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MORTALITY IMPROVEMENTS

ANALYSIS OF THE PAST AND PROJECTION OF THE FUTURE

WITH IMPROVED GLOBAL MORTALITY CONFIRMED, THE QUESTION BECOMES, "WHAT ADJUSTMENTS DO ACTUARIES NEED TO MAKE?" THIS ARTICLE ANSWERS THAT AND OTHER QUESTIONS. BY MARIANNE PURUSHOTHAM

OVER THE LAST CENTURY, general population mortality has improved significantly and on a global basis. As this trend appears likely to continue at least over the near term, mortality improvements are expected to continue to impact the viability of national social programs worldwide as well as the financial stability of insurance programs, including pension plans and annuities.

As a result of the current trends in mortality improvement, insurers have begun to incorporate longer term assumptions regarding mortality improvement in both pricing and financial projections, resulting in greater scrutiny from both an audit and regulatory perspective.

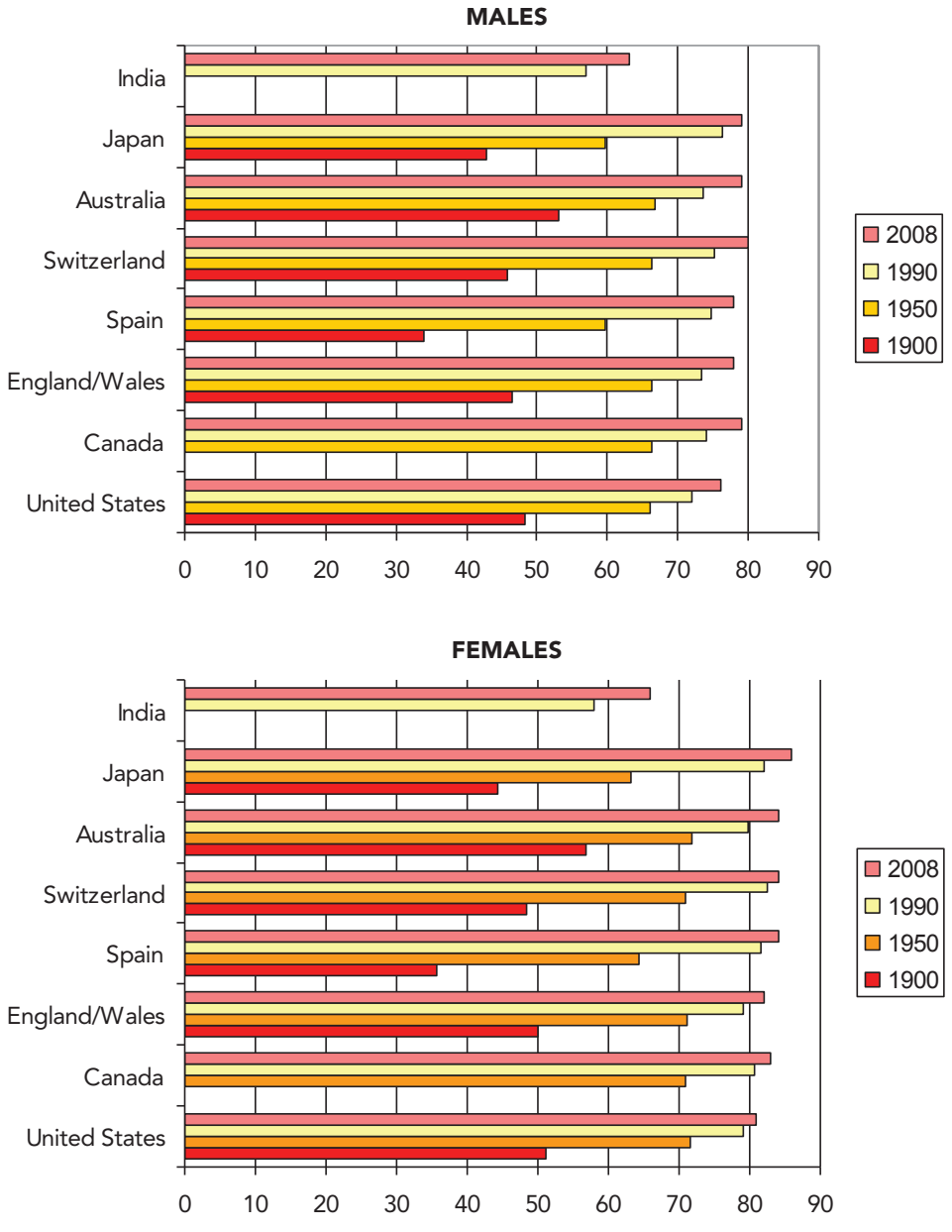
To assist actuaries in developing mortality improvement assumptions for various product lines including individual annuities, pension, life insurance and long-term care insurance, the Society of Actuaries (SOA) commissioned a research project to compile both historical data regarding mortality improvement experience as well as information regarding techniques for modeling future assumptions. This article provides a general overview of information included in that report.

MORTALITY IMPROVEMENT EXPERIENCE

Population Data

From 1900 to 1950, enormous strides were made in improving mortality rates on a global basis, particularly at ages under 35. This was largely due to an expanded focus on public

Population Life Expectancy at Birth by Country



Source: U.S. Census Bureau Estimates from Various Databases, *American Journal of Clinical Nutrition*, Changes in Life Expectancy 1900-1990, published 1992 and World Health Organization, Statistics 2010.

health initiatives in many countries that led to the introduction of large-scale immunization programs, penicillin and sulfate drugs, and other disease eradication methods.

Since 1950, both in the United States and across the globe, mortality improvement and resulting increases in life expectancy have continued, but at a slower pace. The most recent data from the World Health Organization indicates that male and female life expectancies at birth are nearing 80 and 85 respectively for many developed nations.

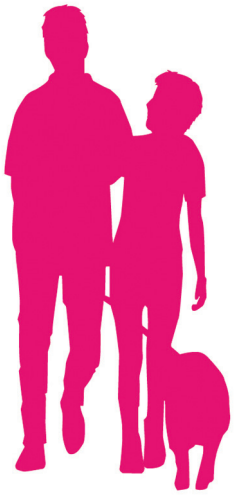
UNDERSTANDING THE SOURCES OF PAST IMPROVEMENTS IN MORTALITY CAN BE VALUABLE IN THE PROCESS OF DEVELOPING ASSUMPTIONS REGARDING THE FUTURE.

FACTORS AFFECTING POPULATION MORTALITY IMPROVEMENT LEVELS

Understanding the sources of past improvements in mortality can be valuable in the process of developing assumptions regarding the future. Therefore, the SOA report also examined the correlation between mortality improvement levels and various demographic factors.

Age

Between 1940 and 2006, improvements in mortality were strong for most age groups, including infants, children, young adults, the middle ages, retirement and old age.



One tool in the analysis of changes in life expectancy at birth is the examination of changes in rates of mortality between specific ages. Here we discuss improvements in mortality during key life stages for four of the more developed countries (United States, Canada, United Kingdom and Australia) during the period 1940 to 2007.

The following trends are noted:

- **Infants** (the rate of mortality between ages 0 and 1): Rates of mortality improvement for infants have slowed in recent years in all four countries, from highs averaging between 3- and 5-percent per year between 1940 and 1980 to rates generally less than 2 percent during 2000 to 2007.

- **Children** (the rate of mortality between ages 1 and 20): Greater mortality improvements were exhibited by this group during the period 1940 to 1960 (between 3- and 8-percent per year) as children and young adults benefited from the impact of stronger public health initiatives. Improvements also appear to have picked up between 1980 and 2000, possibly due to a decrease in the number of deaths from accident or injury.

- **Young Adults** (the rate of mortality between ages 20 and 35): Rates of mortality improvement for young adults are also driven to a large extent by lower rates of accident and injury. With a few exceptions, this age demographic has experienced a decline in improvement levels during the current decade. The most notable exception to this trend is Australia, where young adults exhibited a notable increase in mortality improvement (nearly 4.9 percent per year for males and 3.1 percent per year for females) during the period 2000 to 2007.

- **Middle Ages** (the rate of mortality between the ages of 35 and 65): Individuals aged 35 to 65 have experienced moderate but steady levels of improvement in mortality since 1960 (generally between 0.5 and 2.5 percent per year).

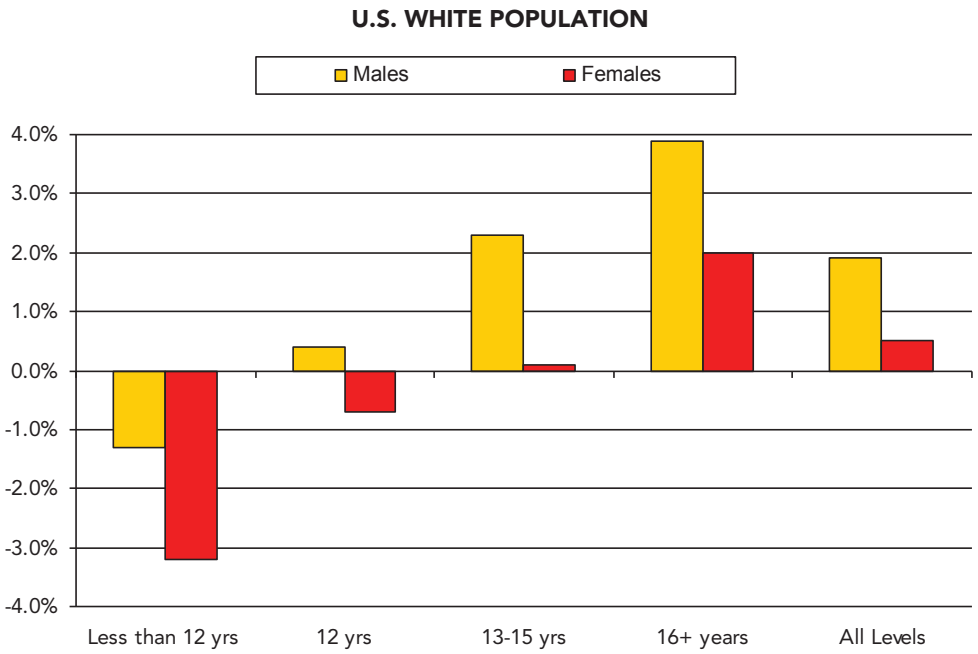
- **Retirement Ages** (the rate of mortality between the ages of 65 and 85): Individuals between ages 65 and 85 have exhibited lower levels of improvement, with the largest increases occurring between 2000 and 2007 (between 1- and 2-percent per year).

- **Old Age** (the rate of mortality between the ages of 85 and 100): Since 1940, the population age 85 and older has exhibited little or no improvement and even some deterioration in mortality experience. This observation has led some to theorize that in the future, mortality improvements are likely to be focused at the older ages where fewer strides have been made to date. And, there is evidence for increasing improvement levels over the current decade for the oldest ages.

Gender

In the United States and Canada between 1980 and 2000, male improvements outpaced female improvements by an average of 0.5 percent per year. In the United Kingdom, males experienced greater

Differences in Mortality Improvement by Level of Education Achieved



Source: Widening of Socioeconomic Inequalities in U.S. Death Rates, 1993 to 2001, Ahmedin Jemal, Elizabeth Ward, Robert N. Anderson, Taylor Murray, Michael J. Thun, published 2008.

levels of improvement for ages over 45 while females experienced greater improvements for ages under 45. And during the most recent experience period examined, 2000 to 2007, the pattern of gender differences has become blurred for all three countries. As a result, both the September 2010 Canadian Institute of Actuaries report[1] recommending mortality improvement levels for individual life insurance and annuity products and the most recent U.S. Social Security Administration Technical Panel report[2] assume that differences in mortality improvement levels by gender will be eliminated over the next few decades.

Geographic Region

There is data to support some variation in mortality improvement experience by geographic region for the United States, Canada and the United Kingdom, with the lowest levels of improvement generally seen in the more rural and lower-income areas of the countries. These differences were generally small for the experience periods and countries examined.

Socioeconomic Status

The results of several population-based studies support the view that socioeconomic factors such as wealth, income level, highest attained level of education, and marital status are highly correlated with mortality and mortality improvement experience. The wealthier, more highly educated and married populations tend to exhibit lower levels of mortality and also appear to have experienced larger levels of mortality improvement. As an example, for the U.S. white male population ages 25 to 64, the results of a 2008 study of experience between 1993 and 2001 shows that mortality improvements for those with 16 or more years of education were approximately twice those of the population as a whole.

LIFE INSURANCE DATA

For life insurance in particular, actuaries have less consistent data on which to base their views regarding future mortality improvement levels, especially over the longer term. Care needs to be taken in interpreting insured data as changes in select mortality over time may be impacted more by changes in the industry including shifts in the target market, distribution methods, underwriting processes or risk classification structures than true improvements in life insured mortality. Data regarding improvements in ultimate mortality may be more reliable since a major factor, the impact of underwriting changes over time, should be greatly dampened.

Utilizing the results of regular periodic studies of individual life insurance mortality experience produced by national actuarial organizations over the past several decades, changes in mortality rates for life insureds can be calculated for the select and ultimate period for the United States, Canada and the United Kingdom.

Focusing on ultimate period mortality, we note the following trends in improvements versus the general population results.

United States

For the experience period between 1978 and 2006, the pattern of mortality improvement by age and gender is quite similar between the insured population in the ultimate period and the general population. Insureds and the general population exhibited similar age patterns of mortality, with insured mortality improvements slightly greater than the general population on an amount basis and slightly lower than the general population on a number of policies basis.

Canada

In Canada between 1972 and 2007, life insureds in the ultimate period also experienced levels of mortality improvement similar to or greater than the population in general at the typical insurance-buying ages (35 to 84) on an amount basis.

United Kingdom

In the United Kingdom between 1980 and 2000, greater improvement levels were seen for permanent assureds (whole life and endowments policies) than the population in general for males, while female permanent assureds exhibited rates of mortality improvement more similar to the population in general. Note that in the United Kingdom, mortality data is only available on a number of policies basis at the current time.

MORTALITY IMPROVEMENT PROJECTION TECHNIQUES

Today, insured mortality improvement assumptions are often developed from an extrapolation of past trends in population mortality along with some element of professional judgment. However, in today's environment where mortality improvement assumptions can have a material impact on financial results, actuaries are beginning to focus greater attention on the analysis and review of past experience, the factors that have influenced that experience, and more robust methods for developing future assumptions.

The academic community has made important strides in advancing modeling and projection techniques for mortality and mortality improvements over the past several decades and a brief overview of these techniques follows.

First, mortality projection models generally fall into one of the following basic categories.

- **Predictive modeling.** A predictive model begins with the identification of a group of factors (predictors) that can influence future results for a given value being estimated, e.g., mortality, mortality improvement or other items of interest. Focusing on life insurance mortality improvement as an example, many of the predictors available for traditional experience analysis (e.g., age, gender, product type, smoker status, risk classification) can be included in a predictive modeling exercise. There have been multiple and extensive applications of predictive modeling in the property-casualty insurance industry for experience analysis, pricing, underwriting, claims management and strategic planning purposes. Through application of predictive modeling, the impact of each of these factors on mortality or mortality improvement is identified, and a model is developed that estimates future values as well as the probability of a specified outcome (for example, future mortality improvement levels within a specified range) under various conditions.

- **Extrapolative projection techniques.** This category of projection models includes the earliest methods used by actuaries, economists and demographers in setting future mortality improvement assumptions based on the projection of past trends that were identified in the historical data.

  A typical extrapolative approach involves fitting a model to actual mortality experience for each individual calendar year in the experience period available. The parameters underlying the models for each calendar year are then plotted to identify significant pat-

WANT MORE INFORMATION?

This article is based on the SOA sponsored research paper, "Global Mortality Improvement Experience and Projection Techniques" by Marianne Purushotham, Emil Valdez, and Huijing Wu. It can be found on the SOA website at::

terns that can aid in the determination of future parameter values for projection of future experience.

Gompertz and Weibull are well-known extrapolative models for mortality projection over time due to their relative simplicity. The Gompertz model, for example, projects mortality as the sum of an attained age dependent component and an attained age independent component. The Lee-Carter model and its many variations have also been used extensively on a global basis, and Lee-Carter is one of the methods employed by the Social Security Administration in the United States for modeling future levels of mortality improvement. Lee-Carter is a stochastic mortality projection model based on the identification of both the impact of attained age and calendar year.

- **Relational or targeting methods.** The basic approach for relational projection methods is to develop a function F that relates mortality in a specific population under study to mortality for a reference population. The development of the function F is typically dependent on testing the fit of the relationship between the population being modeled and the reference population.

Reference populations could include long-term historical averages for a specified country (e.g., low mortality countries such as Sweden and Japan are often used in this capacity). Another approach is to assume that future mortality improvements trend from their current levels to a long-term target assumption such as 2- to 2.5-percent per decade.

A LIMITATION OF BOTH ALL-CAUSE AND CAUSE-SPECIFIC MORTALITY MODELS IS THAT ANY DATA IS RESTRICTED TO THE DEATH ITSELF.

- **Cause-of-death specific models.** To date, the more common practice has been to apply one of the models discussed earlier to all-cause insured or population mortality experience to develop projections of future results. However, it has also been argued that future all-cause mortality experience can only be reasonably understood if trends in specific causes of death and future likely changes are understood. In theory, any of the models discussed here can be applied to the mortality experience for specified cause-of-death groupings and then combined in some manner across all the groupings to produce aggregate assumptions. For these models, limiting the number of major groupings by cause of death has been important in maintaining a sufficient level of credibility.

- **Disease-based models.** A limitation of both all-cause and cause-specific mortality models is that any data is restricted to the death itself. Therefore, there is no consideration of the potential impact of the timing and development of disease that may have led to the death, including the impact of comorbidities. In this modeling context, better estimates of future mortality can be produced by considering the progression of disease as well as potential interactions between different existing morbidities. However, disease-based models are quite complex, typically involving multi-state transitions and corresponding probabilities of transition that require detailed, longitudinal data regarding the treatment and progression of various diseases. This type of information has been obtained in the United Kingdom through access to patient health databases supporting public health care programs. However, in the United States, privacy laws make this type of data difficult, if not impossible, to obtain and therefore disease-based models have not been used extensively to date.

Bearing in mind the current limitations of insured data as compared to population data as well as the advantages and disadvantages of the various modeling approaches in current use, an industry level effort of the following form could produce valuable information to aid actuaries in their efforts to monitor trends and set assumptions regarding the future.

1. Construct and continually refresh a detailed database of information regarding the past and current impact on mortality of various key factors including lifestyle

trends and behaviors, past and recent medical advances, and demographic/societal changes utilizing both insurance industry data and other outside sources. This information will allow for a better understanding of the potential impact of changes in these areas on current and future projections.

A partial list of factors that are expected to impact future mortality improvement levels includes the following:

- Medical advances—Collect data regarding new advances in health care that are expected to impact mortality improvements (newly introduced diagnostic tests, treatments, phamaceuticals). Consider the potential reduction in mortality and the population that will be impacted and the period of time over which the reduction is expected to emerge.

- Lifestyle changes—Track levels of smoking (number of new smokers and rates of quitting in adulthood), alcohol intake, and levels of obesity and expected impact on mortality.

- Changes in levels of disease incidence including emerging new diseases—Collect data regarding new diseases and disease types as well as growth or decline in current disease diagnoses.

- Access to medical care—Follow the development of the health care reform initiative in order to gauge its potential impact on future mortality and mortality improvement levels.

2. Select a sound modeling and projection methodology, preferably one that provides a reasonable fit to recent historical experience. In determining the experience basis for model parameter development, due consideration will need to be given to balancing the need for a sufficient number of years to reduce "noise" in the average annual rates with the need for the model to reflect what has occurred in the recent past.

3. Modify the initial results from application of the projection technique developed in 2 (above) by applying actuarial and other expert judgment regarding future expectations as to changes in the factors discussed in 1 (page 25) and their impact.

Some areas that are being closely watched by academicians and the medical community include obesity levels, smoking habits, and genetic indicators. And there is some evidence to support potential slowdowns in mortality improvement in the United States over the next several decades as a result of health impacts of increased obesity levels.

Mortality improvement now has a material impact on financial results in many areas of the global economy and the insurance industry and will require greater attention by actuaries. This approach allows for the application of a rigorous modeling methodology in the development of a baseline improvement assumption, while retaining the element of professional judgment that forms the basis of current approaches and allows for incorporation of reasoned views regarding the uncertain future. A

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ENDNOTES:

1 "Mortality Improvement Research Paper," Canadian Institute of Actuaries, September 2010. *http://www.actuaries.ca/members/publications/2010/210065e.pdf*

2 "Technical Panel Report on Assumptions and Methods (2007)," Report to the Social Security Advisory Board, Washington D.C., October 2007. *http://www.ssab.gov/documents/2007_TPAM_REPORT_FINAL_copy.PDF*