Member's Paper

Update on Mortality Improvement

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Abstract	Résumé
New data has recently become available beyond what was used in constructing MI-2017. This paper looks at what the impact would have been on MI-2017 if the new data had been available earlier; the construction method is the same as stated in the report on MI-2017. It concludes that a revision to MI-2017 is warranted because of two significant features: the recent improvements at older ages are distinctly lower than what MI-2017 expected; and the opioid crisis appears to have had a material impact at the young adult ages, resulting in significant mortality deterioration.	De nouvelles données qui vont au-delà de celles utilisées pour concevoir l'échelle d'amélioration de la mortalité MI-2017 sont maintenant disponibles. Ce document examine quel aurait été l'impact sur l'échelle MI-2017 si ces nouvelles données avaient été disponibles plus tôt. La méthode de construction de l'échelle est la même que celle énoncée dans le rapport sur l'échelle MI-2017. Le document conclut qu'une révision de l'échelle MI-2017 est justifiable compte tenu de deux éléments importants : en comparaison avec les prévisions de MI-2017, les améliorations récentes de la mortalité à des âges plus avancés sont nettement inférieures et la crise des opioïdes semble avoir un impact important sur les âges des jeunes adultes, entraînant ainsi une détérioration importante de la mortalité.

1 Background

When the Mortality Improvement Task Force was named, the population data in the Human Mortality Database (HMD) at http://www.mortality.org/ was available only to 2011. Two years later, when the task force wanted to publish, data beyond 2011 had still not been released. The task force was pleased that the Office of the Chief Actuary of the Canada Pension Plan had made Old Age Security (OAS) data for the years 2006–2015 available on a confidential basis, and MI-2017 was born (see CIA document 217097).

In March, population data was published on HMD to 2016. The Office of the Chief Actuary has again made summary OAS data available on a confidential basis, now for 1999–2018. If we had had these data available when MI-2017 was created, would it look materially differently? That is the question that this article seeks to answer.

One note of caution: the work shown here is my own. No one else on the task force has reviewed my work. I am not recommending that my work replace MI-2017.

2 Applying the new data

To see the impact of the new data, one should apply the same method as for MI-2017, as well as all the same parameters except for those related to the year at which actual data ends. That is easily done, except for one group of parameters for which "same" is ambiguous. For MI-2017 the "ultimate" year for improvement rates is 2033, grading down to 2023 at younger ages; that, however, was calculated as 20 years out from the last year of actual data used, grading to 10 years out at younger ages. It could be called "same" to use either 20 years out or 2033 as the ultimate year. I tested both, and the former seems more reasonable to me.

For MI-2017, because data were available only to 2011 for HMD but to 2015 for OAS, the OAS improvement rates were applied to HMD data over age 65, and HMD data at other ages was extrapolated to 2015, using the overall improvement rates of OAS.

To follow the method most closely, one would use the OAS data to 2018 for ages over 65 and extrapolate the HMD data from 2016 to 2018 for other ages. However, one might also consider the HMD data only, and one might consider replacing HMD data with OAS data to 2016 without using 2017–2018. I tested all three, and the first seems to me to be most reasonable.

One might ask, "Why extend HMD data when it is available until 2016?" The main reason is that OAS is undoubtedly a dataset with much better accuracy than HMD. OAS is administrative data, subject to normal checks. The HMD exposures are taken from census data, which are self-reported and collected from the whole population only every five years. A secondary reason is that it is always better to have more recent data if the quality is good enough.

As a reminder, the method in summary is:

1. Extend HMD data approximately for ages 0–65 using the pattern of improvement in OAS data and the pattern of mortality by age in HMD.
2. Graduate with two-dimensional Whittaker-Henderson for ages 0–100 and years 1967 to the latest year available for OAS data.
3. Drop the last two years of data to avoid edge effects.
4. Set the upper age for improvement at 105, and grade linearly from age 95–105.
5. Choose the length of time in years (varying by age) at which the ultimate improvement rate is reached.
6. Set the ultimate improvement rates.
7. Fit a cubic curve separately for each age, using the last year of data, the ultimate year, and the slopes at those two points.

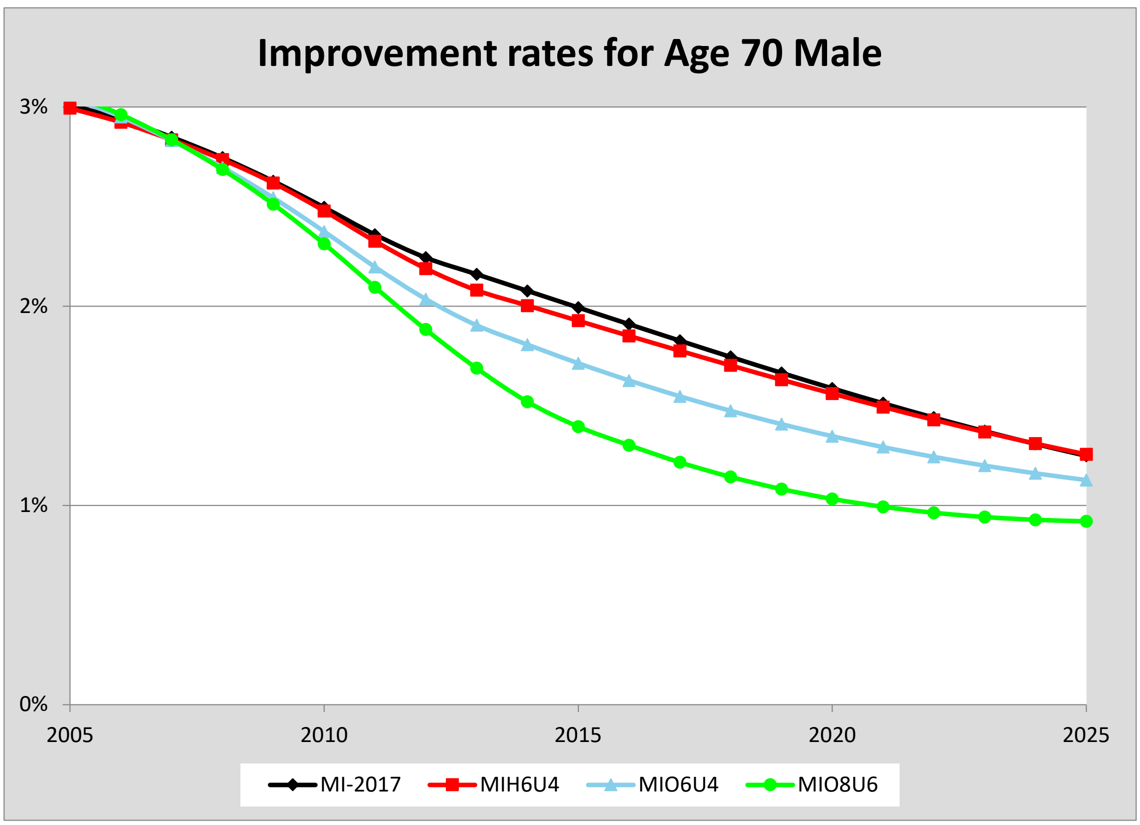
A note on naming: MI-2017 is the scale as published, except that calculations are performed on the unrounded version. All the new scale names begin with MI, followed by H6 (HMD data to 2016), O6 (OAS data replacing HMD to 2016) or O8 (OAS data replacing HMD and extended to 2018), and finally, Uy, where "y" is the last digit of the ultimate year at age 65. So MI-2017 could be called MIO5U3, and the most direct comparison is MIO8U6.

For greater clarity, the names of improvement scales shown are:

1. MI-2017, the scale currently in use, OAS/HMD data to 2015, ultimate in 2033.
2. MIH6U4, HMD data to 2016, ultimate in 2034.
3. MIO6U4, OAS/HMD data to 2016, ultimate in 2034.
4. MIO8U6, OAS/HMD data to 2018, ultimate in 2036.
5. MIH6U3, HMD data to 2016, ultimate in 2033.
6. MIO6U3, OAS/HMD data to 2016, ultimate in 2033.
7. MIO8U3, OAS/HMD data to 2018, ultimate in 2033.

3 Change in improvement rates

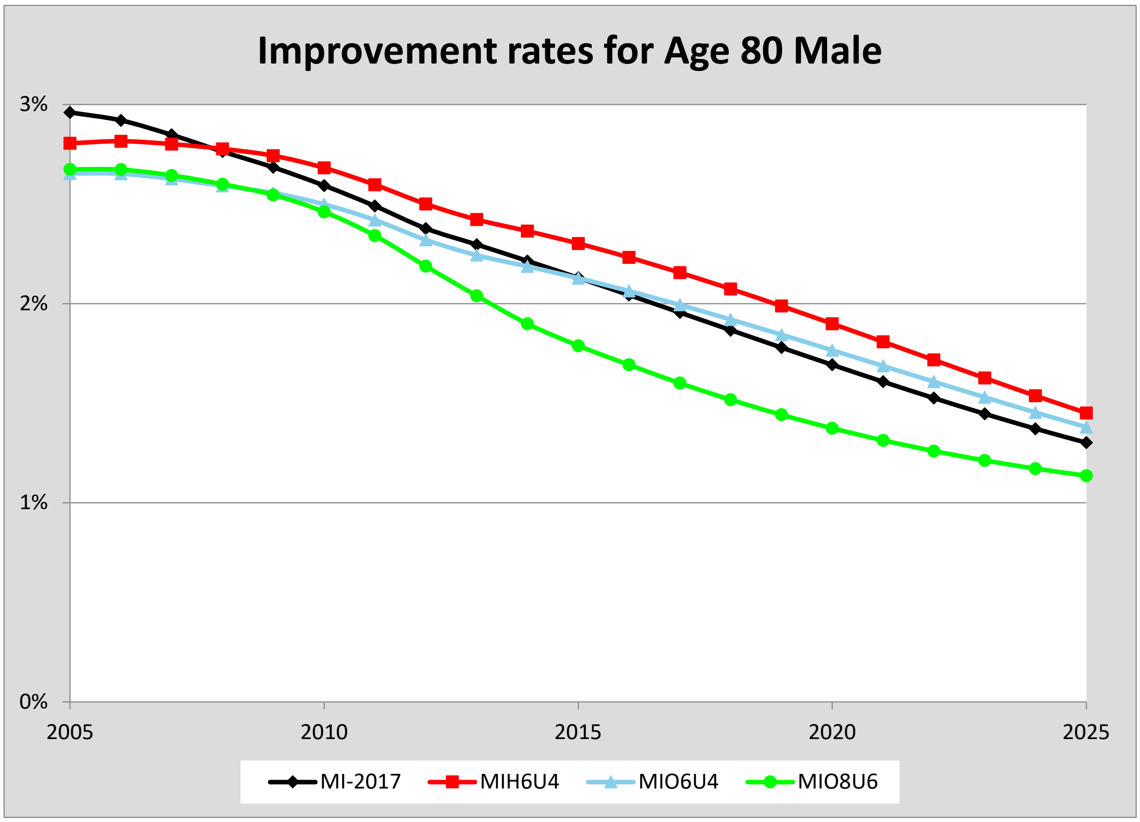
The chart below compares four scales for a male aged 70 over the years 2005 to 2025.



Rates for earlier years than those shown should be close, but they will not be identical because OAS data is used all the way back to 1999, rather than to 2007, as is the case for MI-2017. Also, the graduation process can produce small variations in earlier years, but the variations decrease in size as one goes farther back in history. Rates for later years will come together at the ultimate year – in this case, 2036.

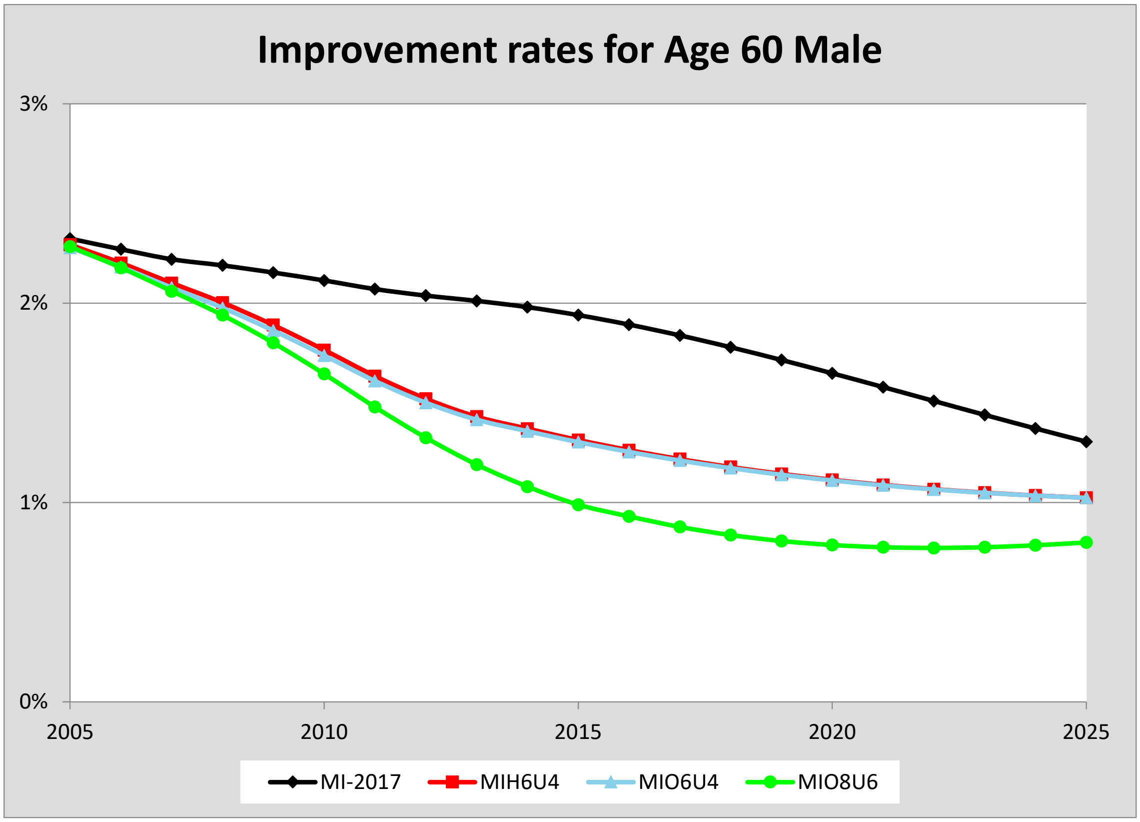
The improvement rates for MIH6U4 differ from MI-2017 negligibly at age 70, but the difference is much larger when the OAS data in brought in. The difference between MIO8U6 and MI-2017 at 2016 is as great as 61 basis points, more than enough to be significant.

The next chart shows improvement rates for a male aged 80, and the picture is quite different.



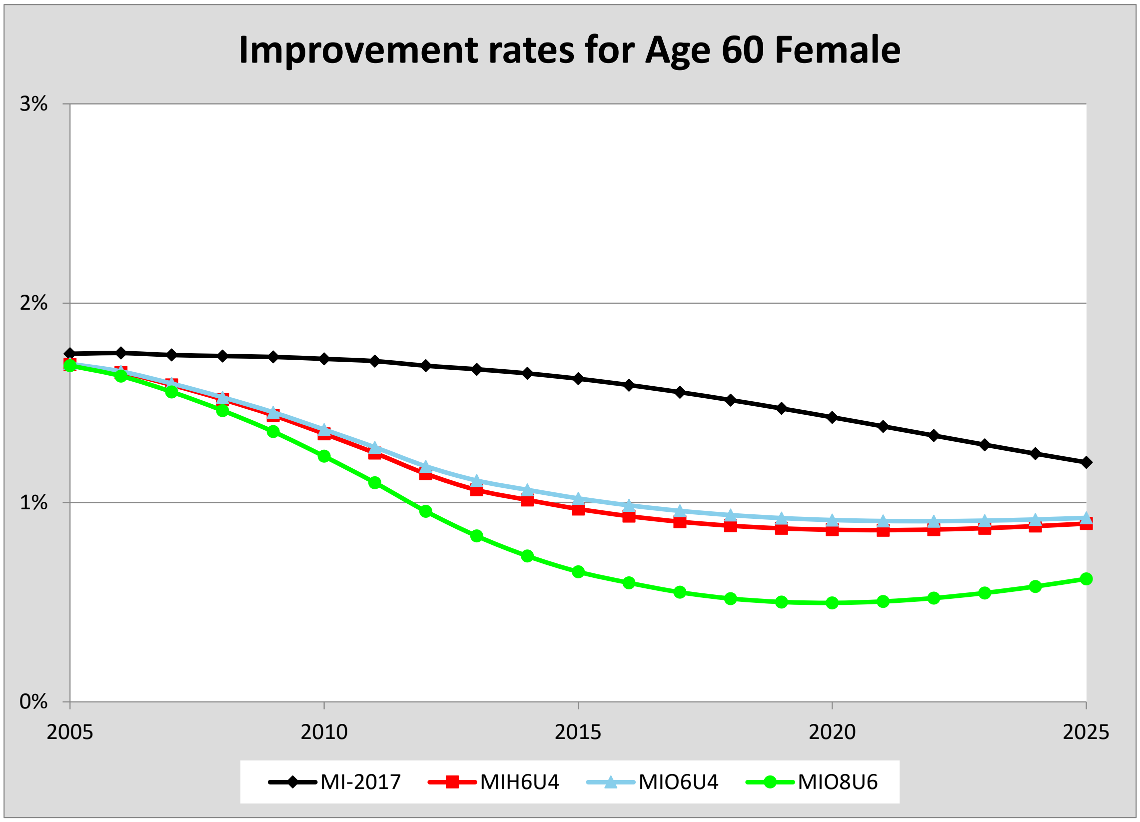
In this case, MIH6U4 is clearly higher than MI-2017, and MIO8U6 is lower, but the difference does not exceed 35 basis points.

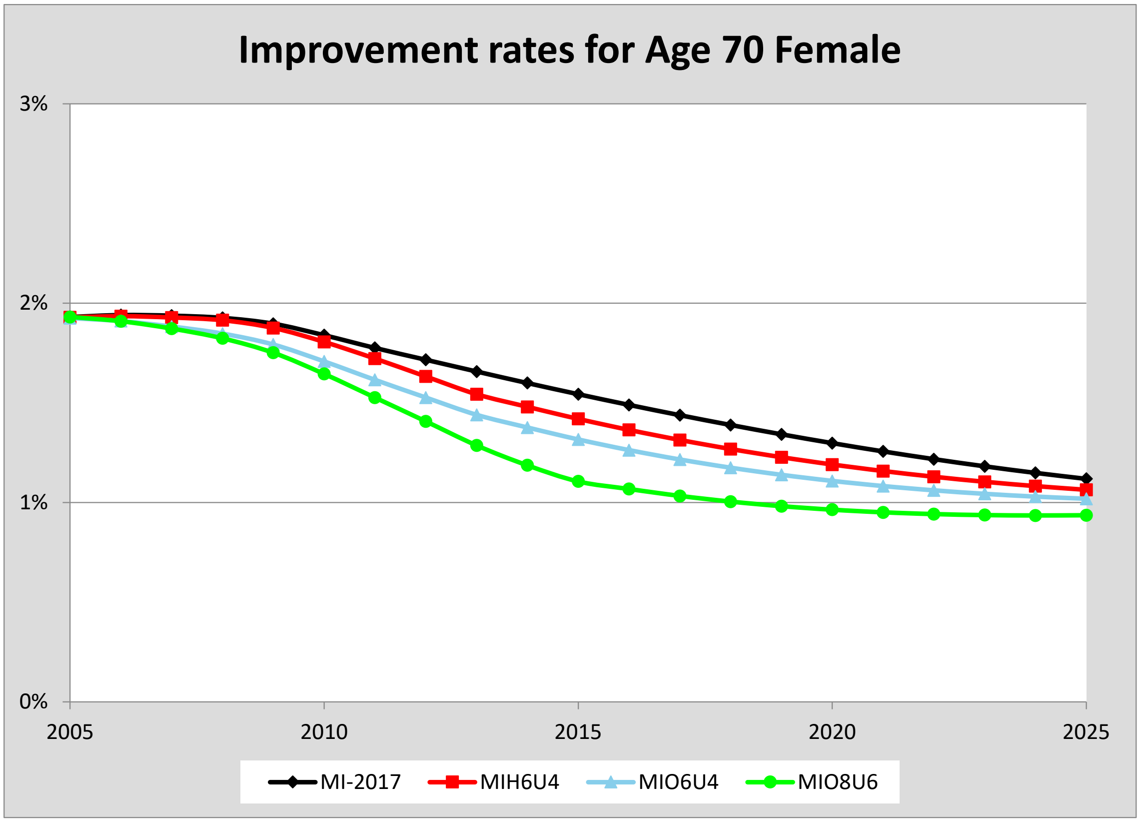
The next chart shows a male aged 60, and the picture is again different.

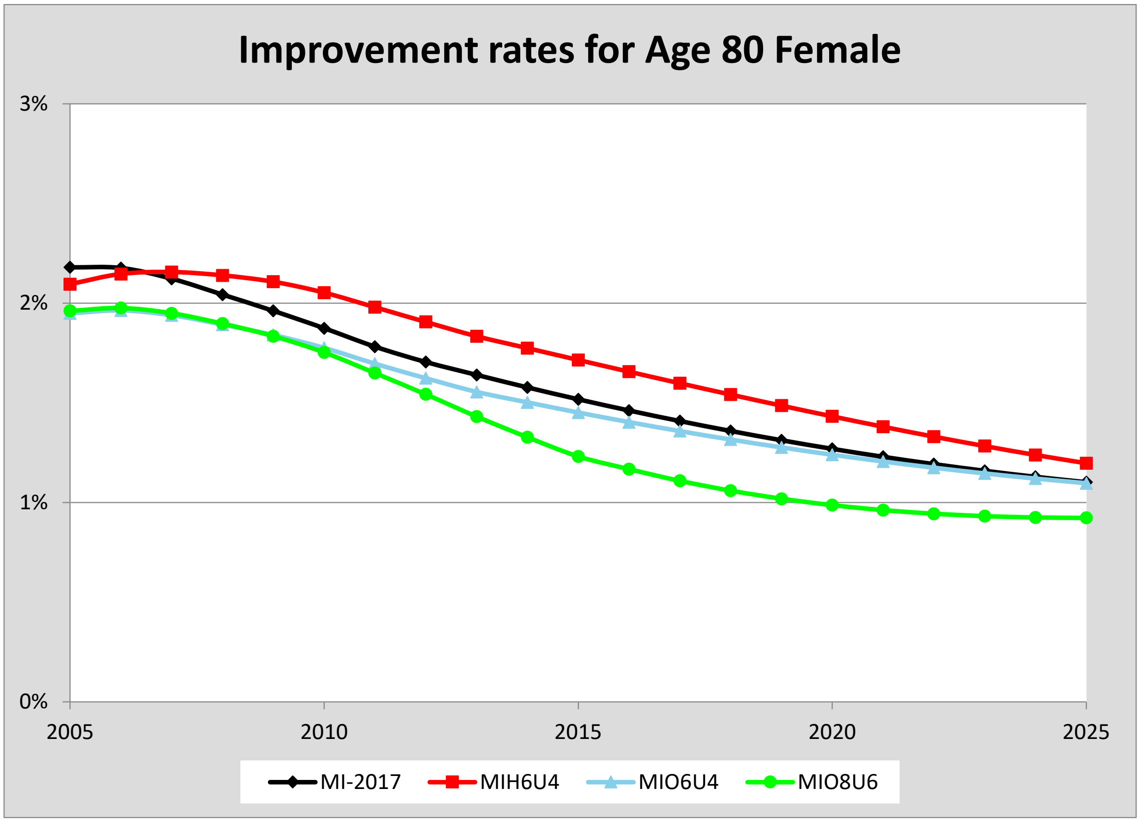


All new scales are well below MI-2017, and the difference is as great as 95 basis points for MIO8U6. Note that in this case there is no relevant OAS data to use. The HMD data is used without modification for MIH6U4 and MIO6U4. For MIO8U6, the HMD data is extended for 2017–2018.

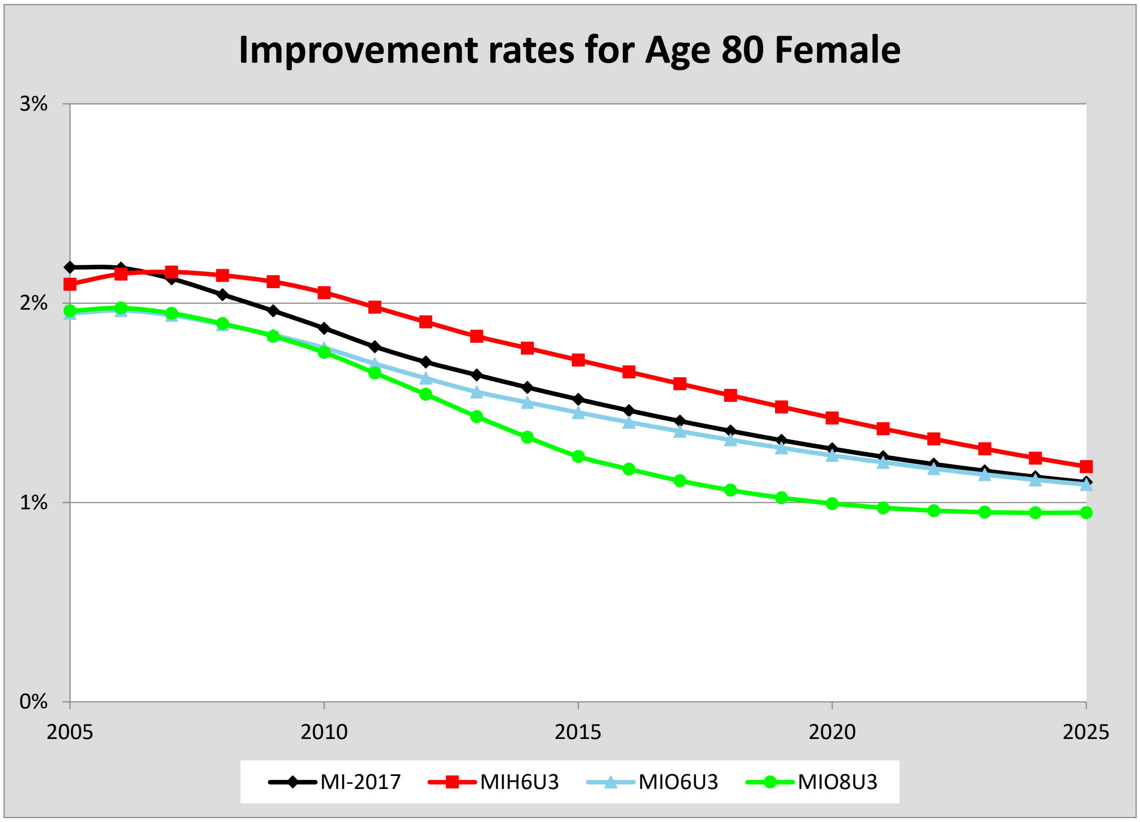
The next three charts show comparable information for females at ages 60, 70, and 80. As we have seen in recent years, the improvement rates are lower than for males, and the differences are more moderate.


Improvement rates for Age 60 Female
3%
2%
1%
0%
2005
2010
2015
2020
2025
MI-2017
MIH6U4
MIO6U4
MIO8U6


Improvement rates for Age 70 Female
3%
2%
1%
0%
2005
2010
2015
2020
2025
MI-2017
MIH6U4
MIO6U4
MIO8U6



As mentioned earlier, another choice for a consistent method would have been to use the same year at which the ultimate improvement rates are reached as is used in MI-2017 (that was 2033, grading to 2023 at younger ages). The following chart shows MI-2017 compared with three other consistent scales for a female aged 80. As you can see, little difference is evident between the chart below and the one just above. For example, MIO8U3 and MIO8U6 differ only after 2016, and then by only, at most, three basis points for a female aged 80. Other sex-age comparisons are similar.



Over all ages and both sexes, MIO8U6 is never materially higher than MI-2017, and is often much lower. How much difference there will be in actuarial values because of differences in improvement rates is not intuitive. That is dealt with in the next section.

4 Change in actuarial values

4.1 Annuity present values

The table below shows changes in the present value, at 4 per cent, of a single life annuity at various ages for males and females. The calculation is of the annuity value on the indicated scale less the annuity value on MI-2017, and then divided by the annuity value on MI-2017. Thus, a negative number indicates a decrease in annuity value. The mortality table used in all cases is GAC2012.

Change in monthly annuities at 4% on GAC2012 as of start of 2020			
	MIH6U4	MIO6U4	MIO8U6
M50	0.0%	-0.3%	-0.9%
M60	0.2%	-0.4%	-1.2%
M70	1.0%	0.1%	-1.2%
M80	2.0%	0.2%	-1.6%
M90	3.1%	0.1%	-2.3%
F50	0.1%	-0.1%	-0.7%
F60	0.3%	-0.1%	-0.9%
F70	1.0%	0.1%	-1.1%
F80	2.4%	0.7%	-1.5%
F90	3.3%	1.2%	-2.2%

What is immediately clear is that the method for obtaining the data to be graduated is very important. If HMD data were to be used without modification, improvement rates would increase enough overall that life annuity values would rise. If HMD central death rates were changed for ages 66–100 to be consistent with those of OAS, but not extended to 2018, the overall impact of the new scale would be very similar to MI-2017. If HMD rates were changed for ages 66–100 and extended for ages 0–65 to 2018, life annuity values would decrease.

The annuity rates at individual ages are important to pricing actuaries, but valuation actuaries are more interested in the overall impact. To estimate that, I simulate a valuation of pension liabilities. The portfolio of annuities to be valued is the sum of all annuities in the Group Annuitant Mortality Study for 2016. All annuities are treated as single life annuities with no certain period. The annualized income for secondary annuitants is cut in half, but other annualized income is taken in full. Expenses and margin for adverse deviations are ignored. The interest rate is 4 per cent. The values are in billions at the start of 2020.

Present value of portfolio at 4% on GAC2012 as of start of 2020		
Scale	Value	Change
MI-2017	21.56	
MIH6U4	21.86	1.4%
MIO6U4	21.59	0.2%
MIO8U6	21.27	-1.4%

The results are consistent with those of the preceding table. There would be a decrease of about 1.4 per cent in present values with MIO8U6, but an increase of about 1.4 per cent with MIH6U4. This table, and the prior one, seem to me to be conclusive evidence that MI-2017, if recalculated on the newly released data, would be materially different from what was published. Before deciding that MI-2017 must be updated, we need to understand the data better. That is dealt with in section 5.1.

4.2 Insurance net premiums

Actuaries who practice more with insurance than annuities will be concerned about the impact at lower ages. The table below shows the change in net premiums for 10-year term insurance on CIA9704 at 4 per cent (expenses, lapses, and renewals are ignored).

Change in Term10 net premiums at 4% on CIA9704 as of start of 2020						
	Male			Female		
	MIH6U4	MIO6U4	MIO8U6	MIH6U4	MIO6U4	MIO8U6
NS30	14.5%	14.2%	27.0%	5.3%	5.1%	11.2%
NS40	7.4%	7.7%	13.3%	-0.3%	0.7%	4.9%
NS50	6.8%	6.9%	11.1%	5.4%	5.2%	10.7%
NS60	5.7%	8.4%	13.0%	6.2%	6.7%	11.5%
NS70	-1.1%	1.0%	5.6%	-0.2%	3.0%	5.6%
SM30	14.5%	14.1%	26.9%	5.3%	5.1%	11.2%
SM40	7.4%	7.7%	13.2%	-0.4%	0.6%	4.9%
SM50	6.7%	6.9%	11.0%	5.3%	5.1%	10.5%
SM60	5.9%	8.5%	13.0%	6.5%	6.8%	11.7%
SM70	-1.1%	0.9%	5.3%	-0.1%	2.9%	5.5%

The increase in premium rates over those calculated with MI-2017 is astonishingly high, particularly for males and particularly for MIO8U6. It is especially surprising because the CIA's annual study of insurance experience does not hint that such a large change in improvement rates has taken place. We must seek an explanation in the data. One is offered in section 5.2.

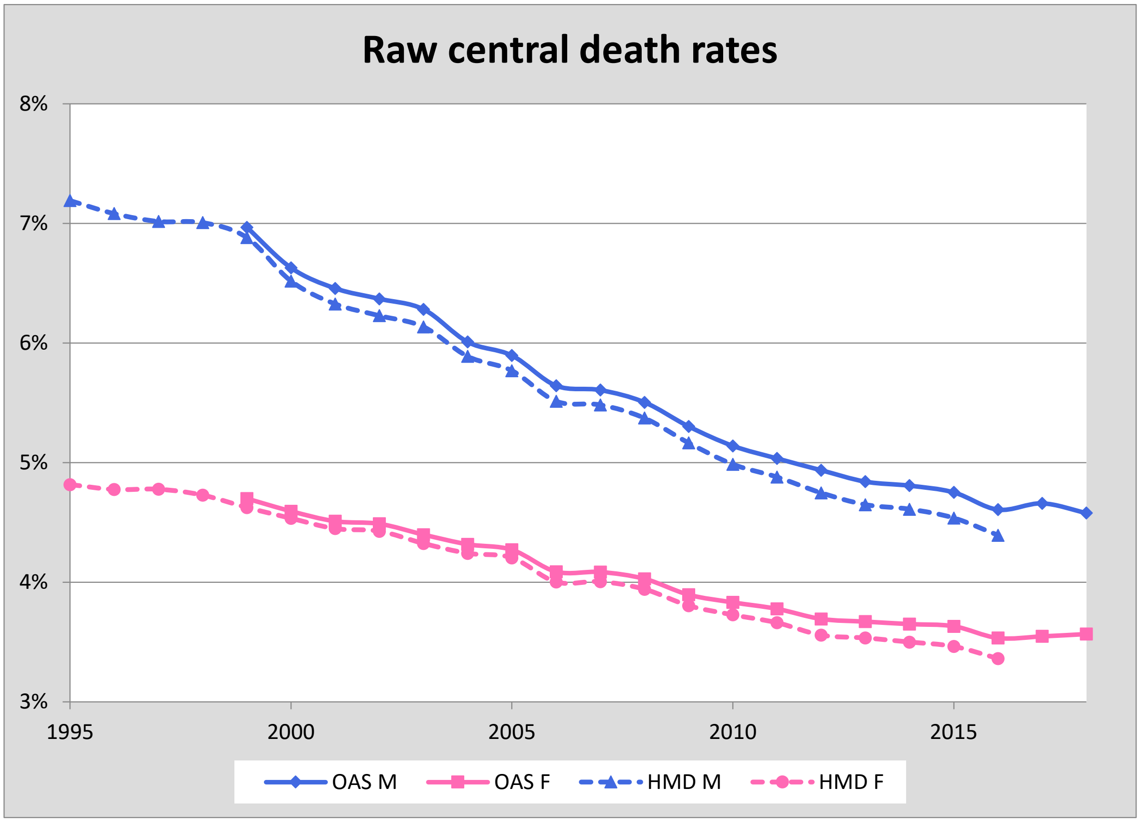
5 Understanding the impact

5.1 Post-retirement ages

The use of OAS data along with HMD is predicated on the assumption that essentially the same lives are in both, and that administrative data is likely to be more accurate. We would expect to see very little difference between MIH6U4 and MIO6U4, but some of the differences are, in fact, notable.

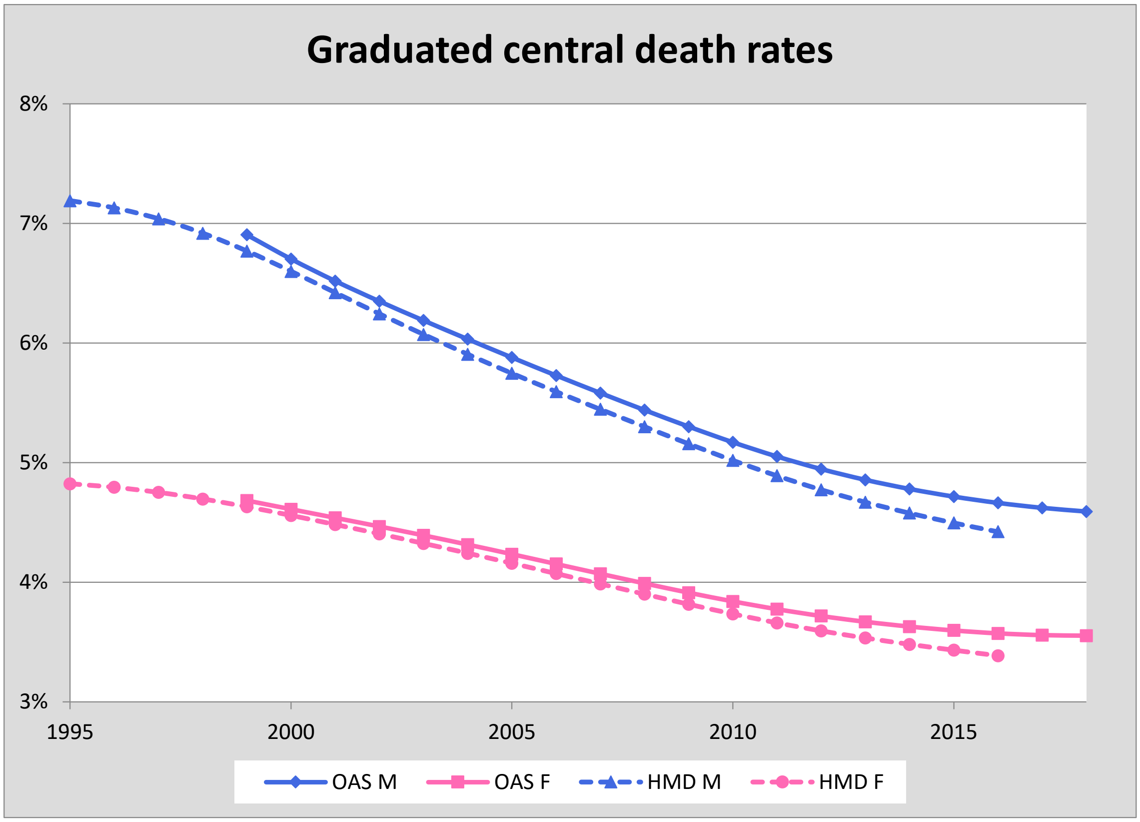
What are the differences between the two datasets?

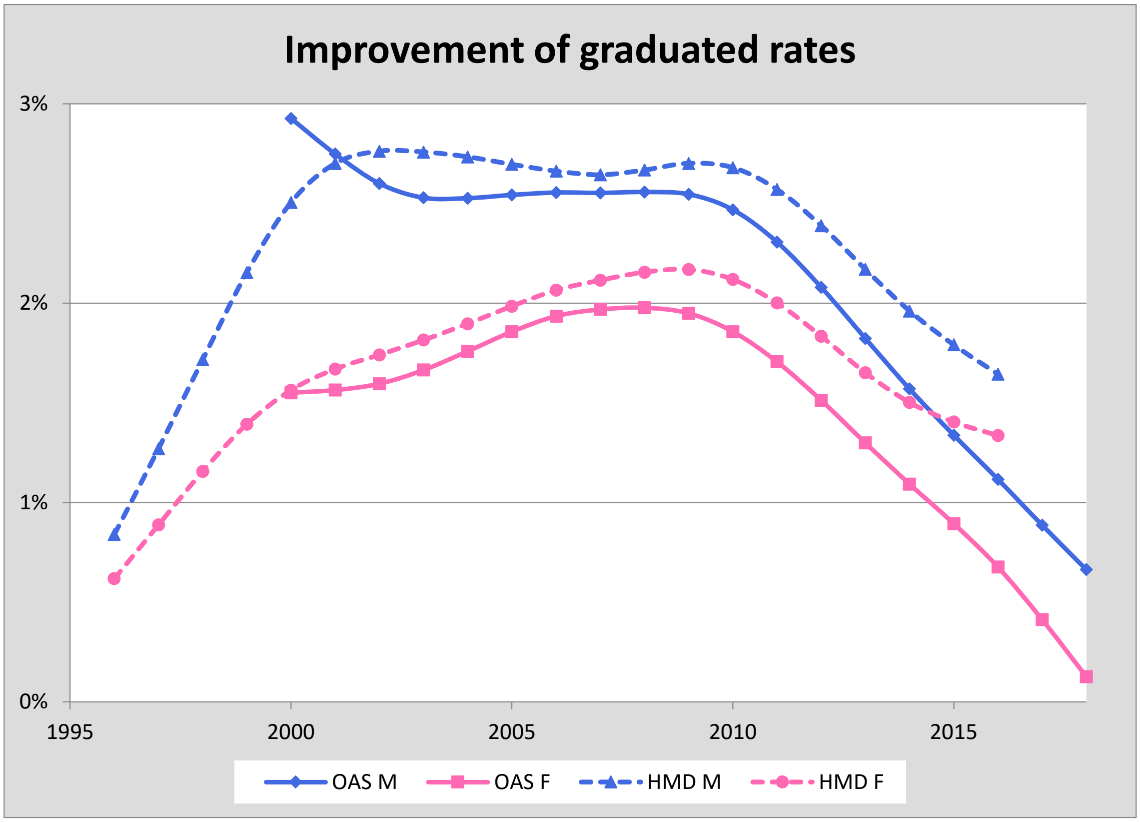
The following chart shows the age-adjusted central death rates for OAS and HMD data. The age adjustment considers ages 70–90 only. The standard population is the exposure for 2016 for the OAS data. The OAS rates are represented by solid lines, the HMD by dashed lines.



The OAS and HMD lines look close together, but there appears to be a gradual divergence between the two sets. In the final two years, for which there is no HMD data, the OAS rates are fairly flat, implying no improvement.

To get a better sense of what is going on, it is reasonable to graduate the age-adjusted central death rates and then calculate age-adjusted improvement rates (although one should be cautious of edge effects).

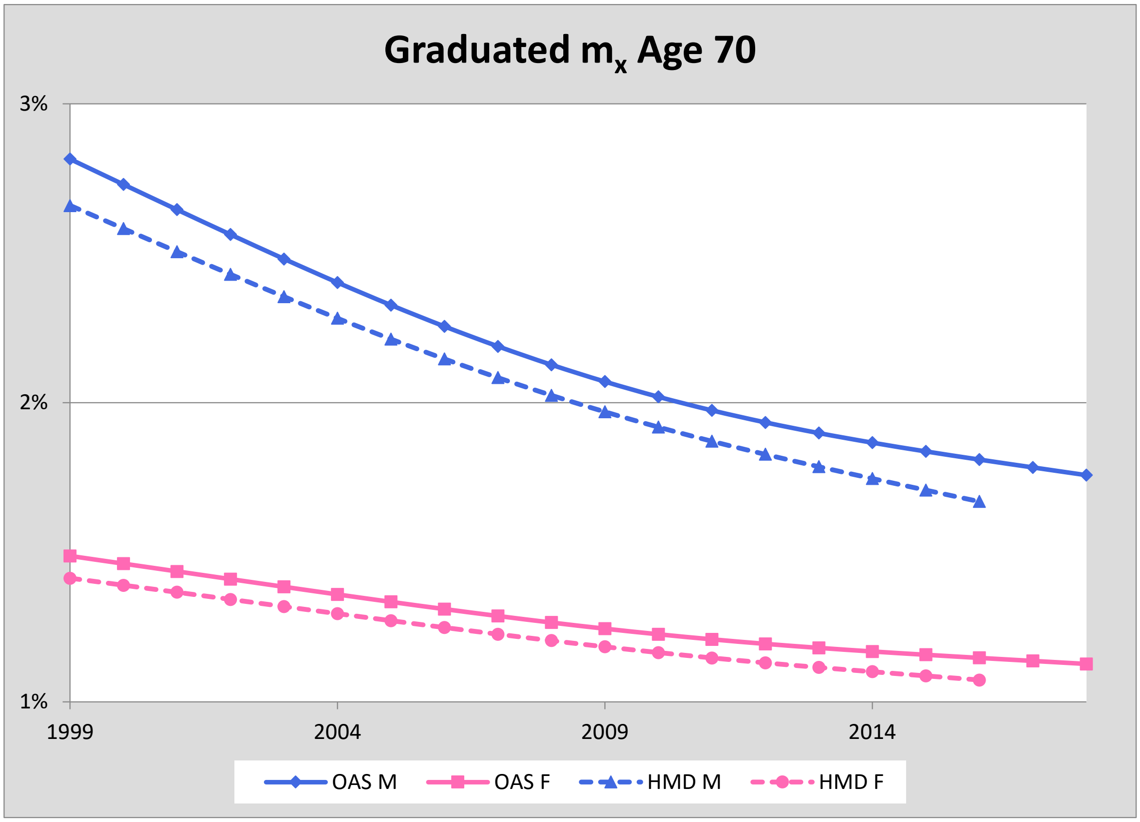

Graduated central death rates
8%
7%
6%
5%
4%
3%
1995
2000
2005
2010
2015
OAS M
OAS F
HMD M
HMD F

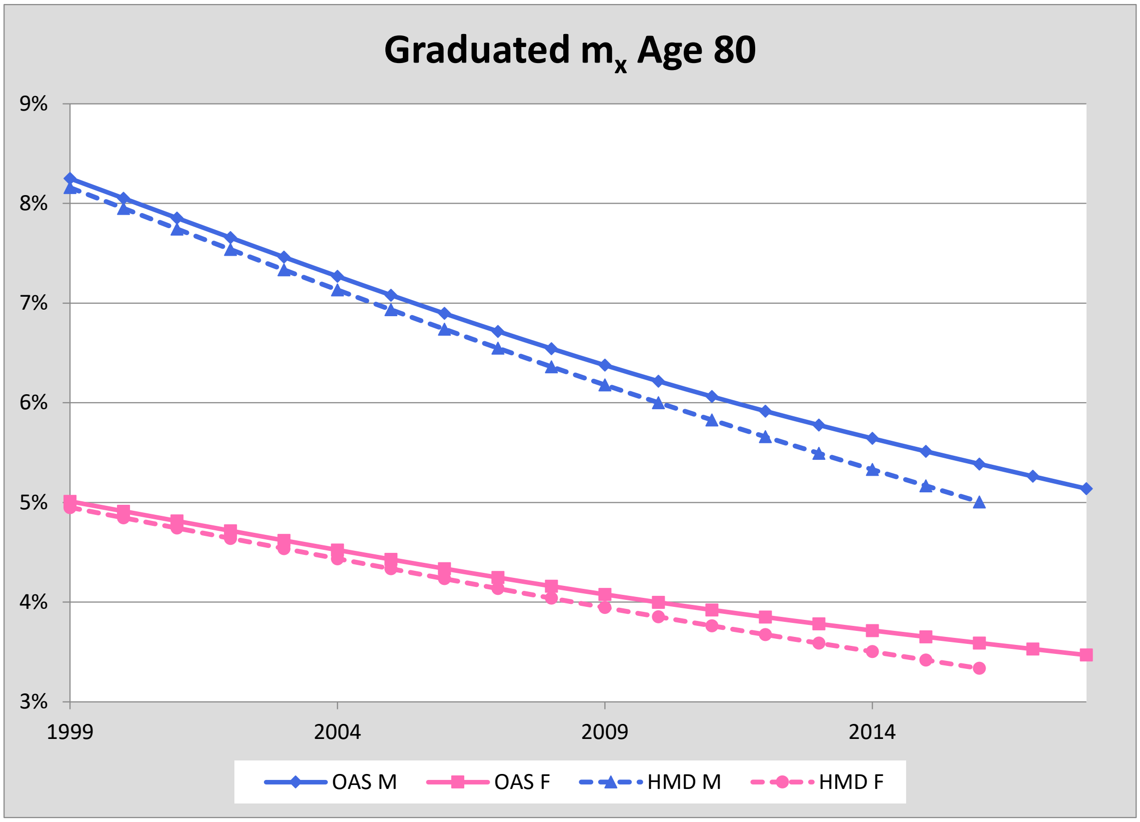


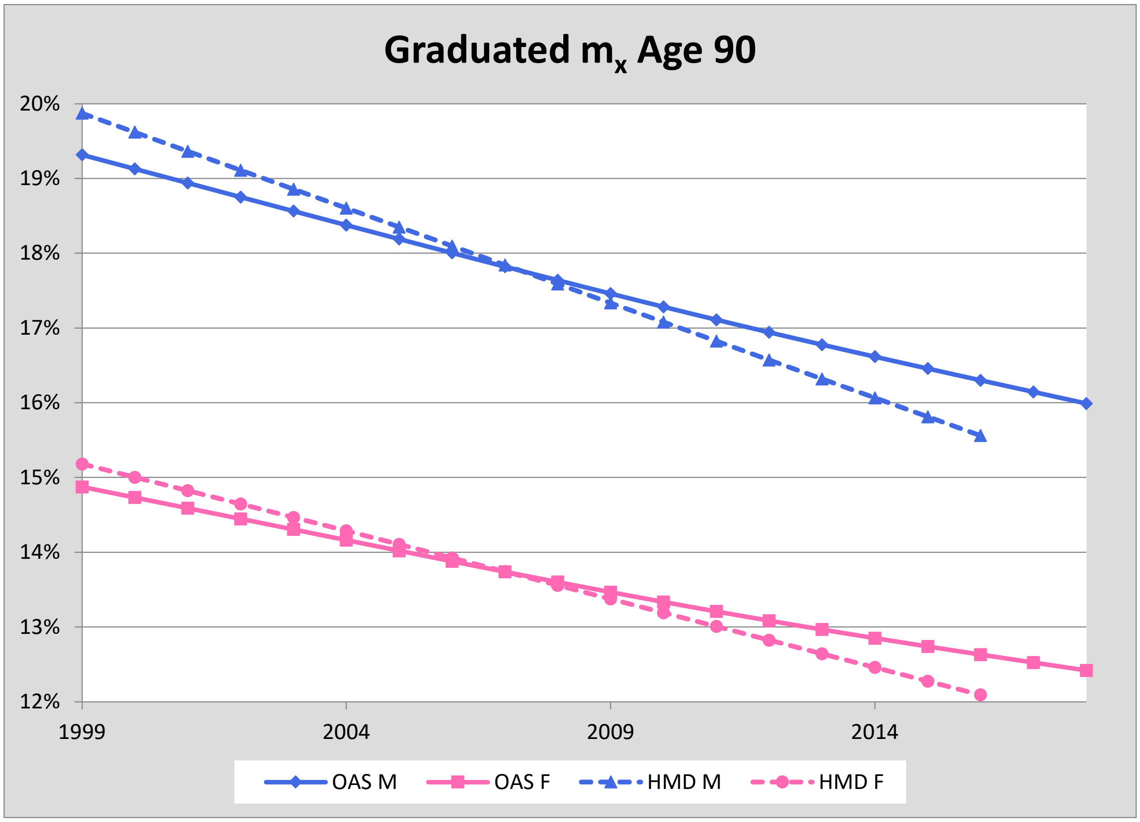
The divergence of the OAS and HMD improvement rates, particularly after 2010, is noteworthy. One might speculate that given that, since 1989, OAS has been clawed back through tax for those with high incomes, some of the wealthier members of the population may be counted in HMD data but absent from OAS. Unfortunately, we do not know enough about the datasets to make a determination here.

It is also possible that the lack of improvement in OAS data in the final two years is merely a fluctuation, and is having too large an effect on improvement rates. It is not uncommon to see a delay in improvement for a few years followed by larger improvement.

It may not be worthwhile to look at the variation in death rates at individual ages because of fluctuation, but looking at graduated death rates may be instructive. The following charts show graduated central death rates for ages 70, 80, and 90.


Graduated m_x Age 70
3%
2%
1%
1999
2004
2009
2014
OAS M
OAS F
HMD M
HMD F


Graduated m_x Age 80
9%
8%
7%
6%
5%
4%
3%
1999
2004
2009
2014
OAS M
OAS F
HMD M
HMD F

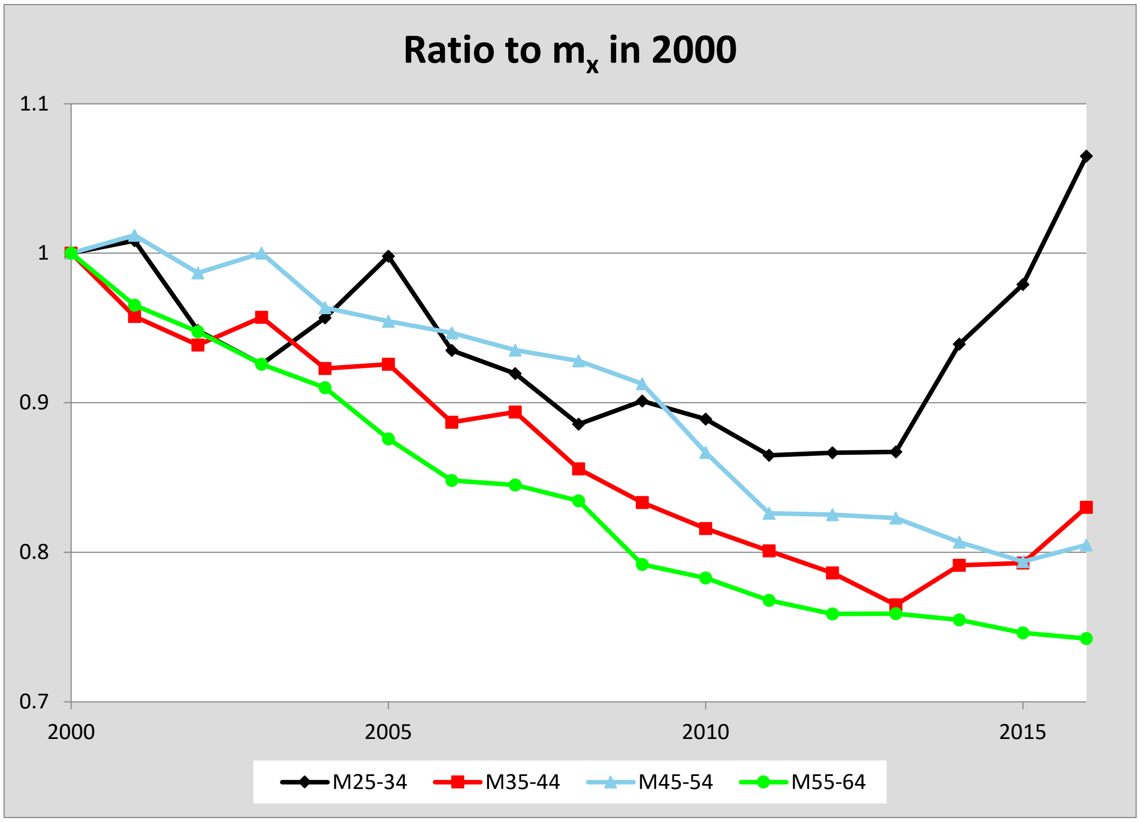


At age 70, the curves for OAS and HMD are very close to parallel, as one would expect. At age 80, the curves show a slight divergence. The rates for age 90 are unexpected; there is strong divergence and a cross-over around 2007. The differences are large enough that one might suspect data problems. Further study may be warranted.

An examination of the exposures for OAS and HMD shows that OAS exposures are generally lower than HMD, as expected. However, at the higher ages, OAS exposure can exceed HMD. For example, for a male aged 90, OAS exposure is greater for 1999–2012, except for 2009. In 2011 the ratio of OAS to HMD is 1.029 (the highest), and the ratio decreases rapidly to 0.969 (the lowest) in 2016. Female aged 90 ratios decrease from 1.012 (not the highest) to 0.981 (the lowest) over the same period. Note that both 2011 and 2016 are census years. One might hypothesize that ages were more accurately reported in the 2016 census than in earlier ones for age 90, but one cannot know.

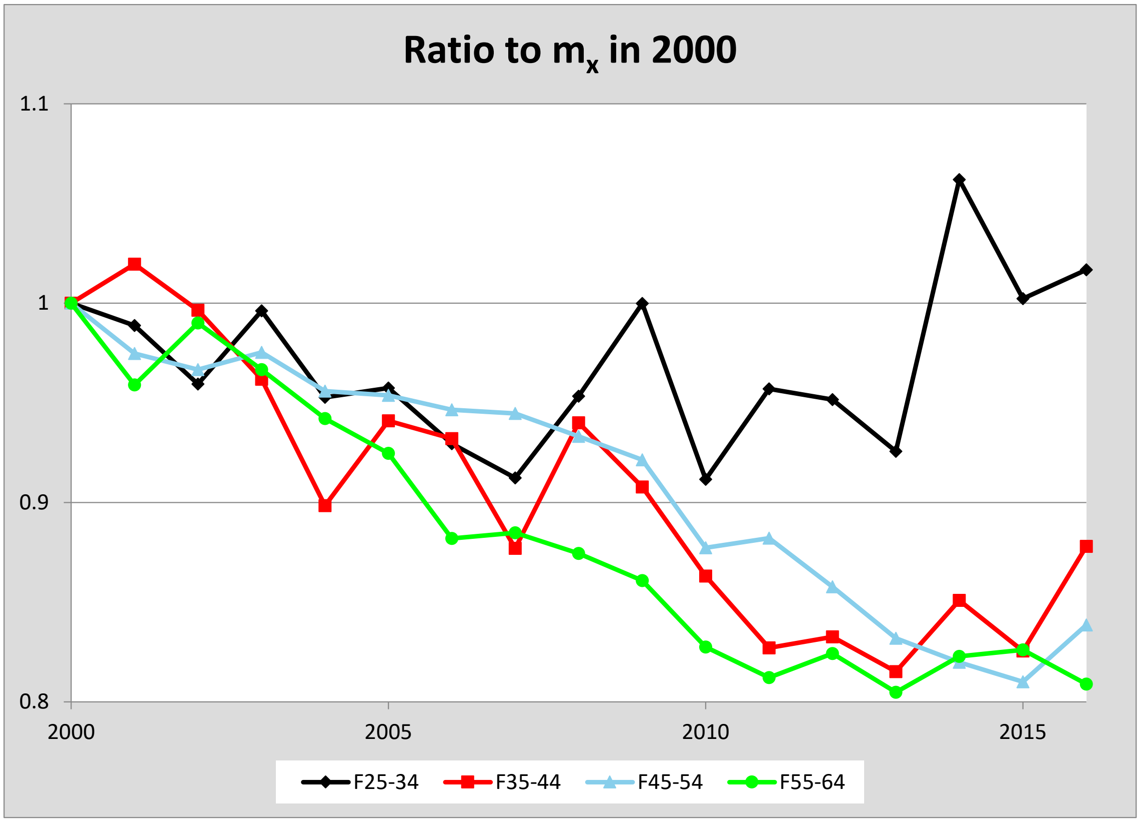
5.2 Early adult ages

The chart below shows the average central death rates for males in decennial age groups from HMD. The rates each year are expressed as a ratio of the rate for that year to the rate for 2000.



The increase in the central death rates for ages 25–34 over the last few years is very large. It seems to be a new feature in the data that has arisen very suddenly. Unfortunately for the task described in this article, no graduation method will deal very well with such a large change. There is also a noticeable uptick for the 35–44 group, but the higher ages show continued mortality improvement.

The chart below shows comparable information but for females.

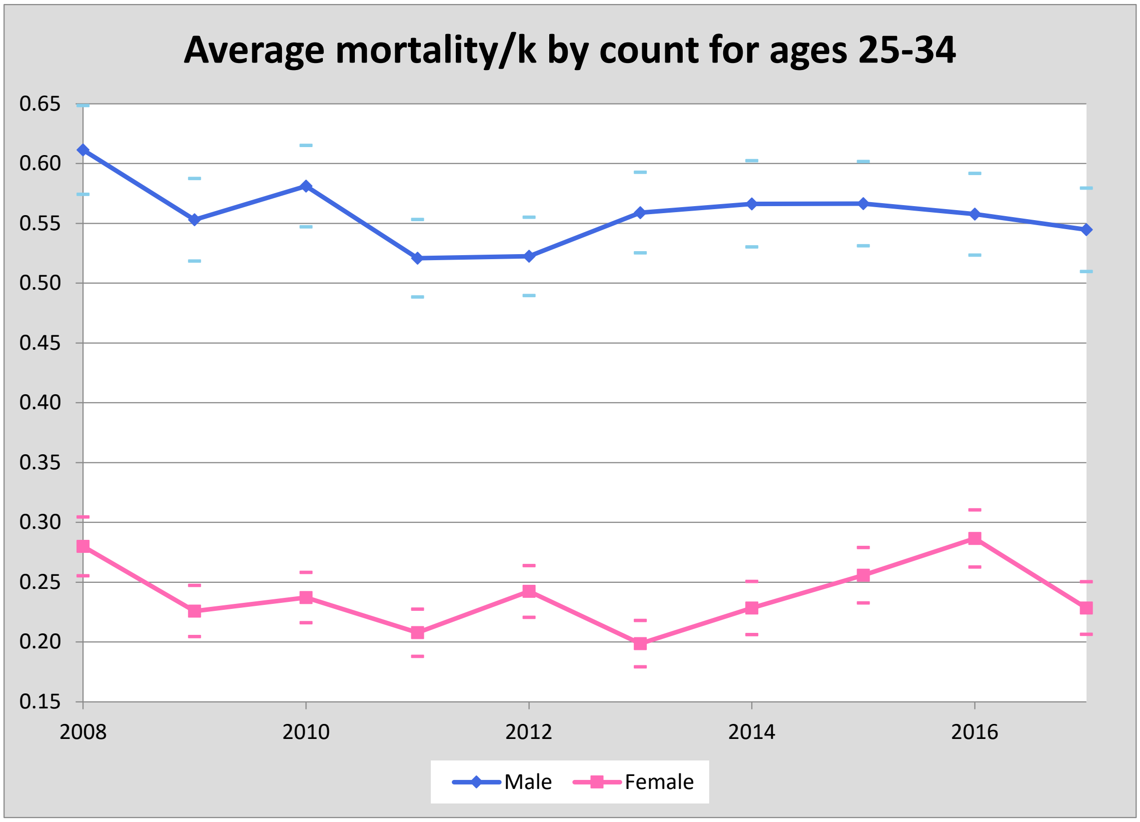


The changes in the central death rates are directionally similar to those for males, but the impact is less.

As many of you will already have guessed, the increase in central death at lower ages can be explained by the huge increase in opioid deaths. About three-quarters of those deaths are in males, and the deaths peak around age 30. According to Statistics Canada,[1] there were 648 accidental deaths for males 25–34 in 2013. The number increased to 965 in 2016 (the last year for HMD) and to 1,221 in 2017. My rough estimate from other StatCan data of the opioid deaths for males 25–34 is 550 and 820 for 2016 and 2017, respectively. There is therefore good reason to believe that the entire increase is related to opioid deaths.

What are the implications for insurance? The following table shows the average mortality rate for attained ages 25–34 based on the annual reports of the CIA individual insurance mortality study. All standard risk classes are combined. There are, of course, far fewer lives in this study than in HMD (which includes the whole population). There are tick marks on the chart indicating approximately one standard deviation above and below the averages. The chart covers the years 2008–2017; HMD data ends at 2016.

[1] See https://www150.statcan.gc.ca/t1/tbl1/en/tv.action?pid=1310039401&pickMembers%5B0%5D=2.7&pickMembers%5B1%5D=3.2



We do not see much improvement at these ages, but there is no indication of the large deterioration shown in the HMD data. This is surprising because the CIA data goes one year farther than HMD. It seems reasonable to infer that the subpopulation that buys insurance does not include many at risk of opioid overdose, at least in the years for which we have experience. This age group warrants careful attention in future. It is not clear whether a revision to MI-2017 should recognize the mortality deterioration in the general population or the slight improvement in the insured population.

6 Conclusions

Mortality improvement is important enough to actuaries, particular in the annuity and pension fields, to warrant a close watch by the profession. There may be enough movement in observed improvement rates to justify a revision of MI-2017. I recommend that the CIA take action, via either a new task force or a project under the Research Council. By the time work begins in earnest, there may be another year of data available.

Note that my conclusion is based on observed experience only. If the consensus view of ultimate improvement rates has changed, the need for revision MI-2017 will be greater.