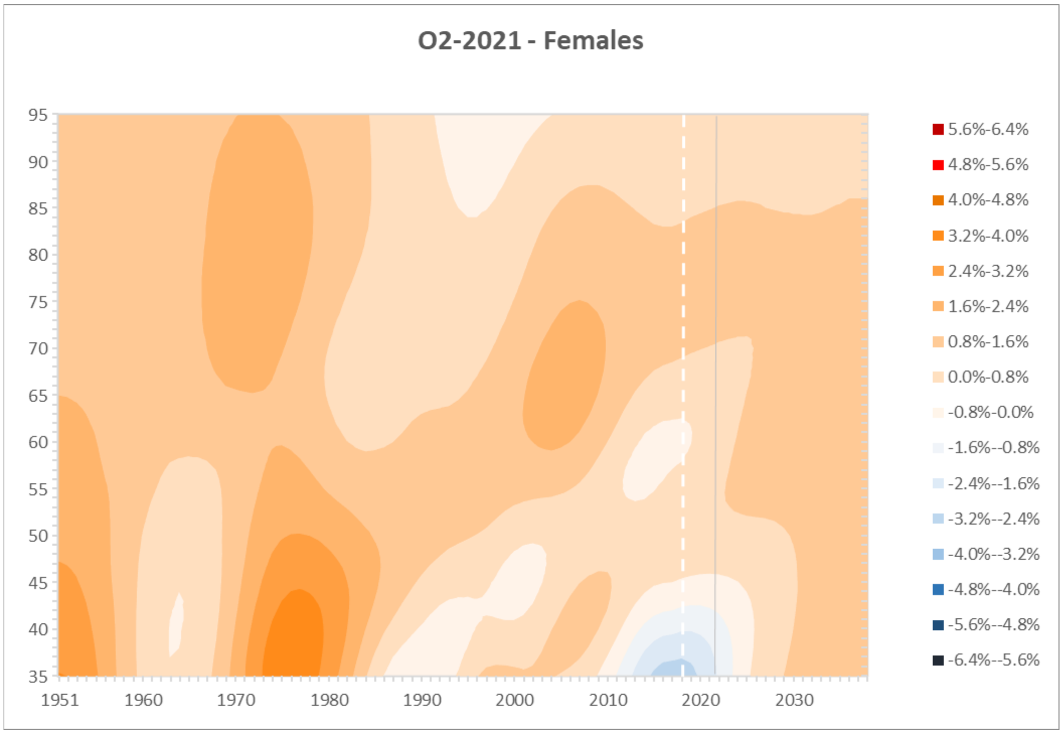
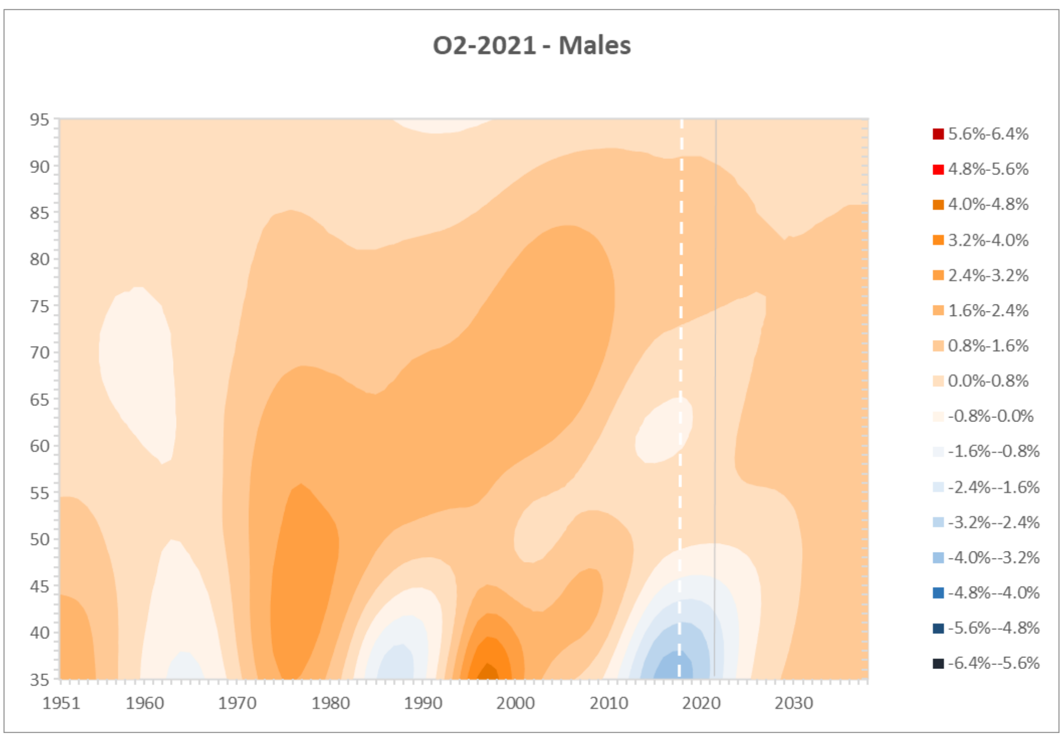


Figure A.4

SCALE O2-2021 HEAT MAP, MALES



Appendix B: Development of SSA-Style Mortality Rates for 2017-2019

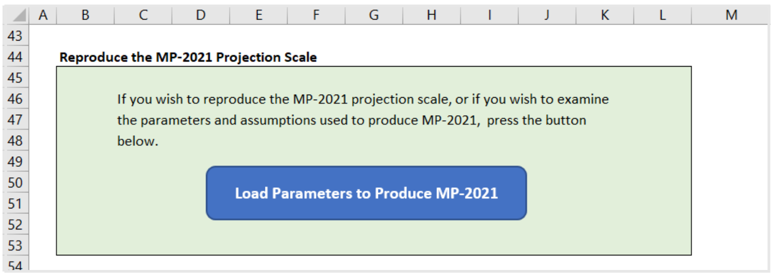
RPEC followed the methodology described in the SSA's Actuarial Study No. 120 (Bell and Miller 2005) in its development of estimated mortality rates for 2017–2019. The deaths for ages below 65 were taken from the CDC Wide-ranging Online Data for Epidemiologic Research WONDER database (CDC 2021), and the exposures for ages below 65 were taken from the most recent population estimates published by the U.S. Census Bureau (USC 2020). Deaths and exposures for ages 65 and above were made available to RPEC by the CMS.

Appendix B1.3 of the Scale MP-2016 Report (SOA 2016) detailed multiple adjustments made to the Medicare data, including averaging adjacent Jan. 1 populations to approximate a July 1 population count and estimating a forthcoming true-up to preliminary death counts for ages 65–69. These adjustments are no longer made due to an update to the manner in which the CMS data has been provided. The CMS exposures are now presented as of mid-year, removing the need for averaging, and there are no longer predictable and significant true-ups of data that take place after the initial release.

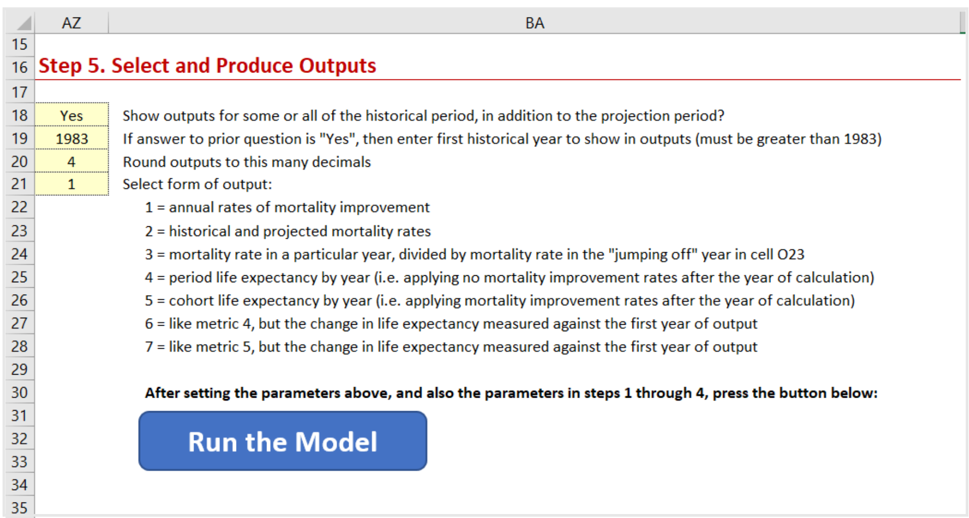
Once the raw gender/age-specific death and exposure databases for each calendar year had been developed, RPEC used the iterative process described in Actuarial Study No. 120 (Bell and Miller 2005) to develop graduated "SSA-Style" mortality rates for 2017–2019.

Appendix C: Using the MIM-2021 Application Tool to Produce Scale MP-2021

Analogous to past versions of the RPEC_2014 Model Implementation Tool, the MIM-2021 Application Tool contains buttons that allow for reproduction of Scale MP-2021. On the "1. model" tab, first click on the button that says, "Load Parameters to Produce MP-2021", found near the bottom of the "Step 1" section.



Next, on the same tab, click on the "Run the Model" button under Step 5, shown below.



The female and male MP-2021 scales will then display at right under the "Summary of Results" section. The buttons at the top of the "Summary of Results" section can be used to generate heat maps or graphs of the improvement rates in the scales.

Appendix D: Examples of COVID-19 Adjustments in MIM-2021 Application Tool

The MIM-2021 Application Tool allows users to specify loads for **mortality rates** (note: not **improvement** rates) due to the COVID-19 pandemic. These rates are input on a select-and-ultimate basis, with individual loads that can be specified by age and sex for each individual calendar year from 2020 through 2024, with a load (by age and sex) that will apply for calendar years 2025 and beyond.

These loads should be input in "Step 4b. COVID-19 Loads". This appendix details examples of how various inputs to these loads affect the resultant mortality improvement rates. These examples are merely illustrations of how the tool responds to the input and should **not** be considered recommendations for mortality loads.

These examples will focus on the mortality improvement rates for females from Scale MP-2021. Below are select Scale MP-2021 mortality improvement rates for females age 49–51 with no adjustment for COVID-19.

	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027
49	0.0103	0.0094	0.0084	0.0073	0.0063	0.0054	0.0047	0.0042	0.0041	0.0042
50	0.0113	0.0107	0.0099	0.0090	0.0080	0.0070	0.0063	0.0057	0.0053	0.0053
51	0.0115	0.0113	0.0108	0.0101	0.0093	0.0084	0.0077	0.0070	0.0066	0.0064

Example 1. Single Load for 2020

Suppose a user inputs a 15% mortality load for 2020 (note: this can be varied by age but is the same for all ages in this example) and leaves all the remaining load cells blank. This assumption means that mortality rates are 15% higher than what they would have been in 2020 absent COVID-19, but that mortality rates in all years after 2020 are unaffected and revert to what they would have been if no load had been input.

Step 4b. COVID-19 Loads

Applied after base MI rates
"10.00%" means 1.10 times mortality rate
Blanks indicate a 0% load

	Female					
	2020	2021	2022	2023	2024	2025+
49	15.00%					
50	15.00%					
51	15.00%					

Below are the resultant improvement rates that correspond to this input:

	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027
49	0.0103	0.0094	-0.1403	0.1368	0.0063	0.0054	0.0047	0.0042	0.0041	0.0042
50	0.0113	0.0107	-0.1386	0.1382	0.0080	0.0070	0.0063	0.0057	0.0053	0.0053
51	0.0115	0.0113	-0.1376	0.1392	0.0093	0.0084	0.0077	0.0070	0.0066	0.0064

Note that the 2020 improvement rate becomes very negative in response to the 15% mortality load for 2020. However, because there is no such load for 2021, the 2021 improvement rate becomes large and positive to revert projected 2021 mortality rates to what they would be had no loads been input at all. There are no changes to improvement rates for 2022 and beyond.

Example 2. Gradual Wear-off

Suppose instead that the user inputs the below loads to model a gradual wear-off of the effects of COVID-19 for females, with some persisting long-term effects.

Step 4b. COVID-19 Loads

Applied after base MI rates
"10.00%" means 1.10 times mortality rate
Blanks indicate a 0% load

	Female					
	2020	2021	2022	2023	2024	2025+
49	15.00%	10.00%	8.00%	5.00%	3.00%	2.00%
50	15.00%	10.00%	8.00%	5.00%	3.00%	2.00%
51	15.00%	10.00%	8.00%	5.00%	3.00%	2.00%

This input creates gradually decreasing loads from 2020 through 2025. Note that the 2.00% load input for 2025 applies for all years 2025 and beyond. Below are the resultant improvement rates from these COVID-19 loads to Scale MP-2021.

	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027
49	0.0103	0.0094	-0.1403	0.0505	0.0244	0.0330	0.0236	0.0139	0.0041	0.0042
50	0.0113	0.0107	-0.1386	0.0520	0.0260	0.0346	0.0252	0.0153	0.0053	0.0053
51	0.0115	0.0113	-0.1376	0.0531	0.0273	0.0360	0.0266	0.0167	0.0066	0.0064

The 2020 improvement rate becomes the same as in Example 1. However, the 2021 through 2025 improvement rates have significantly increased from the Scale MP-2021 values. A 15% load on 2020 mortality rates and a 10% load on 2021 mortality rates create a situation in which mortality is substantially lower in 2021 than 2020, so the 2021 improvement rate is high and positive. Similar logic applies for the other years of the wear-off, albeit to a smaller degree in this example. Note that improvement rates for 2026 and beyond will not change from their Scale MP-2021 values even though the long-term mortality rates have increased. The reason is because the 2% load is a constant multiplier to mortality for all years 2025 and after, so the ratio of mortality rates in consecutive years after 2025 remains the same as if there were no input loads.

The below table shows the development of the above mortality improvement rates using the example of mortality rates computed using the Pri-2012 Total Dataset mortality rate for a female age 50 and Scale MP-2021. Note that the adjustments to improvement rates are independent of the underlying mortality table chosen.

Table D.1

EFFECT OF COVID-19 LOADS ON MORTALITY IMPROVEMENT;
FEMALE AGE 50 USING PRI-2012 TOTAL DATASET AND SCALE MP-2021 WITH LOADS SHOWN

Year	Mortality Rate	Improvement	Mortality Load	Mortality with Loads	Improvement with Loads
2017	0.00261			0.00261	
2018	0.00258	0.0113		0.00258	0.0113
2019	0.00256	0.0107		0.00256	0.0107
2020	0.00253	0.0099	15.00%	0.00291	-0.1386
2021	0.00251	0.0090	10.00%	0.00276	0.0520
2022	0.00249	0.0080	8.00%	0.00269	0.0260
2023	0.00247	0.0070	5.00%	0.00260	0.0346
2024	0.00246	0.0063	3.00%	0.00253	0.0252
2025	0.00244	0.0057	2.00%	0.00249	0.0153
2026	0.00243	0.0053	2.00%	0.00248	0.0053
2027	0.00242	0.0053	2.00%	0.00246	0.0053

Appendix E: Annuity Factors Computed at 7.0%

Table E.1 presents a comparison of monthly deferred-to-62 annuity-due values using various SOA mortality tables, all calculated generationally as of 2021 ("Generational @ 2021") using Scale MP-2021. The Pri-2012 column of the table uses the "total dataset" version of Pri-2012. These annuity values were computed using these specifications:

Employee rates for ages below 62 and retiree rates for ages 62 and older
A discount rate of 7.0%

Table E.1

MONTHLY DEFERRED-TO-62 ANNUITY-DUE VALUES AT 7.0% AS OF JAN. 1, 2021
SOA MORTALITY TABLES PROJECTED WITH SCALE MP-2021

	Age	Pri-2012	PubG-2010	PubT-2010	PubS-2010
Females	25	0.9593	0.9837	1.0039	0.9660
	35	1.8643	1.9149	1.9579	1.8804
	45	3.6293	3.7344	3.8242	3.6665
	55	7.0888	7.3034	7.4892	7.1629
	65	10.8808	11.2201	11.5444	10.9504
	75	8.4197	8.7987	9.1448	8.5227
	85	5.4551	5.7282	6.0166	5.6108
	95	3.1159	3.2303	3.2755	3.2229
Males	25	0.9105	0.9298	0.9663	0.9306
	35	1.7695	1.8059	1.8804	1.8098
	45	3.4479	3.5210	3.6688	3.5276
	55	6.7470	6.9013	7.1918	6.8975
	65	10.3605	10.5887	11.0509	10.5051
	75	7.8707	8.0767	8.5189	7.9175
	85	4.8935	5.0907	5.3842	4.9227
	95	2.7041	2.8630	2.8905	2.8154

Table E.2 shows how these annuity factors compare to those calculated using Scale MP-2020.

Table E.2

IMPACT OF UPDATING FROM SCALE MP-2020 TO MP-2021 USING VARIOUS BASE MORTALITY TABLES
COMPARISON OF MONTHLY DEFERRED-TO-62 ANNUITY-DUE VALUES AT 7.0% AS OF JAN. 1, 2021

	Age	Pri-2012	PubG-2010	PubT-2010	PubS-2010
Females	25	0.20%	0.15%	0.13%	0.17%
	35	0.20%	0.16%	0.14%	0.18%
	45	0.22%	0.18%	0.15%	0.20%
	55	0.21%	0.17%	0.14%	0.19%
	65	0.22%	0.18%	0.15%	0.21%
	75	0.37%	0.31%	0.28%	0.34%
	85	0.38%	0.34%	0.32%	0.36%
	95	0.38%	0.37%	0.36%	0.37%
Males	25	0.08%	0.04%	0.05%	0.06%
	35	0.06%	0.05%	0.04%	0.06%
	45	0.09%	0.07%	0.06%	0.08%
	55	0.12%	0.10%	0.08%	0.10%
	65	0.16%	0.14%	0.12%	0.14%
	75	0.33%	0.29%	0.25%	0.31%
	85	0.29%	0.28%	0.25%	0.29%
	95	0.19%	0.20%	0.19%	0.20%

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