ACTUARIES ARE PAYING ATTENTION TO CLIMATE DATA

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Imagine it is July in a city in the upper Midwestern United States. Usually it is hot and muggy in the summer, with bugs flying and the lush greenery steaming. But this week the temperatures have soared far above the usual high 80s, and the nights bring no relief. Day after day triple-digit heat leaves most everyone limp and tired. But for some people, the heat is more than just a tiresome nuisance; it is life threatening. The city has a large low-income elderly population, with a large percentage suffering from chronic obstructive pulmonary disease, diabetes, congestive heart failure, and kidney disease. Their old houses and apartments do not have functioning air-conditioning and they are reluctant to go outside or to ask for help. The heat wave is life threatening for them and they have few resources and amenities to cope with the heat stress. The hospitals that serve them are stretched to capacity normally; now the emergency rooms need to turn away ambulances and there are no more vacant beds for patients in extremis. The euphemism for the result is “increased morbidity and mortality due to heat-related causes.” The blunt statement is that the heat is making people very sick or even killing them. This is of course, not a far-fetched scenario, since we have read the news stories including from Chicago, Paris, and Sydney. Nor are scenarios featuring floods in the Southeast or tornados in Oklahoma or drought-exacerbated fire in the West. These events are all driven by climate, and in a world where the climate is changing, so is the risk of any of these scenarios occurring. In this article I provide an overview of how and why actuaries assess various risks, and the role a changing climate can have in those calculations. For climate scientists, I hope this provides insight into how event attribution research can be relevant to actuaries. In addition, for other actuaries I hope this article will contribute to

an awareness as to why considering climate change, and research such as extreme event attribution, is important for our profession to effectively finance future risk.

WHY IS IT IMPORTANT FOR ACTUARIES TO BE AWARE OF RISKS ASSOCIATED WITH CLIMATE CHANGE IN THEIR PROFESSIONAL CAPACITY?

For years actuaries have used the motto “risk is opportunity” to describe the ways that their analytic techniques offer our clients and employer’s ways to offset, hedge, or exploit risk to their advantage. But not all risk is good, especially when the risk contemplated involves financial or personal harm to a large portion of our population, risk that can only be mitigated and not avoided. Insurance helps all of us face and finance this risk.

The actuarial profession is more diverse than most people realize and nearly all actuaries pick a specialty and confine their practice to areas in which they have specific experience. There are many kinds of actuaries and each looks at different types of risk, and at risk across different time scales. For example, some look at property and casualty risk, such as crop insurance or flood insurance. Most people are familiar with this through auto or homeowner’s insurance policies. These policies often look in the short term for issues that have more frequency, but the cost of each event can vary from small to large. Actuaries who work in life insurance, disability, or casualty insurance study a singular or rare life-changing event. The cost of each event is more certain and here the probability of the event is low, so the timing of the event is important. Another kind of actuary works with health insurance, which combines a bit of both short-term and long-term risk, with very large variations in the size of each individual health claim, from a \$2.00 antibiotic prescription to the expense of life-saving multiple organ transplants. Many people will have at least one prescription over a year, while very few will need a new heart and lungs simultaneously. Other actuaries look at the risk associated with financial instruments.

Insurance is a promise that a premium paid today will cover some or all the expense of an unfortuitous

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event happening tomorrow. This means there needs to be enough financial resources available to pay for the event when the event happens, even if the event is far into the future or a rare catastrophic event. Actuaries calculate these premiums. In general, actuaries look backward to think forward, by using historical experience to predict future events. What if the past does not prepare us for a future event? What if the pattern and severity of the variability of these events is changing so much faster than before, so fast that the past, instead of being a guide, will seriously underestimate the future?

To put things in context, here are some basics. There are three components of risk for insured events: the probability the event will occur, the timing of the event, and the distribution of the severity of the expense of the event. When actuaries price for the risk, they take all these things into account. If there is a low likelihood of loss and a predictable outcome, then it is easy to manage the risk. For instance, you do not expect your toaster to stop functioning and the replacement cost is easy to estimate. But other risks are harder to predict and the outcomes much more uncertain. A tornado tearing through a small town leaving devastation in its path is an example of an event that is much less likely to predict with certainty, and the severe consequences are suffered by many residents and business. A consistent feature of actuarial work is the idea that there needs to be a large enough population or group of events to make a consistent and accurate prediction. The impact to the overall financial risk of any component needs to be large enough to make a difference to the total predicted financial picture. Nearly all actuarial work includes a provision for exceptional experience, sometimes using an explicit margin, or in surplus capital, which functions like a rainy-day fund.

Nearly every kind of actuary will have some part of their analysis impacted by climate change and so they are asking the question: What does the future look like for the financial risks associated with climate change and are they different than the experience in the near past? Some climate risk will be absorbed into the actuarial models organically. If the change is gradual, the models will also change gradually and reflect the increased general risk of, for example, higher overall temperatures and drought. However not all change will be as predictable.

An actuary may be pricing with an assumption, based on historical analysis, that 100-yr floods are a rarity, and that only a few houses in a neighborhood will be affected. But what if 100-yr floods are now 20-yr floods or 5-yr floods, and those floods are larger and more damaging than before? And places

that did not flood in years past now begin to flood. Or what if the sea level rises so that flood damage due to tidal shifts can happen even without a severe storm (Jacobs et al. 2018; Sweet et al. 2018)? The U.S. National Climate Assessment has documented some of these changes in precipitation that are already being experienced (Walsh et al. 2014).

An actuary may be examining the risk of interruption of normal business operations. The list of risks sounds like a biblical litany of the apocalypse; fire, flood, pestilence, infrastructure collapse. These losses may be severe, if regional, and the impact may go on for a long time. Storm losses due to hurricanes can take decades to repair, so if big regional storms are larger and more frequent, this is of great concern.

The concept of additional risks from hurricanes, flood, fire and drought to physical structures, crops, infrastructure, or ongoing business may be something we can all imagine, but climate variation does not just bring changes that impact our belongings, dwellings, and infrastructure. It also damages the health and well-being of the population. The author is a health actuary, which means most of the risk models she works with focus on the short term for annual rating. Misunderstanding the role of climate change in any rating cycle may not have implications that reach out for decades, but on the other hand, the size of the health delivery system means that even very small deviations from estimations of future costs have considerable financial consequences. Consider the example in Table S1 that is a generalized financial model that considers an event, such as the Paradise fire, that increases both the cost of care for a person with a chronic disease as well as the prevalence/severity of the chronic disease in a 1-yr period.

For a state with a million Medicaid members this sort of change in average costs and disease severity, something that is conceivable as climate extremes become more frequent, could result in budget shortfalls of hundreds of millions of dollars. For Medicare coverage the risk is even more severe due to the prevalence in the beneficiary population of chronic diseases that are negatively impacted by high temperatures or severe events.

This change in variability comes at the same time as other rapid developments in potential financial chaos, such as global pandemic, the sudden emergence of drug-resistant organisms, or the emergence of expensive therapies. Estimating future costs, even for something as short term as health insurance, is complicated by the variability of climate change, and the financial implications have the potential to be staggering.

TABLE S1. Estimates of annual costs for care: A straw model.

	Total members	Members with complex disease (10% of the population)	All other members
Members	75,000	7,500	67,500
Average monthly cost per member	\$600	\$2,450	\$394
Total annual cost	\$540,000,000	\$220,500,000	\$319,500,000
Suppose the cost of care for the complex 10% is 1% higher than expected			
	Total members	Members with complex disease (10% of the population)	All other members
Members	75,000	7,500	67,500
Average monthly cost per member	\$602	\$2,475	\$394
Total annual cost	\$542,205,000	\$222,705,000	\$319,500,000
Excess annual cost	\$2,205,000		
Suppose further that the percent of the population identified as complex chronic grows by 5%			
	Total members	Members with complex disease (10% of the population)	All other members
Members	75,000	7,875	67,125
Average monthly cost per member	\$613	\$2,475	\$394
Total annual cost	\$551,565,250	\$233,840,250	\$317,725,000
Excess annual cost	\$11,565,250		
	13		
If it were a million people this would translate into			
	\$154,203,333		

HOW IS THE ACTUARIAL PROFESSION RESPONDING?

The actuarial profession is responding to the challenges presented by climate change or, if you must, increased climate variability. The profession may not publish articles or studies in academic journals as much as it folds changes into models to reflect the increased risk to clients and employers based on historical studies. The profession is conservative and carefully studies credible and demonstrated experience before making changes to their models. The studies and changes are unfolding both locally and privately, for specific needs and for the profession as a whole. The effort may be as local as an actuary with a regional-based plan with a specific issue and as broad as international work groups looking at global effects. The Resources and Environment Working Group of the International Actuarial Association has been working to connect actuaries from across the globe working on actuarial aspects of climate change. We are seeing articles appear in actuarial journals that are starting to raise awareness among actuaries (e.g., Hall 2017; Stryker 2018). The Society of Actuaries has also established

a Climate Index Working Group that produced a technical report entitled “Determining the impact of climate change on insurance risk and the global community Phase 1: Key Climate Indicators.”¹

Most of the actuarial profession is privately employed and so much of the body of work is not published, but rather used internally on behalf of clients and employers. Academic actuarial research is very much focused on the development of advanced predictive statistical models; many actuaries are focused on the examination and understanding of the vast amounts of proprietary data used to develop pricing, reserving, trend, and capital models for their insured populations. Actuaries convene for conferences and webinars to discuss observations and changes in practice patterns, but collaboration is often difficult because of the nature of our employment. However, there are concerted efforts across the profession to start integrating the best available climate science into risk assessments. In particular,

¹ www.soa.org/research-reports/2012/research-2012-climate-change-reports/

attribution of specific losses to particular events could be more impactful with access to broader studies over larger populations within a particular type of event such as heat waves or forest fire.

Another example of how the profession is making progress in integrating climate change information is in North America, where the four major actuarial organizations have joined forces to create and maintain the Actuaries Climate Index (ACI; <http://actuariesclimateindex.org/home/>). The climate index was officially launched 30 November 2016, although it was several years in development. The ACI uses six components to create a summary index to measure the relative change in climate measures over history. The components are the frequency of temperatures above the 90th percentile, the frequency of temperatures below the 10th percentile, the maximum rainfall per month of five consecutive days, annual maximum consecutive dry days, the frequency of wind speed above the 90th percentile, and sea level change.

Furthermore, all four organizations—the Canadian Institute of Actuaries, the American Academy of Actuaries, the Casualty Actuarial Society, and the Society of Actuaries—have active committees sponsoring studies, articles, and talks about the role of a changing climate in the actuarial practices to manage financial risk. All of these organizations have devoted sections of their websites to document and discuss what actuaries think about when they are modeling for the variations in weather events including focusing on likelihood of an event, when the event might happen, and the severity of an event, all in the context of financial implications. There are regular presentations to the profession at meetings and in webinars, especially about the ACI.

The profession is beginning to absorb the financial impact of changes in the extent and severity of climate changes as exhibited in losses due to weather extremes and the body of actuarial work on climate is growing rapidly. While some may remain skeptical, losses and statistics will make even the cautious actuary think twice.

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