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Mortality projection: Making reasonable assumptions about future lifetimes

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Summary

How much longer will people live in the future? This is difficult to predict. The Society of Actuaries (SOA) has created very precise projections of mortality improvement that are updated each year. These annual updates are reasonable and based on the most current information, but the precision can cause volatility in the annual calculations of pension costs and liabilities. This paper presents two alternative options for mortality projection based on historical mortality improvement data. These alternatives are intended to reduce volatility from changes in the mortality improvement assumption, and therefore lead to more stable long-term pension cost and liability calculations, while providing a reasonable estimate of the long-term pension liability in accordance with the Actuarial Standards of Practice (ASOPs).

Mortality assumptions are made of two parts: (1) a base table reflecting how long people are actually living today, and (2) a mortality projection assumption predicting how much longer people will live in the future. This paper only deals specifically with the second part, the mortality projection assumption. The options in this paper are designed to minimize the impact of changes in the mortality projection assumption while still providing a reasonable projection of future mortality. Using one of these options along with a base table based on current experience is intended to result in appropriately calculated costs and liabilities in accordance with ASOPs, while not introducing unnecessary inconsistencies from year to year.

The objective of this paper is to present methods an individual actuary, and the public plan retirement boards they work with, can use to select a reasonable mortality projection assumption that:

- Is appropriate for the purpose of budgeting predictable pension contributions
- Reflects the actuary's professional judgment
- Takes into account relevant historical data
- Reflects the actuary's (and other parties) estimate of future experience
- Has no significant bias

The above criteria are adapted from ASOP No. 35, which governs the selection of mortality and other demographic and noneconomic assumptions and will be expanded on in the body of this paper.

In "The Signal and the Noise: Why so Many Predictions Fail—but Some Don't," Nate Silver says, "The signal is the truth. The noise is what distracts us from the truth." Consistent with that philosophy, we looked for the important elements of truth in historical data and made four observations.

Four observations from historical data:

1. People continue living longer.
2. Mortality improvement is often very different from one decade to the next.
3. Males and females have alternated in having the more rapid rate of improvement.
4. Mortality improvement tends to decline at older ages.

GUIDELINES

The following five guidelines are used in this paper as criteria to select mortality projection assumptions. They are implied by the observations and objective above.

1. Assume mortality will improve.
2. Observe mortality improvement over very long periods.
3. Choose assumptions an individual actuary can assess using that person's own professional judgment.
4. Choose reasonable long-term assumptions reflecting a purpose of providing sound, predictable funding for pension contributions. Therefore, do not choose assumptions that will change more rapidly than needed.
5. Focus on accuracy, not precision. Specifically, assumptions that assign different rates of future mortality improvement to (a) males and females, (b) different birth years, and (c) different future years may not necessarily improve the overall accuracy or reasonableness of an assumption when the purpose is to calculate predictable pension liabilities for a large group. This is due to the unpredictable level of overall mortality improvement in any future year or decade. Adding an additional layer of complexity that creates an additional level of precision can cause assumptions to change more rapidly than needed without necessarily improving accuracy.

Two potential options reflecting these guidelines are:

- A 60-year unisex average of mortality improvement
- 100% to 120% of the MP ultimate rates (the Society of Actuaries' Mortality Projection ultimate rates)

Note that the MP-2014 through MP-2019 male and female mortality projection scales all use the same ultimate values. These "MP ultimate rates" are 1.00% until age 85 and then decline to zero at age 115.

Each option has advantages. The 60-year average directly reflects actual observed data and self-adjusts in a gradual and systematic manner. Using a specific percentage of the MP ultimate rates introduces no year-to-year changes in assumed mortality improvement and therefore produces stable, predictable pension cost and liability calculations as long as future mortality improvements show the table to remain reasonable.

While this paper focuses on these potential options, other alternative options for selecting and developing mortality improvement scales also exist. It is the responsibility of the actuary and the public plan retirement boards to select a reasonable assumption.

The remainder of this paper provides support for this summary.

Historical data

Figures 1 to 5 are based on data available from the Social Security Administration (SSA) website. Specifically, the SSA provides historical rates of death from 1900 to 2016. This data is used to calculate historical mortality improvement. The SSA database is used because it is large, statistically credible, and publicly available.[1]

FIGURE 1: AVERAGE ANNUAL IMPROVEMENT, AGE 60-90 (10 YEARS ENDING)

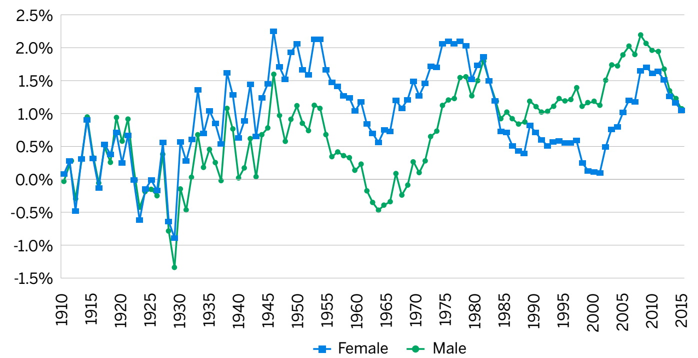

Figure 1 shows the average annual mortality improvement for males and females over rolling 10-year periods for the key ages of 60 to 90. A 1% improvement in mortality means the probability of death in one year decreased by 1%. For example, a 1% decrease in a 3.00% probability of death leads to a 2.97% probability of death in the following calendar year at the specific age.

Figure 1 supports the following observations from the summary at the beginning of this paper.

Observation 1: People continue living longer.

Both males and females show mortality improvement in most of the 10-year periods in Figure 1. This supports Guideline 1: Assume mortality will improve.

This is not inconsistent with a recent Virginia Commonwealth University study, which found that working age Americans (ages 25 to 64) are dying at higher rates. First, Americans over age 64 continue dying at lower rates, which causes longer lifetimes in retirement and therefore more years of benefit payments. In terms of mortality assumptions, it is the mortality rates during retirement, not during working ages, that are the primary driver of pension funding requirements.

Perhaps more important is that, as shown in Figure 1, there have always been periods where various influences have temporarily decreased the rate of mortality improvement. Figure 1 shows that average male mortality improvement in the 10-year period ending in 1964 for the key ages of 60 to 90 actually declined by 0.5%. However, the influences that have caused mortality improvement to temporarily decline in the past have not produced sustained periods of decline, as shown under Observation 2 below.

A current example is that although the opioid epidemic is an extremely important crisis to address, it would need to get even worse to cause continued declines in mortality improvement. On the other hand, if it is successfully addressed then the result could be a reversal, with resulting increases in future mortality improvement as its impact lessens. These short-term impacts are precisely why we believe it is so important to observe mortality improvement over very long periods, and not necessary to overly weight the impact of recent trends. This is consistent with Guidelines 2 and 5.

Observation 2: Mortality improvement is often very different from one decade to the next.

As seen in Figure 1 and the corresponding table in Figure 2, average mortality improvement can change by more than 1% over a decade. The mortality improvement of one decade has not necessarily been a reliable indicator of the mortality improvement in the next decade, or over a longer period for either males or females.

FIGURE 2: AVERAGE MORTALITY IMPROVEMENT BY DECADE (AGES 60-90)

	1960s	1970s	1980s	1990s	2000-2009	2007–2016
MALE	-0.09%	1.56%	0.87%	1.11%	2.19%	1.07%
FEMALE	1.21%	2.03%	0.39%	0.25%	1.65%	1.05%

Observation 3: Males and females have alternated in having the more rapid rate of improvement.

Figure 1 shows that for the 10-year periods ending in 1985 through 2010 male improvement was more rapid than female improvement. This caused males to be "catching up" to the longer life expectancy of females. Based on this period alone one potential conclusion could be that male life expectancy will continue to "catch up" to female life expectancy and we should assume that more rapid improvement for males will continue. However, Figure 1 also shows that more recently the two lines have been converging until, in the most recent 10-year period ending in 2016, the average rate of improvement was almost the same: 1.07% for males and 1.05% for females.

Looking back further, for the 10-year periods ending in 1930 through 1980, female mortality improved more rapidly. Females were living longer than males on average and extending their lead in life expectancy. In the future, either male or female longevity could increase more rapidly. This is consistent with the MP ultimate rates that are the same for males and females. Therefore, the precision of using different mortality improvement assumptions for males and females may not improve the accuracy of the calculation for the purpose of budgeting predictable pension contributions.

FIGURE 3: UNISEX 60-YEAR AVERAGE OF MORTALITY IMPROVEMENT

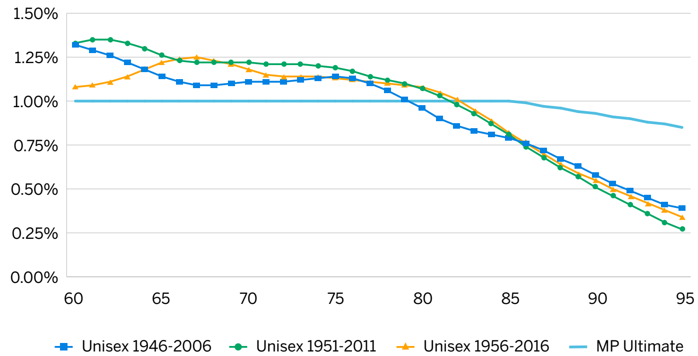

Figure 3 shows the unisex (combined male and female) average rates of mortality improvement by age for three different 60-year periods spaced five years apart compared to the MP ultimate rates. In the Society of Actuaries studies the MP ultimate rates apply to improvement that occurs more than 15 years in the future. MP tables have been produced annually from 2014 through 2019. Although the "select period" portion of the MP tables that apply to the near future has been updated each year, there has been no change to the MP ultimate rates. The MP ultimate rates are identical for males and females, with values that are a level 1.00% until age 85 and then decline slowly to 0.85% at age 95, and then more rapidly to 0% at age 115.

Observation 4: Mortality improvement tends to decline at older ages.

The 60-year averages in Figure 3 show that the rate of mortality improvement has generally declined starting near age 80. Although not shown here, the 60-year averages for males and females are very similar. The MP ultimate rates are generally consistent with this historical experience although the MP ultimate rates are somewhat lower before age 80 and somewhat higher after age 82.

FIGURE 4: AVERAGE ANNUAL IMPROVEMENT, AGE 60-90 (40-60 YEARS, UNISEX)

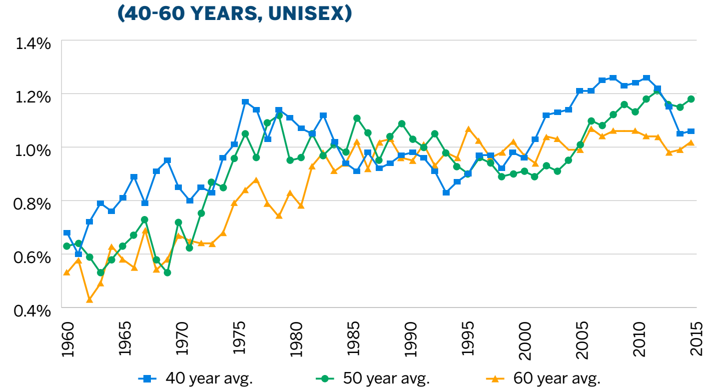

Figure 4 shows rolling 40-year, 50-year, and 60-year averages of historical mortality improvement for the key ages of 60 to 90 in the periods ending 1960 to 2016.

Guideline 2: Observe mortality improvement over very long periods

Figure 1 above showed that mortality improvement is often very different from one decade to the next. Figure 4 looks at longer periods that might be used to calculate a more stable historical average. The 60-year periods show more stability than the 40-year and 50-year periods, as demonstrated by the minimum and maximum values since 1985 in the table in Figure 5.

FIGURE 5: AVERAGE MORTALITY IMPROVEMENT FROM AGE 60 TO 90 FOR PERIODS ENDING IN 1985 OR LATER

	40 YEARS	50 YEARS	60 YEARS
MINIMUM VALUE	0.83%	0.89%	0.92%
MAXIMUM VALUE	1.26%	1.21%	1.07%

Stability of two reasonable options compared to the MP tables

We believe two reasonable alternatives to the MP tables are:

- A 60-year unisex average of mortality improvement experience
- 100% to 120% of the MP ultimate rates (the Society of Actuaries Mortality Projection ultimate rates)

Using the most recent standard MP (Mortality Projection) table is one reasonable option. However, these tables have shown material changes from year to year. The MP tables assume different amounts of mortality improvement in each future year until an ultimate level is reached after about 15 years. Although the ultimate level of improvement has not changed from MP-2014 to MP-2019, the near-term improvement has been adjusted every year, as shown in Figure 6.

FIGURE 6: FEMALE MP COMPARISON (AVG. OF FIRST 10 YEARS)

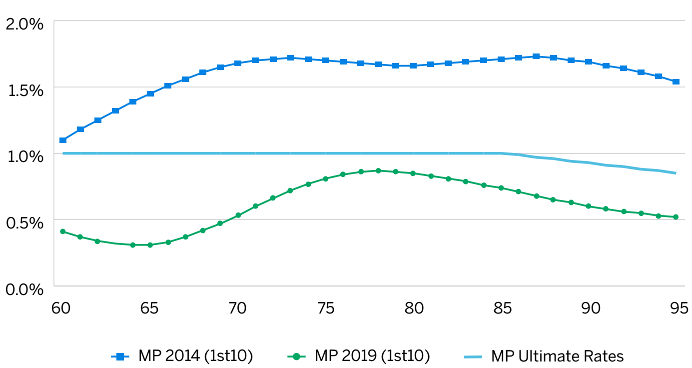

Figure 6 shows the average projected improvement at specific ages for the first 10 years in the female MP-2014 and MP-2019 tables.

- The MP-2014 male and female tables both graded from rates that were significantly higher in the early years down to the MP ultimate rates.
- Five years later, the MP-2019 male and female tables both graded from rates that were significantly lower in the early years up to the MP ultimate rates.
- The additional layer of complexity and precision of using different improvement rates in the early years, as opposed to using the MP ultimate rates for all years, accomplished opposite results in the MP-2014 and MP-2019 tables.

The table in Figure 7 compares the changes over the last five years of the MP tables to the change over the last five years of the 60-year average tables.

FIGURE 7: MP TABLES VS. 60-YEAR AVERAGE TABLES, LAST FIVE YEARS

	AVERAGE AGE 60 - 85
FIRST 10 YEARS OF MP-2014 (FEMALE)	1.58%
FIRST 10 YEARS OF MP-2019 (FEMALE)	0.61%
5 YEAR CHANGE	**-0.97%**
	AVERAGE AGE 60 - 85
FIRST 10 YEARS OF MP-2014 (MALE)	1.44%
FIRST 10 YEARS OF MP-2019 (MALE)	0.62%
5 YEAR CHANGE	**-0.82%**
	AVERAGE AGE 60 - 85
MP-2014 ULTIMATE (MALE & FEMALE)	1.00%
MP-2019 ULTIMATE (MALE & FEMALE)	1.00%
5 YEAR CHANGE	**0.00%**
	AVERAGE AGE 60 - 85
60 YEAR AVG 1951 - 2011 (UNISEX)	1.16%
60 YEAR AVG 1956 - 2016 (UNISEX)	1.11%
5 YEAR CHANGE	**-0.05%**

Based on the average values from age 60 to 85, Figure 7 shows that over the five most recent years:

- The first 10 years of the MP tables have decreased by 0.97% for females and by 0.82% for males
- The 60-year average has decreased by 0.05%
- The MP ultimate rates have not changed

Observations:

- The 60-year averages and the MP ultimate rates have been more stable and predictable than the first 10 years of the MP tables
- The 60-year averages and the MP ultimate rates at key ages are between the highest and lowest averages in the first 10 years of the MP tables
- 100% to 120% of the MP ultimate rates would be generally consistent with historical experience

Guideline 5: Focus on accuracy, not precision

This paper focuses on accuracy, not precision. Precision that increases complexity but does not improve accuracy can cause assumptions to change more rapidly than needed.

- As observed in Figure 6 above, the precision and complexity of using different improvement rates in the early years, as opposed to using the MP ultimate rates for all years, accomplished opposite results in the MP-2014 and MP-2019 tables. Using different improvement rates in the early years does not appear to have increased accuracy.
- That change over five years from 2014 to 2019 does not support the goal of predictable budgeting for pension contributions.

Similarly, although there is strong historical evidence that mortality improvement has varied by birth year, the level of overall changes in mortality improvement imply this precision and complexity may not improve accuracy. The 2019 Social Security Long-Range Demographic Assumptions report also points out that, if the improved longevity in some birth year groups is primarily due to interventions that have lowered death rates for individuals with compromised physiology, then death rates for the people in those birth year groups at older ages might actually be worse.

The approach in this paper also ignores "by-cause" analysis, which includes the expected future impact of factors such as: smoking, obesity, cardiovascular disease, respiratory disease, and cancer. There is disagreement on the impact each of these will have on future lifetimes. For the reasons above, the two alternatives in this paper do not vary the mortality improvement assumption by: (a) males and females, (b) different birth years, and (c) different future years. This type of precision may not improve overall accuracy. In addition, the complexity added by these factors makes it more difficult to compare assumptions to historical data and assess reasonableness. This in turn makes it more difficult to reflect the judgments of individual actuaries and public plan retirement boards.

REASONABLENESS UNDER ACTUARIAL STANDARD OF PRACTICE NO. 35 (ASOP NO. 35)

The two options presented in this paper support the five characteristics of a reasonable assumption from Section 3.3.5 of ASOP No. 35, as follows:

"Appropriate for the purpose of the measurement." Combining one of these two mortality projection options with appropriate periodic updates to the base mortality table supports the purpose of actuarial valuations intended to produce predictable costs and sound funding.

"Reflect the actuary's professional judgment." These two mortality projection options have the transparency to allow the individual actuary (and other parties) to use their professional judgment to determine whether they consider them reasonable or not.

"Takes into account historical and current demographic data that is relevant as of the measurement date." These assumptions are based on data available from the Social Security Administration (SSA) website, which is a large, statistically credible, up-to-date, and publicly available source of historical data.

"Reflects the actuary's estimate of future experience, the actuary's observation of the estimates inherent in market data (if any), or a combination thereof." Similar to the previous characteristic, these estimates of future experience are based on observations inherent in the SSA data.

"Has no significant bias." These two mortality projection assumptions were specifically chosen to avoid any significant bias when compared to the historical experience noted above.

EXPERIENCE ALWAYS VARIES FROM ASSUMPTIONS

No matter how carefully an assumption is chosen, even if it has no significant bias, actual future experience will almost always be different, sometimes better and sometimes worse. ASOP No. 35 requires that the assumption *"reflects the actuary's professional judgment."*

It goes on to say that:

"...different actuaries will apply different professional judgment and may choose different reasonable assumptions. As a result, a range of reasonable assumptions may develop, both for an individual actuary and across actuarial practice."

This paper provides background to assist an individual actuary in choosing a reasonable assumption. Ultimately, it is the actuary's responsibility to use an assumption that reflects individual professional judgment, although it is almost certain that the assumption will not exactly fit future experience.

Conclusion

This paper presents only two potential mortality projection assumptions of the many from which an individual actuary can choose. These two options were specifically chosen to support: the purpose of predictable year-to-year pension cost and liability calculations, and an individual actuary's ability to exercise professional judgment concerning a reasonable assumption under ASOP No. 35.

End note

[1] Specifically, the SSA database uses (a) data from the National Center for Health Statistics (NCHS) reflecting NCHS data on deaths and U.S. Census Bureau estimates of population for years before 1968, and ages below 65, and (b) Medicare data on deaths and enrollments for ages 65 and over in years 1968 through 2016.

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