

Mortality and Longevity

MIM-2021 Application Tool User Guide





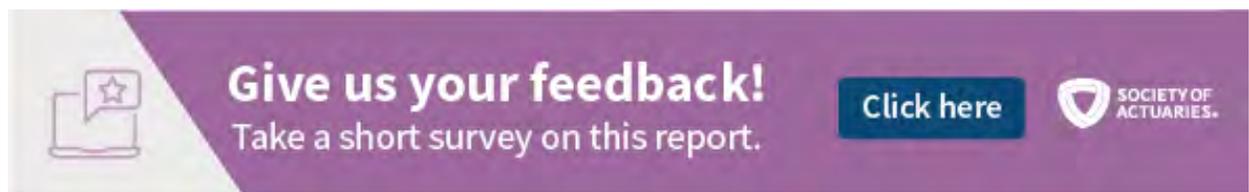
MIM-2021 Application Tool User Guide

AUTHOR

Longevity Advisory Group:
 Larry N. Stern, Chair, FSA, MAAA
 Jean-Marc Fix, FSA, MAAA
 Sam Gutterman, FSA, MAAA, CERA, FCAS,
 FCA, HonFIA
 R. Dale Hall, FSA, MAAA, CERA, CFA
 Thomas A. Jones, ASA, MAAA
 Allen M. Klein, FSA, MAAA
 Patrick David Nolan, FSA, MAAA
 Laurence Pinzur, Ph.D.
 Ronora Stryker, ASA, MAAA
 Patrick Wiese, ASA

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MIM-2021 Application Tool User Guide

Section 1: Introduction

Two Excel-based tools (and accompanying user guides) were released in connection with the MIM-2021 Report¹. The MIM-2021 Data Analysis Tool was created to help users compare and analyze various historical U.S. mortality data sets. The MIM-2021 Application Tool enables users to develop their own set of mortality improvement rates (or in some cases deterioration) under the MIM-2021 framework. This document is a step-by-step guide for the MIM-2021 Application Tool.

As described in that Report, the conceptual underpinnings of the new projection model are:

- Short-term mortality improvement rates should be based on recent experience.
- Long-term mortality improvement rates should be based on expert opinion.
- Short-term mortality improvement rates should blend smoothly into the assumed long-term rates over an appropriate transition period.

The MIM-2021 Application Tool first requires the user to select a set of mortality rates as the historical basis for the projection. These historical mortality rates are used to develop a pattern of mortality improvement prior to the projection period, as well as establishing the starting values for short-term mortality improvement rates.

Then the user must enter a number of inputs into the underlying model related to the assumed long-term level of mortality improvement:

- Certain key dates in the future, including the overall time horizon for the projection,
- Assumptions for the long-term – and, if desired, the intermediate-term – levels of mortality improvement, and
- The type of results desired, e.g., the calculated mortality improvement rates or life expectancies produced by applying those rates to a set of base mortality rates.

The smooth blending of mortality improvement rates from recent experience to the assumed long-term rates is performed by the MIM-2021 Application Tool, and is based on a set of interpolating curves described in more detail in the “Step 2” subsection of Section 2.

As described in Section IV of the MIM-2021 Report², the MIM-2021 Application Tool always produces two sets of gender-specific mortality improvement arrays – one in which the rates are projected horizontally along individual ages and a second in which the rates are projected diagonally along individual year-of-birth cohorts. The final array of MI rates is based on a user-specified linear combination of the two projections.

Section 2: Tab 1

STEP 1: SELECT THE APPROPRIATE HISTORICAL DATA SET

The MIM-2021 Application Tool comes preloaded with a number of sets of historical U.S. mortality rates, including:

- Population mortality rates published by the Social Security Administration (SSA) going back to 1982.
- Population mortality rates developed from National Center for Health Statistics (NCHS) death counts starting in 1982 and U.S. census data going back to 1980.
- A variety of subsets of the NCHS national population data set, split into ranges (quintiles and deciles) based on estimated socioeconomic categories³. These subsets can be selected individually, or blended in combination with other subsets to more closely approximate the anticipated mortality experience of the covered population to which the resulting mortality improvement rates are to be applied.
- Two additional groups of “static” NCHS decile data sets. These deciles have been based on socioeconomic categories fixed as of 1980⁴ and 2016, respectively, as contrasted to the subsets described in the immediately preceding bullet, which reflect changes in socioeconomic deciles as they varied over time.

With respect to the last two bullets, socioeconomic category 1 represents individuals living in the lowest socioeconomic scored quintile/decile counties in the U.S., and categories 5 (for quintile) and 10 (for decile) represent individuals living in the highest socioeconomic scored counties in the U.S.

Note that there is no option for combining quintile data sets with decile data sets. Such a combination can still be accomplished by selecting the desired combination of decile subsets, making sure the total allocation adds up to 100%.

Figure 1 displays the opening input cells⁵ for Step 1.

Figure 1
MIM-2021 APPLICATION TOOL STEP 1 INPUT CELLS

Step 1. Select the Appropriate Historical Dataset

1 Dataset for determining rates of mortality improvement
 1 = SSA
 2 = NCHS, national-level (no quintiles or deciles; rather, all data merged together)
 3 = NCHS, quintiles
 4 = NCHS, deciles
 5 = NCHS, static deciles based on 1980 socioeconomic data
 6 = NCHS, static deciles based on 2016 socioeconomic data

Weight Placed on Each Quintile or Decile of NCHS Data (for options 3 through 6 above)

1	2	3	4	5	6	7	8	9	10	Total

1 = lowest socioeconomic decile; 10 = highest decile (5 = highest quintile)

The two national-level population data sets (options 1 and 2) do not require any further inputs in Step 1. If the user opts for one of the quintile or decile data sets (options 3 through 6), the appropriate number of slots become open for weighting percentages. Figures 2 and 3 show examples for Option 3 (NCHS quintiles) and Option 4 (NCHS deciles), respectively.

Figure 2
MIM-2021 APPLICATION TOOL STEP 1 INPUT CELLS – OPTION 3 EXAMPLE

Step 1. Select the Appropriate Historical Dataset

3 Dataset for determining rates of mortality improvement
 1 = SSA
 2 = NCHS, national-level (no quintiles or deciles; rather, all data merged together)
 3 = NCHS, quintiles
 4 = NCHS, deciles
 5 = NCHS, static deciles based on 1980 socioeconomic data
 6 = NCHS, static deciles based on 2016 socioeconomic data

Weight Placed on Each Quintile or Decile of NCHS Data (for options 3 through 6 above)

1	2	3	4	5	6	7	8	9	10	Total
0%	0%	0%	0%	0%						0%

1 = lowest socioeconomic decile; 10 = highest decile (5 = highest quintile)

Figure 3
MIM-2021 APPLICATION TOOL STEP 1 INPUT CELLS – OPTION 4 EXAMPLE

Step 1. Select the Appropriate Historical Dataset

- 4** Dataset for determining rates of mortality improvement
- 1 = SSA
 - 2 = NCHS, national-level (no quintiles or deciles; rather, all data merged together)
 - 3 = NCHS, quintiles
 - 4 = NCHS, deciles
 - 5 = NCHS, static deciles based on 1980 socioeconomic data
 - 6 = NCHS, static deciles based on 2016 socioeconomic data

Weight Placed on Each Quintile or Decile of NCHS Data (for options 3 through 6 above)

1	2	3	4	5	6	7	8	9	10	Total
0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%

1 = lowest socioeconomic decile; 10 = highest decile (5 = highest quintile)

Note in each of the options 3 through 6, the “Total” cell must equal exactly 100% before proceeding to subsequent steps.

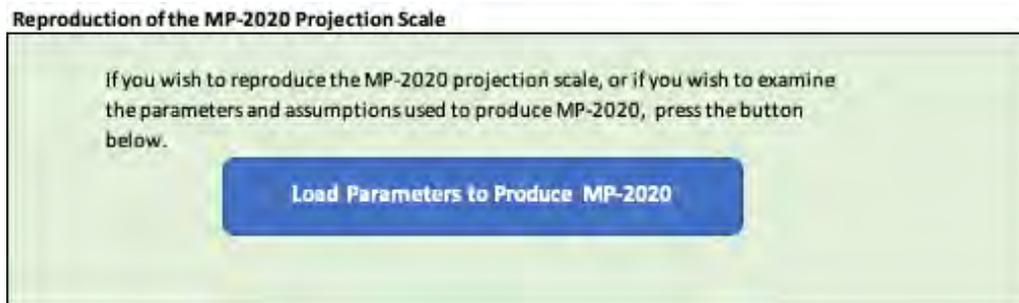
Step 1 also includes two optional inputs. By entering “Yes” in cell B38, the user can enter a set of gender-/age-specific base mortality rates⁶. These user-supplied mortality rates will not be used to generate any historical or future MI rates. Rather, they will be used (in lieu of the base rates in the selected historical mortality table) in the calculation of certain results described in the “Step 5” section.

Figure 4
MIM-2021 APPLICATION TOOL STEP 1 INPUT CELLS – CELL B38

No I wish to enter a base table of (ultimate) mortality rates in columns AI and AJ. With this setting, if you output projected mortality sets, the base year mortality table will be drawn from the same dataset selected in cell B18.

The user can also load the parameter set that will reproduce the results of the MP-2020 mortality improvement scale previously released by the SOA’s Retirement Plans Experience Committee using the “Reproduction of the MP-2020 Mortality Improvement Scale” Button (Figure5).

Figure 5
MIM-2021 APPLICATION TOOL STEP 1 INPUT CELLS – REPRODUCE MP-2020 MORTALITY IMPROVEMENT SCALE BUTTON



STEP 2: SPECIFY OVERALL STRUCTURE AND TIMEFRAME FOR THE PROJECTION

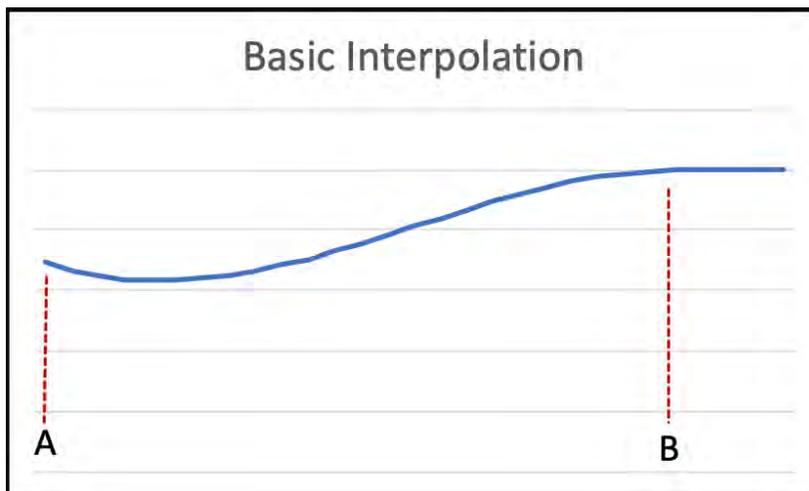
Four key years (labeled A, B, C, and D) can be input starting in cell B9 of the MIM-2021 Application Tool. These dates relate to the overall structure and timing of the transition period from the beginning of the projection period to the point at which the assumed long-term rates begin to apply. Each calculated gender-/age-specific mortality improvement rate in years subsequent to the year in which the long-term rate structure is first attained is set equal to the corresponding assumed long-term rate.

There are two types of interpolation structures for the transition periods⁷: Basic and Advanced.

Basic Interpolation

The Basic Interpolation structures requires the input of two years (separately for each of the horizontal and diagonal projections):

- Year A: The year from the selected historical data set from which the future mortality improvement rates are generated (also referred to as the “jumping-off” point); and
- Year B: The first year in which the assumed long-term mortality improvement rates are attained.

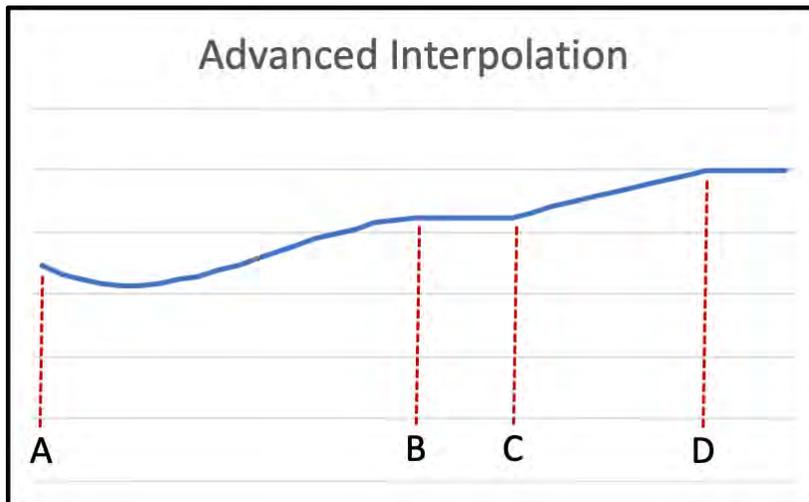


The Basic Interpolation curve is a cubic polynomial passing through two MI rates (at years A and B) and matching two specified slopes at those times. Additional information about these cubic polynomials, including their underlying formulae, can be found in Appendix A of the MIM-2021 Report.

Advanced Interpolation

The Advanced Interpolation structures allow the user to include a set of intermediate-term MI rates at some time between year A and the first year in which assumed long-term mortality improvement rates are attained. Four years (separately for each of the period and cohort projections) are required under this structure:

- Year A: Same as Year A above;
- Year B: The year in which the assumed intermediate-term improvement rates are first attained;
- Year C: The year (on or after Year B) through which the intermediate-term improvement rates remain constant before converging linearly to the assumed long-term rates in Year D; and
- Year D: The first year in which the assumed long-term mortality improvement rates are attained.



Between years A and B, the Advanced Interpolation curve uses the same type of cubic polynomials employed in the Basic Interpolation structure. The interpolation curve remains constant for the period between B and C, where it starts a linear convergence to the assumed long-term rates in year D.

2.1.1 INPUTS TO STEP 2

Figure 6 displays the opening input cells for Step 2.

Figure 6
MIM-2021 APPLICATION TOOL STEP 2 INPUT CELLS

Step 2. Specify Projection Structure and Time Horizon

Through which point in time do you wish to project?	B
Weight Placed on Cohort Projection	50%

Specify the transition periods between sets of improvement rates

Time Point	A	B	C	D
By Age	2016	2026		
By Cohort		2036		

The first input cell in Step 2 (cell R18) determines which of the two interpolation structures will be used. A selection of “B” or “C”⁸ indicates the Basic Interpolation will be used, while a selection of “D” indicates the Advanced Interpolation methodology is desired.

The second input cell (R19) determines the user’s desired balance between the horizontal and diagonal projections. It is acceptable for the user to enter values of either 0%, which would produce a horizontal-only projection (thereby deemphasizing any “cohort” effects), or 100%, which would produce a diagonal-only projection deemphasizing any “period” effects.

The Basic Interpolation entries in the preceding display can be interpreted as follows:

- The jumping-off year for the projection is 2016. This year must be selected from the historical data set and must be the same for both the age and cohort projections.
- The first year the assumed long-term MI rates are attained is 2026 for the age (horizontal) projection and 2036 for the cohort (diagonal) projection.
- Two sets of interpolated MI rates are generated by means of two families of cubic polynomials, one set in the horizontal direction (between 2016 and 2026) and a second set in the diagonal direction (between 2016 and 2036).
- The final set of MI rates are calculated as a 50%/50% blend of the two sets of projected values.
- All MI rates after 2036 are equal to the corresponding MI rate in 2036.
- The mortality-related results specified in Step 5 and displayed in Step 6 will be calculated through 2036.

The Basic Interpolation entries in Figure 7 (with year C selected) can be interpreted in the same way, except that the mortality-related results in the final bullet point above will be calculated through 2050, not 2036.

Figure 7
MIM-2021 APPLICATION TOOL STEP 2 INPUT CELLS – BASIC INTERPOLATION ENTRIES

Step 2. Specify Projection Structure and Time Horizon

Through which point in time do you wish to project?	C
Weight Placed on Cohort Projection	50%

Specify the transition periods between sets of improvement rates

Time Point	A	B	C	D
By Age	2016	2026	2040	
By Cohort		2036	2040	

The following displays an illustrative example of a projection using the Advanced Interpolation structure.

Figure 8
MIM-2021 APPLICATION TOOL STEP 2 INPUT CELLS – ADVANCED INTERPOLATION ENTRIES

Step 2. Specify Projection Structure and Time Horizon

Through which point in time do you wish to project?	D
Weight Placed on Cohort Projection	75%

Specify the transition periods between sets of improvement rates

Time Point	A	B	C	D
By Age	2016	2026	2040	2060
By Cohort		2036	2036	2060

The Advanced Interpolation entries in Figure 8 can be interpreted as follows:

- The jumping-off year for the projection is 2016.
- The MI rates in the age-based projection attain the assumed intermediate-term values in 2026 (by means of a family of cubic polynomials) and remain fixed at that level until 2040, at which point they converge linearly to the assumed long-term rates in 2060.
- The MI rates in the cohort-based projection attain the assumed intermediate-term values in 2036 (by means of a family of cubic polynomials), at which point they immediately start to converge linearly to the assumed long-term rates in 2060.
- The final set of MI rates is calculated as a 25%/75% blend of the horizontal and diagonal projections, respectively.
- All MI rates after 2060 are equal to the corresponding MI rate in 2060.
- The mortality-related results specified in Step 5 and displayed in Step 6 will be calculated through 2060.

STEP 3: SELECT PROJECTION ASSUMPTIONS

In Step 3 the user selects assumptions about:

1. The years of the historical mortality data set from which the starting values of the MIM-2021 projection are calculated;
2. The years of the historical mortality data set from which the starting slopes of the MIM-2021 interpolating cubic polynomials are calculated, including constraints on how large those initial slopes can be in absolute value;
3. The gender-/age-specific long-term MI rates; and
4. If the Advanced Interpolation structure has been selected, the gender-/age-specific intermediate-term MI rates.

Before delving into the details of the Step 3 entries, it is important to keep in mind that all of the historical mortality improvement experience referenced in this Step has been previously smoothed using the 2D Whittaker-Henderson methodology described in Appendix A of the MIM-2021 Report. So, for example, an assumption based on a single year of experience does not reflect two “raw” values, but rather two values that have been smoothed in both the age and calendar year directions.

Figure 9 displays the first section of the input cells for Step 3.

Figure 9
MIM-2021 APPLICATION TOOL STEP 3 INPUT CELLS

Historical Period Across Which to Compute Improvement Rates at Time Point A		
	Start	End
For setting improvement rates at time point A	2015	2016
For setting slopes of improvement rates at time point A	2015	2016

Note: It is recommended that cell V30 be set equal to cell Q23.

Constraints on Improvement Rate Slopes at Time Point A	
Maximum absolute value of horizontal (period) slope	0.0000
Maximum absolute value of diagonal (cohort) slope	0.0000

The first row of inputs determines the years of smoothed experience used to calculate the starting gender-/age-specific MI rates at the beginning of the projection period. Since short-term mortality improvement rates should be based on recent experience, these years should be close to, but not beyond, year A selected in Step 2⁹. The opening values of 2015 and 2016, for example, mean the MI values at point A will be based on the change in smoothed mortality rates between those two years. If the two selected years are further than one year apart, mortality changes are calculated using geometric averages. These inputs determine the opening MI values for both the horizontal and diagonal projections.

The second row of inputs deal with the initial slope of the interpolating cubic polynomial at point A. For example, the opening values of 2015 and 2016 in the fourth row mean the initial slope of the interpolating cubic is calculated based on the change in MI values between those two years. (This is in contrast to the entries in the first row of Step 3, which are calculated based on the change of smoothed mortality rates.)

The next set of inputs allows the user to add constraints on how steep the jumping-off slopes of the interpolating cubic polynomials can get in absolute value. Although there is some logic in attempting to pick up some of the recent trend in near-term MI rates by reflecting some or all of the historical slope at point A, analysis performed by RPEC¹⁰ has indicated year-over-year volatility of the MI rates tends to be

mitigated by assuming a jumping-off slope of zero for both the horizontal and diagonal projections. This can be achieved by entering the value of zero in cells U41 and U42. Alternatively, users can reflect some limited degree of initial MI slope by restricting its maximum absolute value in cells U41 and U42¹¹.

Users have two options for selecting long-term, and if desired intermediate-term, gender-/age-specific mortality improvement rates:

- The assumed MI rates can be entered directly in columns AA through AD of Tab 1 as appropriate, based on the selected Interpolation Structure, or
- The rates can be calculated as the geometric average across a selected period of time from the historical mortality data set.

Since long-term rates are conceptually expected to be based on “expert opinion”, it is anticipated many users will decide to opt for the first approach above and enter those rates manually, rather than being over reliant on some period of past mortality experience. If the user decides to enter these assumed values manually, the remaining four input cells in Step 3, shown below, should all be left blank.

Figure 10
MIM-2021 APPLICATION TOOL STEP 3 INPUT CELLS – MANUALLY INPUT ASSUMED VALUES

Historical Period Across Which to Compute Improvement Rates at Times B and D

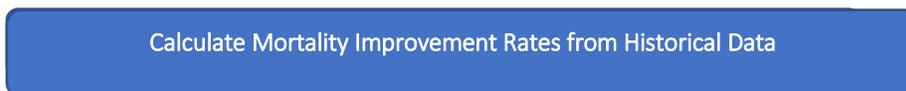
	Start	End
For setting improvement rates at time point B		
For setting improvement rates at time point D		

Users who wish to base their assumed long-term MI rates on some period of the historical database should enter values based on their selected Interpolation Structure:

- Basic Interpolation: Enter the selected beginning and ending years for the long-term rates in the first row of cells (relating to point B) and leave the second row of cells blank;
- Advanced Interpolation: Enter the selected beginning and ending years for the intermediate-term rates in the first row of cells (relating to point B) and enter the selected beginning and ending years for the long-term rates in the second row of cells (relating to point D).

After entering all of the Step 3 inputs, the user must press the “Calculate Mortality Improvement Rates from Historical Data” button (Figure 11) to run the macro that generates the final sets of MI rates:

Figure 11
MIM-2021 APPLICATION TOOL STEP 3 RUNNING MACRO



STEP 4: REVIEW AND REFINE THE ASSUMPTION SET

Step 4 provides the user an opportunity to review and, if necessary, refine the assumptions generated after pressing the final button in Step 3. The gender-specific information summarized for ages 20 through 120 differs based on the interpolation structure selected in Step 2.

- If the Basic Interpolation structure was selected:
 - Columns Y and Z: The initial MI rates at Year A
 - Columns AA and AB: The assumed long-term MI rates at Year B
 - Columns AC and AD: Intentionally blank
 - Columns AE through AH: The initial slopes of the cubic polynomials, reflecting any assumed restrictions in absolute value

- If the Advanced Interpolation structure was selected:
 - Columns Y and Z: The initial MI rates at Year A
 - Columns AA and AB: The assumed intermediate-term MI rates starting at Year B and continuing unchanged until Year C
 - Columns AC and AD: The assumed long-term MI rates at Year D
 - Columns AE through AH: The initial slopes of cubic polynomials, reflecting any assumed restrictions in absolute value

If the user opts to input a set of base mortality rates different from the historical base rates (by selecting “Yes” in cell B38 of Step 1), those rates should be entered in Columns AI and AJ, and identified in cell AJ20 with the appropriate “Table Year”.

STEP 5: SELECT AND PRODUCE OUTPUTS

Figure 12 displays the opening input cells for Step 5.

Figure 12

MIM-2021 APPLICATION TOOL STEP 5 INPUT CELLS

Step 5. Select and Produce Outputs

Yes	Show some or all of the historical period, in addition to the projection period?
1983	If answer to prior question is “Yes”, then enter first historical year to show in outputs (must be greater than 1983)
5	Round outputs to this many decimals
1	Select form of output:
	1 = annual rates of mortality improvement
	2 = historical and projected mortality rates
	3 = mortality rate in a particular year, divided by mortality rate in the “jumping off” year in cell O23
	4 = period life expectancy by year (i.e. applying no mortality improvement rates after the year of calculation)
	5 = cohort life expectancy by year (i.e. applying mortality improvement rates after the year of calculation)
	6 = like metric 4, but the change in life expectancy measured against the first year of output
	7 = like metric 5, but the change in life expectancy measured against the first year of output

The first three entries are self-explanatory. In the fourth entry, the user specifies which results (two-dimensional, age and calendar year) should be displayed in the results section of the Tool:

1. Annual mortality improvement rates
2. Mortality rates
3. The ratio of calculated mortality rates to the corresponding rates in the year in cell O23
4. Period life expectancies; i.e., applying no mortality improvement rates after the year of calculation
5. Cohort life expectancies; i.e., applying mortality improvement rates after the year of calculation
6. The change in period life expectancies measured against the first year of output
7. The change in cohort life expectancies measured against the first year of output

Other than the mortality improvement rates (option 1), all generated values are determined from the user-selected set of base rates, if any, entered in columns AI and AJ of Step 4.

The MIM-2021 Application Tool results are then generated by pressing the “Run the Model” button (Figure 13).

Figure 13
MIM-2021 APPLICATION TOOL STEP 5 RUN THE MODEL BUTTON



SUMMARY OF RESULTS

The selected gender-/age-/year-specific values produced by the Tool start on column AO of Tab 1. The summary section also includes two buttons that generate graphics designed to help the user analyze the results (Figure 14).

Figure 14
MIM-2021 APPLICATION TOOL SUMMARY OF RESULTS BUTTONS



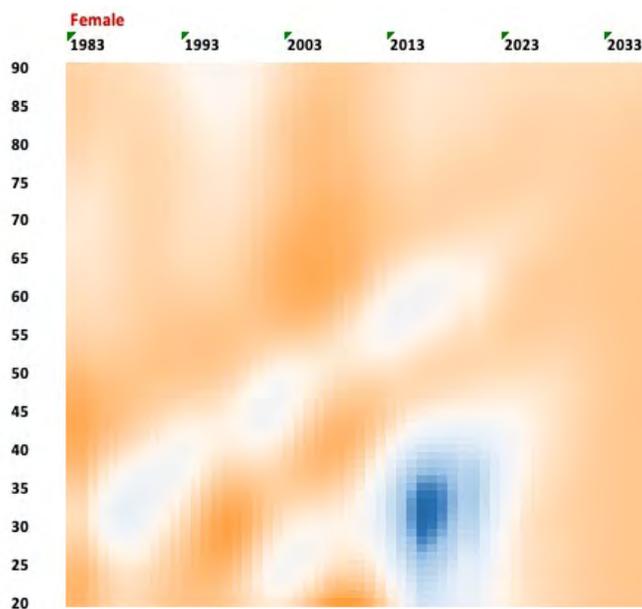
The heat maps are displayed on Tab 2, and the graphs are displayed on Tab 3. More discussion of these tabs is included in the next section.

Section 3: Tabs 2-5

TAB 2

Heat maps can be generated for all of the result options described in Step 5 except for options 4 and 5, the two arrays of life expectancies. Heat maps can be generated for options 6 and 7, the arrays of changes in life expectancies. An example of a heat map showing female MI rates for ages 20 through 90 covering the period 1983 through 2036 is shown in Figure 15.

Figure 15
MIM-2021 APPLICATION TOOL HEAT MAP EXAMPLE

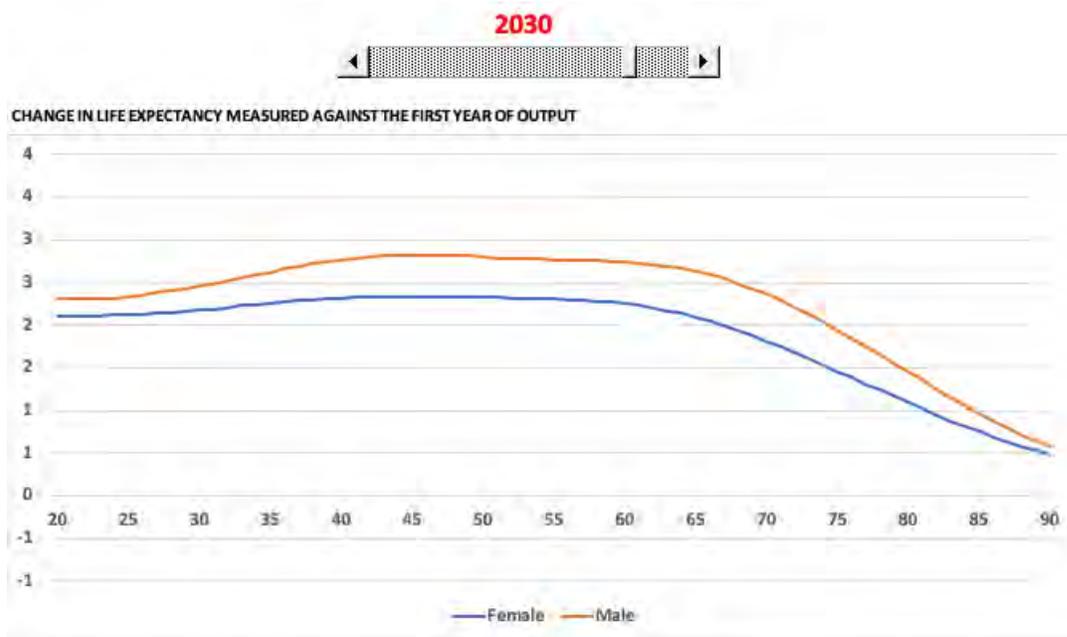


A table with the color-coded legends for each of the possible heat map results is included in the upper left portion of Tab 2. Certain ranges of values and associated colors¹² have been pre-entered into the heat map legend, but the user can modify these if desired. Users who wish to change the color palette must first select “User-Specified” in cell I13. Next, the user must enter their desired color scheme in range C11:R11 by adjusting the background color of each cell (for each cell, press “format” on the Excel menu, followed by “fill”, and then select the desired color). Additionally, with the parameters in C7:R10, a user may adjust the numerical ranges that are mapped to each color. Note that each value in C7:R10 is the upper boundary of a numerical “bucket”, and these boundaries must be entered in ascending order from left to right. All model outputs that exceed the boundary values shown in the final bucket (in range R7:R10) will be mapped to the color of cell R11. Any time the color scheme is changed, or the numerical buckets are changed, the user must re-run the model on Tab 1 for the new colors to take effect on the heat map(s).

TAB 3

A dynamic graph can be generated for all of the result options described in Step 5. When “Run Dynamic Graph” is pressed, the graph loops dynamically from the first year of output to the final year of output. For each year, the data is briefly displayed on the graph; then the graph cycles onward to the next year. Figure 16 displays the format of the graphs on Tab 3, in this case showing an example of the projected increase in period life expectancies between 2000 and 2030 for ages 20 through 90.

Figure 16
MIM-2021 APPLICATION TOOL TAB 3 GRAPH FORMAT



The speed of this dynamic process can be adjusted using the parameter in cell B11 that represents the number of seconds between “slides” or years. Increasing this parameter will slow the graph down, while decreasing the parameter has the opposite effect. The permissible range of values for B11 is from 0 to 5 (seconds between slides).

Alternatively, a user may step through the data manually using the slider positioned just above the graph. Slide to the right to increase the year displayed on the graph, and slide to the left to decrease the year.

TABS 4 AND 5

Tab 4 contains the smoothed mortality rate data for each of the six data sets described earlier (see the six data options shown in Step 1 of the modeling process). Tab 5 contains the corresponding mortality rates in its “raw” or unsmoothed form. On each of these two tabs, columns B and C indicate the data set, column D indicates the year of data, and column E indicates the gender (“m” = male, “f” = female). Columns G through DM show mortality rates by age. The data set acronyms in column B are defined on the “contents” tab in range C21:E25.

While the unsmoothed data runs from ages 0 to 110, the smoothed data runs only from 15 to 97. This asymmetry arises because the smoothing process [described in Appendix A of the MIM-2021 Report] was restricted to ages 15 to 97.

In the case of the SSA data set, “unsmoothed” is not an entirely accurate description of the data. In fact, the data was smoothed by the Social Security Administration using a one-dimensional process in which each year of data was smoothed separately. This data, in turn, was smoothed by the Advisory Group using a two-dimensional smoothing process (by calendar year and age), thus creating the “smoothed” SSA data shown on tab 4.

Section 4: Considerations For Selecting Certain Model Assumptions

Much of the flexibility of MIM-2021 derives from the user’s ability to select various parameters in connection with the interpolating curves. This section of the User Guide provides insights in connection with these important model assumptions.

ASSUMPTIONS REGARDING THE YEARS SELECTED FOR THE JUMPING-OFF MI RATES

In Step 3 of Tab 1, it is recommended the end year for selecting the historical period used to generate the jumping-off MI rates and slopes (cells V30 and V31, respectively) be the same as year A. The rationale for this recommendation is, otherwise, significant MI rate discontinuities can occur at the jumping-off year.

As an illustration, Figure 17 is a heat map showing the MP-2020 MI rates for males, which has a jumping-off year of 2016 (highlighted) and which has jumping-off values based on the smoothed mortality rates between 2015 and 2016. Figure 18 is the heat map showing how the projected rates would change if the jumping-off values were based on the smoothed mortality rates between 2005 and 2006.

Figure 17
MP-2020 MI MALE RATES

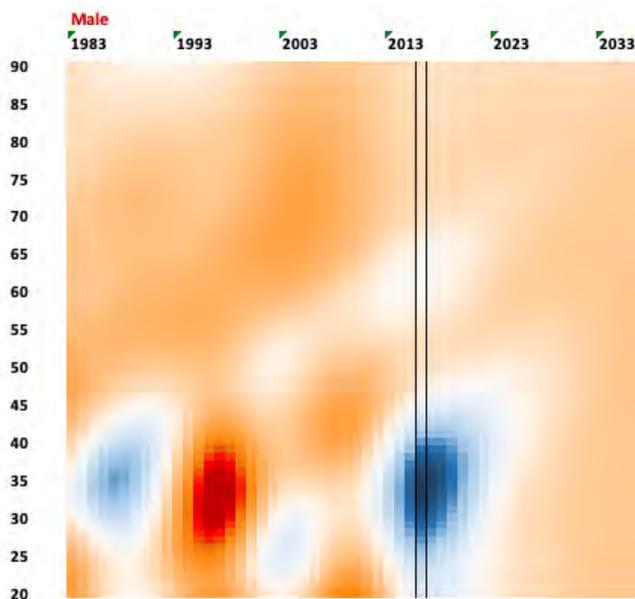
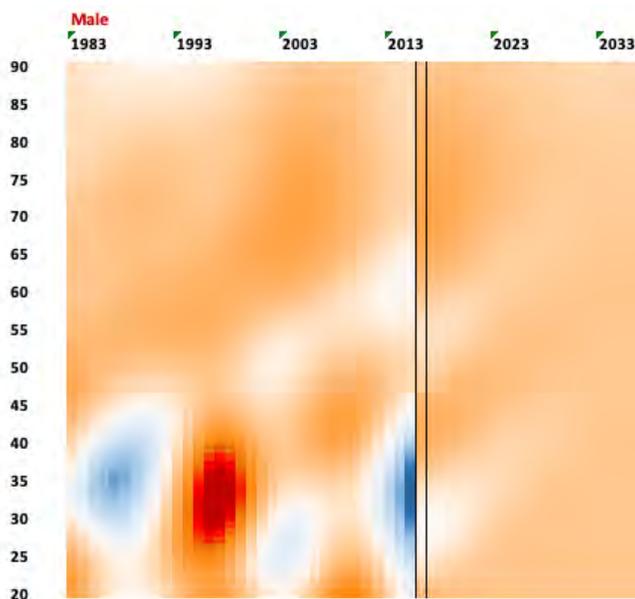


Figure 18
PROJECTED MI MALE RATES BASED ON THE SMOOTHED MORTALITY RATES BETWEEN 2005 AND 2006

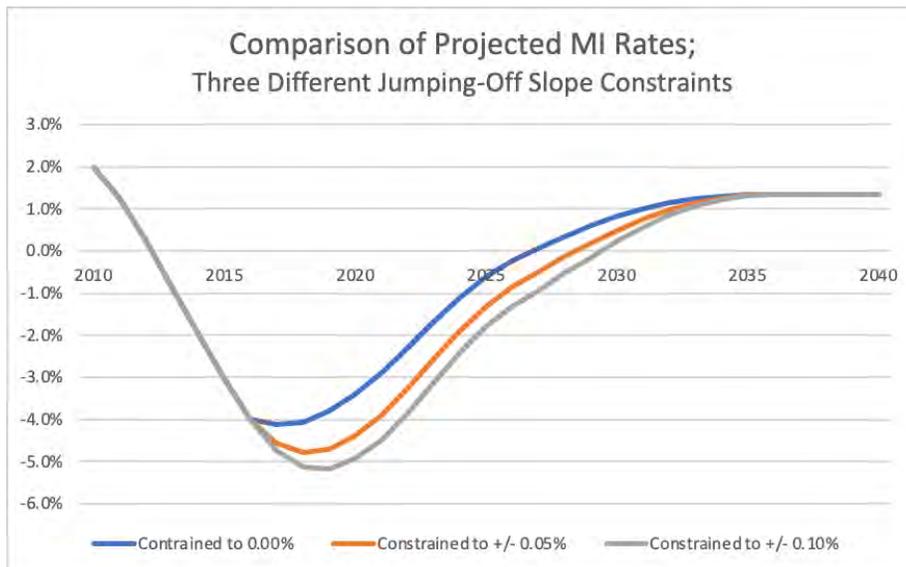


Notice how the 2016 rates in Figure 18 mirror the mortality improvement rates from ten years prior, and how that creates a discontinuity starting in the jumping-off year.

ASSUMPTIONS REGARDING THE JUMPING-OFF SLOPE CONSTRAINTS

The parameters in Step 3 of Tab 1 include constraints on the absolute value of the slopes of the interpolating cubic polynomials at year A. Although it might seem logical to anticipate that some degree of the most recent historical MI slope would continue into the near-term future, back-testing analysis performed by RPEC indicated reflecting those slopes tends to increase year-over-year volatility in the MP scales. Figure 19 illustrates an example of the impact of limiting the absolute values of the slopes in 2016 to 0.00%, 0.05%, and 0.10%, respectively, on projected age-40 MI rates for males.

Figure 19
IMPACT OF LIMITING THE ABSOLUTE VALUES OF THE SLOPES IN 2016



As can be seen in this example, the decision of whether or not to limit the slopes at the jumping-off year can have significant implications throughout for the entire cubic polynomial convergence period, which could influence the year-over-year stability of MIM-2021 results.

ASSUMPTION REGARDING WEIGHT PLACED ON COHORT PROJECTION

In Step 2 of Tab 1, the user must enter in cell R19 the desired balance between the horizontal projection along individual ages and the diagonal projection along individual year-of-birth cohorts. An entry of 0% means the set of MI rates generated by the spreadsheet will be based entirely on the horizontal projection, whereas an entry of 100% will produce MI rates based entirely on the diagonal projection.

The following illustrates the impact this weighting assumption has on projected MI rates, based on the following example:

- Historical mortality data set: National-level NCHS for females
- Jumping-off year: 2016 (highlighted in the heat maps that follow)
- Jumping-off values: Determined between years 2015 and 2016
- Jumping-off slopes: 0.0%
- Interpolation Structure: Advanced
 - Intermediate MI rates: 1.75% for all ages; attained 2036 and continuing through 2041
 - Long-term MI rates: 1.00% for all ages; attained 2051

The only differences in the three MI heat maps shown in Figures 20, 21, and 22 are the assumptions selected for weighting the cohort projection; 0%, 50%, and 100%, respectively.

Figure 20
WEIGHT PLACED ON COHORT PROJECTION = 0%

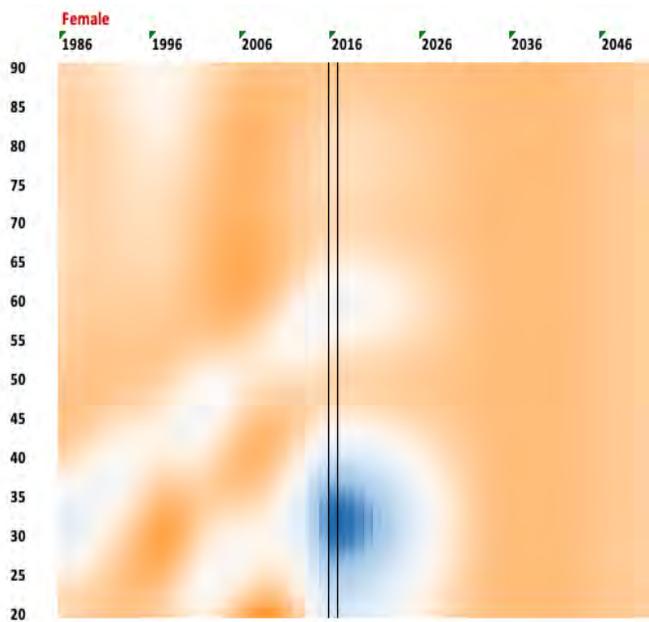


Figure 21
WEIGHT PLACED ON COHORT PROJECTION = 50%

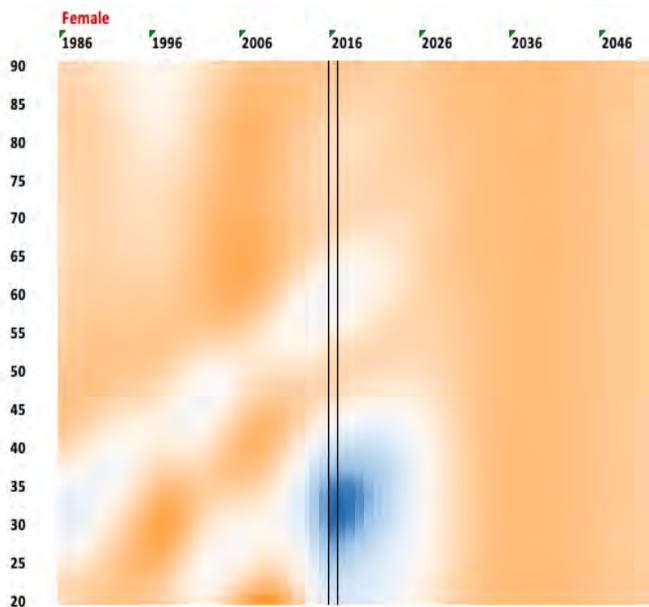
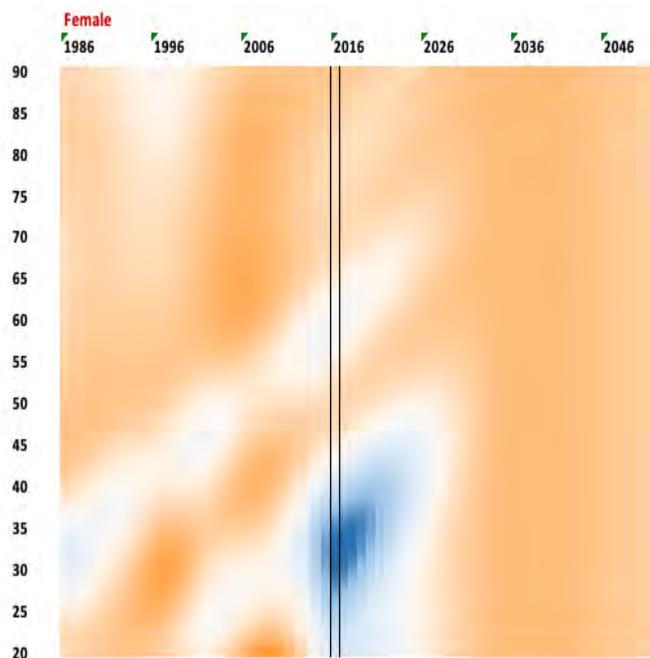


Figure 22
WEIGHT PLACED ON COHORT PROJECTION = 100%



Section 4.4 of the MP-2014 Report describes the reasoning RPEC used in arriving at its decision to base all of its MP scales to date (2014 through 2020) on a 50%/50% blend of the horizontal and diagonal projections. In particular, the RPEC highlighted the fact that year-of-birth effects for certain age cohorts have persisted in the U.S. population for many decades, and hence not reflecting some continuation of those into the future would be inappropriate.

On the other hand, it was RPEC's opinion the heat maps based on the 100% diagonal interpolations could potentially overemphasize future cohort effects. After reviewing a number of weighting combinations, RPEC concluded a model based on the simple average of the 100% horizontal and the 100% diagonal interpolations produced an appropriate balance of anticipated age/period and cohort effects for many retirement-related applications.

Since other mortality data sets could produce historical horizontal and diagonal MI patterns different from those produced by the national-level SSA data set used by RPEC, users should not necessarily assume any single blending percentage (e.g., 50%/50%) will be appropriate for all applications.

ASSUMPTIONS REGARDING THE LENGTH OF THE HORIZONTAL AND DIAGONAL TRANSITION PERIODS

The new model also provides users with great discretion in the length of the transition periods (horizontal and diagonal) between the jumping-off year and the year in which the assumed long-term rates are fully attained. Users should be aware that potentially unanticipated MI rates might arise in certain situations where (1) the assumed horizontal/diagonal blending percentage is strictly between 0% and 100%, and (2) the assumed convergence periods for the horizontal and the diagonal projections are relatively far apart. The situation is best explained through the following simplified example.

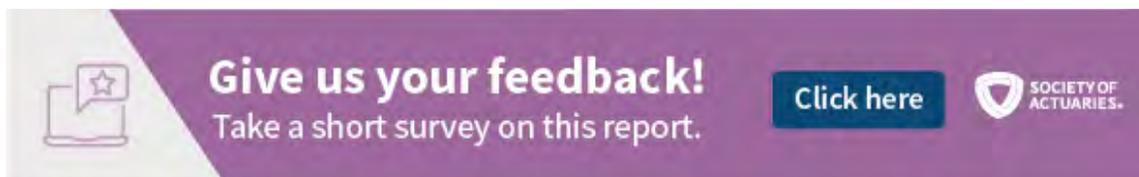
Example assumptions:

- Interpolation structure: Basic (i.e., cubic only; no intermediate-term rates)
- Horizontal/diagonal blending percentages: 50%/50%
- Jumping-off MI value: 0.0%
- Jumping-off slope: 0.0%
- Assumed Long-Term Rate: 1.0%
- Horizontal convergence period: 40 years
- Diagonal convergence period: 10 years

The resulting MI rate ten years after the jumping-off year is equal to 0.58%, which is the result of blending:

- 50% of the MI rate at year 10 of the horizontal projection (0.16%) with
- 50% of the MI rate at year 10 of the diagonal projection (1.0%).

The blended rate of 0.58% results from the attainment of the full set of long-term rates in the diagonal projection much sooner than the attainment of the full set of long-term rates in the horizontal projection. Obviously, the same situation would occur if the disparate time frames for the horizontal and diagonal projections were reversed.



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Section 5: Acknowledgments

The authors' deepest gratitude goes to those without whose efforts this project could not have come to fruition: the volunteers who generously shared their wisdom, insights, advice, guidance, and arm's-length review of this study prior to publication. Any opinions expressed may not reflect their opinions nor those of their employers. Any errors belong to the authors alone.

Mary Bahna-Nolan, FSA, MAAA, CERA

James Berberian, ASA, EA, MAAA, FCA

Kevin Mark Bye Jr, ASA

Timothy D. Morant, FSA, MAAA

Marianne Purushotham, FSA, MAAA

Linn K. Richardson, FSA, MAAA, CERA

Manuel S. Santos, FSA, FCIA

George Silos, FSA, MAAA, CERA

Joel C. Sklar, ASA, MAAA

Jim Toole, FSA, MAAA, CERA

At the Society of Actuaries:

Cynthia MacDonald, FSA, MAAA, Sr. Experience Studies Actuary

Jan Schuh, Sr. Research Administrator

Endnotes

¹ Society of Actuaries. 2021. “Developing a Consistency Framework for Mortality Improvement”.

<https://www.soa.org/resources/research-reports/2021/developing-consistency-framework/>.

² For additional details, see Society of Actuaries. 2014. “Mortality Improvement Scale MP-2014 Report”, Section 3.

<https://www.soa.org/globalassets/assets/files/research/exp-study/research-2014-mp-report.pdf>.

³ Barbieri, Magali. 2020. “Mortality By Socioeconomic Category in the United States”. Society of Actuaries.

<https://www.soa.org/resources/research-reports/2020/us-mort-rate-socioeconomic/>.

⁴ Since official U.S. census data was not available as of 1982, the decennial census as of 1980 was used to establish socioeconomic categories for this group of static NCHS data sets.

⁵ Throughout the MIM-2021 Application Tool, input/parameter cells are identified with a yellow background.

⁶ The MIM-2021 Application Tool is not currently designed to accommodate user-supplied select-and-ultimate mortality rates. However, users who wish to apply MIM-2021 mortality improvement rates to select-and-ultimate mortality tables can only do so for a single birth/policy issuance cohort (e.g., those insureds who are issued insurance policies during a specified period at age 30) or all those in their “ultimate” durations after the effects of underwriting selection have worn off.

⁷ A “transition period” starts in the first year of projection and ends in the year in which the assumed long-term rates are first attained.

⁸ Although the mortality improvement rates produced under option “C” are identical to those produced under option “B”, its selection can be used to produce more years of mortality-related information than can option “B”; this is discussed further in the Step 5 section.

⁹ The potential implications of selecting years further away from year A can be found in Considerations For Selection Certain Model Assumptions section of this document.

¹⁰ See Society of Actuaries. 2016. “Mortality Improvement Scale MP-2016 Report”, Section 4.2

<https://www.soa.org/globalassets/assets/files/research/exp-study/mortality-improvement-scale-mp-2016.pdf>

¹¹ A warning message will be pop up if the user selects values greater than 0.01 in these cells.

¹² The default heat map color palette is the same as that used in the Scale MP-2020 Report.

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With roots dating back to 1889, the [Society of Actuaries](#) (SOA) is the world's largest actuarial professional organization with more than 31,000 members. Through research and education, the SOA's mission is to advance actuarial knowledge and to enhance the ability of actuaries to provide expert advice and relevant solutions for financial, business and societal challenges. The SOA's vision is for actuaries to be the leading professionals in the measurement and management of risk.

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Society of Actuaries
475 N. Martingale Road, Suite 600
Schaumburg, Illinois 60173
www.SOA.org