

## Calculating Generational Mortality Rates

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The idea of using generational mortality rates for valuing pension benefits has been gaining traction in recent years. Many large plans are already using 2-dimensional mortality improvement scales for purposes of FASB accounting, and the IRS appears to be considering including a 2-dimensional mortality improvement scale under IRC Sections 430 and 417, possibly beginning as early as 2017. So, whether we want to or not, it's probably time for small plan actuaries to start looking at understanding and calculating these rates.

The mortality tables currently mandated under IRC Sections 430 and 417 are static tables, meaning that they apply the same age-based mortality rates for all participants into the future. For example, they assume that a 65-year-old in 2034 will have the same life expectancy as a 65-year-old in 2014. On the other hand, generational mortality tables are considered 2-dimensional, meaning that mortality rates are dependent on both the person's age and the year that age is attained. Accordingly, assuming mortality is expected to improve, the mortality rate for a 65-year-old in 2034 will be lower than the mortality rate for a 65-year-old in 2014 under a generational table. When doing valuations using generational mortality rates, you essentially have to generate an individual mortality table for each participant, with mortality rates specific to that participant's age in the year of the valuation and each future year. To generate the individual mortality table for each participant, you start with a static table, to which the 2-dimensional mortality improvement factors specific to that individual are applied.

The factors in a 2-dimensional mortality improvement scale are arranged in an array, where, for a given Age  $x$  and Calendar Year  $y$ , the factors in the column for Calendar Year  $y$  represent the smoothed changes in mortality rates between Calendar Year  $y-1$  and Calendar Year  $y$ . A sample from Scale MP-2014 (males) is as follows:

Age/Year	2014	2015	2016	2017	2018	2019	2020	2021
55	0.0134	0.0145	0.0150	0.0150	0.0146	0.0140	0.0133	0.0125
56	0.0109	0.0121	0.0130	0.0134	0.0134	0.0131	0.0126	0.0120
57	0.0090	0.0103	0.0113	0.0121	0.0125	0.0124	0.0121	0.0117
58	0.0078	0.0091	0.0102	0.0111	0.0117	0.0120	0.0118	0.0116

Note that the mortality improvement factors represent mortality improvement in the year *prior* to Age  $x$ . For example, the mortality improvement factor in the cell for age 55 and calendar year 2014 (0.0134) represents the mortality improvement between 2013 and 2014 for a participant who is age 55 in 2014.

Note also that the mortality improvement scale must be coordinated with the static mortality table being used. For example, if you are using a 2014 table as your static mortality table, that table already reflects mortality improvement through 2014, and therefore, the mortality improvement factors in the 2014 column (which represent mortality improvement between 2013 and 2014) would not be applicable in calculating the generational mortality rates.

Consider a male participant who is age 55 in 2014, for whom we want to calculate the pre-retirement generational mortality rates at ages 55, 56, 57, and 58 for our 2014 valuation. We are using the RP-2014 Employee (total dataset) mortality table as the static table for pre-retirement, and we are using Scale MP-2014 to reflect mortality improvement (as sampled above). A sample from RP-2014 Employee (males) mortality table is as follows:

Age/Year	$q_x$
55	0.002788
56	0.003079
57	0.003407
58	0.003779

Again, since the static table we are using is a 2014 table, the pre-retirement generational mortality rate for this participant at age 55 will be equal to the (unadjusted) mortality rate at age 55 from the static table (0.002788).

For age 56, we will need to reflect 1 year of mortality improvement between 2014 and 2015. This mortality improvement is reflected in the cell corresponding to age 56 and calendar year 2015 in the MP-2014 array. The generational pre-retirement mortality rate for him at age 56 is:

$$\begin{aligned} q_{56}^g &= q_{56} \times (1 - \text{MIF}_{56/2015}) \\ &= 0.003079 \times (1 - 0.0121) = 0.003042 \end{aligned}$$

where:  $q_{56}^0$  = the generational mortality rate at age 56  
 $q_{56}$  = the static table mortality rate at age 56, and  
 $MIF_{56/2015}$  = the mortality improvement factor for age 56 in 2015

For age 57, we need to reflect 2 years of mortality improvement between 2014 and 2016. This mortality improvement is reflected in the cells corresponding to age 57 and calendar years 2015 and 2016 in the MP-2014 array. The generational pre-retirement mortality rate for him at age 57 is:

$$q_{57}^0 = q_{57} \times (1 - MIF_{57/2015}) \times (1 - MIF_{57/2016})$$

$$= 0.003407 \times (1 - 0.0103) \times (1 - 0.0113) = 0.003334$$

For age 58, we need to reflect 3 years of mortality improvement between 2014 and 2017. This mortality improvement is reflected in the cells corresponding to age 58 and calendar years 2015, 2016, and 2017 in the MP-2014 array. The generational pre-retirement mortality rate for him at age 58 is:

$$q_{58}^0 = q_{58} \times (1 - MIF_{58/2015}) \times (1 - MIF_{58/2016}) \times (1 - MIF_{58/2017})$$

$$= 0.003779 \times (1 - 0.0091) \times (1 - 0.0102) \times (1 - 0.0111) = 0.003665$$

Pre-retirement generational mortality factors for subsequent ages would be calculated using the same methodology for each future year. Note that it is clear from the above that it would be a lot easier to calculate the generational mortality rates if we already had the 1-MIF factors, so the first thing I would recommend doing is to convert all the MIF factors to 1-MIF factors.

The post-retirement static mortality table, in conjunction with the mortality improvement scale would be used to determine post-retirement generational mortality factors in the same manner. For example, let's assume this participant will retire at age 62, and that we are using the RP-2014 Healthy Annuitant (total dataset) mortality table as the post-retirement static table. The static table mortality rate for a male age 62 is 0.008854. That rate will need to be adjusted to reflect mortality improvement for 7 years between 2014 and 2021. This mortality improvement is reflected in the cells corresponding to age 62 and calendar years 2015 through 2021 in the MP-2014 array. Using the following 1-MIF factors, which have been generated from Scale MP-2014 (male), the generational post-retirement mortality rate at age 62 for this participant would be 0.008219.

Age/Year	2014 (1-MIF)	2015 (1-MIF)	2016 (1-MIF)	2017 (1-MIF)	2018 (1-MIF)	2019 (1-MIF)	2020 (1-MIF)	2021 (1-MIF)
62	0.9923	0.9916	0.9906	0.9897	0.9890	0.9885	0.9883	0.9883

Note again that although the above sample includes the 2014 1-MIF factor, it is not being used. The first 1-MIF factor applicable to this situation is the factor in the 2015 cell, which represents mortality improvement between 2014 and 2015.

The generational mortality rates for each participant will be the same from year to year, assuming that your static mortality tables and mortality improvement scale remain the same. In the following year (2015), the participant in our example will be age 56, and the same factors would be used to determine his generational mortality rates beginning with age 56 as shown above. Both the participant's attained age and the year of the valuation must be used as a reference, in order to determine the correct mortality improvement factors to apply to the static table mortality rates.

For example, say you were doing a 2015 valuation with a male participant who is age 55 in 2015. That participant's generational mortality rates should not be the same as the generational mortality rates for the participant who was age 55 in 2014. The generational mortality rate at age 55 for the participant who is age 55 in 2015 would be:

$$q_{55}^0 = q_{55} \times (1 - MIF_{55/2015})$$

$$= 0.002788 \times (1 - 0.0145) = 0.002748$$

where:  $q_{55}^0$  = the generational mortality rate at age 55  
 $q_{55}$  = the static table mortality rate at age 55, and  
 $MIF_{55/2015}$  = the mortality improvement factor for age 55 in 2015

The generational mortality rate at age 56 for this participant would be:

$$q_{56}^0 = q_{56} \times (1 - MIF_{56/2015}) \times (1 - MIF_{56/2016})$$

$$= 0.003079 \times (1 - 0.0121) \times (1 - 0.0130) = 0.003002$$

These compare to the generational mortality rates at ages 55 & 56 of 0.002788 and 0.003042 for the participant who was age 55 in 2014. This may seem obvious, but getting your spreadsheet to do this can be tricky.

SOA's Mortality Improvement Scale MP-2014 Report includes the following monthly deferred-to-62 annuity due rates for a 2014 valuation, using 6% interest, RP-2014 Employee (total dataset) as the static pre-retirement mortality table, RP-2014 Healthy Annuitant (total dataset) as the static post-retirement mortality table, and Scale MP-2014 for mortality improvement, which you can use to test your calculations:

Age	Male	Female
25	1.4379	1.5195
35	2.5363	2.6853
45	4.4770	4.7497
55	7.9755	8.4544
65	11.4735	12.0932
75	8.6994	9.3996
85	5.4797	6.1785

Note that for ages above age 62, the monthly deferred-to-62 annuity due rates represent monthly annuity due rates for an annuity payable beginning at age x using the RP-2014 Healthy Annuitant (total dataset) static rates as adjusted for mortality improvement using Scale MP-2014 (i.e., they are not deferred rates, and they use the post-retirement static mortality table adjusted for mortality improvement).

Note also that the RP-2014 Employee mortality rates only go to age 80. If you happen to have a participant over age 80 who is still working, the post-age-80 pre-retirement static rates should be populated with the RP-2014 Healthy Annuitant rates. Likewise, the RP-2014 Healthy Annuitant rates start at age 50, and if you happen to have a retirement age less than age 50, aside from worrying about an IRS audit, the pre-age-50 post-retirement static rates should be populated with the RP-2014 Employee rates.

SOA published Scale MP-2014 in 2014, in conjunction with the RP-2014 mortality tables. Since its publication, many have criticized it for overstating mortality improvement. Scale MP-2015 was published in 2015, which is based on 2 more years of data, and reflects slightly lower mortality improvement. SOA also published Scale BB as a 2-dimensional mortality improvement scale back in 2012. Scale BB assumes more modest mortality improvement.

Note that if Scale MP-2015 (or Scale BB) is used, the RP-2014 mortality rates need to be scaled back to 2006 (the central year of data used for the RP-2014 tables) using Scale MP-2014. This is because the RP-2014 mortality rates have already been adjusted for mortality improvement based on Scale MP-2014 between 2006 and 2014. Factors for scaling the RP-2014 mortality rates back to 2006 are included in the excel file containing the Scale MP-2014 factors (available from the SOA website). If you are using the RP-2014 mortality rates scaled back to 2006 in conjunction with Scale MP-2015 (or Scale BB), note that you now have a 2006 static table. This means that mortality improvement from Scale MP-2015 (or Scale BB) should be reflected beginning with the year between 2006 and 2007 (the 2007 column).

More information regarding the RP-2014 tables and the MP-2014, MP-2015, and BB mortality improvement scales (including the rates & factors in excel format), can be found at SOA's website:

RP-2014 Mortality Tables Information & Rates

<https://www.soa.org/Research/Experience-Study/pension/research-2014-rp.aspx>

Mortality Improvement Scale MP-2014 Information & Rates

<https://www.soa.org/Research/Experience-Study/pension/research-2014-mp.aspx>

Mortality Improvement Scale MP-2015 Information & Rates

<https://www.soa.org/Research/Experience-Study/Pension/research-2015-mp.aspx>

Mortality Improvement Scale BB Information (rates can be retrieved via a download link in the Q&A publication)

<https://www.soa.org/Research/Experience-Study/Pension/research-mortality-improve-bb.aspx>