

THE Actuary

VOLUME 14 ISSUE 4

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STRIKING THE RIGHT NOTE

Examining the failures, successes and possibilities of a classic longevity instrument—the longevity bond



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Exploring longevity risk

BY ROBERT L. BROWN

Every three years, the Society of Actuaries (SOA) holds an absolutely magnificent symposium called “Living to 100.” The sixth in this series took place in Orlando in January 2017. I have attended five of the six symposia and was pleased to be a speaker this past January.

While in Orlando, I was wearing two hats. Yes, I was a panel participant, but I also knew that I was responsible for this August/September issue of *The Actuary*, which was to focus on longevity issues. What better way to line up six good articles on longevity than to take advantage of the wealth of talent and knowledge at the Living to 100 Symposium? That is what I did. By the time I left Orlando, I had promises for six articles from eight authors—and that is what you will find in this issue.

I am pleased with the international flavor (or “flavour”) of this issue, as we have three authors from the United



States, two from Canada and one from the United Kingdom. We are all facing similar issues, so one country’s possible solution is a case study elsewhere.

I’d also like to make two expressions of gratitude. First, thank you to the authors. You can join in this thanks by reading and responding to their fine articles. And thanks to my fellow contributing editors, the SOA staff involved in

the production of this publication and all those who have a hand in putting our magazine together. It is truly a collaborative effort.

Finally, I am pleased with the scope of the coverage on this topic, from the human side of longevity to a very technical paper on how to hedge the longevity risk. I hope you like reading these articles as much as I liked pulling this issue together. Please read, learn and enjoy. ■

RELATED LINK

Presentations from the 2017
Living to 100 Symposium
livingto100.SOA.org



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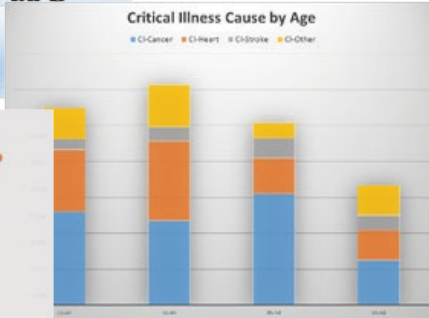
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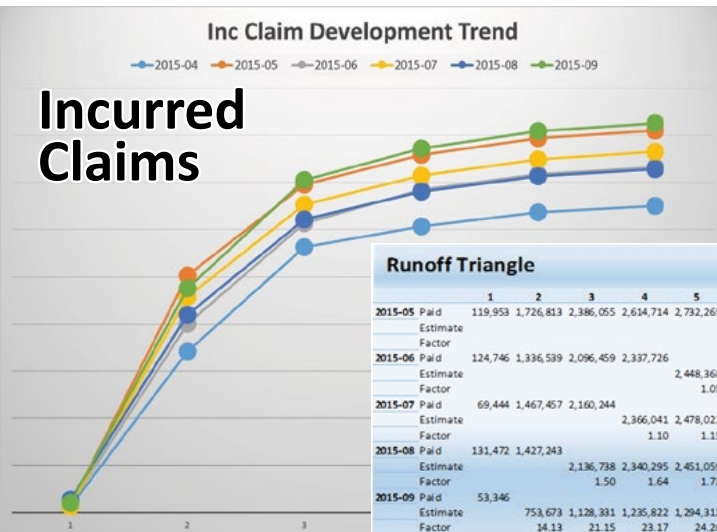
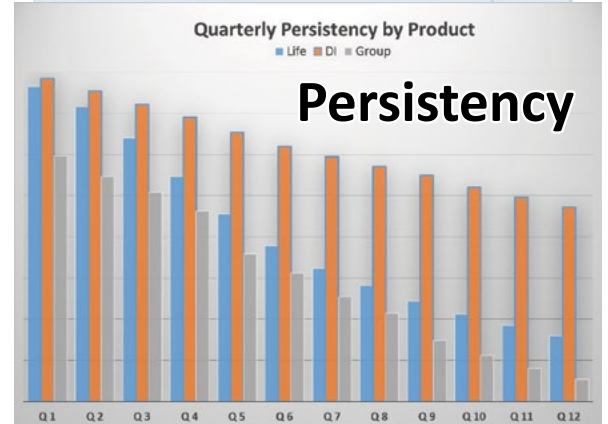
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Mortality by Date					
	2013	2014	2015		Total
			2015-Q1	2015-Q2	2015-Q3
Exposure	55,759	57,051	14,439	14,525	
Actuals	281	332	57	78	
Expecteds	201	212	54	55	
A/E	140%	157%	105%	141%	



Insured Risk

Persistency by Issue Date								
	2011	2012	2013	2014	2015			2015 Total
					2015-Q1	2015-Q2	2015-Q3	
Y 1	88.38%	88.19%	87.91%	88.14%	89.54%	91.61%	90.04%	90.28%
Q 1	96.96%	96.63%	96.16%	97.06%	96.68%	97.35%	97.41%	97.11%
Q 2	94.61%	94.47%	93.81%	94.96%	94.48%	95.97%		95.22%
Q 3	91.91%	91.44%	91.18%	91.77%	92.16%			92.89%
Q 4	88.35%	88.19%	87.93%	88.01%				
Y 2	77.79%	77.02%	74.28%	74.84%				
Y 3	70.90%	69.64%	66.96%					



Incurred Claims

Runoff Triangle							
		1	2	3	4	5	6
2015-05	Paid	119,953	1,726,813	2,386,055	2,614,714	2,732,265	
	Estimate						2,780,815
	Factor						1.02
2015-06	Paid	124,746	1,336,539	2,096,459	2,337,726		
	Estimate					2,448,368	2,491,873
	Factor					1.05	1.07
2015-07	Paid	69,444	1,467,457	2,160,244			
	Estimate			2,366,041	2,478,023	2,522,055	
	Factor			1.10	1.15	1.17	
2015-08	Paid	131,472	1,427,243				
	Estimate		2,136,738	2,340,295	2,451,059	2,494,612	
	Factor		1.50	1.64	1.72	1.75	
2015-09	Paid	53,346					
	Estimate	753,673	1,128,331	1,235,822	1,294,312	1,317,311	
	Factor	14.13	21.15	23.17	24.26	24.69	



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Living our strategic plan

It's been my privilege to help bring the 2017–2021 Society of Actuaries (SOA) Strategic Plan to life through our ongoing strategic efforts. October 2016 marked both the start of my presidency with the SOA and the approval of the strategic plan. In my past president's letters in *The Actuary*, I've discussed predictive analytics, member participation, professional development and, most recently, our global efforts. All of these topics directly connect to and align with our strategic plan. It truly does guide the SOA Board with our decisions as we support you—the membership—and help advance the actuarial profession.

To paraphrase our strategic vision, we strive for actuaries to be highly sought-after professionals who develop and communicate solutions for complex financial issues. As our strategic mission notes, our organization provides members with research and education to help measure and manage risk to improve financial outcomes for companies and the public. So how are we bringing this plan to life?

Thus far in 2017, we have taken on several activities as part of the strategic plan. We have looked at our knowledge and perspectives, insight and influence, as well as our organizational capabilities. For instance, we are focusing on our educational and research offerings, the building of our intellectual capital, the promotion of the profession and how we support the future of the profession.

I've spoken a lot about predictive analytics, and I'm glad to see the continued effort and interest from our members and candidates. There's the Predictive Analytics Certificate Pilot Program that concludes later this year, and from there the SOA Board will decide on next steps with this type of professional development offering. For the future of the profession, we announced and rolled out the curriculum changes for candidates pursuing the associate designation. Parts of these changes reflect the growing need for experts in working with data analytics, an area perfect for actuaries to lead.

BY JEREMY J. BROWN

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from the **PRESIDENT**

During the past few months, we have ramped up planning for future strategic research programs and have helped narrow down which key industry and societal issues to focus on for the next three to five years. We're currently identifying and reviewing potential research ideas, and I look forward to seeing the potential projects and their outcomes to advance the profession.

Another example of how the SOA is supporting its strategic plan involves staying ahead of potential issues and identifying new opportunities. At the SOA Board and staff level, we have a new process for enhanced environmental scanning and decision governance. These improvements help expand our abilities to find, assess and make decisions involving critical trends that affect the organization and process. We aim to act efficiently and strategically with our decision-making processes.

Additionally, we seek new ideas on how we approach curriculum development and professional development for candidates and members outside of the United States and Canada. It is an ongoing process, and it will take time to ensure we make the best decisions on how we adapt our education efforts for the international markets.



Candidate Connect Luncheon
at the 2016 SOA Annual
Meeting & Exhibit in Las Vegas

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“ We strive for actuaries to be highly sought-after professionals who develop and communicate solutions for complex financial issues.”

My final example of 2017 initiatives that support the strategic plan is CAA Global. It is the public interest joint venture we formed with the Institute and Faculty of Actuaries (IFoA). CAA Global oversees and promotes the certified actuarial analyst (CAA) qualification around the world. We have taken on these efforts to help individuals who work with actuaries to obtain sound technical skills.

We will continue to provide updates on these initiatives and our continued efforts in bringing the strategic plan to life through the next several years. I urge you to learn more about how the strategic plan was built, what it outlines and how we use it. ■

RELATED LINKS

SOA Strategic Plan

[SOA.org/strategic-planning](https://soa.org/strategic-planning)

[SOA.org/strategic-planning/building-the-plan](https://soa.org/strategic-planning/building-the-plan)
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CAA Global

caa-global.org

SOA Curriculum

[SOA.org/curriculumchanges](https://soa.org/curriculumchanges)

Retirement report released

A ROUNDUP OF NEWS FROM THE GLOBAL COMMUNITY

Whether you travel the world or never leave your home country, you are affected by global organizations, international requirements and the increasingly international nature of the actuarial profession itself. Here is some news from around the world.

THE FUTURE OF RETIREMENT IN CHINA

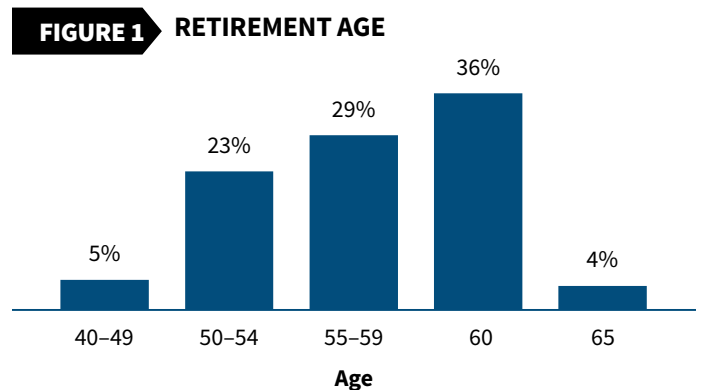
LIMRA and the Society of Actuaries (SOA) recently published the final results of their research on the current state and future opportunities of the retirement market in China.

This research project focused on a series of six reports. Authored by Lauren Finnie, this research examines consumer attitudes, beliefs and behaviors on various retirement issues. These issues include retirement goals and objectives, retirement risks, retirement savings, available retirement options, use of financial advisers and strategies for managing retirement risks.

The research included 2,013 participants, ages 35 to 70, from 23 provinces, municipalities and regions in China, with 74 percent of the participants active in the workforce and 26 percent retired. The data was collected in 2015 via online and face-to-face interviews. See **FIGURE 1** for an example of what can be found in *The Future of Retirement in China* reports.

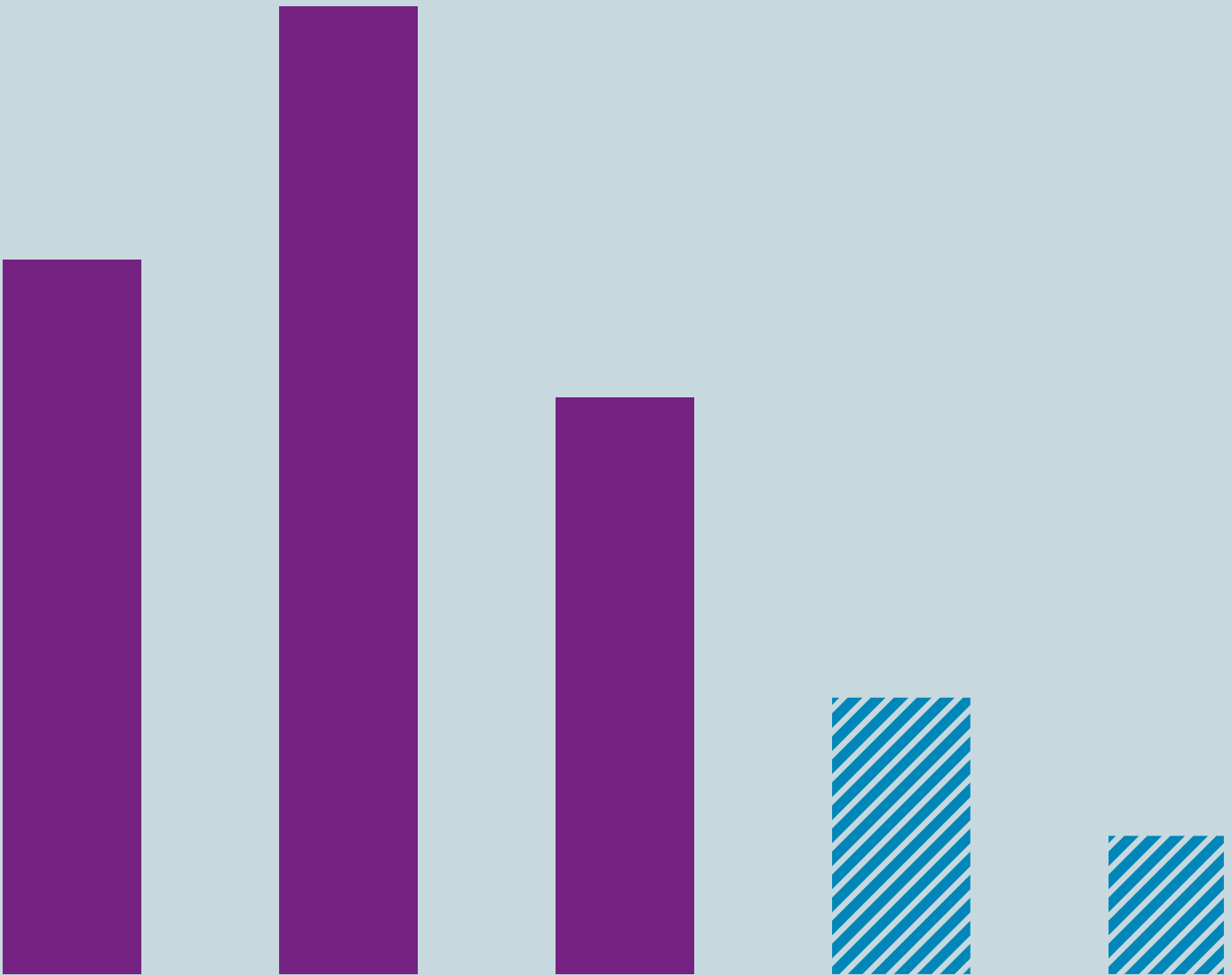
The size and diversity of China's massive population made sample design critical. Using face-to-face interviews, LIMRA and the SOA were able to include both urban and non-urban respondents.

"For most workers and retirees, retirement means freedom ... a chance to do what they want with their time, including hobbies and traveling," the researchers noted from the categorized, open-ended responses. But urban and non-urban individuals expressed different goals for their retirement. Maintaining health and well-being is of greater importance to non-urban respondents than to their urban counterparts. Non-urban respondents also are more likely to value spending more time with their friends and family in retirement.



There are different retirement ages for men and women in China. In this study, the average retirement age was 58 for male respondents and 54 for female respondents.

Source: *The Future of Retirement in China*



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Read more about the ESCI, the *NAAJ*, the best paper of 2016 and other related information by visiting the Related Links.

RELATED LINKS

Emerging Sources Citation Index
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North American Actuarial Journal
bit.ly/SOA-NAAJ

PRIMING ACTUARIES FOR THE FUTURE

“Actuaries have always done predictive analytics, but it’s become more important than ever,” notes Stuart Klugman, FSA, CERA, Ph.D., Society of Actuaries (SOA) senior staff fellow, in a new video titled “Enhancing the Curriculum: Priming Actuaries for the Future.”

“Companies of all kinds and actuaries in all practice areas are collecting more data and need the technical ability to process a larger amount of data,” says Klugman. “What they need now are the tools to successfully process that data to make good business decisions for their clients and for their employers.”

In the short video, Klugman and Kory Olsen, FSA, CERA, MAAA, assistant vice president at Pacific Life Insurance Company and general chair of the SOA Education Executive Committee, explain how the associate of the SOA (ASA) curriculum has changed to help members across the board, enhancing the quality and rigor of the SOA education system to keep its commitment to move the profession forward.

“Actuaries have always been problem-solvers,” concludes Klugman. “For their clients and for their employers, the

enhanced education in predictive analytics will take that a step further because the whole predictive analytics process is one of problem-solving.”

RELATED LINK

Enhancing the Curriculum: Priming Actuaries for the Future
bit.ly/SOA-ASA-Video



PENSION SECTION UPDATE

BY GRACE LATTYAK



The Pension Section adopted an amended mission statement last year that emphasizes adaptation to change. Pension actuaries have become very used to constant change in our industry and practice, and the Pension Section strives to help its members keep up with change through the research and education it sponsors.

The way pension actuaries measure longevity and apply longevity assumptions to valuations has evolved significantly over the past few years. The Society of Actuaries (SOA) is publishing annual updates, whereas before we might have kept the same mortality table over a long period of time. Plan sponsors are choosing to review their own mortality experience and weigh the credibility of this experience to better estimate their liabilities instead of relying on industry tables that generally were required in the past. These changes have required pension actuaries to change their practice and brush up on skills they may not have used much since their formal education, such as credibility theory. The Pension Section has funded research and sponsored continuing education sessions or webinars

on these topics to assist its members in adapting to the new normal.

Many public pension plans around the United States continue to face rising and volatile funding requirements for various reasons, including failure to make recommended actuarial contributions, lower future capital market expectations and the continued maturation of these plans. This has resulted in increased scrutiny regarding the perceived sustainability and affordability of these plans. In response, some public pension plans have made changes to benefit provisions or funding strategies, and many others are evaluating their best course for the future.

In order to assist plan sponsors and plan actuaries with determining the best future path, we have revived the Retirement 20/20 initiative—this time with a focus on public plans. We are asking for papers that provide realistic strategies for benefit design and funding practices for public pension plans—in full recognition of the environment in which these plans operate—including thoughts on how to transition from the current state. We hope these papers will elevate the

discussion regarding changes to public pension plans.

Many pension actuaries have a desire to broaden their skill sets to be able to consult around broad retirement risks and plan designs. The Pension Section continues to add tools to its toolkit, including a recent paper regarding evaluating defined contribution (DC) plans in a methodical, quantitative way.

Discussion around state retirement plans and open multiple employer plans may further change how retirement benefits are delivered in the United States. Some Canadian provinces are experimenting with risk-sharing designs and paying variable benefits from DC plans, which may influence the future direction of other provinces or companies with regard to their retirement programs. However the landscape shifts, the Pension Section will strive to provide research and education to help its members adapt. ■

Grace Lattyak, FSA, EA, FCA, is associate partner at Aon Hewitt in San Francisco.

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WHAT WERE THEY THINKING?

ACTUARIES RESPOND TO THE HUMAN SIDE OF LONGEVITY

BY ANNA M. RAPPAPORT

The traditional job of actuaries includes measuring mortality; building mortality tables; and designing, pricing and conducting financial analysis for products with a longevity component. However, actuaries also are involved with the human side of longevity. This article will provide details on several projects from the Society of Actuaries (SOA) that are focused on this human side of longevity. Projects include research from the SOA's Committee on Post-Retirement Needs and Risks, an actuarial longevity calculator, the Living to 100 and Beyond project and sponsorship of the Sightlines Project.



RETIREMENT

SAVINGS



EXPENSES

TRAVEL

WHY SHOULD ACTUARIES CARE?

Before discussing the specific projects, think about why actuaries would want to know about these issues. We know that people, at times, do not make decisions as rational economic beings, and we know quite a lot about the drivers of decisions. In a world where retirement security quite often depends on personal savings and defined contribution plans, the decisions individuals make—and their knowledge about longevity—are extremely important.

Actuaries are involved with a number of services and programs for this period later in life. These programs and services usually are focused on financial security and financing of health and long-term care benefits. But achieving success in old age is about more than money. Insights on the human and nonquantifiable aspects of aging enhance the chance that the programs and services with which actuaries are involved will be successful.

PROJECTS FROM THE COMMITTEE ON POST-RETIREMENT NEEDS AND RISKS

An ongoing public attitude survey research program enables us to understand how the public perceives and expects to manage risks associated with longer life. The program provides insights into the human aspects of longevity and how people feel and expect to act as they age. This research demonstrates that, for many people, action is a result of factors such as knowledge and feelings rather than purely being a mathematically-driven activity. While actuarial and mathematical analysis is an important driver of behavior for some people, it plays

no role at all for others. This research program includes a biennial survey; three sets of focus groups, including focus groups with individuals who had been retired for 15 years or more in 2015; and some in-depth interviews. In 2015, in-depth interviews also were conducted with caregivers of people requiring long-term care.

The work of the committee through 2015 provides a strong indication of the human story. In 2017, late-in-life interviews will be conducted with retirees older than age 85 and, in some cases, their children. This 2017 work will fill a gap, focusing on the period usually missed in such research.



“Retirees’ top three concerns with regard to post-retirement risks are inflation, health care expenses and paying for long-term care.”

findings

FINDINGS FROM THE COMMITTEE ON POST-RETIREMENT NEEDS AND RISKS

Some key findings from the Society of Actuaries' (SOA's) Committee on Post-Retirement Needs and Risks public attitude research include:

- Knowledge gaps: There continue to be gaps in planning and the use of shorter planning horizons at retirement than are recommended for comprehensive planning.
- Many retirees prefer not to spend down their assets. They prefer to live on their regular income and try to adjust their expenses.
- Some retirees prefer dealing with things as they happen rather than building a plan to deal with risks. Planning often tends to be limited to “predictable” cash flows, where such cash flows include regular periodic expenses. Expenses that can be expected, even though retirees may not specifically know when or how the expenses might happen, are often not part of a retiree’s planning.
- Where people plan for retirement expenses, a common approach is to focus on short-term cash flows. People are much more likely to plan for medical premiums than for uncovered medical expenses. In the 2015 focus groups with longer-term retirees, it was surprising to learn that home repairs and dental expenses were unexpected expenses for a number of the participants.
- The top concerns with regard to post-retirement risks are inflation, health care expenses and paying for long-term care. These top concerns have been found consistently over repeated iterations of the survey, although the priority of concern changes. This is the eighth biennial survey. Given the extent of Medicare and other acute health care insurance coverage, and the relative infrequency of long-term care coverage, there is a disconnect between the results and the level of risk retirees face.
- Pre-retirees continue to be more concerned than retirees about most risks.
- Pre-retiree expectations do not line up well with retirees’ actual experiences. There are two areas where pre-retiree expectations and retiree experience consistently have been out of sync. In the 2015 survey, retirees retired at a median age of 60, substantially earlier than age 65, which is the median age at which pre-retirees say they expect to retire. There is a similar finding in several of the surveys. Working in retirement is another area where expectations of pre-retirees differ from the actual experience of retirees. While many pre-retirees say they expect to continue working longer, most current retirees have not actually done so. Both of these areas are troubling because they encourage people to “underplan.”
- The top risk management strategies being used are similar to what was found in prior surveys, including reductions in spending, increasing savings and paying off debt. As in prior years, risk protection products other than health insurance are not used very often. These strategies help with cash flow but do not address major unpredictable expenses.
- Retirees and pre-retirees seem to have relatively little concern about some important risks such as fraud. Even where people accept that a risk is important in society, it is not uncommon for them to think that it will not happen to them.

Many of the findings from the committee’s public attitude research (see “Findings” sidebar on page 17) can be explained by “behavioral finance,” a scientific study of how people make financial decisions and behave. This is in contrast to traditional economics, which predicted that people would figure out the best solution for themselves and make the rationally economic choice after doing the analysis. During the last 30 years, we have learned a lot more about behavioral finance and its influence on financial decision-making.

THE LONGEVITY CALCULATOR AND UNDERSTANDING LONGEVITY

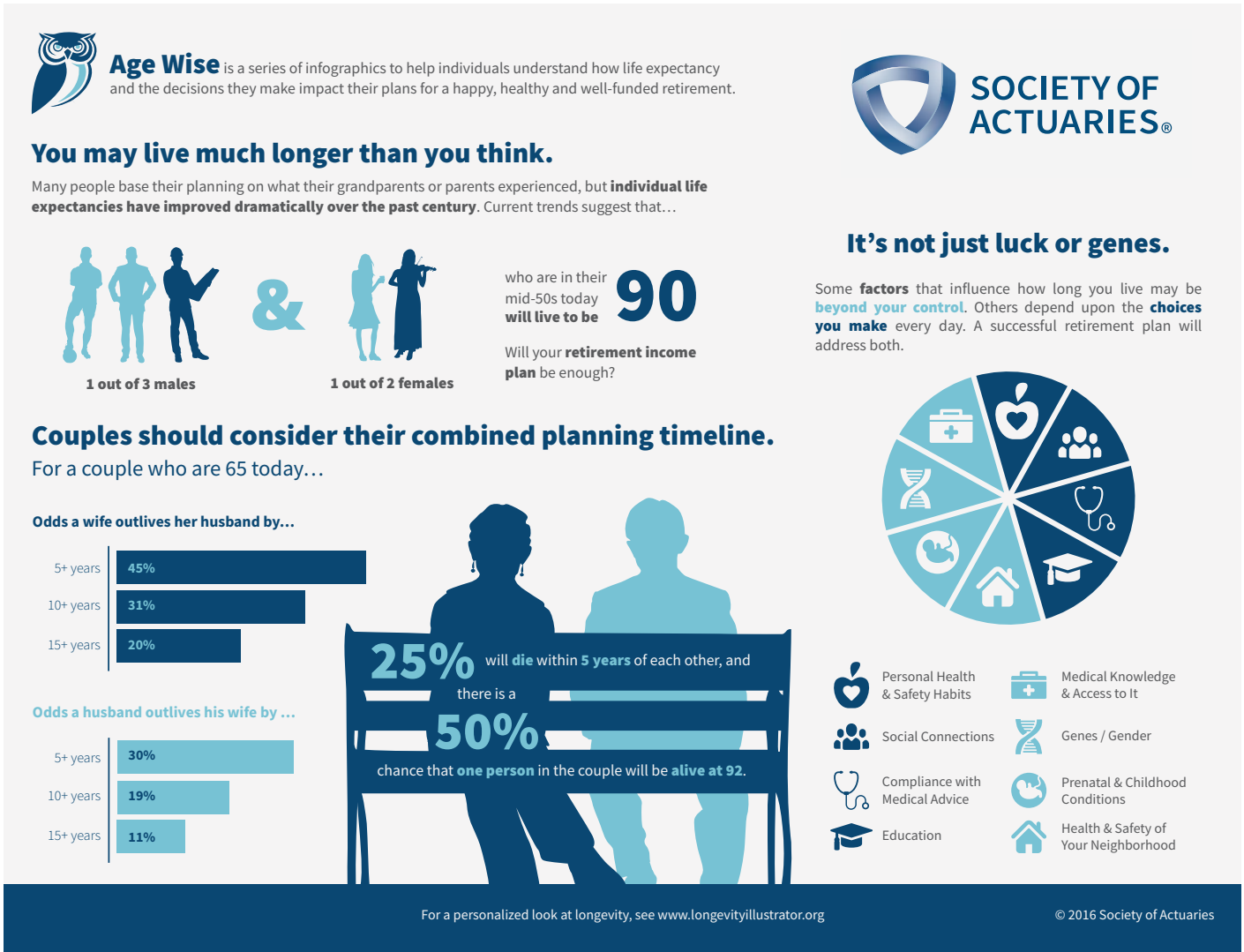
Understanding longevity is a challenge. The Post-Retirement Risk Survey indicates that more people underestimate

longevity than get it right, and that many plan for too short of a period. Even those people who reasonably understand longevity often plan for too short of a time period, often much shorter than their lifetime horizon.

It is difficult for many people to remember that longevity is uncertain. If a large group of people all retired at age 70, a few will die in the year after retirement and a few will live beyond age 100. If a group of people all knew their average life expectancy and planned to use their money by that date, then about half of them would have planned a future where they run out of money.

The SOA and the American Academy of Actuaries (the Academy), working jointly, produced the Actuaries Longevity Illustrator. This tool allows the user to calculate his or

FIGURE 1 SOA AGE WISE LONGEVITY INFOGRAPHIC



her expected lifetime, taking into consideration health status as well as age. For couples, the results include the probability of living to a various number of years—for each member of the couple, for either or for both. The charts help people understand the variability of life expectancy.

The Committee on Post-Retirement Needs and Risks created two different sets of materials to help with understanding longevity-related issues. One of the special topics in the 2015 Post-Retirement Risk Survey was understanding longevity, and there also is a special report on that topic. In addition, the committee prepared several infographics to be used with the tool, for various audiences who need to understand longevity. The first infographic is shown as **FIGURE 1**. Its key messages are:

- People may live longer than they think.
- Couples need to think about their joint longevity.
- A variety of factors contribute to longevity.

THE SIGHTLINES PROJECT

The Stanford Center on Longevity, together with a number of sponsors, including the SOA, conducted the Sightlines Project. This project is focused on helping people enhance their chances of living an independent 100-year life. The project investigates how well Americans are doing in three areas the research identified as critical to well-being as people age: financial security, healthy living and social engagement. While financial security and health have long been recognized as part of successful retirement, many people have not recognized the importance of social engagement. The findings are based on analyses of data from several large studies. The project includes recommendations for improving results in each area. It also identifies specific points on which progress is needed, as well as areas where Americans are doing well. The project is very exciting because it includes data and indicators that

can be measured over time. These results are intended to stir national debate, guide policy development, stimulate entrepreneurial innovation and encourage personal choices that enhance living independent, 100-year lives.

THE LIVING TO 100 AND BEYOND RESEARCH PROGRAM

The SOA has sponsored a research program titled “Living to 100 and Beyond” for the last 15 years. This is a space for new ideas, exchange of information, controversies, learning how other disciplines view related issues, and identifying points of agreement and disagreement. The cumulative program output since 2002 includes more than 150 scientific papers, a number of presentations and panel discussions, and six symposia. The symposia, which occur every three years, bring together a diverse group of experts with varying perspectives on the need to understand changing life expectancies and adapt to longer life expectancies. One of the features of the 2017 Living to 100 Symposium was emphasis on improving living conditions and the human side of longevity.

action

ACCESS ADDITIONAL INFORMATION ABOUT LIVING TO 100

For each of the six Living to 100 symposia, there is a monograph on the Living to 100 website at livingto100.SOA.org. The 2017 monograph that includes the new papers should be posted late in 2017.

Presentations from 2017 can be found embedded in the program on the website. All of the papers from 2002 to 2014 and the findings are summarized in a report prepared by Ernst and Young. This report is split between technical issues and implications, and can be accessed at bit.ly/100-Insights. The report also highlights areas of agreement and differences, and it includes abstracts for all of the published papers in an appendix.

ONLINE!

To view the SOA Age Wise Longevity Infographic Series, visit SOA.ORG/RESEARCH/AGE-WISE. For a personalized look at longevity, visit LONGEVITY ILLUSTRATOR.ORG.

At the 2017 Living to 100 Symposium, a key topic related to the human side of longevity was “The Changing Face of Eldercare,” which focused on big ideas: making communities friendly to an aging population and steps that support people staying in the community longer. The World Health Organization (WHO) established a program of age-friendly communities and a process to help communities become more age-friendly. The eight domains of an age-friendly community are community and health care, transportation, housing, outdoor space and buildings, social participation, respect and social inclusion, civic participation and employment, and communication and information. There are 332 age-friendly cities today in 36 countries. The AARP is the U.S. affiliate of this network. The AARP program focuses on safe, walkable streets; age-friendly housing and transportation options; access to needed services; and opportunities for residents of all ages to participate in community life. Age-friendly communities do not replace the need for senior housing and nursing homes, but they give people new options and may make it feasible for them to stay active in the community longer.

Another trend focused on helping people live in their communities longer is the “Village” movement, or the formation of neighborhood-based groups for seniors that support people aging in the community. Such organizations are based heavily on volunteerism and people helping each other. The first village was formed in Boston in the Beacon Hill neighborhood in 2002. My view is that villages are very helpful and can supplement and take the place of extended family for seniors who need to be part of a support network where they live.

PUBLIC POLICY ISSUES

Population aging is changing the fabric of our societies and affects many areas of policy. Much of the policy deals with human issues. Many societies are focused on helping people age successfully, and public programs offer some level of financial support and support for health care. They may offer additional support for the elderly. At the 2017 Living to 100 Symposium, major public policy issues related to aging were the subjects of a panel on big-picture issues. That panel provided perspectives from the United States, the United Kingdom and Canada.

David Sinclair, director of the International Longevity Center in the United Kingdom, provided insights into several big policy challenges in the United Kingdom. They include meeting the cost of aging, saving more, providing an adequate workforce, getting older people to spend more, delivering health and care (which we would

call long-term care or long-term services and supports), maximizing the opportunity of technology and responding to the issues surrounding housing wealth. In my view, there is a major overlap with big underlying issues in the United States. These issues are all closely connected to human issues linked to aging.

Robert Brown, retired professor from the University of Waterloo, provided insights into the aging issues getting attention in Canada. Social Security benefits recently have been increased, and after an attempt to raise the retirement age, the legislation was reversed. The majority of the public does not have employer-sponsored benefits. There are challenges in the efficient and effective delivery of health and long-term care. Canada seems to be going in a different direction than many countries by increasing social benefits.

John Cutler, an attorney and senior fellow at the National Academy of Social Insurance, pointed to the huge uncertainty in the United States linked to the 2016 presidential election. Concern about jobs, particularly among mid-career people and those nearing retirement, as well as flat or declining wages seemed to be very important in the election. But other than encouraging manufacturing in the United States, it is unclear what, if anything, will be proposed to address these issues. The federal government plays a huge role in health care, and it is unclear how that role may change going forward. Proposals to modify that role are a high priority in the new administration, but there is no consensus about the replacement programs. Less visible but also very important are the need to bring Social Security into financial balance and several pension issues.

CONCLUSION

Actuaries are very familiar with measuring and projecting mortality and using information about longevity for financial analysis. But success with respect to management of longevity by many different stakeholders requires a greater understanding of longevity by individuals as they make decisions, consideration of what people think about when they plan for the future, and an understanding of what can make life better as people age. ■

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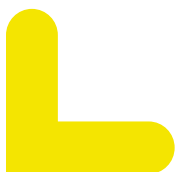
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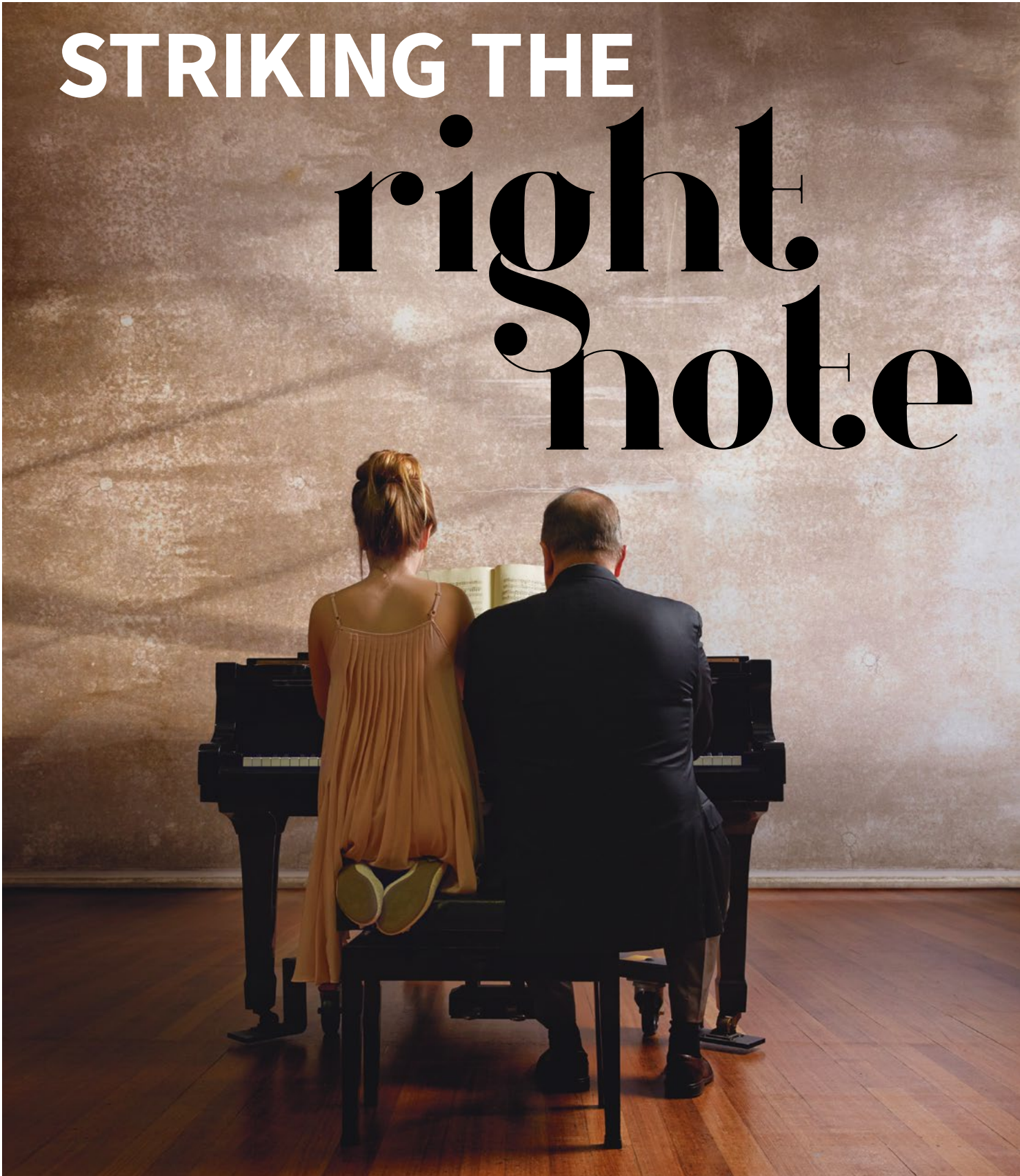


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STRIKING THE

right note



THE PAST FAILURES, PRESENT SUCCESSES AND FUTURE POSSIBILITIES OF THE CLASSIC LONGEVITY INSTRUMENT, THE LONGEVITY BOND

BY DAVID BLAKE

Systematic longevity risk is a key risk factor in many life insurance and pension products. For example, annuity providers are exposed to the risk that the mortality rates of pensioners will fall at a faster rate than anticipated in their pricing and reserving calculations. Yet annuities are commoditized products. They sell mainly on the basis of price (although factors such as service and credit rating are also considerations), and profit margins need to be kept low in order to gain and then protect market share. If the mortality assumptions built into the prices of annuities turn out to be gross overestimates, this cuts straight into the profit margin of annuity providers.

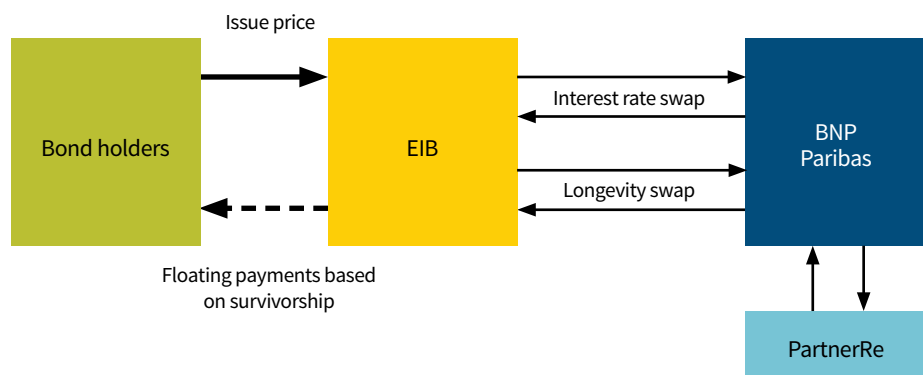
In principle, systematic longevity risk can be hedged with an appropriate hedging instrument. The classic hedging instrument is a longevity bond, an annuity bond paying coupons linked to a mortality index, such as the realized mortality experience of the national population of 65-year-olds on the issue date (with no return of principal), so that the payouts on the bond correlate highly with the payments an annuity provider needs to make on its annuity book.

In this article, we take a historical sweep over the market for longevity bonds, looking at past failures, current successes and what lessons can be learned for the future of this type of instrument.

THE PAST: THE CLASSIC LONGEVITY BOND—A DISAPPOINTING FAILURE

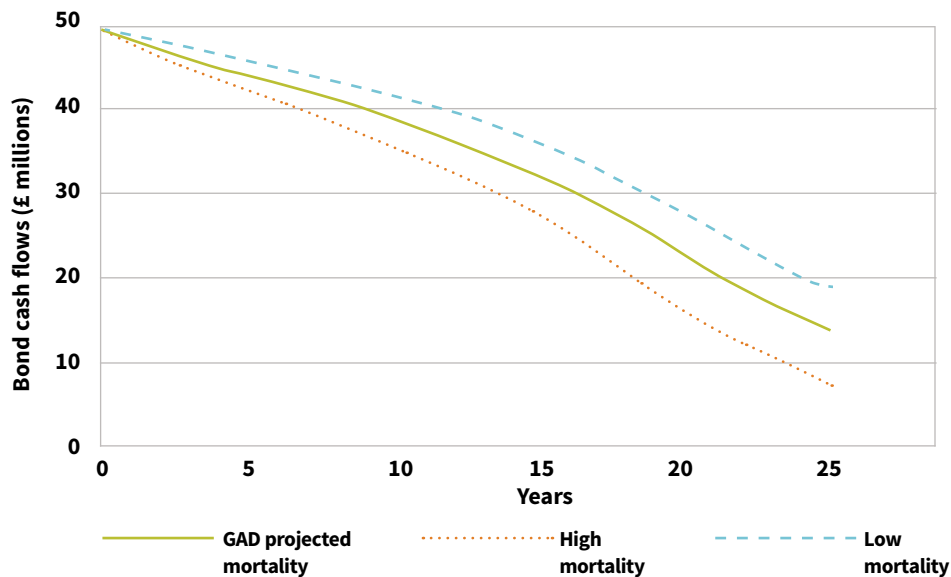
One of the earliest attempts at creating a capital market in longevity-related instruments was the proposal to issue long-dated longevity bonds (or survivor bonds) made more than 15 years ago.^{1,2} As a reference population cohort dies out, the coupon amounts decline but continue in payment for a fixed term (in the case of longevity bonds) or until the entire cohort dies (in the case of survivor bonds). To illustrate, if after one year, 0.8 percent of the reference population has died out, the second year's coupon payment will be 99.2 percent of the first year's payment, and so on.

FIGURE 1 THE STRUCTURE OF THE EUROPEAN INVESTMENT BANK LONGEVITY BOND



Source: Adapted from Blake, David, Andrew Cairns, and Kevin Dowd. "Living with Mortality: Longevity Bonds and Other Mortality-Linked Securities." *British Actuarial Journal* 12, no. 1 (2006): 153–197.

FIGURE 2 COUPONS ON THE EUROPEAN INVESTMENT BANK LONGEVITY BOND



Source: U.K. Government Actuary’s Department

The first attempt to issue a longevity bond was in November 2004, when the European Investment Bank (EIB) attempted to launch a 25-year £540 million longevity bond with an initial coupon of £50 million. The reference mortality index was based on 65-year-old males from the national population of England and Wales, as produced by the U.K. Government Actuary’s Department (GAD). The structurer/manager was BNP Paribas, which assumed the longevity risk but reinsured it through Bermuda-based PartnerRe (see **FIGURE 1** on page 23). The target group of investors was U.K. pension funds. **FIGURE 2** shows how the coupons might change on the bond: If mortality is lower than projected by the GAD, the coupons on the bond will decline by less than anticipated, and vice versa. The bond holder—for example, a pension fund paying pensions to retired workers—is therefore protected from the systematic longevity risk it faces.

PROBLEMS

After a year of marketing, the EIB longevity bond had not generated sufficient demand to be launched and was withdrawn. There are a number of reasons for this, including the following.

Design Issues

The EIB bond had a number of design weaknesses that made the bond an imperfect hedge for longevity risk. The

basis risk in the bond was considered to be too great. The bond’s mortality index was a single cohort of 65-year-old males from the national population of England and Wales. While this might provide a reasonable hedge for male pension plan members in their 60s, pension plans also have male members in their 70s and 80s, as well as female members.

Pricing Issues

The longevity risk premium built into the initial price of the EIB bond was set at 20 basis points.³ Given that this was the first ever bond brought to market, investors had no real feeling as to how fair this figure was. There was concern that the upfront capital was too large compared with the risks being hedged by the bond, leaving no capital for other risks to be hedged. In addition to hedging interest rate risk, this bond also hedged longevity risk, but the bond’s payments were in nominal terms and hence did not hedge inflation risk.

Institutional Issues

There was a range of institutional issues that the bond’s designers failed to confront. To start, the issue size was too small to create a liquid market. Market makers did not welcome the bond, because they believed it would be closely held and they would not make money from it being traded.

Further, the issuer did not consult widely enough with potential investors or their advisers before the bond was

announced. Advisers were reluctant to recommend it to pension plan trustees. They said they welcomed the introduction of a longevity hedge but did not like the idea of the hedge being attached to a bond. Indeed, they were somewhat suspicious of capital market hedging solutions *per se*, preferring instead insurance indemnification solutions, such as a buy-out (an insurance company buys the pension plan liabilities and relieves the plan sponsor of all risks—investment, inflation, interest rate, as well as longevity risk—associated with running a pension plan) or a buy-in (an insurance company sells a bulk annuity policy to a pension plan, which is used to pay the pensions when due, and hence hedges only the longevity—and possibly also the inflation—risk). In other words, advisers and trustees were used to dealing with risk by means of insurance contracts that fully removed the risk concerned and were not yet comfortable with capital market hedges that left some residual basis risk. Fund managers at the time did not have a mandate to manage longevity risk, and similarly saw no reason to hold the bond.

The reinsurer, PartnerRe, was not perceived as being a natural holder of U.K. longevity risk. This turned out to be a rather significant point, since it was discovered that no U.K.-based or EU-based reinsurer was willing to provide cover for the bond, and PartnerRe itself was not prepared to offer cover above an issue size of £540 million.

Educational Issues

The longevity bond was a new concept that was completely unfamiliar to most players in the market. For it to be successful, a major educational effort would have been needed on all the issues already discussed, especially structure, basis risk, hedge effectiveness and liquidity. This education process needed to be broad enough to cover the entire industry and involve defined benefit (DB) plan sponsors, fiduciaries, investment consultants, plan actuaries and insurers.

LESSONS LEARNED

The EIB bond was a very innovative idea, and it is disappointing that it was not a success. Nevertheless, important lessons have been learned from its failure. Two of the most important lessons relate to mortality indices and mortality forecasting.

Mortality Indices

The EIB bond's actual cash flows would have been linked to the mortality of 65-year-old males from England and Wales. This single mortality benchmark was considered inadequate to create an effective hedge. It soon became

apparent that what was needed was a set of mortality indices against which capital market instruments could trade. The most prominent attempt to do this was the LifeMetrics Indices launched in March 2007 by J. P. Morgan in conjunction with the Pensions Institute and Towers Watson.⁴ The indices comprise publicly available mortality data for national populations, broken down by age and gender. Both current and historical data are available, and the indices are updated to coincide with official releases of data. The indices cover the key countries—the United Kingdom, the United States, Holland and Germany—where longevity risk is perceived to constitute a significant economic problem. In launching LifeMetrics, J.P. Morgan recognized the critical importance of education and provided educational materials, including documentation, software, data and presentations, to the industry at no cost.

Mortality Forecasting Models

The EIB bond's projected cash flows depended on projections of the future mortality of 65-year-old males from England and Wales. The U.K. GAD prepared these projections, but the model used to make these predictions was not published and the projections themselves were adjusted in response to expert opinion in a way that has not been made transparent. What was needed to complement transparent mortality indices were more transparent stochastic mortality forecasting models. This deficiency was addressed in subsequent years by a number of mainly academic researchers who developed and published different forecasting models.⁵

THE PRESENT: THE KORTIS BOND—A MODEST SUCCESS

In December 2010, with the lessons learned from the EIB bond, Swiss Re launched an eight-year longevity-based bond valued at \$50 million. To do this, it used a special purpose vehicle, Kortis Capital, based in the Cayman Islands. The bond was designed to hedge Swiss Re's own exposure to longevity risk.

The bond holders are exposed to the risk of an increase in the spread between the annualized mortality improvement in English and Welsh males ages 75 to 85 and the corresponding improvement in U.S. males ages 55 to 65.⁶ The mortality improvements will be measured over eight years from Jan. 1, 2009, to Dec. 31, 2016. The bonds matured on Jan. 15, 2017,⁷ although there is an option to extend the maturity to July 15, 2019. The principal will be at risk if a Longevity Divergence Index Value (LDIV) exceeds the attachment point or trigger level of 3.4 percent over the risk period. The exhaustion point, at or above

background

which there is no return of principal, is 3.9 percent. The principal will be reduced by a principal reduction factor (PRF) if the LDIV lies

between 3.4 and 3.9 percent. See the “Background” sidebar for how to derive the LDIV.

If there is a larger-than-expected increase in the spread between the mortality improvements of 75- to 85-year-old English and Welsh males and those of 55- to 65-year-old U.S. males, the principal of the bond will be reduced. The exposure Swiss Re is hedging comes from different sources. For example, Swiss Re is the counterparty in a £750 million longevity swap with the Royal County of Berkshire Pension Fund that was executed in 2009, and consequently is exposed to high-age English and Welsh males living longer than anticipated. It also has reinsured a lot of U.S. life insurance policies and is exposed to middle-aged U.S. males dying sooner than expected. The longevity note provides a partial hedge for both exposures and will help Swiss Re reduce its regulatory capital. In exchange for putting their capital at risk, investors receive quarterly coupons equal to three-month London Interbank Offered Rate (LIBOR) plus a margin.

THE FUTURE: A CRUNCH POINT COMING?

The Kortis bond was a success—but only one such bond has been issued to date, so the success at \$50 million can only be described as modest. By contrast, there have been \$200 billion of buy-outs and buy-ins globally between 2006 and 2016.⁸

Governments could consider helping to both encourage and facilitate the development of the longevity risk transfer market. In particular, they could play a pump-priming role, as argued some years ago by the U.K. Pensions Commission.⁹ For example, they could consider issuing longevity bonds to establish the riskless term structure for the longevity risk premium, as they do in the inflation-linked bond market in respect to the inflation risk premium. Similarly, the regular issuance of longevity bonds—even in a small size—would provide pricing points to catalyze the development of the market, in addition to providing value as a hedging instrument.

Of particular concern is extreme longevity risk associated with individuals older than 90—a risk that the private sector is unwilling to hedge. The government could consider helping by selling deferred annuities to this group. This would be a form of risk sharing between the state and the private sector. The state’s contribution would be

DERIVING THE LONGEVITY DIVERGENCE INDEX VALUE (LDIV)

The *LDIV* is the spread between the annualized mortality improvement in English and Welsh males ages 75 to 85 and the corresponding improvement in U.S. males ages 55 to 65. It is derived as follows.¹

Let $m^y(x, t)$ be the male death rate at age x and year t in country y . This is defined as the ratio of deaths to population size for the relevant age and year. Annualized mortality improvements over n years are defined as:

$$Improvement_n^y(x, t) = 1 - \left[\frac{m^y(x, t)}{m^y(x, t - n)} \right]^{\frac{1}{n}}$$

The annualized mortality improvement index for each age group is found by averaging the annualized mortality improvements across ages x_1 to x_2 in the group:

$$Index(y) = \frac{1}{1 + x_2 - x_1} \sum_{x=x_1}^{x=x_2} Improvement_n^y(x, t)$$

The *LDIV* is defined as:

$$LDIV = Index(y_2) - Index(y_1)$$

where y_2 is the England and Wales population aged 75 to 85, and y_1 is the U.S. population aged 55 to 65.

The principal reduction factor (*PRF*) is calculated as:

$$PRF = \frac{LDIV - Attachment\ point}{Exhaustion\ point - Attachment\ point}$$

¹ Hunt, Andrew, and David Blake. “Modelling Longevity Bonds: Analysing the Swiss Re Kortis Bond.” *Insurance: Mathematics and Economics* 63 (2015): 12–29.

to issue these instruments, leaving the private sector (life companies and the capital markets) to design better annuity products and trade longevity risk up to age 90. The main benefit from a capital market perspective of a government-issued longevity instrument would be to offer a standardized liquid benchmark that would help to establish the risk-free price of longevity risk at different terms to maturity.

So far, however, there has been little sign of progress on any of these fronts. This is unfortunate since it will lead to a crunch point in the near future. There are growing signs

of a capacity constraint in the insurance and reinsurance markets for both buy-outs and buy-ins. The only way for this constraint to be relieved and for capital to be released in the (re)insurance industry so it can continue offering buy-outs and buy-ins is for longevity risk to be transferred to capital markets investors, such as sovereign wealth funds, insurance-linked securities investors, hedge funds and so on. Currently, this group of investors has shown only limited interest in longevity risk as an asset class—and the reasons for this and potential solutions have been explained in this article. ■

GOVERNMENTS COULD HELP TO BOTH ENCOURAGE AND FACILITATE THE DEVELOPMENT OF THE LONGEVITY RISK TRANSFER MARKET.

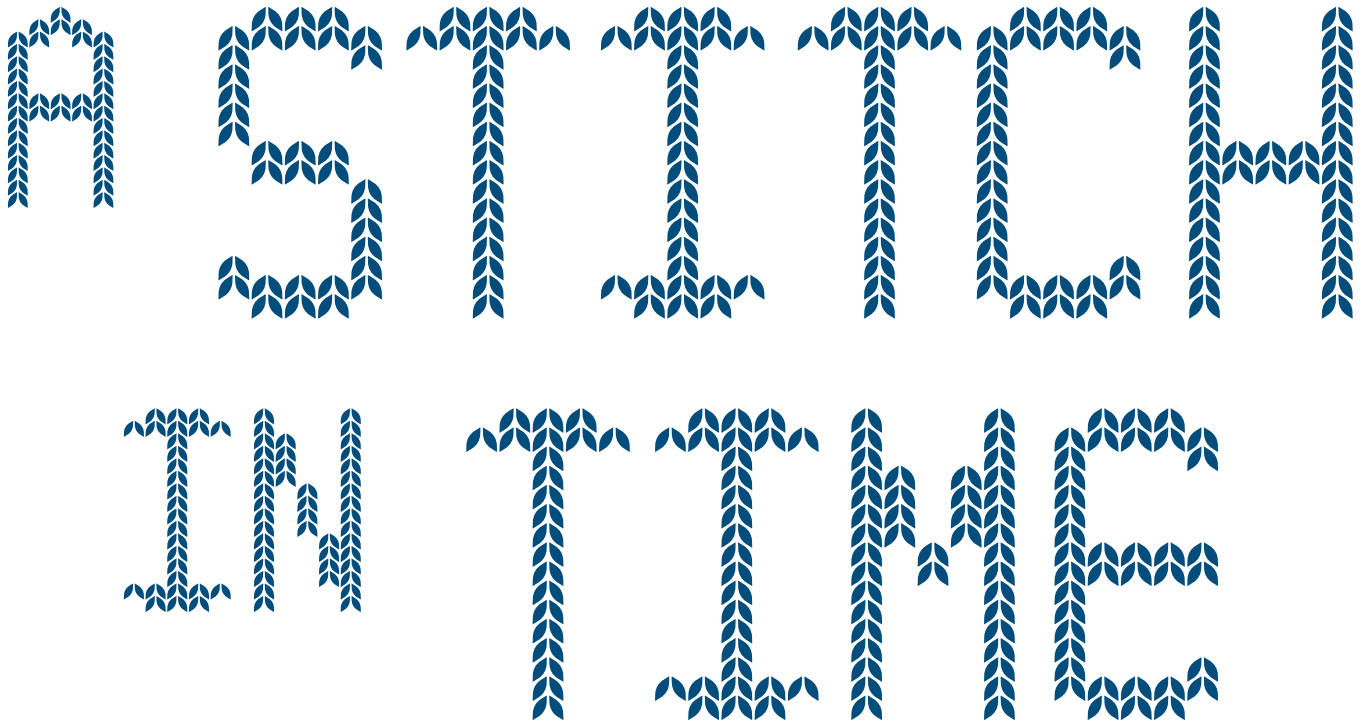


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- ⁶ It is important to recognize that the Kortis longevity bond was not a true longevity bond in the sense we have described, because it involved transferring the risk associated with the spread (or difference) between the longevity trends for two different population groups rather than the trends themselves.
- ⁷ The payoff of the bond depends on population mortality data for 2016 for England and Wales and the United States, neither of which is currently available (U.K. data are expected in July or August 2017; the United States is a lot slower at releasing data).
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- ⁹ *A New Pensions Settlement for the Twenty-First Century*. Pensions Commission. The Stationery Office. (2005): Norwich, England.

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THE SIGHTLINES PROJECT: A MEASURE OF THE PROGRESS AND STEPS AMERICANS ARE TAKING TO LIVE LONG AND WELL

BY TAMARA SIMS, STEVE VERNON AND JIALU STREETER

It's been well documented that the populations of developed nations are aging, with many people living well into their 70s, 80s, 90s and beyond. As a result, the proportion of citizens living at older age groups is increasing significantly relative to the rest of the population in developed nations.¹

During the 20th century, life expectancy at birth increased by roughly 30 years for many developed nations. This gift of longer life is one of humankind's greatest achievements. It's the result of many factors, including reliable and safe food and water, efficient and effective sanitation, vaccinations against formerly deadly infectious diseases, electricity, broad-based public education systems, and a reduction in warfare and violent deaths. These advantages typically are available to citizens of all walks of life in developed nations.

Looking at it from an evolutionary perspective, this increase in life expectancy occurred in the blink of an eye. As a result, our species isn't truly prepared to live long, healthy lives.

As individuals, it just doesn't come naturally to us to plan ahead for long periods of time, including saving for the distant future and protecting against chronic diseases that can result from many years of unhealthy behaviors. For example, a recent survey report by the Society of Actuaries (SOA) indicates that only 19 percent of retirees plan ahead for 20 years or more; and well over one-third (40 percent) either don't plan ahead or report they haven't thought about it.² Yet most retirees will live well beyond 20 years.

As a society, we haven't redesigned institutions, systems or policies fast enough to keep up with this sudden shift in longevity. For example, working longer is a reasonable response to the challenge of financing longer lives, yet workforce participation among the 65+ age group is less than 20 percent (although this percentage has been increasing since 2000).³ This is a result of several factors, including resistance by older individuals to work longer and an inability for them to find work, and employers' beliefs that older workers cost more and are less productive.



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This significant achievement also generates new challenges. There's much concern about the potential economic strain of supporting an aging population and the costs that will likely be incurred across the board by individuals, families and communities, and federal, state and local governments.⁴

One key outcome that has researchers interested in the life expectancy increase is that improvements in longevity and well-being within the past 50 years have been increasingly concentrated in the educated and affluent populations.^{5,6,7,8} Of the many reasons attributed to this gap, the most common are higher prevalence of obesity and smoking, lower availability of healthy foods and quality health care, and exposure to harmful elements in lower-income jobs and communities.

How can more Americans from all walks of life live better and longer? What steps can we take collectively to help mitigate looming costs and realize the full potential of an aging society?

To help answer these questions, the Stanford Center on Longevity (SCL) initiated the Sightlines Project.⁹ The project identifies action steps that individuals can take to live long and live well, and measures the prevalence of Americans who are taking these steps. The goal of the project is to provide insight, stimulate conversation, motivate further research and generate ideas that promote wellness for all Americans in this age of human longevity.

Our aim is to help people arrive at their later years financially secure, physically healthy and socially engaged; and live well as long as possible. It's best if they take action steps toward these goals *as early as possible*—not start thinking about them as they approach their retirement years.

As a result, it's critical to make valuable social connections, engage in healthy behaviors and build financial security *throughout* adult life. How are Americans of all ages and all walks of life doing with these goals? Tracking is a critical first step, and that's the mission of the SCL's Sightlines Project.

PROJECT OVERVIEW

SCL convened a group of scientists, researchers and experts from Stanford and elsewhere and asked them to identify variables that predict long and healthy lives. We spent two days together, debating evidence and identifying the best predictors of longevity and well-being.

We focused on action steps that are malleable—actions that people can feasibly take in their daily lives. We acknowledge that many of the action steps may be difficult

for individuals to take on their own, without support from peers, technologies, organizations or communities.

Based on existing literature, we identified more than 100 behaviors and metrics with known links to longevity and well-being. This began an iterative process to narrow the list of indicators and seek large-scale, high-quality data sources that allowed us to compare how each present-day age cohort is doing relative to its same-aged counterparts from 15 to 20 years ago.

After reviewing the available data from multiyear studies of more than 1.2 million Americans completed over two decades, SCL identified seven nationally representative surveys to be analyzed. Ultimately, we distilled the findings



“Three overarching areas that are critical to well-being across the life span are financial security, healthy living and social engagement.”



FIGURE 1 ACTIONS LINKED TO A LONG, HEALTHY LIFE

Action/Metric	Domain	Subdomain	Source
Exercise moderately	Healthy living	Healthy daily activities	NHANES
Maintain healthy BMI	Healthy living	Healthy daily activities	NHANES
Low sedentary time	Healthy living	Healthy daily activities	NHANES
Sufficient sleep	Healthy living	Healthy daily activities	NHANES
Eat five fruits and vegetables	Healthy living	Healthy daily activities	BRFSS
Avoid excessive alcohol consumption	Healthy living	Avoid risky behaviors	NHANES
Avoid tobacco and nicotine use	Healthy living	Avoid risky behaviors	NHANES
Avoid illicit drug use	Healthy living	Avoid risky behaviors	NHANES
Threshold income	Financial security	Cash flow	CPS-ASEC
Manageable debt	Financial security	Cash flow	SCF
Emergency funds	Financial security	Cash flow	SCF
Investments	Financial security	Asset growth	SCF
Retirement savings	Financial security	Asset growth	SCF
Home ownership	Financial security	Asset growth	CPS-ASEC
Healthy insurance	Financial security	Protection	CPS-ASEC
Long-term disability/care	Financial security	Protection	SCF & CEX
Life insurance	Financial security	Protection	SCF
Friend social support	Social engagement	Meaningful relationships	MIDUS
Family social support	Social engagement	Meaningful relationships	MIDUS
Frequent friend interactions	Social engagement	Meaningful relationships	MIDUS
Meaningful interactions with spouse/partner	Social engagement	Meaningful relationships	MIDUS
Frequent family interactions	Social engagement	Meaningful relationships	MIDUS
Workforce participation	Social engagement	Group involvement	CPS-ASEC
Volunteer	Social engagement	Group involvement	CPS-VS
Participate in community or religious activities	Social engagement	Group involvement	MIDUS
Converse with neighbor	Social engagement	Group involvement	MIDUS

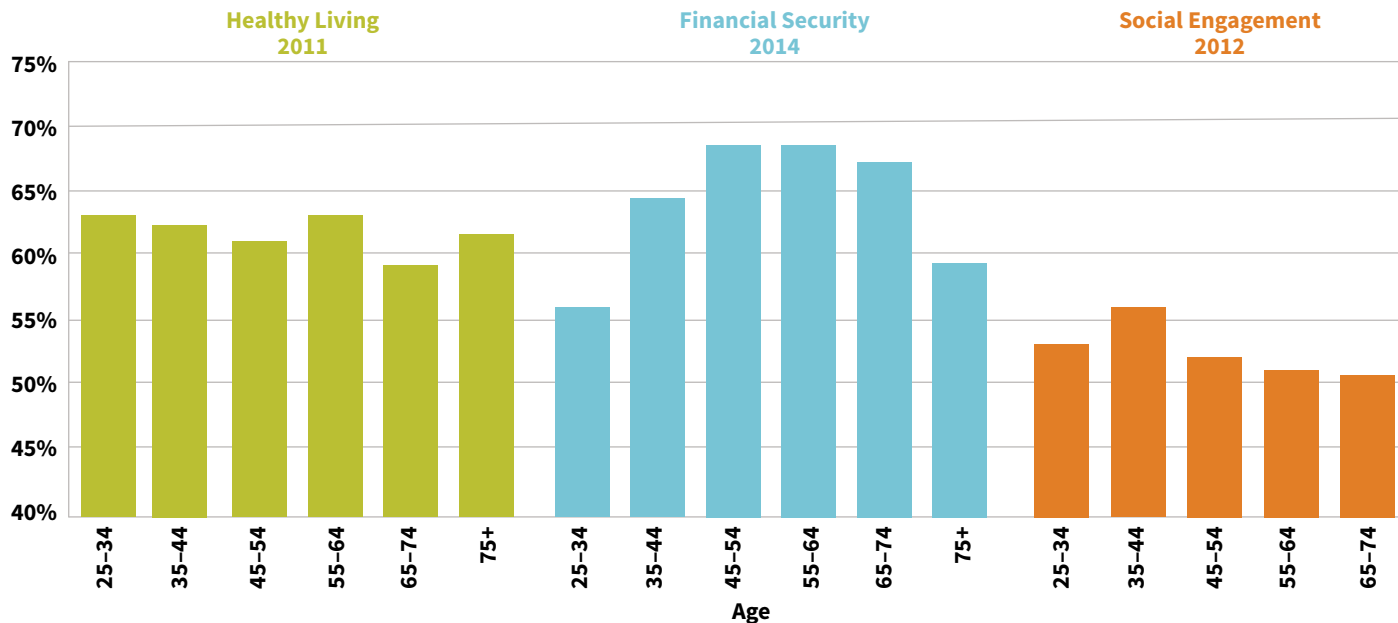
to three overarching areas that are critical to well-being across the life span: financial security, healthy living and social engagement. Within each area, SCL pinpointed eight to nine specific action steps associated with longer, healthier lives.

FIGURE 1 summarizes these action steps and identifies acronyms of the U.S. surveys used for Sightlines (see the “Background” sidebar on page 37 for a description of each acronym).

Taken together, these steps may be used as a checklist for people who want to increase their odds of living a long, healthy life.

These metrics also can be used by policymakers; employers; educational and financial institutions; communities; and local, state and federal governments to assess how they might help their employees, students, customers and citizens realize these action steps and live longer, healthier lives.

FIGURE 2 HOW WELL ARE AMERICANS DOING TODAY?



Source: The Sightlines Project

HOW WELL ARE AMERICANS DOING TODAY?

Overall, how well are Americans doing today in each of the three areas of concern? **FIGURE 2** shows the average percentages of Americans who are taking the action steps in each domain.

It also shows how many Americans are engaging in each action step to a sufficient degree in each of the domains.

➤ **Healthy behaviors:** By 2011, fewer than two-thirds of Americans were taking these action steps—both in aggregate and across age groups.

➤ **Financial security:** In 2014, a little more than two-thirds (67 percent) of Americans age 65 to 74 were taking these action steps, whereas a little more than half (56 percent) of Americans age 25 to 34 were.

➤ **Social engagement:** The prevalence for most Americans who took these steps in 2012 hovered around 50 percent, with the exception of those ages 35 to 44, whose prevalence equaled 56 percent.

It’s useful to look at the overarching domains and understand whether different age groups are doing well in different aspects of well-being today. It is perhaps more important, however, to look back over time to see whether

or not Americans are doing better considering an increased awareness of longer lives and knowledge of the importance of physical, financial and social health.

HEALTHY LIVING: RECENT GAINS OFFSET BY SLIPPAGE

The eight action steps within this domain fall into two categories: healthy daily activities and risky behaviors. Most people are aware of these steps—getting around to actually doing them has proven to be much harder.

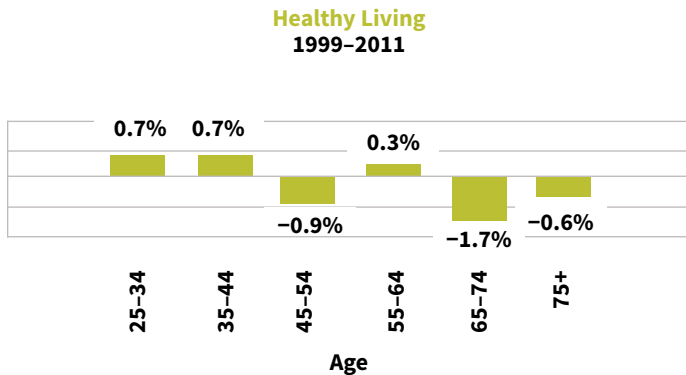
Healthy Daily Activities

- Exercise moderately (at least 150 minutes per week).
- Limit sedentary time (less than 320 minutes per day sitting).
- Maintain a healthy body mass index (BMI) that is below 30.
- Eat five servings of fruits and vegetables daily.
- Get sufficient sleep (between seven and nine hours per night).

Risky Behaviors to Avoid

- Tobacco and nicotine use
- Excessive alcohol consumption
- Illicit drug use

FIGURE 3 OPPOSING ACTION-STEP TRENDS IN HEALTHY LIVING OFFSET OVERALL CHANGE



Source: The Sightlines Project

FIGURE 3 shows the change from 1999 to 2011, illustrating that not much has changed in overall prevalence since 1999. Gains in some areas, such as exercising more and smoking less, have unfortunately been offset by increases in sedentary behavior and obesity.

Here are some potential entry points for organizations and institutions encouraging Americans to improve their health:

- Expand exercise guidelines to include guidelines for sedentary behavior.
- Implement campaigns to promote less sitting and more light physical activities.
- Change employer norms to encourage standing or walking versus sitting during meetings and phone calls.
- Improve definitions of a healthy diet, and increase accessibility to fresh produce and decrease the cost.
- Modify wearables to include meaningful incentives (e.g., benefits that involve feeling happy or socially connected) to nudge healthy behaviors.

FINANCIAL SECURITY: TRENDS ARE OMINOUS

The nine actions within this domain fall into three categories: cash flow, asset growth and protection. Compared to healthy living and social engagement, the financial security action steps can be the hardest for individuals to achieve on their own and are most likely to be improved through help and support from employers, financial institutions and public policy.

Cash Flow

- Earn income that's more than 200 percent of the federal poverty level.

- Keep noncollateralized debt (credit card, student debt, payday loans) to manageable levels, at no more than 20 percent of household income.
- Be able to meet a \$3,000 emergency.

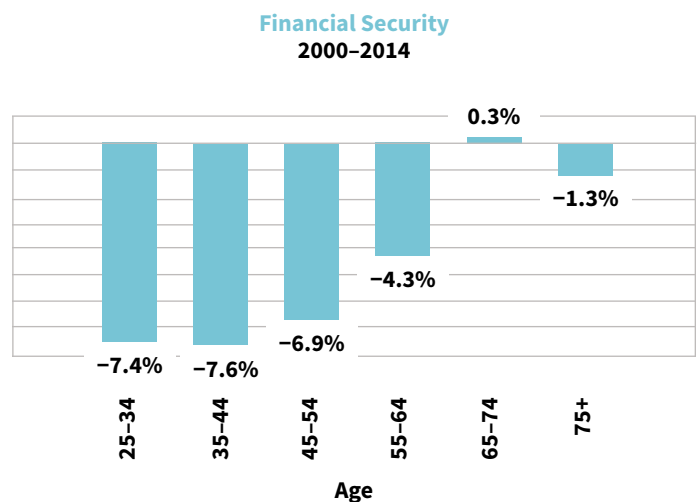
Asset Growth

- Set aside funds for nonretirement goals.
- Save for retirement.
- Own a home.

Protection

- Get health insurance.
- Obtain long-term disability insurance and long-term care protection.
- Buy life insurance.

FIGURE 4 FINANCIAL SECURITY TRENDS ARE OMINOUS



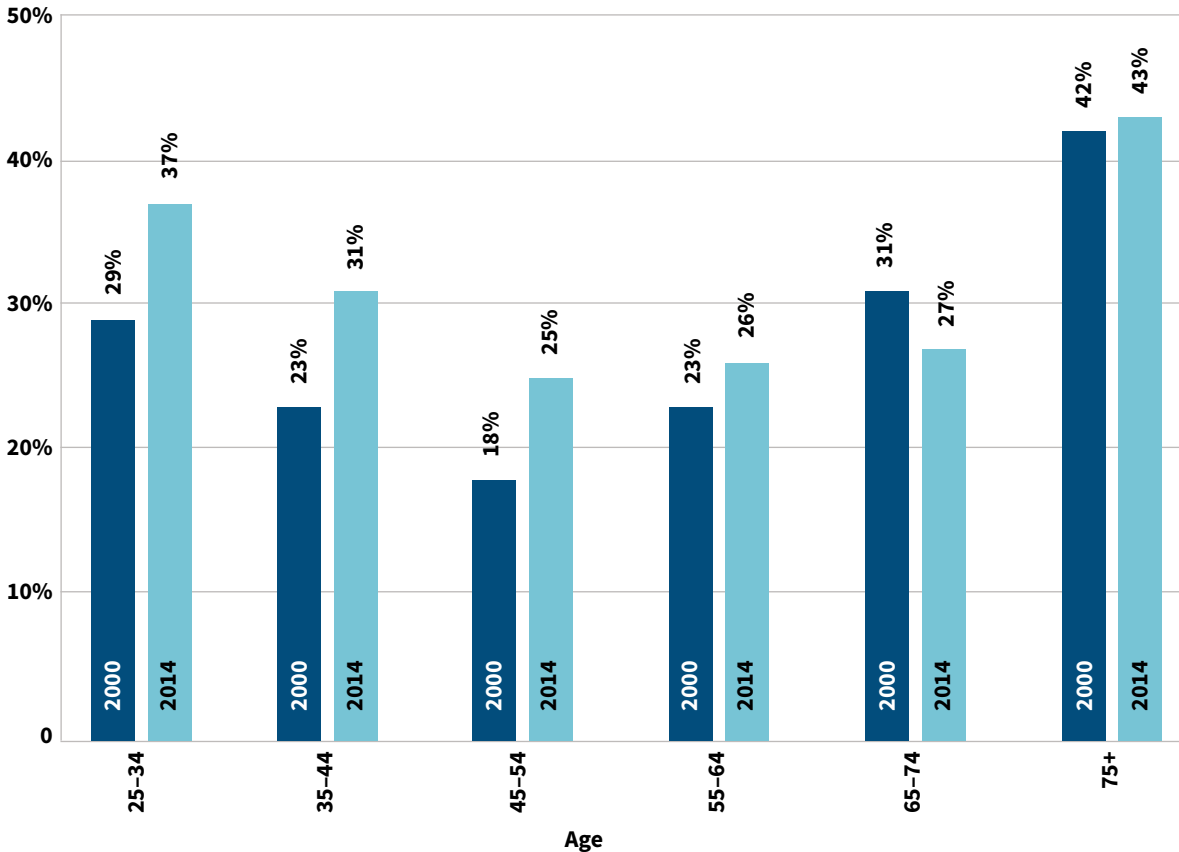
Source: The Sightlines Project

FIGURE 4 shows that all age groups under age 65 have shown troubling declines since 2000.

The foundation of financial security for most individuals is sufficient cash flow to meet current living needs and save for the future. SCL reviewed research that indicates increased odds of undesirable outcomes for individuals and families with incomes below 200 percent of the federal poverty level. These undesirable outcomes include increased mortality and morbidity rates, lower educational attainment, and increased chances of being a victim of crime and violence.

FIGURE 5 MORE AMERICANS LIVING AT OR NEAR POVERTY LEVEL

Income is below 200 percent of federal poverty level



Source: Current Population Survey (CPS)

FIGURE 5 shows that more Americans are living at or near poverty in 2014 when comparing prevalence in the year 2000 to the figures today.

FIGURE 6 shows that asset-building activities, such as home ownership and participation in retirement plans, are down in 2014 for most age groups when compared to 2000.

Here are some potential entry points Americans can use to improve their financial security:

- Address student debt by reexamining college-specific, private, federal, state and local programs to limit initial debt and pay it off more efficiently.
- Institutionalize financial education programs to enhance financial planning abilities and offer post-secondary educational offerings to support a broader range of occupational aspirations at all life stages.
- Increase access and promote larger contributions to saving and retirement plans, especially among the

growing number of workers not covered by employer-sponsored plans, such as automated and progressive defaults.

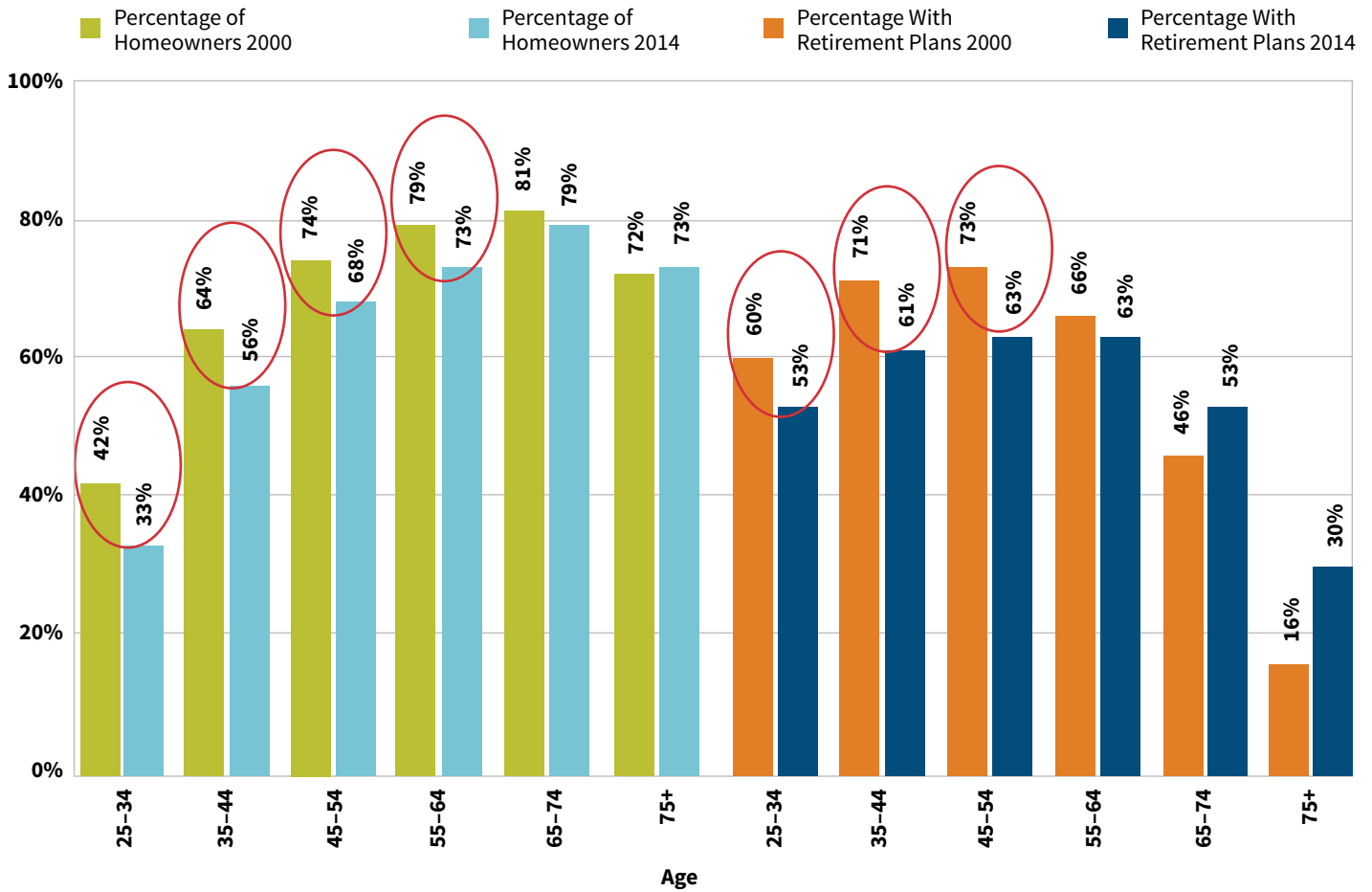
- Provide affordable health insurance programs for individuals who are not eligible for employer- or government-sponsored insurance.

SOCIAL ENGAGEMENT: TRADITIONAL METHODS WANING

Throughout the past few decades, the benefits of this domain have been less obvious than those that come with improved financial security and health. Research demonstrates, however, that social engagement contributes significant benefits to physical and mental health and longevity. Many are surprised to learn that socially isolated people have mortality rates comparable to smokers, and twice the mortality risk of the obese.

The eight action steps listed here fall into two categories: meaningful relationships and group involvement.

FIGURE 6 ASSET-BUILDING ACTIVITIES IN DECLINE



Source: Current Population Survey (CPS)

Meaningful Relationships

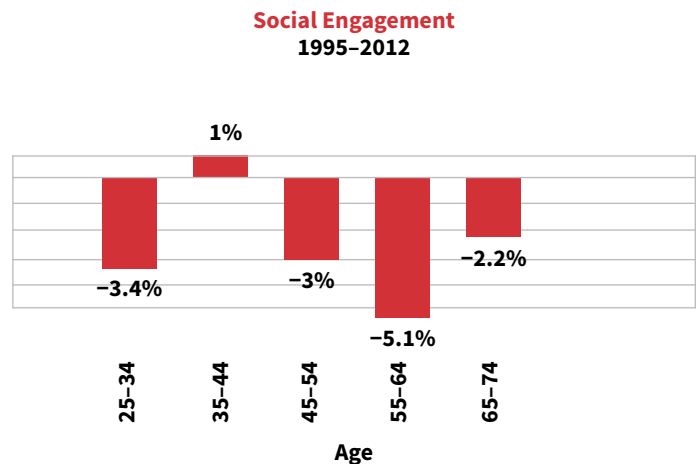
- Have deep interactions with a spouse or partner.
- Seek out frequent interactions with family.
- Get social support from family.
- Have frequent interactions with friends.
- Get social support from friends.

Group Involvement

- Converse with your neighbors.
- Volunteer.
- Participate in the workforce.

FIGURE 7 shows that little has changed since 1999, with one exception: Today’s 55- to 64-year-olds are less likely to be socially engaged than their predecessors.

FIGURE 7 TRADITIONAL SOCIAL ENGAGEMENT WANING



Source: The Sightlines Project

Here are some potential areas where Americans can nurture their social portfolios:

- Rethink the potential of enhancing social interactions and fostering social support in the workplace, particularly when demands at home are high, such as starting a family or caring for a sick loved one.
- Design organizational and community environments to support more proximate social interaction among neighbors and active civic engagement.
- Don't just encourage, but normalize volunteerism, particularly among 55- to 64-year-olds who are approaching retirement and will have the flexibility to give back to their communities.
- Increase accessibility and fine-tune social technology to optimally supplement interpersonal interactions, particularly among groups vulnerable to social isolation.

THE PROPER PERSPECTIVE

Of course, taking all of these steps won't guarantee a long, comfortable, healthy life. Many people take every one of these steps and don't live long, healthy lives; many others have lived a long time in spite of not engaging in most of these healthy behaviors.

In addition, other actions not captured during this initial phase of the Sightlines Project are also beneficial to long-term well-being. However, substantial scientific evidence indicates that living long and well is more realistic for people who take the specific action steps identified in Sightlines. In addition, if most citizens adopt more of these steps, there's a very good chance that the long-term costs and challenges associated with aging will be mitigated.

"There is a great deal that people can do to ensure long and satisfying lives," says Laura Carstensen, psychology professor and founding director of the SCL. "We hope that examining trends among factors known to influence longevity will help to inform national debate and stimulate entrepreneurial innovation."

The challenge of optimizing an aging society is a nice problem to have, given the alternative: navigating the plights of shorter lives, such as widespread famine and plagues that were prevalent just a few generations ago. SCL's Sightlines report provides valuable insights and is highly relevant to stakeholders across the board, including you.



FOUR KEY TAKEAWAYS FOR INDIVIDUALS TO CONSIDER



1 Anticipate living into your 80s and 90s, and raise your children to be centenarians.



2 Think about health broadly as physical, financial and social wellness.



3 Continue learning new ways to be healthy, make good financial choices and connect to others throughout your life in formal or informal settings.



4 Explore ways to be actively engaged in paid or unpaid work for most of your life.

NEXT STEPS AND MORE DETAILS

The Sightlines Project¹⁰ website hosts a wealth of information, including the percentage of Americans doing well in each action step by age, gender, marital status, income, education and ethnicity. These findings are steering the project toward more in-depth reporting on who is most successful and who is most vulnerable to better inform interventions, policies and decision-making. The website also acts as a repository for the latest research on these action steps, expert interviews and commentaries, and ongoing Sightlines projects. More than a website, it serves as a constant resource for those aiming to gain insights and ideas for reshaping the culture of long-lived societies.

ACKNOWLEDGMENT

SCL is grateful to the SOA for the financial support and for providing SOA volunteers to develop the inaugural report of the Sightlines Project. In particular, Anna Rappaport and Sam Gutterman volunteered many hours to the project. ■

background



FOUR KEY TOPICS FOR STAKEHOLDERS AIMING TO MAKE A LARGE-SCALE IMPACT



Develop policies targeted at diverse populations that not only focus on goals to prevent risky and unhealthy behaviors, but focus on goals to promote living well.



Identify appropriate change agents. Effectiveness of policies will vary depending on whether they are implemented by federal, state, local or other private institutions. National interventions might be better suited for indirect behavioral interventions, such as default or opt-out policies. Local interventions can focus on the built environment and direct supportive services. At all levels, it is likely most fruitful to appeal to groups that are meaningful to people, such as those with whom they identify strongly, want to belong or feel they can make a difference.



There is no one-size-fits-all approach. Identify the most vulnerable demographic subgroups and target interventions accordingly. Who is vulnerable depends on many individual characteristics (e.g., age group, ethnicity, gender, educational status) and which aspect of health is at most risk (i.e., physical, financial, social).



Across the board, policy and decision makers need to acknowledge and adjust for this era of longevity. The first step is to recognize that people in their 60s, 70s and 80s are an invaluable resource that should be tapped into, not only for older adults' well-being, but for the benefit of children and young adults, who can learn so much from them.

SIGHTLINES ACRONYMS

Acronyms of databases used in the Sightlines report are related to various topics and include:

Physical Health

- BRFSS: Behavioral Risk Factor Surveillance System
- NHANES: Continuous National Health and Nutrition Examination Survey

Financial Security

- CEX: Consumer Expenditure Survey
- CPS-ASEC: Current Population Survey, Annual Social and Economic Supplement
- SCF: Survey of Consumer Finances

Social Engagement

- CPS-VS: Current Population Survey Volunteer Supplement
- MIDUS: Midlife in the United States

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- ⁸ Bosworth, Barry, Gary Burtless, and Kan Zhang. "Later Retirement, Inequality in Old Age, and the Growing Gap in Longevity Between Rich and Poor." Brookings Institution, January 2016.
- ⁹ The Sightlines Project. Stanford Center on Longevity (February 2016). <http://sightlinesproject.stanford.edu>.
- ¹⁰ <http://longevity.stanford.edu/the-sightlines-project>.

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RETIREMENT



RISKS

A LOOK AT THE SOCIETAL IMPACT OF LIVING LONGER

BY R. DALE HALL

An era promptly ended earlier this year with the death of Emma Morano. Morano, an Italian supercentenarian whose birthday celebrations were broadcast live across Italy, passed away at the age of 117. She credited her longevity success in some part to eating raw eggs, consuming chocolate and positive thinking. With her passing, no one who was born in the 19th century is alive today.

Morano is an example of the increasing number of people who follow the theme of the Society of Actuaries (SOA) signature retirement and longevity program titled Living to 100. While we don't currently have a "Consumption of Raw Eggs" longevity study underway, we increasingly are studying and featuring technical mortality results and the societal impact of living longer. A few years ago, the SOA formed a Longevity Advisory Group to create new projects aimed at the study of longevity, mortality modeling, and new techniques for assessing and predicting future mortality improvement results. This group complements other SOA practice research committees, sections and experience studies committees that similarly are pursuing new and innovative research. New projects on mortality topics at the SOA have quickly branched out to all parts of the SOA's research work.

A RICH HISTORY

As I noted during a presentation at the Living to 100 Symposium in January, the study of mortality at the SOA quickly exceeds more than 100 years—if you include the work done by the two predecessor organizations (the Actuarial Society of America and the American Institute of Actuaries) that combined to form the SOA in 1949. Baked right into the “Reason for Being” statement from the Actuarial Society of America was the intent to gather actuaries across companies and practice areas to study aggregated mortality for use by members. From that history evolved milestones like the first studies focusing on the impact build and blood pressure on mortality in the 1920s, and a variety of annuitant tables issued from the late 19th century through the 1930s. One of the final steps the two predecessor organizations teamed up to create, prior to forming the SOA in 1949, was developing the 1941 Valuation Basic Table (VBT) and Commissioners’ Standard Ordinary (CSO) Table.

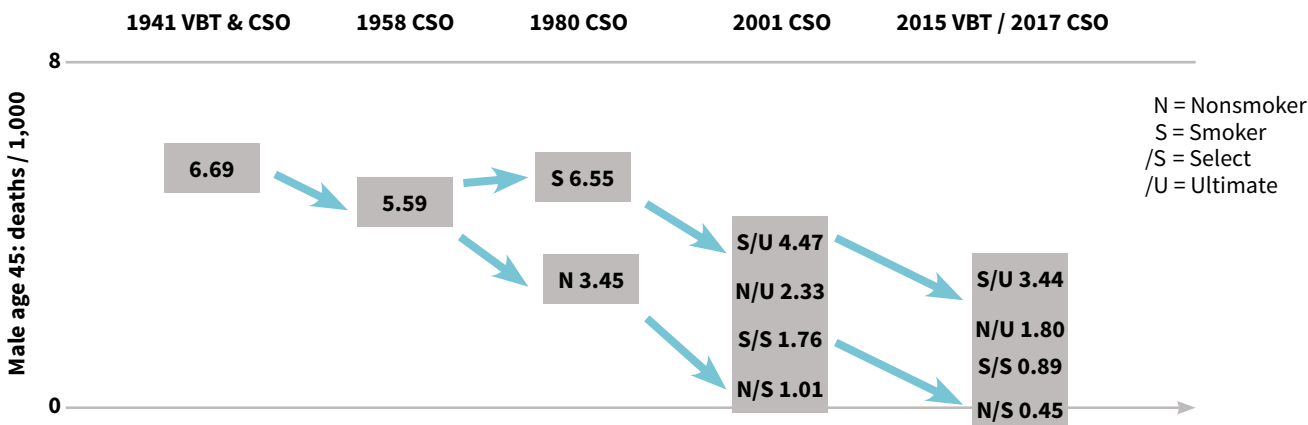
It’s interesting to think about the common vocabulary we use as actuaries today. When someone asks, “What table are you using?” the question really implies a broad group of tables you might be drawing from to set valuation assumptions. With the 1941 VBT and CSO, however, the answer to the question would actually be correct to note one distinct table, as the table combines male and female mortality into one single table and was only created on an age nearest birthday (ANB) basis. The table was based upon the experience of the 16 principal life insurers in the United States and Canada at the time, stemming from experience between 1931 and 1940. As a reference, the

mortality rate for a male at attained age 45 in the table was 6.69 deaths per 1,000—approximately the same rate as an 83-year-old male nonsmoker being selected for life insurance in the 2015 VBT.

As mortality analysis and underwriting grew through the second half of the 20th century, our work at the SOA quickly adapted. The 1958 CSO project includes four main tables as gender-specific mortality was created, and tables were created on both an ANB and age last birthday (ALB) basis. The male attained age 45 mortality rate in the 1958 CSO moved down to 5.59 deaths per 1,000. With tobacco use becoming a more prominent underwriting factor, the 1980 CSO project included a set of 12 main tables, and male nonsmoker rates vaulted down to 3.45 deaths per 1,000.

The 2001 CSO project expanded to recognize the use of select and ultimate mortality, extended term tables and gender blends to get the number of tables to be more than 100, and mortality of a male nonsmoker selected at age 45 moved to 1.01 deaths per 1,000. Finally, with the evolution of relative risk tables, the number of tables in a project has grown even further with the most recent 2015 VBT/2017 CSO project. And that’s even prior to thinking about tables that will evolve for preneed, guaranteed issue and simplified issue business. A male nonsmoker selected at age 45 has a mortality rate of 0.45 deaths per 1,000 in the 2015 VBT. It’s been very helpful for SOA experience studies committees, often in conjunction with American Academy of Actuaries (the Academy) committees and input and guidance from insurance regulators, to produce the types of information needed to assess and value complex individual life insurance liabilities. See **FIGURE 1**.

FIGURE 1 MORTALITY RATE—MALE NONSMOKER



Source: Mortality and Other Rate Tables, *mort.SOA.org*

MORTALITY TABLES ARE KEEPING PACE WITH INDUSTRY NEEDS AS THE INDIVIDUAL LIFE INSURANCE MARKET IN THE UNITED STATES CONTINUES TO HAVE A WIDE VARIETY OF PRODUCT TYPES, UNDERWRITING TECHNIQUES AND DISTRIBUTION METHODS.

Similarly, annuity tables have evolved over the years, leading to the most recent set of analysis produced by the SOA. We recently completed a set of annuity mortality studies, aimed at assessing aggregated U.S. industry results across product lines like individual and group payout annuities, as well as structured settlements. Results are compared to several former studies, especially to identify if any eroding margin is occurring in current U.S. statutory valuation standards. With group annuity exposures in recent years also coming from pension risk transfers exchanged between employer sponsors and life insurance companies, results also are compared to commonly used pension valuation tables. And as the individual life insurance market in the United States continues to have a wide variety of product types, underwriting techniques and distribution methods, mortality tables are keeping pace with industry needs.

LOOKING TO THE FUTURE OF LONGEVITY

We continue to expand our set of studies. The anticipated release of the first U.S. public plans mortality study is in 2018, with the hope of potentially producing tables down to variables like occupation class. With increasing aggregated information on the longevity of participants in public retirement plans, actuaries can have additional insights to produce valuation assumptions and funding discussions with plan sponsors.

As important as mortality studies are, however, the growing focus across many practice areas is in the area of mortality improvement. Research committees at the SOA have been investing an increasing amount of time in gathering data and building mortality improvement models for actuaries to use. In the pension area, the SOA's Retirement Plans Experience Committee (RPEC) has made annual updates to the RPEC_2014 mortality improvement model. This model, along with a set of assumptions researched and selected by the committee, produced the MP-2016 improvement scale in October 2016.

The model, however, also can be used with a wide variety of individually selected assumptions. Actuaries may review the trends and characteristics of the cohort they are studying, select a set of model parameters they think is appropriate, and develop a mortality improvement scale that fits their purpose. The SOA continues to look at how

mortality improvement is changing across national populations and in smaller selected cohorts, such as pension plans and different groups of insured lives. With recent stagnation in mortality improvement in the United States and around the world, it's an important topic for actuaries to understand and develop.

Longevity analysis, however, doesn't just start and stop with evaluating insurance mortality risk. We continue to have a strong group of industry volunteers emphasizing education and noting retirement risks in our Committee on Post-Retirement Needs and Risks. This group frequently has its work highlighted in major media publications and often fields requests to speak on longevity at a broad set of industry meetings. See the "Findings" sidebar on page 42 for some of the highlights of this group's recent work.



**LONGEVITY
ANALYSIS DOESN'T
JUST START AND
STOP WITH
EVALUATING
INSURANCE
MORTALITY RISK.**

findings

SOA COMMITTEE ON POST-RETIREMENT NEEDS AND RISKS RESEARCH

The SOA Committee on Post-Retirement Needs and Risks has produced a number of reports and research projects on retirement risks. Highlights of the group's most recent work include:

➤ A research report by researchers at the University of Southern California on how Americans manage their finances. This survey investigates how the financial lives of Americans have changed with the economic recovery of the past few years and is an update to an earlier survey conducted in 2012.

bit.ly/Manage-Finance

➤ A set of essays exploring the diverse risks associated with defined contribution plan risk management strategies, decumulation strategies for retirement and long-term care financing. Among these “diverse risk” essays is the first prize winner by R. Evan Inglis, titled “The ‘Feel Free’ Retirement Spending Strategy.” The essay reviews some practical advice on how much retirees might “feel free” to spend from an accumulated pool of assets, and also levels where retirees might be advised to spend “no more” in order to maintain retirement security. It’s also helpful that the essay notes other factors that should be considered when formulating a plan, such as the impact of using long-term care insurance and retirement income tax rates.

bit.ly/Diverse-Risks

➤ The staple of this set of work is the committee’s biennial Retirement Risk Survey. The most recent round of the survey was the eighth in the series. The purpose of the study is to evaluate Americans’ awareness of potential financial risks in retirement, how this awareness affects the management of their finances with respect to retirement, and how Americans are managing the process of leaving the workforce.

bit.ly/Retire-Risk-Survey

➤ Growing the number of places where we can highlight SOA research beyond our typical industry meetings, webinars and other continuing professional development events. We were invited by *The Economist* to participate in its recent “Business of Longevity” series and provide collective insights on funding the future and rethinking retirement. It’s just one of many recent examples that highlight how the actuarial profession is viewed as bringing helpful, tangible solutions to managing retirement risks. Look for the video online at ***bit.ly/Funding-Future***. You can see a wide variety of SOA research ideas referenced at the 16-minute mark in response to questions posed by Helen Joyce, international editor of *The Economist*. Topics range from SOA research being helpful in the valuation of pension plans to social retirement program considerations.

➤ We additionally highlight a project by the Stanford Center on Longevity that the SOA co-sponsored. The project reviewed the findings of eight national, multiyear studies of more than 1.2 million Americans conducted over two decades to assess how well Americans are aging in light of increased longevity. Three items critical to well-being as people age—financial security, healthy living and social engagement—were identified and measured.

bit.ly/SOA-Sightlines

One of the goals of our research areas is to fulfill an objective of providing more data and tools for our members. We recently renewed an annual grant to the University of California–Berkeley to continue supporting the work of the Human Mortality Database (HMD). HMD recently extended its work to include cause of death analysis for eight countries and looks to expand to more countries in 2017. It also aims to study mortality tables down to the state level within the United States. With this information, actuaries can be more easily equipped with trends in diseases and mortality. We also have been very pleased with the success of the Longevity Illustrator, a tool developed in partnership with the Academy. This tool allows the public to better assess and measure longevity risk, and plan better with objective data provided by the actuarial profession.

RETIREMENT PREPAREDNESS

The Longevity Illustrator also highlights the growing need for the actuarial profession around the world to promote retirement plans that include lifetime income options. We continue to face a world where longevity risk is analogous to a raging fire hiding within the walls of a house. It's very difficult for the public to notice the risk growing as they age, and it's not until the smoke begins billowing out of the walls that action is taken. By that time, it's far too late to escape the danger. Even when the risk is discussed, many practitioners still talk in terms of a life expectancy metric, noting mainly the increase in life expectancies from birth that have occurred over time.

Longevity risk, however, is a much more delicate issue than simply noting the average ages that might be obtained across a population. First, actuaries need to change the public's vocabulary to switch from "expectancy from birth" to "retirement preparedness." I often use the statistic I call "life preparancy" in my longevity presentations, borrowing the comfortable sound of the phrase "life expectancy" but also injecting the need for preparing for the future. A life preparancy age might be commonly defined as the age to which 90 percent of a population that has already reached age 65 is expected to live in the future.

Just as life expectancies have generally increased across the world in recent decades, so have life preparancy ages. **FIGURE 2** shows results from evaluating static population data from the Human Mortality Database in the United States, Canada, and England and Wales during past decades.

FIGURE 2 SAMPLE LIFE PREPARANCY AGES IN ENGLAND AND WALES, CANADA AND THE UNITED STATES

Year	England & Wales		Canada		United States	
	Female	Male	Female	Male	Female	Male
1940	87.0	84.5	89.1	87.5	88.5	86.6
1950	88.9	86.1	90.0	88.1	90.6	87.9
1960	90.2	86.7	91.4	88.9	91.3	88.2
1970	91.2	87.0	93.0	89.5	92.5	88.6
1980	92.0	87.7	94.5	90.3	94.1	89.8
1990	93.5	89.3	95.2	91.1	95.0	90.9
2000	94.2	90.9	95.5	92.0	94.6	91.5
2010	95.7	93.3	96.8	93.9	96.0	93.5

Source: Human Mortality Database

The life preparancy age for the populations routinely has been higher than many may have expected, even at early dates in the analysis, with notable gains in recent decades. Recent stagnation in mortality improvement since 2010 likely will slow the pace of growth, but the ages help provide mortality data to consider alongside the retirement risks that were discussed at our Living to 100 Symposium.

When Emma Morano passed away, she passed the torch of longevity to others who will follow in her footsteps and perhaps challenge current longevity records. With the assistance of SOA mortality studies and corresponding longevity research, we aspire to keep the people of the world prepared to face their retirement risks head on. ■

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RELATED LINKS

Human Mortality Database
mortality.org

Living to 100
livingto100.SOA.org

Actuaries Longevity Illustrator
longevityillustrator.org



SMART SHOPPING

ADVICE ON FINDING THE OFF-THE-RACK “LONGEVITY SUIT” THAT FITS BEST

BY JOHNNY S.-H. LI AND KENNETH Q. ZHOU

Imagine you are contemplating buying your next suit. The first question in your mind is probably “bespoke or off-the-rack?” The same question arises when the time comes to choose a pension de-risking solution. Broadly speaking, pension de-risking solutions can be divided into two categories: bespoke (indemnity-based) and off-the-rack (standardized).

BESPOKE SOLUTIONS

Bespoke solutions are based on the actual mortality experience of the hedger’s own portfolio. They typically are executed with (re)insurers in the form of buy-ins (through which the asset and liabilities of a pension plan are transferred to an insurer), buy-outs (through which bulk annuities are acquired to pay pensions) or customized longevity swaps (through which fixed cash flows are exchanged for floating cash flows that depend on the actual mortality experience of the hedger’s portfolio).

FIGURE 1 THE EXCHANGE OF CASH FLOWS IN A CUSTOMIZED LONGEVITY SWAP

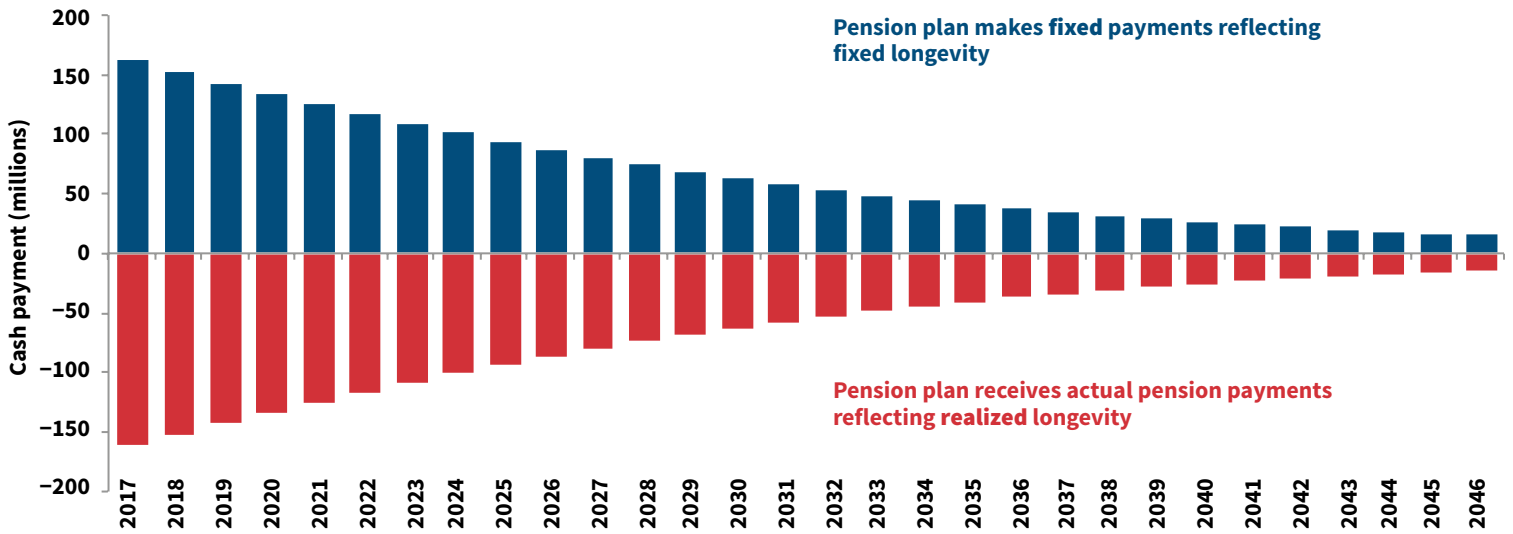


FIGURE 1 illustrates the mechanism behind a customized longevity swap. During the term of the swap, the pension plan (the hedger) will swap pre-agreed monthly payments with the counterparty (a reinsurer) in return for monthly payments dependent on the longevity of the plan’s own members. Should the plan members’ mortality be lighter than expected, the pension plan would receive net payments from the reinsurer that could then be used to offset the corresponding higher pension payouts.

By its definition, a bespoke solution provides a perfect hedge. There is no residual risk about which to worry.

OFF-THE-RACK SOLUTIONS

Alternatively, a pension plan may choose to de-risk with off-the-rack (standardized) solutions. Standardized solutions typically are executed in the form of capital market derivatives, which are linked to broad-based mortality indexes rather than the mortality experience of the hedger’s own portfolio of individuals. The following sections describe examples of such derivatives.

q-Forward

A q-forward is a zero-coupon swap that exchanges at maturity an amount proportional to the realized prevailing mortality rate at a certain age (the reference age) with an amount proportional to a fixed mortality rate.¹ To hedge longevity risk, a pension plan should participate in a q-forward as a fixed-rate receiver so that it would receive a net payment from the counterparty when mortality turns

out to be lighter than expected (i.e., when its liability is higher than expected). **FIGURE 2** illustrates the exchange of cash flows in a q-forward.

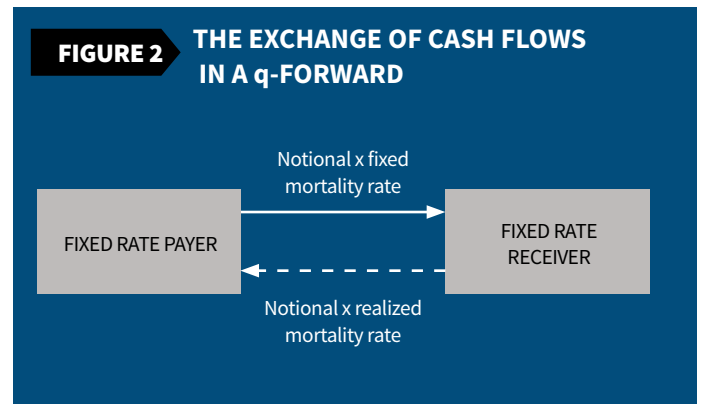
S-Forward

S-forwards are identical to q-forwards, except they are linked to cohort survival rates instead of mortality rates.² S-forwards are regarded as more sophisticated than q-forwards, because a cohort survival rate is a function of multiple mortality rates at multiple time points.

K-Forward

Recently, a conceptual mortality derivative called K-forward has been proposed.^{3,4} A K-forward has the same structure as a q-forward, but it is linked to a “parametric mortality index” constructed using a time-varying parameter in a robust stochastic mortality model. One advantage

FIGURE 2 THE EXCHANGE OF CASH FLOWS IN A q-FORWARD



of K-forwards is that a parametric mortality index is able to capture more information concerning the evolution of mortality than traditional, nonparametric indexes, such as mortality rates and survival rates.

Longevity Experience Options

Longevity Experience Options (LEOs) are out-of-the-money call options on forward survival rates.

Deutsche Bank reportedly executed the first LEO with an insurance-linked securities fund in 2013.⁵

Of course, standardized solutions do not offer a complete elimination of longevity risk. The hedger is subject to certain residual risks that must be managed by other means.

WHY OFF-THE-RACK MAKES SENSE

We all love the process of getting a bespoke suit, from the first consultation to the delivery of the end product that fits perfectly. But let's face it; a bespoke suit is not exactly inexpensive.

The fact that off-the-rack is generally less costly than bespoke applies not only to clothing, but also to financial instruments due to the fact that off-the-rack financial instruments are more liquid. As discussed in one of our previous papers,⁶ there exists profound evidence for an inverse relationship between liquidity and Sharpe ratio (a measure of the compensation to investors who accept the risk entailed) in stock, mutual fund and hedge fund markets. It has been argued that the market for longevity risk transfers is highly akin to a typical financial market,⁷ so it is reasonable to conjecture that off-the-rack longevity hedges are more economical than bespoke ones.

Cost is not the sole factor. In today's market, there are not enough tailors (insurers providing bespoke de-risking solutions) to meet the demand for longevity risk transfers. Using the assets for pension plans (in excess of 31 trillion USD) as a proxy for demand and the assets held by the global insurance industry to cover nonlife risks (2.6 trillion USD) as a proxy for supply, George Graziani⁸ from Swiss Re concluded that the demand for acceptance of longevity risk exceeds supply by a multiple of 10. Experts from Société Générale⁹ also reached a similar conclusion by comparing the potential increase in pension liabilities due to unforeseen longevity improvement with the aggregate capital of the global insurance industry. Therefore, there is a need to invite capital market investors to take longev-



ity risk exposures (in exchange for a risk premium). Such investors prefer off-the-rack to bespoke, because the former is free of the information asymmetry arising from the fact that hedgers (pension plans) have better knowledge about the mortality experience of their own portfolios.

GETTING THE RIGHT OFF-THE-RACK LONGEVITY SUIT

When shopping for an off-the-rack suit, you find the one that best matches your body in terms of waist, chest, shoulder and so on. Likewise, when building a longevity hedge with off-the-rack mortality derivatives, you need measurements of the longevity risk exposure of your portfolio. These measurements can be defined from two different angles:

- Treating the mortality curve as an interest rate yield curve, or
- Applying an analogy between longevity risk and equity risk.

Method 1: Treating the Mortality Curve as an Interest Rate Yield Curve

Interest rate risk and longevity risk share heaps of similarities:

- Both interest rates and mortality rates have “term structures.” Interest (yield) rates on zero-coupon bonds vary with time-to-maturity, while mortality rates vary with age.
- Both interest rate yield curves and mortality curves evolve over time in a random manner.
- Shifts in interest rate yield curves and mortality curves are generally not parallel.

Given these similarities, it makes a lot of sense to measure exposures to longevity risk using metrics that are parallel to interest rate duration and convexity. A metric called “key q-duration” was developed along this line.¹⁰

More specifically, a key q-duration measures the sensitivity of a life-contingent instrument/liability to a specific portion of a mortality curve. It is largely analogous to “key rate duration,” which has been used extensively by traders to measure and manage interest rate risk.

One can find the best-fitting portfolio of off-the-rack mortality derivatives by matching the key q-durations of the hedge portfolio and the liability being hedged. It has

been demonstrated that under idealized assumptions, a hedge calibrated using the method of key q-duration can eliminate more than 90 percent of longevity risk (in terms of variance reduction).

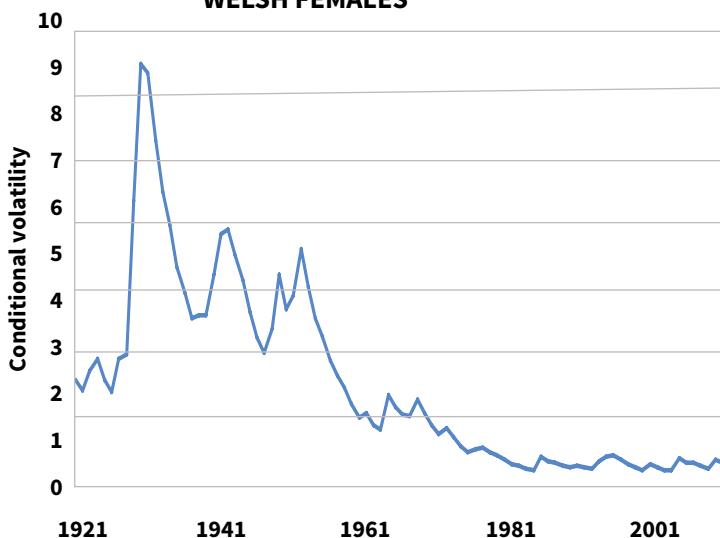
Method 2: Applying an Analogy Between Longevity Risk and Equity Risk

When measuring the risk entailed in a stock option, Greek letters often are used. A Greek letter measures the sensitivity to a specific parameter in an option pricing model. For example, delta measures the first-order sensitivity to S_0 (the time-0 value of the underlying asset) and gamma measures the second-order sensitivity to S_0 .

Analogously, one may measure exposures to longevity risk using “longevity Greeks,” which gauge the sensitivity to changes in certain parameters driving the evolution of mortality in the stochastic process. Of particular importance is the time-varying parameter (the period effect) in the assumed stochastic mortality model. Longevity delta and gamma have been defined to capture the first- and second-order sensitivities to this parameter, respectively. By matching longevity Greeks, one can easily formulate an optimal portfolio of off-the-rack mortality derivatives.^{11,12}



FIGURE 3 **CONDITIONAL VOLATILITY OF THE TIME-VARYING PARAMETER IN THE LEE-CARTER MODEL FITTED TO THE HISTORICAL DATA FOR ENGLISH AND WELSH FEMALES**



Source: Cairns, Andrew J. G. “Modelling and Management of Longevity Risk: Approximations to Survivor Functions and Dynamic Hedging.” *Insurance: Mathematics and Economics* 49, no. 3 (2011): 438–453.

RECENT CONTRIBUTIONS TO GREEK HEDGING OF LONGEVITY RISK

At the 2017 Society of Actuaries (SOA) Living to 100 Symposium, we presented a paper that investigates various aspects of Greek hedging of longevity risk.¹³ The following points are the key findings of the paper.

The evolution of mortality over time is subject to stochastic volatility (see **FIGURE 3**). For this reason, it is important to include the sensitivity to volatility when measuring longevity risk exposures. To this end, we have introduced a new metric called “longevity vega” and demonstrated its usefulness in hedging longevity risk.

We derived semi-analytical formulas for calculating longevity delta, gamma and vega from an extension of the Lee-Carter model. The calculation does not require finite differencing and is therefore not computationally demanding.

We derived and explained the properties of the three longevity Greeks for q-forwards with different specifications. As with developments for equity options, these properties allow us to know more about q-forwards as a



One can find the best-fitting portfolio of off-the-rack mortality derivatives by matching the key q-durations of the hedge portfolio and the liability being hedged.”

risk mitigation tool. In practice, when a perfect Greek neutralization is not always possible, these properties also can guide the hedger to choose an appropriate q-forward that can offset his or her longevity risk exposure in a particular dimension. For instance, if the hedger has an annuity liability with a large longevity gamma, then based on our results he or she should contemplate acquiring a q-forward with a high reference age.

Using the properties of longevity Greeks, we identified and explained several relationships between hedge effectiveness and q-forward specifications. The results reveal several interesting facts. For example, in a delta-vega hedge formed by q-forwards, the choice of reference ages does not materially affect hedge effectiveness, but the choice of times-to-maturity does. This may aid hedgers to better formulate their hedge portfolios in terms of choosing which q-forwards to use and which longevity Greeks to match.

We validated our Greek hedges using a nonparametric bootstrapping method that does not depend on any model. As expected, the hedge effectiveness is somewhat reduced

when the model assumption breaks down, but many of the theoretical relationships between hedge effectiveness and q-forward specifications are still observed, even when the evaluation scenarios are generated by a model-free approach.

CONCLUSION

In summary, off-the-rack longevity hedging solutions offer an attractive alternative to bespoke ones. To ensure that a portfolio of off-the-rack mortality derivatives fits, one can rely on measurements such as key q-durations and longevity Greeks. Our recent results about longevity Greeks give hedgers a better understanding on what fits them well—and what does not.

Other than the search for a good fit, there are several issues surrounding off-the-rack longevity hedging solutions, including population basis risk that arises from the difference in the mortality experience between the hedger's portfolio of individuals and the population to which the mortality derivative used is linked. These issues are not

WHEN SHOPPING FOR AN OFF-THE-RACK SUIT, YOU FIND THE ONE THAT BEST MATCHES YOUR BODY IN TERMS OF WAIST, CHEST, SHOULDER AND SO ON. LIKewise, WHEN BUILDING A LONGEVITY HEDGE WITH OFF-THE-RACK MORTALITY DERIVATIVES, YOU NEED MEASUREMENTS OF THE LONGEVITY RISK EXPOSURE OF YOUR PORTFOLIO.



discussed in this article, but are investigated extensively in a few academic papers.^{14,15} Researchers are now working hard on the topic of standardized mortality derivatives, with a goal of helping you be a smarter suit shopper. ■

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FEATURE
RETIREMENT INCOME PRODUCTS



TONTINE thinking

SHOULD MORTALITY CREDITS BE REINTRODUCED EXPLICITLY IN THE DESIGN OF FUTURE RETIREMENT INCOME PRODUCTS?

BY MOSHE A. MILEVSKY

In the year 1693, the government of England was struggling with the cost of an expensive and unpopular war against France and was looking for an innovative way to finance its expenditures and budget deficits at the lowest possible interest cost and rate. Recall that this was a financial era before long-term bonds or central banks. So, the English decided to try a rather risky strategy, borrowing an idea that recently had been attempted in France (ironically) to finance its war against the English. An act of Parliament was passed that approved the borrowing of £1,000,000 (which today might be worth 100 to 200 times that amount) via something we would now call a **tontine annuity**—the impetus for this article.

Basically, the government offered a syndicate of wealthy lenders 10 percent interest for seven years and then 7 percent interest *in perpetuity*, all in exchange for the £1,000,000. But the principal would never be returned. Thus, for example, in the year 1694 (after one year) the Exchequer would make £100,000 in total interest payments to the syndicate of lenders. The same process would be repeated in 1695, 1696 and so on. Then, in the year 1700, the annual interest payments to the syndicate would be reduced from 10 percent to 7 percent, which is a total

Author's Note: This article includes preliminary material from a research effort on tontines (conducted with various colleagues and students at York University), co-sponsored by the Society of Actuaries (SOA). Tontine annuities were introduced as fiscal instruments of public borrowing in the late 17th century and then morphed into a form of speculative investment during the 18th century. After some undesirable mutations by the (American) insurance industry, tontines fell into disrepute in the late 19th century and were eventually banned by regulators in many legal jurisdictions around the world by the mid 20th century. In this article, I discuss whether the retirement challenges of the 21st century create an opportunity for their reintroduction. Actuarial science, regulation and technology have progressed considerably since the 17th century, and nobody (in their right mind) would propose recycling the original scheme promoted by Lorenzo de Tonti. Rather, this article makes the case for what I call "tontine thinking"—or making mortality credits transparent and explicit—in the design of retirement income products of the future.

outflow of £70,000 per year until the syndicate is gone—defined in a moment. The arithmetic is all pretty basic, but it is notable for being one of the earliest attempts at long-term borrowing in England.

The catch here—or the difference between this fixed-income instrument and any other perpetual coupon bond issued in the last 300 years—is that the annual interest payments would only be distributed to the investors in the syndicate conditional on their original nominee being alive. To clarify here, in the year 1693 when the loan was syndicated, anyone (e.g., the annuitant) who lent or invested £100 (the minimum investment) via this scheme had to select a *nominee* upon whose life the interest payment would be continued. If and when the nominee died, the payments ceased to the annuitant. As one might expect, the nominees to the 1693 tontine were (mostly) young healthy children—the average age of the typical nominee was 10—who were expected to live long lives. But, of course, not all of them did in practice. Some of the earliest mortality tables in England were based on the experience of this group of nominees.

So, for the sake of example, assume that 10,000 annuitants each invested the minimum £100 in the scheme and selected 10,000 distinct nominees. Assume also that by the year 1697, a total of 500 of the nominees had died during the first four years of the scheme. Then the £100,000 of interest for the year 1697 would be distributed among the corresponding 9,500 annuitants, which would result in a dividend of $100,000/9,500 = £10.53$ per annuitant (again, whose nominee was still alive). Actuaries will recognize immediately that the £0.53 more than the guaranteed 10 percent interest were *mortality credits*. Although at the time they were called benefits of survivorship.

Now, fast-forward a quarter of a century. If by the year 1720—incidentally the year of the famous South Sea stock market crash—a hypothetical total of 4,000 nominees had died, then the £70,000 in interest would be distributed to 6,000 annuitants, generating a dividend of £11.67, which can be broken down into 4.67 percent (or £4.67) of mortality credits plus 7.00 percent (or £7.00) of interest. Recall that by construction and design, in the year 1700 the aggregate interest payment to the syndicate was reduced from 10 percent to 7 percent, which leads to a lower numerator. This pattern would continue until the last remaining survivor (nominee) received a dividend of £70,000 until she died, and the tontine was extinguished. Well, that was the plan—at least in broad brushstrokes. In some sense, one can think of this as a type of “lapse-supported” insurance product enabling the issuer to price

using a “better” interest or discount rate, although obviously once the original tontine investment is made there is no point in lapsing. You might as well hold on while your nominee is still alive.

In practice, the 1693 tontine annuity wasn’t fully subscribed, perhaps because investors at the time had better alternatives and a famous astronomer by the name of Edmond Halley counseled against the tontine.¹ The oldest nominee linked to the 1693 tontine was a female who died in 1783 at the age of 100. Yes, she was selected as a nominee at the age of 10. My point here isn’t to tell the full history of the first English tontine loan, but rather to unearth possible lessons or ideas for the retirement income products of the future.

THE RETIREMENT CHALLENGE

With the global decline in defined benefit (DB) pension coverage and the increase in defined contribution (DC) investments—a phenomenon that has been debated and discussed at length—there is also a growing concern among policymakers that retirees of the future will no longer have access to low-cost and efficient longevity pooling schemes (i.e., the actuarial backbone of DB plans). This problem is exacerbated by what financial economists call the *annuity puzzle*, which is the reluctance of older consumers to voluntarily use money or funds from their nest eggs to purchase life-contingent annuities, despite their welfare-enhancing properties. Either way, by choice or by design, generic DC schemes “rob” retirees of mortality credits and the benefits of pooling. This then reduces retirement sustainability, which already is hampered by an era of low (real) interest rates, increasing longevity and reduced discretionary savings. Indeed, these facts are all well-known to specialists. The question is whether centuries-old tontines—or at least the underlying DNA of a tontine—can help. I believe the answer is yes.

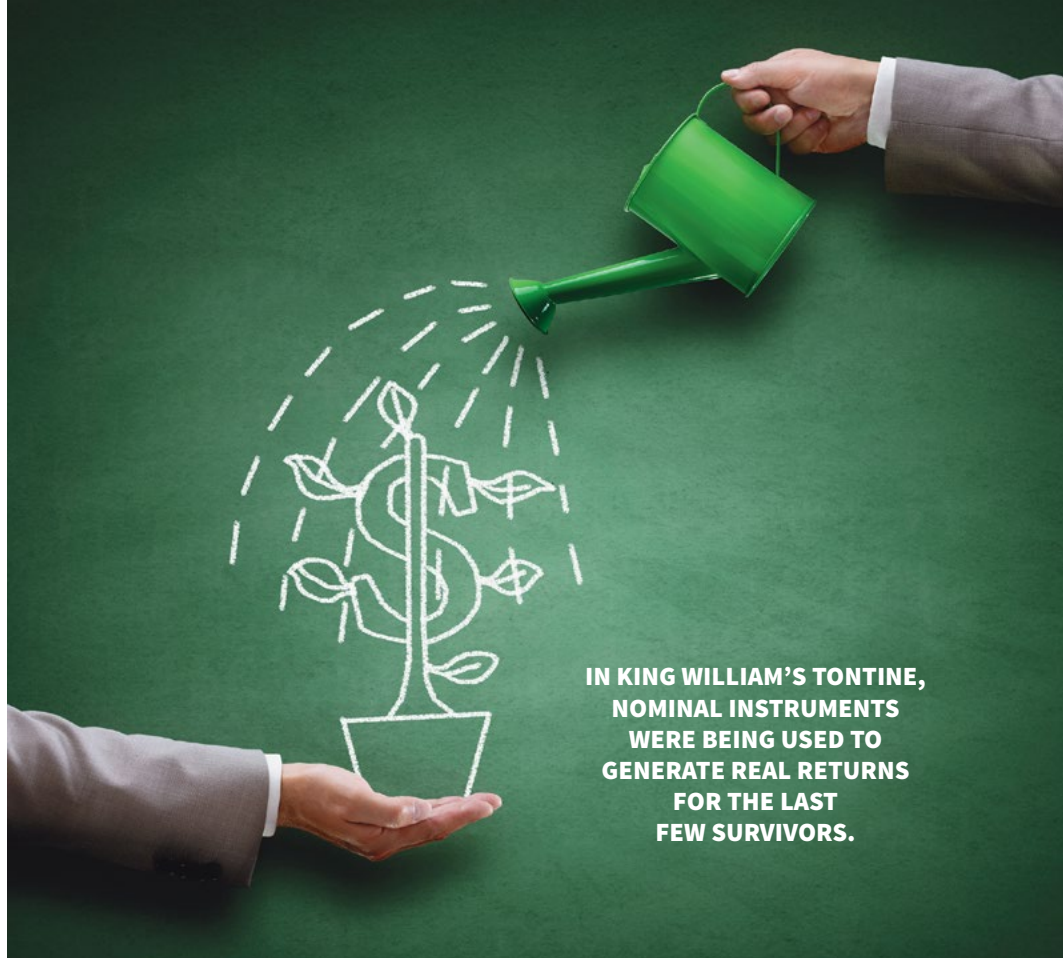
ELEMENTS OF TONTINE THINKING

The original 1693 design that I described—and what has been named King William’s tontine by historians, since he was the reigning English monarch at the time—can inspire future generations of DC retirement income products with what I call “tontine thinking.” In particular, there are four elements of King William’s tontine that are worthy of consideration.

Less Capital Intensive

Unlike a pension plan or annuity company, the issuer of a tontine annuity doesn’t incur much longevity risk. The

“The *annuity puzzle* is the reluctance of older consumers to voluntarily use money or funds from their nest eggs to purchase life-contingent annuities, despite their welfare-enhancing properties.”



**IN KING WILLIAM'S TONTINE,
NOMINAL INSTRUMENTS
WERE BEING USED TO
GENERATE REAL RETURNS
FOR THE LAST
FEW SURVIVORS.**

borrower or issuer makes known fixed payments (the numerator), which are distributed among the survivors (the denominator). The group or syndicate incurs aggregate longevity risk, not the borrower. This then reduces the need for capital (if it was an insurance company) and in theory would increase the expected payout per survivor.

Now, just to be clear, the sponsor does face some modicum of risk in having to forecast whether the one last surviving nominee will live 50, 55 or perhaps 60 years. However, the discounted present value of that (uncertain) liability ending date pales in comparison to the longevity risk faced by pension plans of insurance companies that only sell annuities. Ergo, the lower (or nonexistent) capital requirements should result in better payouts for annuitants and retirees—in exchange for incurring aggregate longevity risk.

Complete Transparency

Anyone who participated in the 1693 tontine annuity knew exactly *why* he or she was receiving a particular dividend in a particular year. The calculation could be done—and was actually reported—on a single sheet of paper that is still preserved today in the archives of the British Library in London. The cash-flow numerator was known in advance, and the denominator of survivors easily could be counted every year at the designated dividend date. The division of the two numbers didn't require any advanced mathematics

or actuarial discretion. One certainly didn't require a 2,000-page legal prospectus to explain to (novice) investors the ins and outs of caps, floors, ratchets and roll-ups. It didn't leave anything to the discretion of actuaries.

Real Longevity Insurance

Like all life-contingent annuities, the tontine annuity would protect the investor against the nominees—which could also be the investor—living longer than they had originally planned or anticipated. The longer they lived, the more income they received. The last few survivors—who by definition had lived very long lives—would receive larger payments, which then (might) serve as a hedge against uncertain medical expenses that (might) increase at a rate higher than inflation. In some sense, nominal instruments were being used to generate real returns. This is a subtle point that is worth repeating. If shocks to population mortality are correlated with shocks to the state of the economy—in other words, they are not statistically independent processes—the tontine's redistribution mechanism might have utility enhancing properties.²

Payments Increase Slowly

One of the interesting features of the 1693 (Williamite) design was the one-time reduction in interest payment to the syndicate. Recall that for the first seven years the

interest rate was 10 percent, and then in the year 1700 it was reduced to 7 percent. This design element differed from the original Lorenzo di Tonti (French) scheme under which the interest paid to the group was constant over the entire horizon. Notice then that as the denominator (survivors) was expected to shrink, the numerator would decline as well, and thus result in levelized payments.

This idea can be extended from a one-time adjustment to a constant reduction in cash flows. In theory, the sponsor could construct a tontine annuity using zero coupon bonds in which the cash flows (numerator) decline at roughly the same rate as the denominator. In some technical work I published with Tom Salisbury,³ we call this a natural (aka levelized) tontine. **FIGURE 1** displays a confidence interval for payments or income over time. On average, payments remain constant, but there is a positive skew in the cash flows—the fingerprint of a tontine—which means that long-lived retirees might receive (very) large payments at the risk of only a modest decline if aggregate longevity was lower than expected.⁴

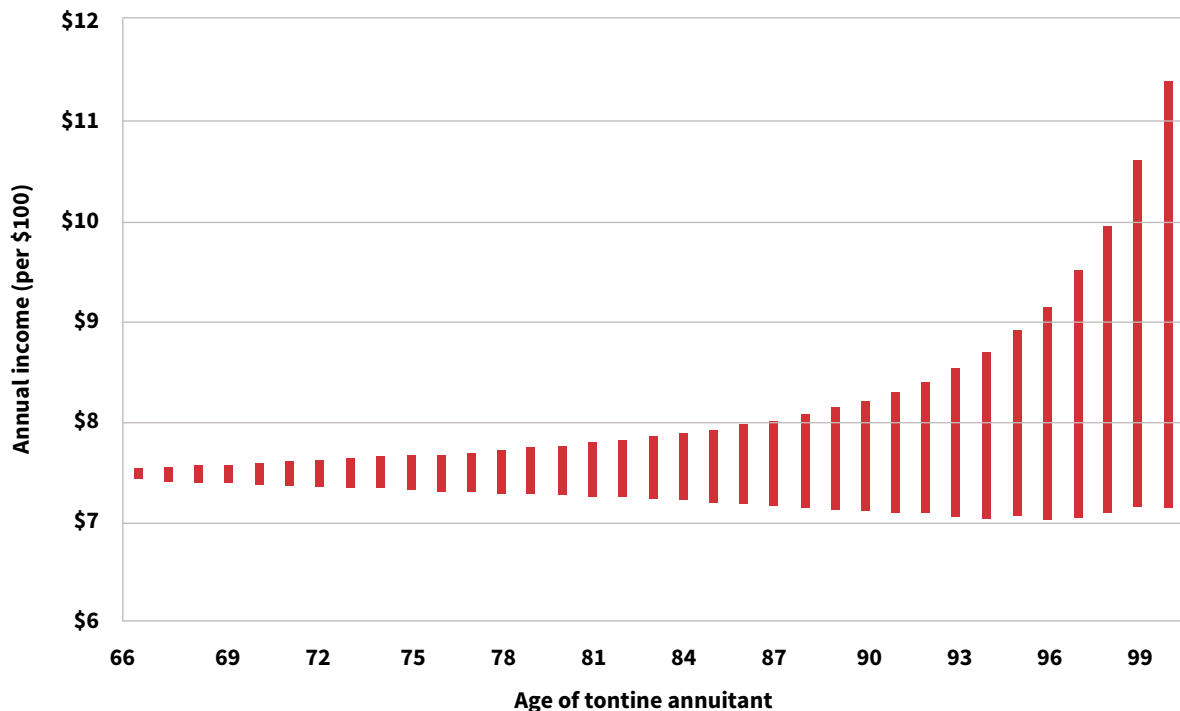
The design of such “pooling” arrangements—where aggregate longevity risk is shared among a group and not incurred by the issuer—is a fertile area of academic research, and other authors^{5,6} have proposed alternative designs. In fact, in an ongoing research project co-sponsored by the SOA, my co-researchers and I are:

- ❶ | Conducting (historical) Monte Carlo simulations to examine how a natural tontine would compare to payouts from conventional annuities, and
- ❷ | Quantifying the utility benefits of natural tontines versus annuities in the presence of background economic risk, such as unexpected medical inflation.

Preliminary evidence suggests that a suitably immunized (or collateralized) tontine annuity might offer 10 percent to 15 percent more income and/or utility value (at retirement age 65) compared to a life annuity.

Of course, there is some “risk,” which is clearly displayed in Figure 1. Payments could indeed decline. In fact, the underlying probability and statistics required to model the next

FIGURE 1 RANGE OF NATURAL TONTINE ANNUITY PAYOUTS: 5TH VERSUS 95TH PERCENTILE WITHIN 1,000 PARTICIPANTS





generation of tontine annuities are well understood and part of the current canon of actuarial theory. Indeed, a Ph.D. in rocket science isn't needed or required to resurrect tontines.

The real challenges would be legal and regulatory rather than scientific. First, the current annuity and insurance industry might be reluctant to concede high-margin products. Next, there are skeptical regulators to win over—perhaps the grandchildren of state insurance commissioners who banned tontine insurance a century ago—and they might not take kindly to anything with the word tontine in the title, regardless of exact substance or economics. These words matter to lawyers.

FINAL THOUGHTS

While the idea of reintroducing a tontine-like structure as yet another retirement product on the menu might seem natural to actuaries, I can personally testify that many members of the public—as well as media, plan sponsors and especially politicians—recoil in horror when tontines are explained to laymen, especially if it is done tactlessly. One well-known financial writer and author⁷ has described tontines as “the most discredited financial instrument in history.”

The principal objection—again, anecdotally—appears to be the direct benefit a surviving investor receives from the immediate death of a member of the original syndicate (or their nominee). Some commentators go so far as to worry about nefarious moral hazard concerns. Of course, the transfer of assets from deceased to survivors, and vice versa, is at the heart of all social insurance systems, albeit perhaps not as transparently. Moreover, the identity of participants and even the entire transfer process can nowadays be made anonymous (via Blockchain) online, although I certainly understand the reluctance to embrace any company's claim that its online data is 100 percent secure and anonymous in perpetuity.

Then, in addition to what some call the ethical dilemma, there is also an aversion to an insurance product with no legacy or bequest value—although that also can be corrected in the design, at the expense of reduced mortality credits. Alas, actuaries of the 21st century already have a ready-made solution to all these problems, but as the *annuity*

puzzle I described can attest, the optimal retirement income product isn't necessarily a very desirable or popular one. More often than not, the suboptimal strategies and products (paying the highest commission) are most widespread.

But to end this article on a positive and *behavioral finance* note, perhaps once retirees are shown the extreme (naked) version of mortality credits and risk pooling—and they reject it after properly thinking it through—they are more likely to embrace the tontine's tamer cousin on the menu; namely, the life annuity in which income is guaranteed, smoothing risk is reduced and the impact of death isn't as obvious. As all good sales and marketing professionals have learned, it helps to have an “over-the-top” product advertised next to the item you really want to sell. Walk into any jewelry store, and you will see what I mean. So perhaps the 17th century tontine can be resurrected as a behavioral anchor that nudges people into generic annuities. Well, that is the theory, at least. ■

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Q&A

PEOPLE PERSON

Q&A WITH HR ANALYTICS SPECIALIST ILANA SULLIVAN

Q: What about your current position in human resources (HR) brings you the most satisfaction?

A: The best part of my job is when I can use the results of my analysis to make recommendations that make our organization an even better place for all employees. I like to help people, so when I see my results being used for workplace improvement, it makes me proud of my job.

Q: Many in the actuarial arena say risk is opportunity. What opportunities have you discovered having moved from a traditional actuarial role to a position in human resources?

A: Actuaries have a great analytic skill set; they are taught how important it is to understand the business they are analyzing; and they learn to communicate in a clear and concise manner. I'm in the business of HR, and as an actuary, it's my job to learn the business, do analyses and make recommendations—all while following all of the ethical and professional responsibilities of an actuary. I hope that I serve as an example and inspire other actuaries to make the move to a nontraditional role. It's good to show that actuaries can do so much more than price insurance products.

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Q: What advice can you provide to other actuaries who are thinking about making a move to a job outside of the traditional actuarial career path?

A: Start learning about the business you are interested in. I learned a lot about insurance products and the insurance industry from actuarial exams, but I didn't know much about HR when I moved to my current role. Actuaries have strong skill sets that can be very valuable in various parts of an organization, but it may be difficult getting leaders around the company to recognize the unique benefits an actuary brings to the table.

Q: How has your background as an actuary positively affected the work you do in your current position?

A: One thing I learned as an actuary working in life insurance was that I was expected to do work at all levels of difficulty. There wasn't any work that was beneath me, and with enough effort, there wasn't any work that was above me. I was expected to do work across the spectrum of complexity. The manager who hired me in my current role said the willingness to do all types of work is a rare trait. Many people want to have all of their work in a very narrow spectrum; however, one of the things I love most about my work is the diversity.

The importance of structure is helpful as well. I always considered myself to be someone who disliked the restrictions of rules and procedures. Once I began working outside of the actuarial team, I realized that actuaries like things more structured—often because of professional and legal requirements—and that my perception of myself was only accurate while in relation to other actuaries. Within HR, I have found I'm the one who is structured and procedural, which is amusing to me.

Q: How are you and your team using predictive analytics and metrics?

A: Examining gender diversity across management roles is one example of the work my team does. This work ranges from providing simple counts of how many women we have in management, to determining how we can recruit more women, to preparing women for leadership roles. The team is using predictive analytics to understand how many women will be in leadership roles in the future based on hiring and turnover trends.

Q: How important is teamwork in your department?

A: Teamwork is critical in my department, especially for someone like me who doesn't have the HR background. I depend on my team to help me learn about the work HR does and to understand where data is stored. Most of the projects we work on individually affect the entire team, so it's important to have an awareness of everyone's work.

Q: What does a team with diverse skill sets (e.g., MBAs, Ph.D.s, scientists, communication generalists, etc.) bring to the success of a project and to a company in general?

A: Some examples of the degrees that members of my team hold include Industrial-Organizational Psychology, Interpersonal/Organizational Communication, Operations Research and Public Administration. This allows us to work on a broad spectrum of projects because our backgrounds and experiences are so diverse. There is usually someone on the team who has experience with a similar project who can serve as a resource or mentor.

Q: What kinds of problems are you solving using data analytics? How is this different from the issues you would address in the role of a more traditional actuary?

A: The issues I addressed in a more traditional role were all related to insurance, but my analyses are now focused on people. Some of the problems we are working on include assessments for our hiring process, predicting employee turnover, social network analysis and effectiveness of training courses. We have implemented assessments to use during the hiring process to give managers more information about potential candidates. We recently worked on a social network analysis to understand the communication patterns among employees and how they relate to important employee outcomes. This gives us a better idea of how and how often different teams work together, which will hopefully guide a greater understanding of team engagement and productivity.

Q: What is the most challenging aspect of your work?

A: Workforce analytics is fairly new to my company. It can be difficult to make complex analyses a priority for our

team when there are still many valid requests for metrics and reports. While we have unlimited ideas for analytics, we have a limited amount of time. This challenges our team to prioritize analysis projects.

Q: What professions did you consider before deciding on becoming an actuary?

A: I considered becoming a teacher because I enjoy helping people learn new things and explaining things in various ways so people can better understand them. This is a very valuable skill for an actuary because a lot of the work we do in a traditional or nontraditional role is complex, yet it often needs to be explained to a nontechnical audience.

Q: What skills positioned you for work in predictive analytics?

A: Communication is one of the most important skills in this role. I'm required to explain difficult topics to others, so I need to read the room and know when people don't understand me.

Q: What has been the most exciting project you have worked on during your career and why?

A: One of the most exciting projects I worked on in this role was an analysis of our current leadership. Our leaders took a few assessments, including a 360 performance review, which has ratings from supervisors, peers and direct reports. I combined the results and analyzed them to determine what traits leaders have across various divisions. My analysis is now used to guide future training of our leadership. Furthermore, divisions are now aware of skills missing on their current teams. They can either look for these skills in future hires or offer additional training opportunities for current employees.

Q: Where do you see the role of predictive analytics in the next five to 10 years? Where will actuaries fit into the equation?

A: I think every company will be using predictive analytics in the next five to 10 years to guide nearly every decision. Using insurance as an example, I see predictive analytics guiding which claims to settle and which should go to court; to identify customer or employee fraud; or to decide what areas to audit or what investments to make.



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Predictive analytics can also help decide the best locations for new buildings; where and how to market to customers; and how often to send communication and on what topics. Actuaries need to develop and expand their predictive analytics abilities and make an effort to understand the business. I envision actuaries doing the basic predictive modeling, with data scientists and statisticians handling the very complex models while hopefully utilizing actuaries to assist in cross communication with the business.

Q: What advice do you have for people who may be interested in positions in predictive analytics?

A: Learn how to use a statistical software system now. Once you understand one, it won't be difficult to learn another. It doesn't really matter which one, but R or Python are great because they're free and open-source programs with extremely helpful communities.

Q: How do you measure success?

A: I know that I'm being successful in my job when new committees and/or projects request me as a resource. I strive to be the best at what I do, and I feel successful when others want my input on decisions.

Q: What is something our readers may not know about predictive analytics, such as possible opportunities for actuaries in this arena?

A: If you took your exams a long time ago, there is a lot of material to review and a lot of new content to learn. Every area is moving toward predictive analytics, so it's important to develop this skill. I hope you will consider working in an HR analytics role. It's a perfect fit for an actuary. If more of us are working in the field, more doors will open for others. ■

RICH RESOURCES

Looking to be a leader in your workplace or in your profession? Here are some resources that can help you in that quest.

ONLINE

SELF-ASSESSMENT: DESIGN YOUR FUTURE

The Society of Actuaries (SOA) Competency Framework presents the general knowledge, skills and behaviors that SOA members have identified as necessary for actuaries' success as individuals and as members of teams and organizations. Read about the self-assessment tool and design your future now.

bit.ly/SOA-Self-Assess

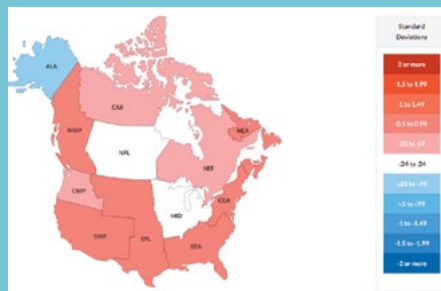


INDEX

THE ACTUARIES CLIMATE INDEX

The Actuaries Climate Index (ACI) is an educational tool designed to help inform actuaries, public policymakers and the general public about climate trends and some of the potential effects of a changing climate on the United States and Canada. The index is an objective measure of observed changes in extreme weather and sea levels, and it is intended to be a useful monitoring tool of climate trends.

ActuariesClimateIndex.org



ONLINE

REGULATORY RESOURCE

This information hub advances actuarial knowledge by providing links to primary sources related to regulation.

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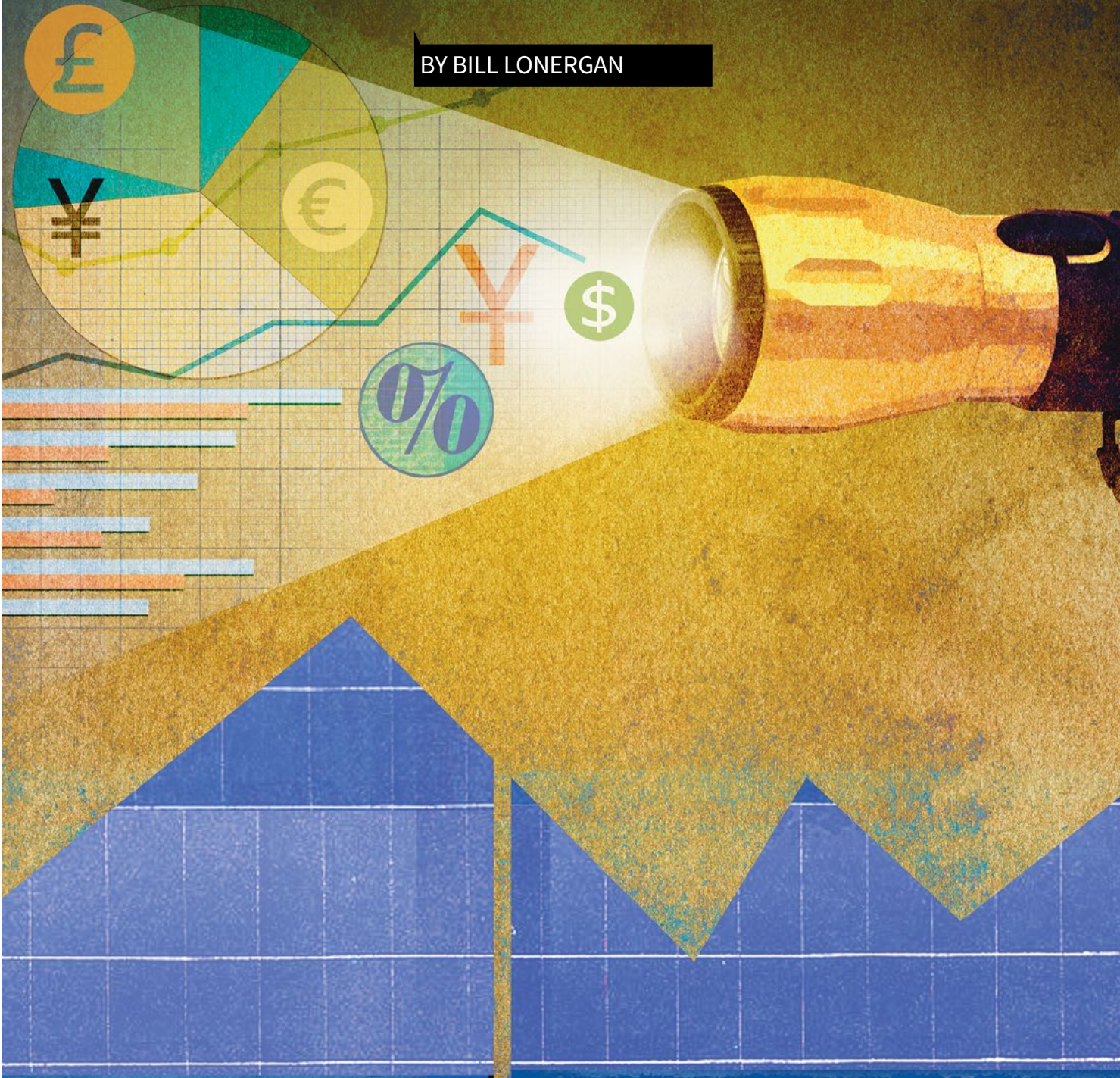
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BRING TO LIGHT

SHARING THE RESULTS OF A FINANCIAL ECONOMICS CONCEPT MAP

BY BILL LONERGAN



“**T**o successfully integrate financial economics into actuarial practice, an actuary needs to know or be able to _____.”

How would you finish this sentence? How do you think other actuaries in the profession would? How should the Society of Actuaries (SOA)?

In order to develop a foundation of financial economics concepts that the SOA could provide to currently practicing actuaries, actuaries in a range of practice areas were asked to provide a comprehensive list of the “concepts,” if you will, or outcomes that complete the sentence fragment that began this article. The idea was to help set the direction for the SOA with respect to curriculum for candidates and professional development for current actuaries. A large number of thought leaders were invited to participate, and more than 50 individuals provided responses.

In brief, a large number of outcomes about financial economics were collected with the idea being to make sure that we are thinking about it as broadly as necessary. These concepts were then sorted by category and reviewed for duplication or gaps in order to come up with a set that represented the range of possible responses. Different ways of wording similar concepts were reviewed for clarity and completeness. The reviewed set was then ranked by relative importance, difficulty and the current state of performance for actuaries.

RESPONSE GROUPINGS

There are some who may feel that financial economics is only of particular interest to investments, but in truth, many of the concepts underlie all of the practice areas within the SOA. Because of this, actuaries from all areas of practice and with various levels of experience were invited to participate in order to obtain the broadest set of responses. Practice areas included risk management, retirement, investments, life, health, general insurance and accounting/finance.

The responses were sorted to identify similarities with other responses or outcomes, and then aggregated into broadly defined groups. The groups identified were Asset Pricing Models, Economic Scenario Modeling, Asset Pricing, Foundations of Portfolio Theory, Risk and Capital, Accounting and Modern Corporate Finance, Incentives and Behavior, Basics of Actuarial Practice and Applying Financial Economics. Here are brief descriptions of each, along with some selected responses to the key question in italics.

Asset Pricing Models: Includes option pricing models, as well as familiarity with historic distributions of returns for more traditional asset classes. *Understand Black-Scholes option pricing; understand the concepts of real-world and risk-neutral probabilities and scenarios, and when each should be used.*

Economic Scenario Modeling: Includes scenario generators, but also covariance of returns and stochastic volatility. *Evaluate models in terms of strengths and limitations; employ principal components analysis to reduce the dimensionality of a set of risk factors and explain important sources of variance.*

Asset Pricing: Includes the concepts of estimating values and/or pricing traditional fixed-income assets with a term structure and equities using beta along with hedging,



embedded options and option strategies. *Understand risk premiums, such as credit risk, equity risk premiums and term risk premiums; understand how a financial liability might be valued in terms of replicating financial instruments.*

Foundations of Portfolio Theory: Includes most concepts from Modern Portfolio Theory and the Capital Asset Pricing Model (CAPM), as well as Modigliani and Miller's Capital Structure theories. *Understand and use CAPM and factor models for equities; be familiar with alternative asset classes, such as real estate and commodities.*

Risk and Capital: Includes looking at risk from several viewpoints, including that of economic capital. *Estimate the cost of capital for a project using different methods; understand and explain the impact of liquidity on financial decision-making.*

Accounting and Modern Corporate Finance: Includes a range of accounting and finance topics. *Understand the financial accounting system currently in use; understand how differences in incentives among stakeholders can affect decisions regarding maximization of shareholder value.*

Incentives and Behavior: Includes behavioral finance theory and how actors in a financial and political system act and react. *Understand the types of cognitive bias; distinguish between principals and agents and understand why their incentives are not always aligned.*

Basics of Actuarial Practice: Includes how financial economics relates to more traditional actuarial areas. *Know how financial economics fits into the broader field of economics and political economy; apply advanced principles of financial economics to actuarial practice.*

Applying Financial Economics: Includes how we would apply the financial economic concepts identified in various settings and different economic environments. *Apply investment insights to asset-liability management; understand the role of financial economics in pricing.*

EVALUATING RESULTS

The particular grouping assigned is not of particular importance, as many of the groupings include concepts closely related to those in other groupings. They simply make it a bit easier to think in terms of a manageable set. Potential users of this work, such as SOA curriculum committees, would of course be more concerned with the specific outcomes rather than the groupings.

What about the importance rankings? While opinions may differ, an attempt was made to determine relative importance. For instance, which concepts are foundational and which, while important, are thought of as secondary or possibly supporting concepts? Current performance levels also were ranked, from Unable to Perform through Excellently Able to Perform. For example, the Basics of Actuarial Practice were generally ranked midway as to relative importance, but current performance ability was ranked much lower. The grouping Asset Pricing Models was ranked at about the same level as the Basics of Actuarial Practice for importance, but for current performance ability was ranked much higher. Of course, this would primarily indicate the level of performance of the particular respondents, not the SOA membership as a whole.

And it is true that the current level of performance was generally higher for the more advanced practitioners, while those at the more novice level acknowledged they had work to do in order to improve their skills.

Interestingly, Applying Financial Economics was the grouping where relative importance was much higher than current performance. Is there a need to help actuaries move financial economics from the world of theory or academic interest to the world of day-to-day business decisions, including portfolio management?

In addition, the curriculum level was requested. For example, is this an outcome to be expected of an ASA, an FSA in general, an FSA in a specific track or practice area, or rather something that would be generally helpful in professional development to practicing actuaries, whether in the SOA or any other organization?

When a similar exercise was done for predictive analytics, the steering group used the concept map to guide construction of the components being added to the ASA pathway in 2018, as well as the content of the pilot certificate program in predictive analytics being conducted this year. Similarly, we expect to use this financial economics concept map to continue and extend the improvements that have been made in both pre-qualification and continuing actuarial education. ■

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DEFINING AND UNDERSTANDING CLIMATE CHANGE FOR ACTUARIES

BY R. DALE HALL

With the year more than halfway over, I'm excited to mention the progress made with research on climate change and extreme weather. The Society of Actuaries (SOA), along with researchers, our volunteering membership and several actuarial organizations, continues to build upon this body of knowledge. It's important to continue providing these actuarial perspectives, especially as it pertains to insurance challenges and new ways to look at and resolve these issues.

I encourage you to read up on this topic. Check out the recent research sponsored by the Climate and

Environmental Sustainability Research Committee, one of the newest practice research committees of the SOA. The author, Mark E. Alberts, FSA, MAAA, explores climate and environmental sustainability research of interest to actuaries. As part of this project, he developed the Climate Sources for Actuaries Resource Index, a repository to inform future environmental research programs. In particular, this project provides indices for research reports, magazine articles and other reading materials, along with presentations and webpages of interest.

Additionally, we developed a report to help answer the questions surrounding data sets, analysis and discussion of

sources on climate change, environmental risks and severe weather. This report aims to expand the conversation about climate science and helps prepare us to understand what we as actuaries may be able to do to help. The researcher references 36 different sources on a variety of topics, from basic climate science and insurance regulations to public-private partnerships and climate risk management. As the researcher Robert J. Erhardt, Ph.D., A.C.A.S., notes, “One purpose of this report was to provide concise summaries of excellent sources that could be just the thing a company or risk manager needed to address a current business problem.”

I also want to share important updates on the Actuaries Climate Index. The organizations working on the index—including the SOA, the American Academy of Actuaries (the Academy), the Canadian Institute of Actuaries (CIA) and the Casualty Actuarial Society (CAS)—released the fall 2016 data, which was the highest seasonal level recorded data for the United States and Canada combined. This fall 2016 index data was 2.07, and the current five-year moving average is 1.07, the highest level recorded for that measure. The fall 2016 data reflects a continued pattern of increased frequency of extreme weather, with high temperatures being the most significant contributor to the increase.

Through the Actuaries Climate Index, we noted how elevated values in the temperature component are helping drive the index higher, particularly in the Northwest Pacific (British Columbia and Yukon Territory) and Southwest Pacific (Arizona, California, Colorado, New Mexico, Nevada and Utah) regions. These regions currently reflect their highest five-year average values, with both experiencing five seasons in the last five years with temperature component values of more than 3.00.

In addition, I want to share a brief update about the continued work from the SOA and the participating organizations as we continue to develop the Actuaries Climate

Risk Index. It will measure correlations among changes in the frequency of extreme events as measured by the index and economic losses, mortality and injuries. Stay tuned. ■

R. Dale Hall, FSA, CERA, MAAA, is managing director of Research at the Society of Actuaries.

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action

GOOD RESEARCH READS

VALUATION REPORTS AND TABLES

Access a variety of valuation materials for use by actuaries. There is a wide range of resources, including relative risk tools, tables and more.

bit.ly/Val-SOA

DISCOUNT RATE SENSITIVITIES IN PENSION PLANS

The SOA and the CIA developed a research report on the relationship between discount rates and pension liabilities. The report examines demographic characteristics of pension plans, and other factors, to establish simple rules for estimating liability over a wide range of discount rates. Canadian Pension Actuary Doug Chandler, FSA, FSIA, discusses the report *Discount Rate Sensitivities in Pension Plans* in his recent podcast. His research examines the means of assessing discount rate sensitivity.

Access the report and listen to the podcast.

bit.ly/Dis-Rate-Sens

RESEARCH FOCUSES ON PARAMETER UNCERTAINTY

Sponsored by the CAS, the CIA and the SOA Joint Risk Management Section and the Joint Risk Management Research Committee, this study examines and describes parameter uncertainty. The research provides structures to incorporate parameter uncertainty in quantifying risk and illustrates the application through case studies.

bit.ly/Par-Uncertain

RELATED LINKS

Research Emerging Topics

bit.ly/SOAClimateResearch

Climate, Weather and Environmental Sources for Actuaries

bit.ly/SOA-Enviroment

Actuaries Climate Index

ActuariesClimateIndex.org

Climate Sources for Actuaries

bit.ly/ClimateSource

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MEETINGS

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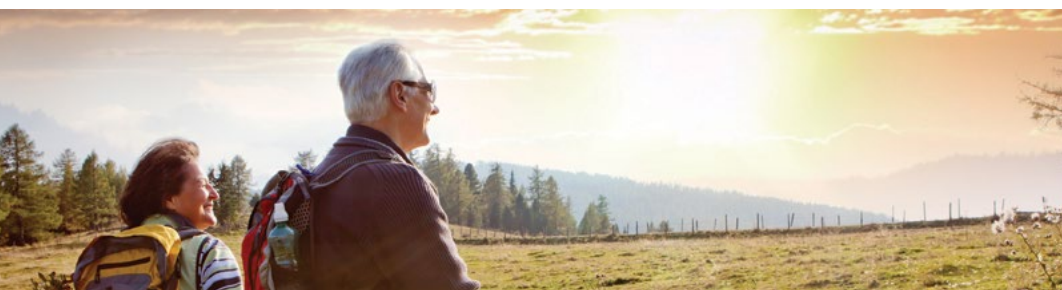
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livingto100.soa.org

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