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The Changing Rate of Change in Mortality Rates—A Historical Perspective

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The Changing Rate of Change in Mortality Rates—A Historical Perspective

Vincent J. Granieri

For actuaries like me, who are charged with forecasting human life expectancy at older ages, assumptions regarding annual mortality improvements are key components of the analysis. Some may believe it is preferable to include some sort of annual mortality improvement assumption in any life expectancy calculation. However, using an inaccurate assumption can be worse than making no mortality improvement allowance at all. While there are many issues regarding how one might derive the annual mortality improvement assumption, such as time frame and data sources, recent experience of the U.S. population life tables suggests this task is becoming more complex.

CONCLUSION

Annual mortality improvement rates observed in the U.S. population life tables published by the Human Mortality Database, out of the University of California, Berkeley, and Max Planck Institute for Demographic Research in Germany have changed dramatically over the past 30 years, hindering efforts to accurately determine and forecast life expectancies at older ages.

METHODOLOGY

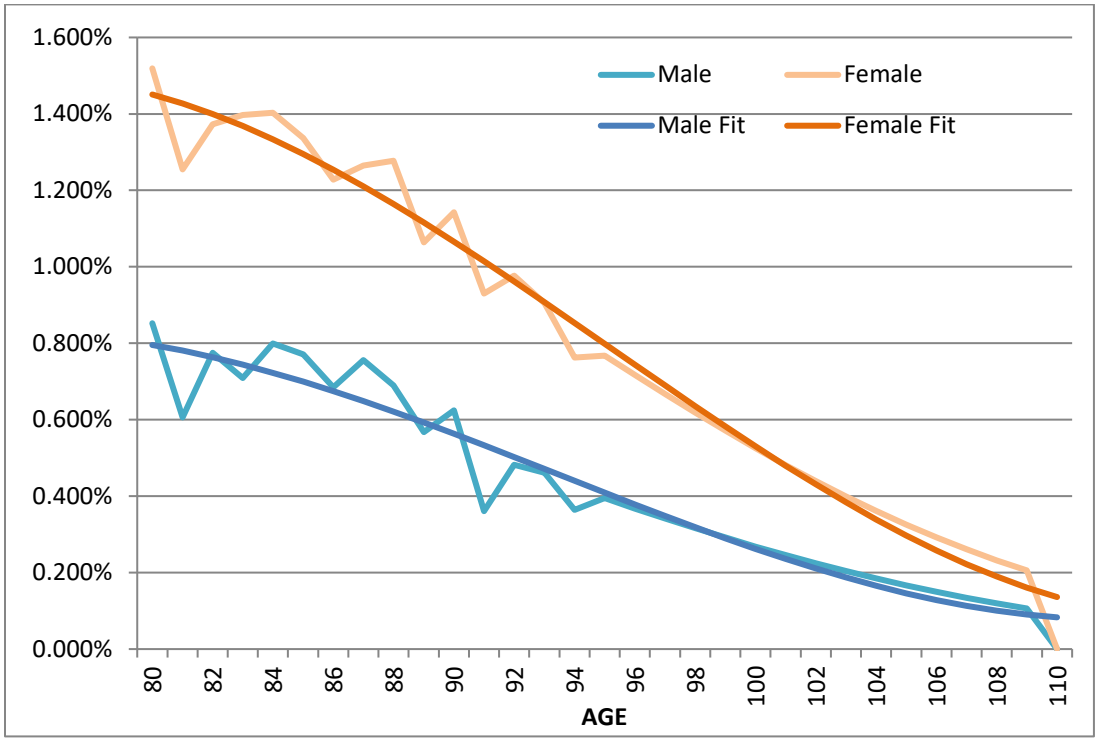
I chose three eras for my analysis; the first era ending in 1990, the second in 2005 and the third in 2016. When I study mortality improvement, I chart mortality improvement for the previous 30-, 20-, 10- and five-year time frames at ages 80 through 110. In other words, 1960 to 1990, 1970 to 1990, and so on; 1975 to 2005, 1985 to 2005, and so on; 1986 to 2016, 1996 to 2016, and so on. Depending on its usage, a shorter or longer time frame may be preferable. I used Microsoft Excel to produce trendlines in the data.

RESULTS

Figures 1–4 are graphs of the annual mortality improvement in the U.S. population life tables for the era ending in 1990, with time frames encompassing 30, 20, 10 and five years prior. Figures 1–3 are remarkable in their consistency, with the shape of the curves all strikingly similar. At age 80, female annual mortality improvement was around 1.5% and male annual mortality improvement was less than 1%. With advancing age, the annual mortality improvement declined, more so for females than males, and the curves seem to meet at 0% improvement as age approached 110. This last observation is logical since the U.S. population life tables end at age 110 with a mortality rate of 100%.

Figure 1

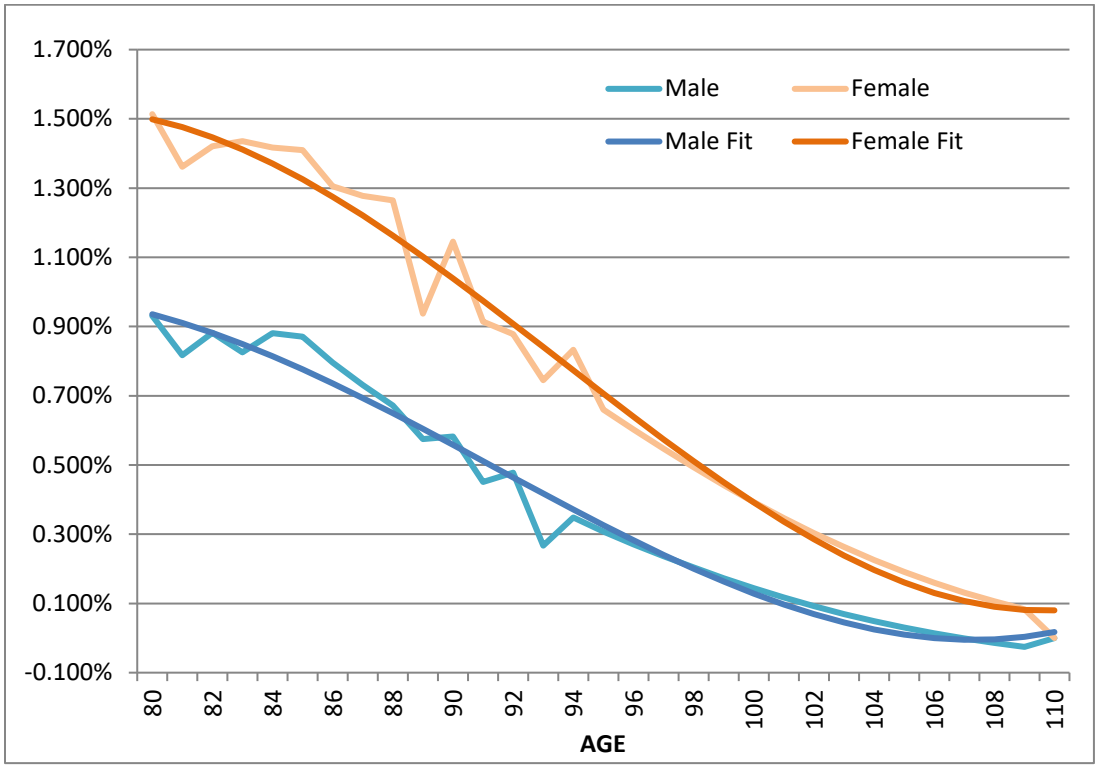
ANNUAL MORTALITY IMPROVEMENT (U.S. LIFE POPULATION), 1960–90



Source: Predictive Resources LLC.

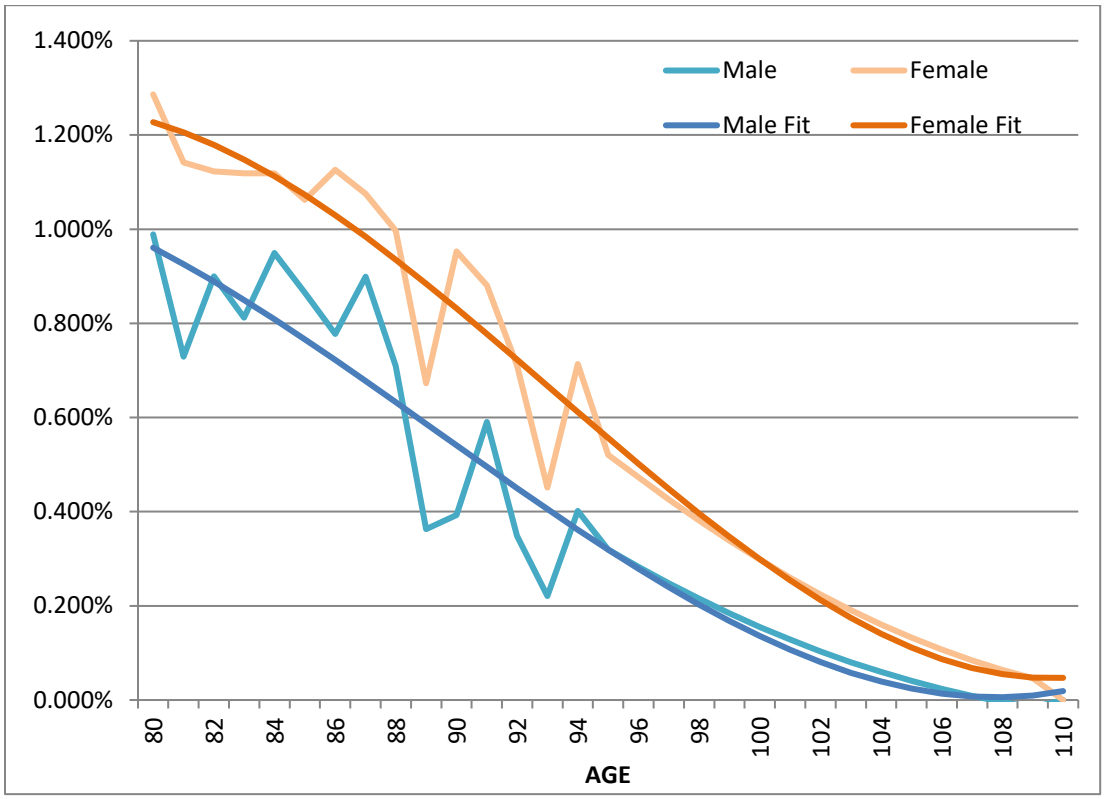
Figure 2

ANNUAL MORTALITY IMPROVEMENT (U.S. LIFE POPULATION), 1970–90



Source: Predictive Resources LLC.

Figure 3
ANNUAL MORTALITY IMPROVEMENT (U.S. LIFE POPULATION), 1980–90

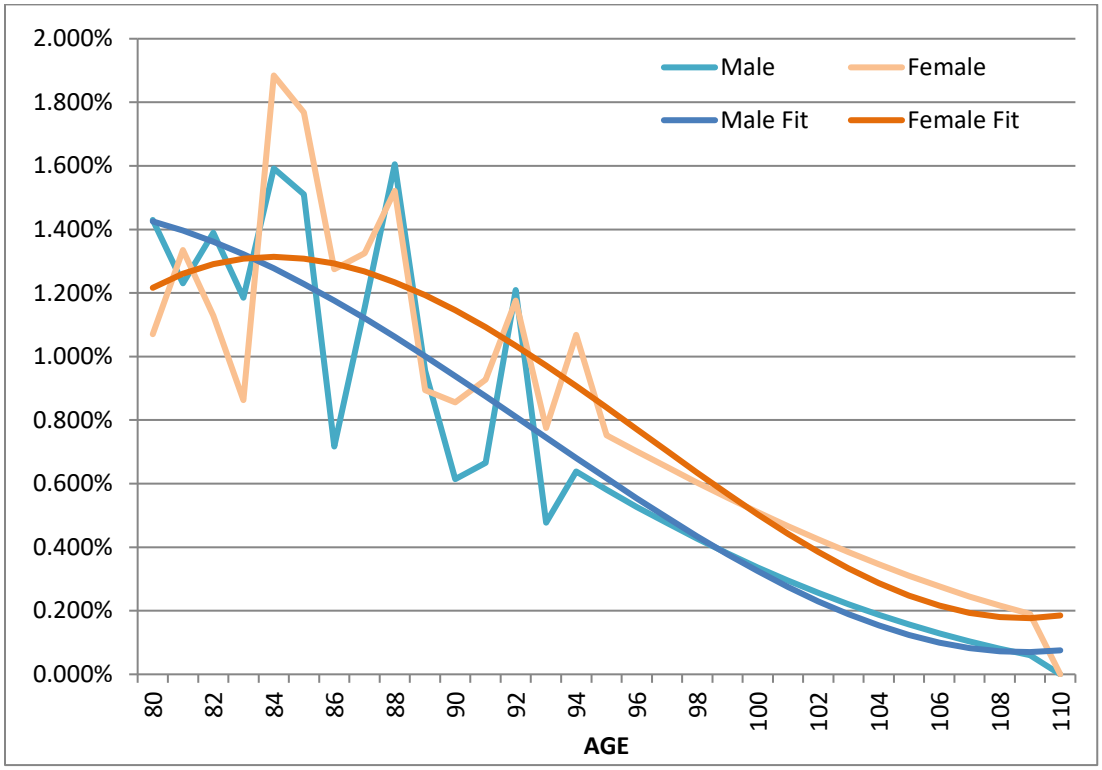


Source: Predictive Resources LLC.

Figure 4 does not fit this pattern until around age 85. Before that, male annual mortality improvement exceeded that of females by a small amount. Notably, as the time frame shrunk from 30 years to five years, male annual mortality improvement rose.

Figure 4

ANNUAL MORTALITY IMPROVEMENT (U.S. LIFE POPULATION), 1985–90

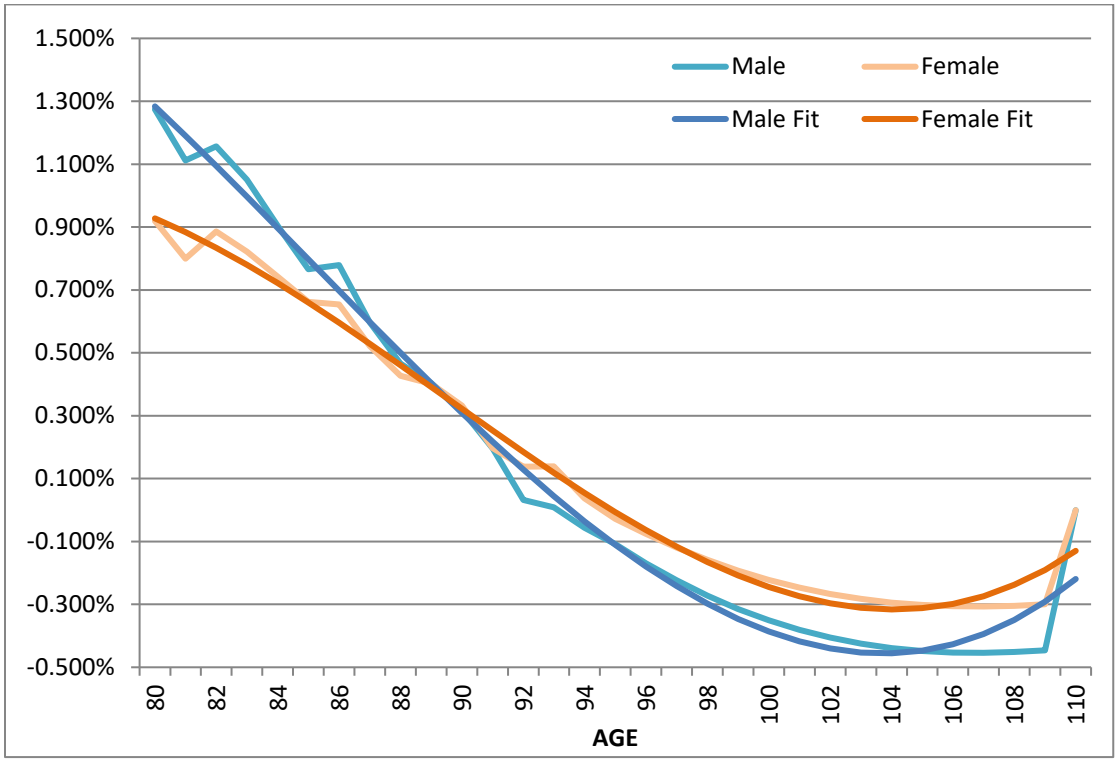


Source: Predictive Resources LLC.

Figures 5–8 show the same 30-, 20-, 10- and five-year time frames for the era ending in 2005. Here, we see a significant reversal from the 1990 era, as male annual mortality improvement is consistently larger than that of females. Further, annual mortality improvement turns negative at the uppermost ages to differing degrees for every time frame. In the longest time frames, female annual mortality improvement at the uppermost ages eventually eclipses that of males. The general shape of the curves, with declining annual mortality improvement rates as attained age increases, is consistent with Figures 1–4.

Figure 5

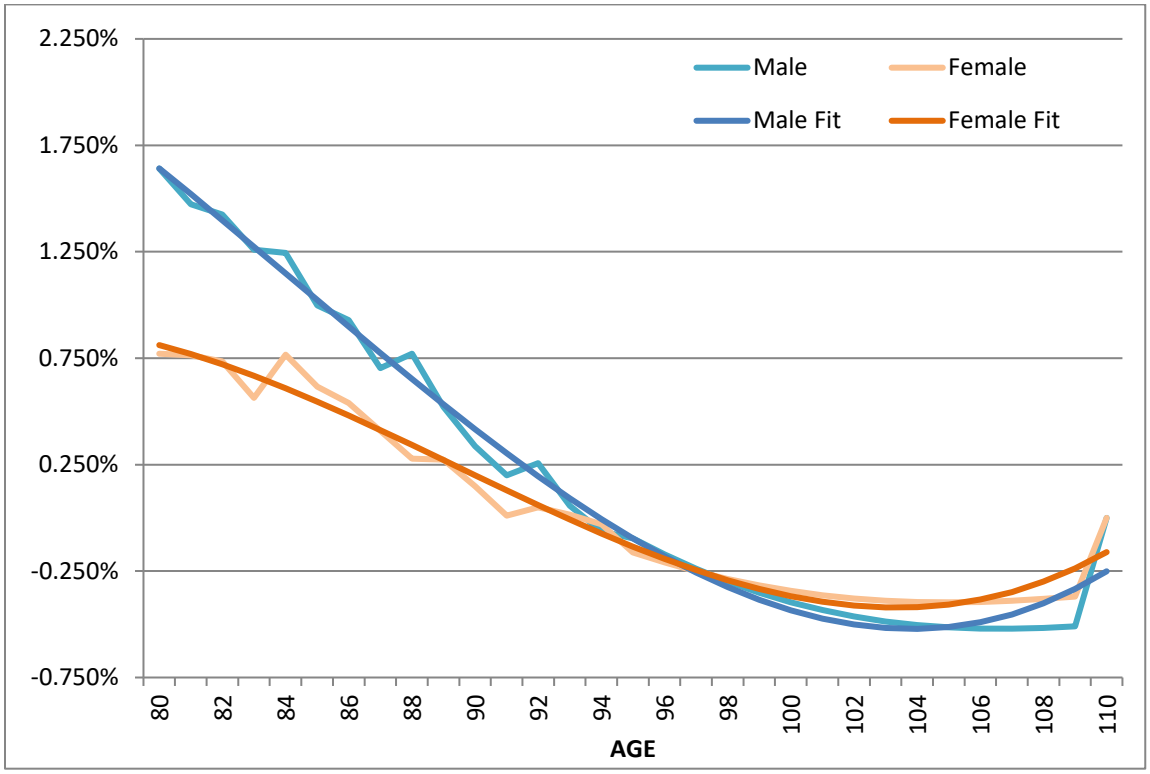
ANNUAL MORTALITY IMPROVEMENT (U.S. LIFE POPULATION), 1975–2005



Source: Predictive Resources LLC.

Figure 6

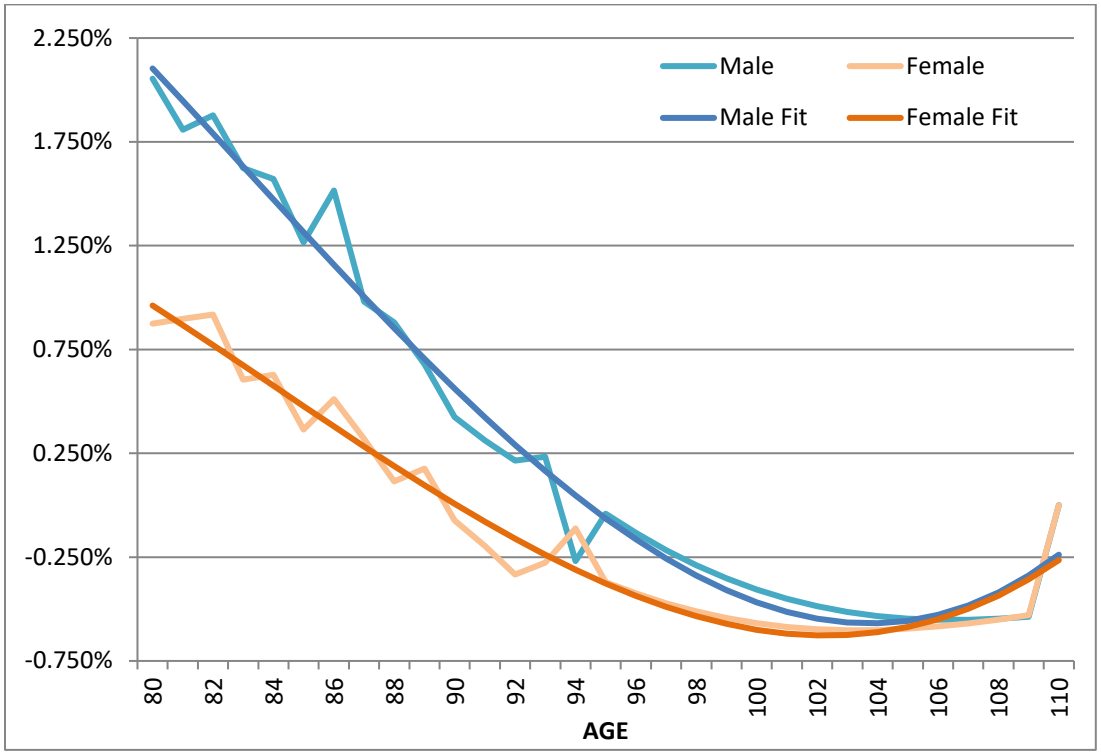
ANNUAL MORTALITY IMPROVEMENT (U.S. LIFE POPULATION), 1985–2005



Source: Predictive Resources LLC.

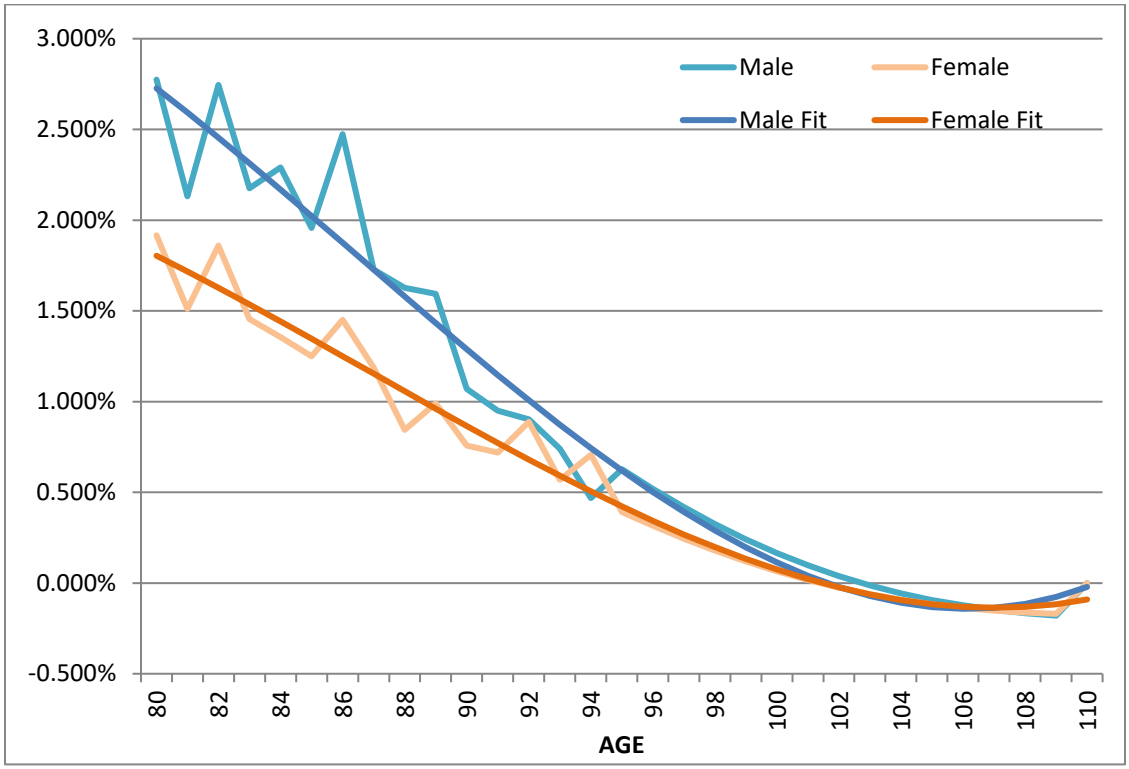
Figure 7

ANNUAL MORTALITY IMPROVEMENT (U.S. LIFE POPULATION), 1995–2005



Source: Predictive Resources LLC.

Figure 8
ANNUAL MORTALITY IMPROVEMENT (U.S. LIFE POPULATION), 2000–05

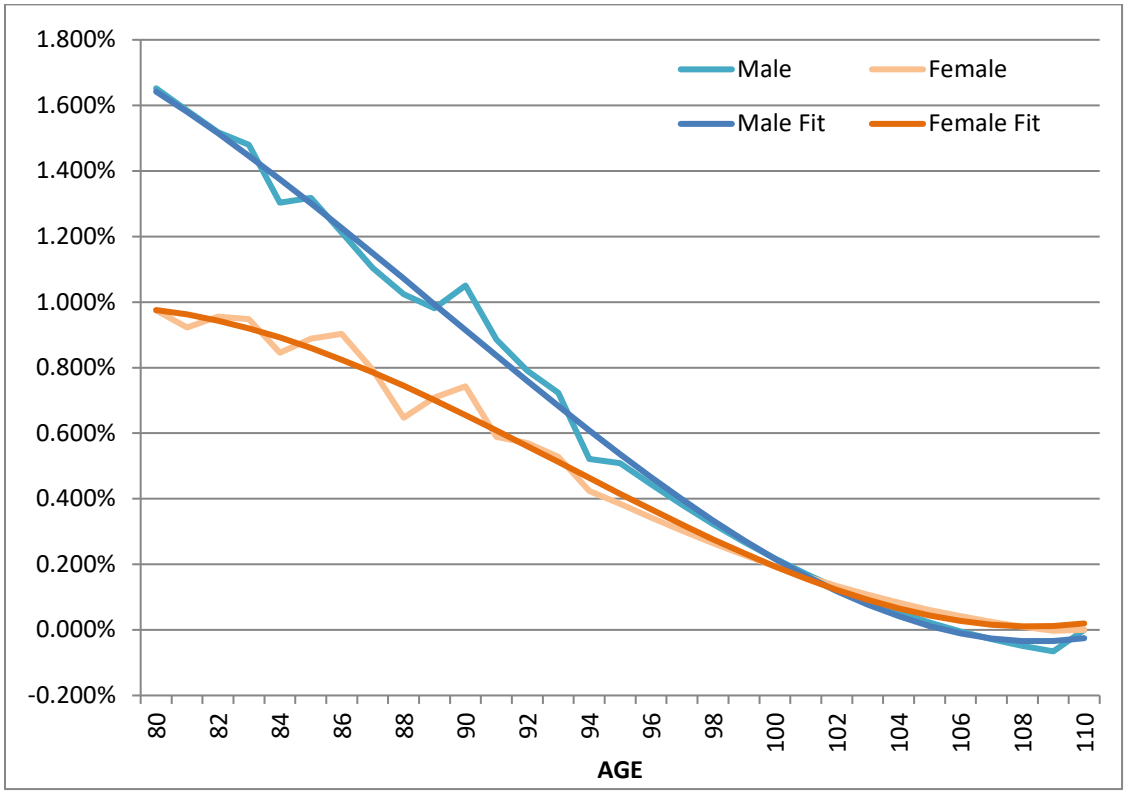


Source: Predictive Resources LLC.

Figures 9–12 show the same time frames for the era ending in 2016. For the 30- and 20-year time frames, the graphs resemble those of the 1990 era, with males and females reversed! They also bear some resemblance to the graphs in the second era, ending in 2005. However, a totally new pattern emerges for the 10- and five-year time frames. Annual mortality improvement for males is still greater than that of females, but annual mortality improvement increases with age until the early 90s, when it starts to decline. However, the nominal mortality rates do not increase.

Figure 9

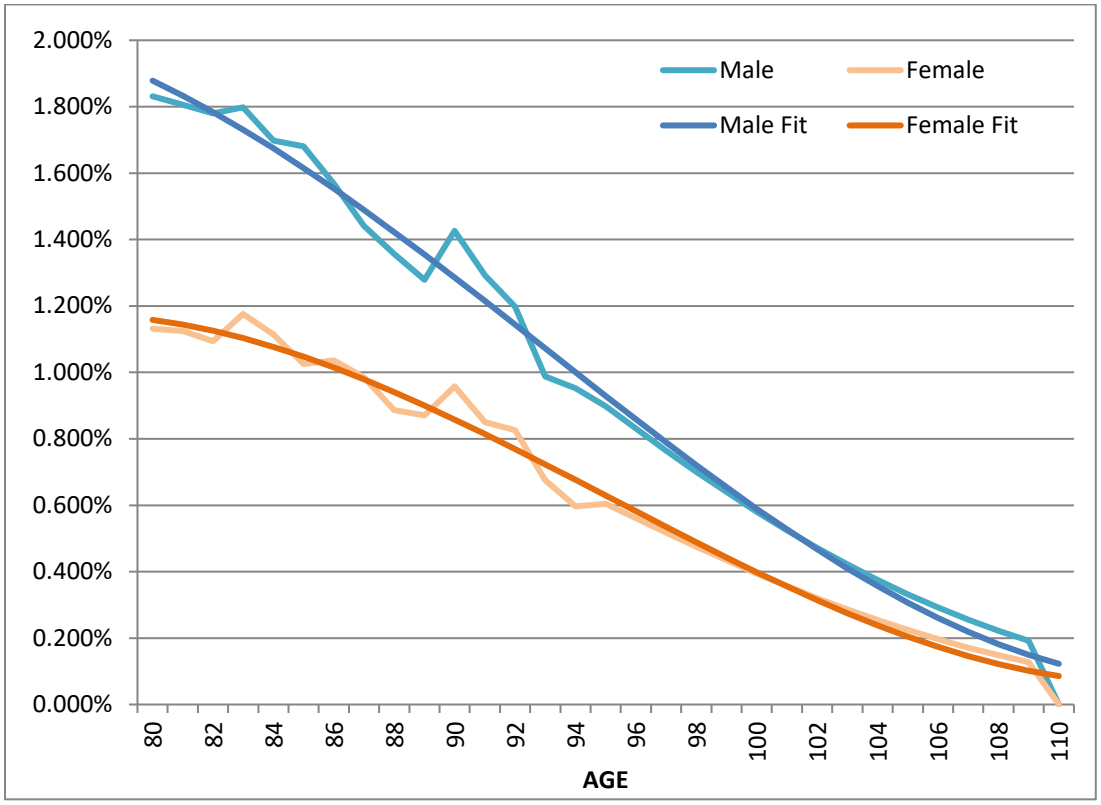
ANNUAL MORTALITY IMPROVEMENT (U.S. LIFE POPULATION), 1986–2016



Source: Predictive Resources LLC.

Figure 10

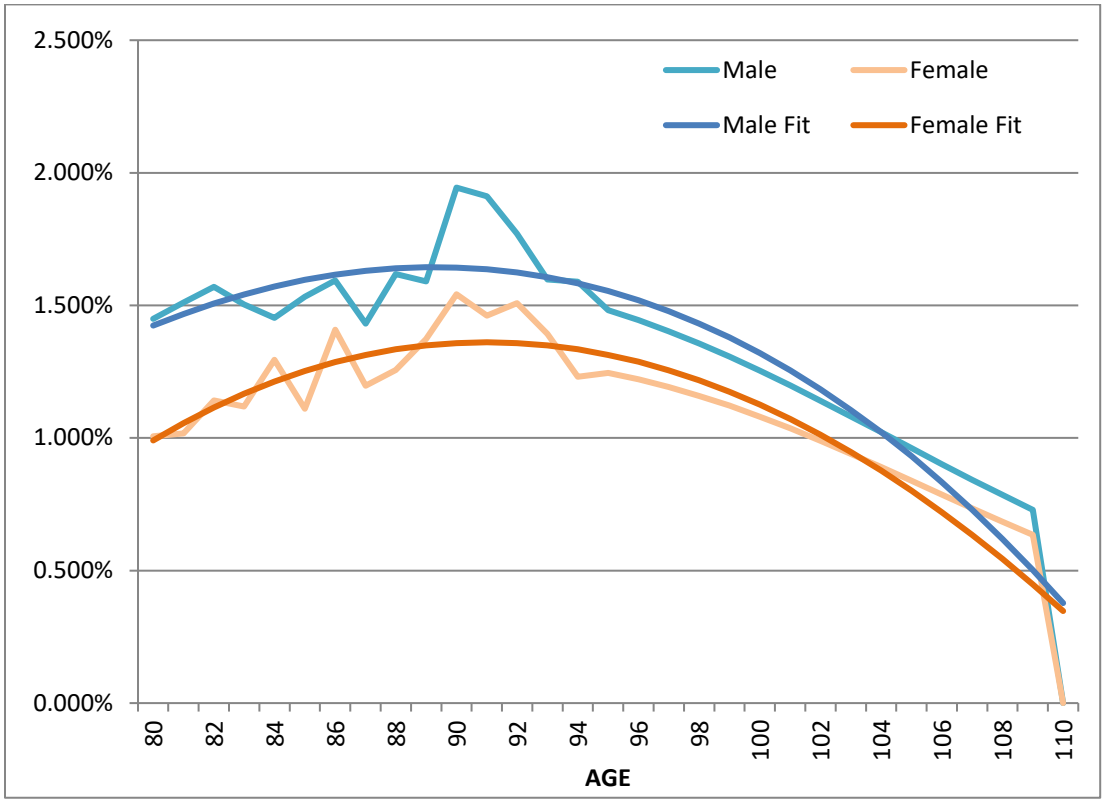
ANNUAL MORTALITY IMPROVEMENT (U.S. LIFE POPULATION), 1996–2016



Source: Predictive Resources LLC.

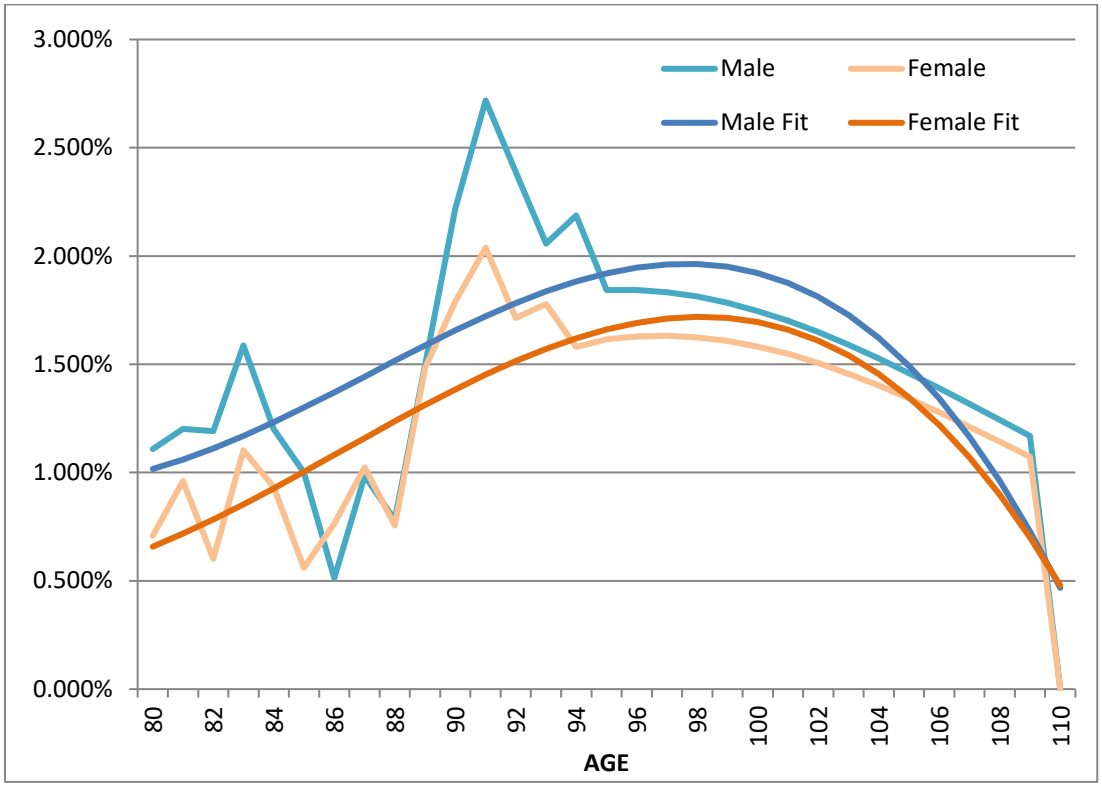
Figure 11

ANNUAL MORTALITY IMPROVEMENT (U.S. LIFE POPULATION), 2006–16



Source: Predictive Resources LLC.

Figure 12
ANNUAL MORTALITY IMPROVEMENT (U.S. LIFE POPULATION), 2011–16



Source: Predictive Resources LLC.

DISCUSSION

Imagine we are back in 1990 with the data from Figures 1–4. Our job is to forecast longevity, and we want to utilize the U.S. population life tables to forecast mortality improvement. The data seem to tell us to maintain female annual mortality improvement somewhat above male annual mortality improvement. It's also reasonable to infer that overall annual mortality improvement rates decline with advancing age, with the difference between males and females shrinking as well. Some might note that trend and project a further decline in the difference between female and male annual mortality improvement rates in the future.

Figures 5–8 illustrate how bad that forecast would have been. In this era, male annual mortality improvement is larger than that of females (it can reach or exceed 2% per year), far higher than anything studied in the 1990 era. Further, the difference doesn't always shrink with shortening time frames, and annual mortality improvement is actually a decline at the oldest ages. Presumably, the medical advances in treatment of cardiovascular disease, which is more prevalent in males than females, is at least partially responsible for flipping the male and female annual mortality improvement from the 1990 to the 2005 era. I will leave it to the reader to postulate the reasons why nominal mortality rates increased for the oldest ages in this era.

Now, let's move forward and assume we are in 2005. We face the same challenge: to forecast longevity using available information in the U.S. population life tables. I am going to ignore the issue of whether we should pay any attention to the era ending in 1990; after all, it has been 15 years and that data is certainly not as applicable as it once was. More recent data suggests acceleration of annual mortality improvement for males and a steeper slope for both the male and female curve, resulting in actual annual *increases* in nominal mortality for both genders at the uppermost ages.

Figures 9–12 suggest these forecasts would also be incorrect. It appears there is an inflection point somewhere after the turn of the century that pushes down male annual mortality improvement (and to a smaller degree female annual mortality improvement) at attained ages below 85, and increases it for both genders between ages 85 and 100 and, to a lesser degree, at ages above 100. Again, we should note the implications of the U.S. population life tables ending at age 110.

Finally, we return to the present. Based on what we have seen, do we have any confidence in using the observed annual mortality improvement rates in the third era ending in 2016, for forecasting life expectancy? I think not.

As I face the challenge of determining annual mortality improvement rates in today's world, my inclination is to note medical advances, and factor those into my mortality improvement assumptions, even though they may not show up in the data for years. For example, cancer research has accelerated in the past few years, increasing life expectancy for victims of many cancers such as lymphoma and multiple myeloma, which were quite short only a few years ago. We have reached the point where we must look forward as well as backward in determining expected annual mortality improvement assumptions.

Vincent J. Granieri, FSA, EA, MAAA, is CEO and founder of Predictive Resources LLC. He can be reached at *vgranieri@predictiveresources.com*.