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Living to 100, So What?

By Kai Kaufhold

A friend of mine always interrupts me with "Kai, what's the 'So, what?'" every time I launch into an excited report on the latest great paper that I have read or an inspiring presentation that I recently heard. I secretly believe he's just trying to avoid listening to me geekily ramble on about some technical issue that he isn't that interested in, but it usually does make me get to the point. So, what was the "So, what?" of the sixth Living to 100 Symposium, which the SOA hosted in Orlando in January 2017?

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Living to 100 is made for giving actuaries a wider view. Topics relevant to aging and the aging society which are presented and discussed at Living to 100 include genetics, bio-gerontology and medicine in general, but also questions relating to how the aging population is already affecting today's society and what will actually become of us in our own old age. Hearing about research developments in fields outside the actuarial realm is incredibly important if you take our responsibility for both our industry and society at large seriously. Understanding why efforts to refine our understanding of metabolic processes at the cell level are important and what impact they may have on the health and vitality of the individual gives us a better sense for the context within which we actuaries analyze mortality and morbidity experience data and project future trends in mortality. We are part of a greater picture and getting the chance to connect with others working in various fields related to longevity and aging is inspiring. However, for me the real widening of the view is much more up close and personal. As someone who has worked for 20 years in life reinsurance and on reinsurance related topics, I have been able to take away a handful of ideas and methods which extend the tools and methods I apply in analyzing life insurance risks, every time I have attended Living to 100. This year was no different, so here are my top three relevant take-aways which will find their way into my everyday work in reinsurance:

IT'S OKAY TO BORROW THE TABLE SHAPE FROM YOUR NEIGHBOR

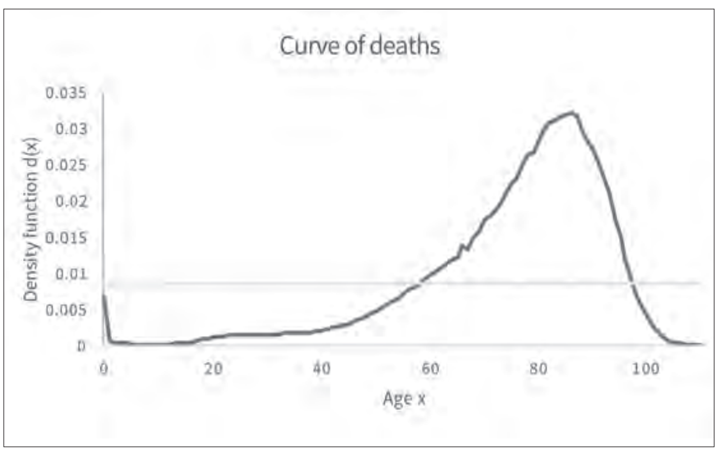
In reinsurance, we are often faced with the challenge that we have to come up with mortality assumptions for a product or a specific market, for which only a limited amount of experience data exists. We then normally rummage around in the toolbox until we find a mortality table or a set of data which we think might be "close enough" to the problem at hand. Then, as reinsurers, we convince ourselves that we can take the leap of faith and apply the existing table—with some adjustments—to the problem we are working on. This has always left me with a nagging feeling of doubt. In a paper presented at Living to 100[1], Jack Yue and Hsin Chung Wang from Taiwan showed in a more rigorous way, how to "[Use] Life Table Techniques to Model Mortality Rates for Small Populations." These techniques include the so-called standard mortality ratio (SMR) which is nothing other than our well-known and often used actual-over-expected (A/E) ratio. The added benefit here was that the authors showed how to construct useful weightings for individual age groups to optimize the applicability of one (larger) population's mortality table to the experience of a small (neighboring) population. Furthermore, Yue and Wang show how they tested the applicability of the results. Who knows, this test may one day soon find its way into a pricing memo helping to justify why I have borrowed Austrian tables to model Slovenian mortality instead of using Italian tables—or the other way around. Or are you trying to develop a product for a particular market within a region of the U.S., for which you don't trust the standard industry tables, but you don't have enough local experience data to build your own regional table? Weighted SMR's might just do the trick.

THERE ARE FOUR THINGS TO LOOK AT WHEN COMPARING MORTALITY TRENDS ACROSS DIFFERENT COUNTRIES

Dealing with insufficient data and "borrowing" from related data sources is a running theme in a reinsurance actuary's daily work, and becomes especially important when dealing with mortality trends and the evolution of mortality over time. When a given population, target market or group of insured lives does not have sufficient data to measure time trends, the natural reaction is to use data from a larger source. In many instances, this will be the general population mortality data for the country for which the reinsurance is being priced. For smaller countries, the data source will usually be a large

neighbor, where the choice is usually made based on proximity and perceived similarity in culture and qualitative aspects of historical mortality. Martin Genz presented a paper that carried out a comprehensive international comparison of mortality trends based on the evolution of the curve of deaths.[2] He applied a framework that uses four quantitative measures to describe the position and the shape of the curve of deaths and its evolution over time. These four measures are the modal age at death, the upper bound, the degree of inequality and the number of deaths at the modal age at death.

Figure 1.
Illustration of Curve of Deaths for US Males in 2013



Source: General population mortality experience for males in the U.S.A. in 2013, extracted from Human Mortality Database at mortality.org. Average death rate 8.6 per 1,000, modal age at death M = 86, UB = 110 years, DoI = 4.34 and d(M) = 0.032

For a given population, each of these statistics is determined for each year in the study period, giving four specific time series. By comparing the changes in these statistics for different populations over time, you can make a much more informed decision about whose mortality trends have been similar and whose different. Very useful information for a reinsurer to have.

THE MORTALITY PLATEAU VARIES FROM COUNTRY TO COUNTRY. WHAT DOES IT SIGNIFY?

One of the recurring themes of Living to 100 is the question of what actually happens to mortality rates at the very advanced ages. Does mortality continue to increase with age at a constant rate, or does the rate of mortality increase slow down or even level off?

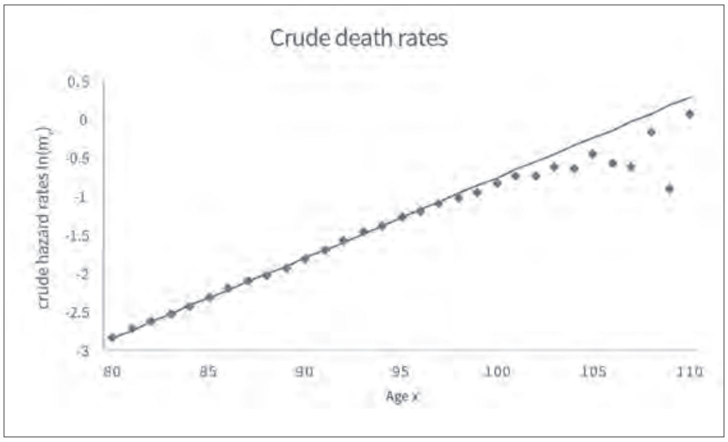
This is where my friend would normally interrupt and hit me with his “So, what?” The reason why this question is important

The chart in Figure 2 shows the crude death rates on a logarithmic scale. Between ages 80 and 95, these very closely follow a linear pattern.

to actuaries and society at large is that the shape of the mortality curve at those ages has a material impact on the cost of providing retirement benefits to pensioners. Consider the curve of deaths in Figure 1 (Pg. 33). Half of all deaths occurred between the ages 69 and 89. Any changes to the mortality rates at these ages will have a huge impact on the number of survivors to advanced ages beyond 90 or even 100. However, given the historically low population at those ages, we have only very little data out there, on which to form an opinion. Therefore, improving the general understanding of oldest age mortality behavior is especially important.

"And what is all the fuss about, then?" my friend is likely to ask now, getting a little worried that I will begin to torture him with esoteric models and stuff. This is where a picture comes in handy.

Figure 2
Death Rates for U.S. Males in 2013 on a Logarithmic Scale.



Source: General population mortality experience for males in the U.S.A. in 2013, extracted from Human Mortality Database at mortality.org. The death rates m_x are calculated as the number of deaths between ages x and x+1 divided by the average population exposed to risk for that age group. A straight line was fitted to the death rates for ages 80 to 95, in order to illustrate the deceleration at ages above 95 years.

The chart in Figure 2 shows the crude death rates on a logarithmic scale. Between ages 80 and 95, these very closely follow a linear pattern. For older ages, this constant rate of increase appears to become gradually slower. A number of possible explanations have been put forward for this phenomenon of mortality deceleration. One possible cause could be overstated ages at death and under-reported deaths for high ages. In other words, flawed data. An alternative explanation might be that for an individual, the rate of mortality increase does actually slow down at the extreme ages. This would have far-reaching consequences for pension liabilities and social security systems the world over, once a larger number of people make it to age 100. Finally, another alternative explanation has been put forward by Prof. James Vaupel and others. This explanation is the starting point of the paper which Prof. Roland Rau of Rostock University in Germany presented.[3] According to Vaupel, Rau and other demographers, the apparent deceleration in mortality rates can also be explained by the fact that the population for which the mortality experience is gathered is heterogeneous with respect to mortality. In other words, the total population is made up of a number of different groups with different levels of mortality (or frailty, as engineers would put it). For example, we know that the U.S. general population mortality for males which is shown in Figure 1 and Figure 2 is made up of different socio-economic groups with different levels of mortality. Furthermore, the mortality data shown in these charts also relates to many different birth cohorts. People born in 1910, for example, will have been 103 in 2013 when the data was collected, and will have had somewhat different experiences in life from those born in 1933, say, who were 80 at the time of observation. Such generational differences may be another contributing factor for heterogeneous mortality rates, which in turn can be mathematically shown to cause the deceleration pattern, even though each individual would continue to see a constant rate of increase in their mortality rates.

The facts that Roland Rau presented at the 2017 Living to 100 Symposium are another indicator that the third, more technical explanation may be true. His research team managed to fit models to the mortality experience data of males and females in seven industrial countries, which displayed statistically significant results for a mortality plateau in each country. However, the mortality plateau in different countries had a fairly wide range. This tells us that (1) the level of the mortality plateau is not likely a universal constant built into the human biology, and (2) that it depends on the different circumstances in the different countries. It could possibly be interpreted as an indicator for the disparity of mortality rates within each country.

In my own work on Longevity Reinsurance transactions, I have made a similar observation, which also points towards the plateau being a function of how heterogeneous a group of individuals is with respect to mortality. When analyzing the historic mortality experience of a pension plan, I am often able

to fit the same model type, which Roland Rau used to quantify the mortality plateau, i.e., the frailty model according to R.E. Beard[4] (1959):

$$\mu_x = \frac{e^{\alpha+\beta x}}{1+e^{\alpha+\beta x+\varrho}} \longrightarrow e^{-\varrho}$$

According to this mortality law, the force of mortality μ_x will tend towards a constant $e^{-\varrho}$ at very large ages x. When fitting the Beard model to mortality data without differentiating between different risk factors that might influence mortality, such as socio-economic status and health status, it is often possible to estimate a parameter for the plateau $e^{-\varrho}$. As soon as one includes explanatory variables that distinguish between mortality for different pension size bands, ill-health retirement vs. normal retirement or different life-style groups, for example, the statistical significance of $e^{-\varrho}$ tends to disappear, which means that the parameter ϱ is likely zero and $\mu_x \longrightarrow 1$.

"So, what?" my friend cries, frustrated by the fact that I did manage to get a formula in. The "So, what?" is that this is emerging research into the behavior of oldest age mortality which will likely have an important impact on pension liabilities and social security systems across the globe. And it was presented at the SOA's 2017 Living to 100 Symposium. If you didn't manage to attend the symposium, never fear! A monograph containing all the papers and transcripts of the presentations will be coming out shortly, so you can brush up on mortality plateau, mortality trends and even good old A/E ratios without having to travel to Orlando in January and meet hundreds of interesting people. ■

Kai Kaufhold, Aktuar DAV, is managing director of Ad Res, an actuarial consulting firm in Cologne, Germany. He can be contacted at *kai.kaufhold@adreservices.com.*

ENDNOTES

1 Yue, J. C. and H.C. Wang (2017) Using Life Table Techniques to Model Mortality Rates for Small Populations, presented at 2017 SOA Living to 100 Symposium

2 Genz, M. (2017) A Comprehensive Analysis of the Patterns of Worldwide Mortality Evolution, presented at 2017 SOA Living to 100 Symposium

3 Rau, R., M. Ebeling, F. Peters, Chr. Bohk-Ewald and T.I. Missov (2017) Where is the level of the mortality plateau?, presented at 2017 SOA Living to 100 Symposium

4 Beard, R.E. (1959) Note on some mathematical mortality models. In: The Lifespan of Animals, G.E.W. Wolstenholme and M. O'Connor (eds.), Little, Brown, Boston, 302-311.