Climate Change and the Life Insurance Industry

Sam Gutterman, FSA, CERA, FCAS, MAAA, FCA

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Introduction

Our climate has a wide range of effects on the risks undertaken by a life insurance company involving both its investments and its insurance operations. Internal management and its regulators are increasingly focused on the extent of potential risks associated with changes in the climate and their impacts on premium levels, financial results and reporting, and its financial soundness, as well as the value offered by and ability to fulfill promises made to their customers.

The first thing most actuaries think of when considering the impact of climate change on a life insurer is its effects on investments.[1] However, increasing attention is being drawn to its impact on the mortality and morbidity risks undertaken by insurers, as indicated in International Actuarial Association (2017)[2] and Gutterman (2023).[3] This article addresses these latter risks, focusing on their impact on high-income countries, especially the United States and Canada.

This article's objective is to provide a practical framework that may enable an actuary to analyze the relationship between climate-related risks and mortality, which may be particularly useful to life, health, and pension actuaries whose work involves the projection of mortality.

Climate-related risks include both immediate and consequential losses and damage associated with hazards driven by one or more climatic factors, including temperature, precipitation, humidity, air pressure, and wind. They include weather-related events, which tend to cover a short-term period and can affect the health and mortality of life insureds and annuitants. Likewise, adverse trends in the broader category of climate and environmental conditions can also wreak havoc on people's lives. All these risks can affect property and businesses, as well as their life and health. They have grown more severe as anthropomorphic causes have exacerbated the severity and, in some cases, the frequency of climatic events and conditions.

These can affect the expectations and volatility of mortality risks that affect the bases of prices, reserves, economic capital, and enterprise risk management (ERM) of life insurers. Actuaries need to consider adapting their underlying assumptions and methods utilized within their processes to assess these risks.

The Impact of Climate Change on Life Insurance and Annuities

Climate change, the long-term change in global climatic factors and weather patterns, is increasingly affecting the business of providing life insurance. This change encompasses global warming and related weather and environmental hazards, such as rising sea levels, shrinking mountain glaciers and ice melt, warming and toxic oceans and atmosphere, and the increasing spread of infectious diseases. This article does not distinguish between man-made or naturally occurring climate change. Instead, it focuses on the current and future adverse consequences of climate and environmental risks, regardless of cause. Although these issues are global in nature, this article focuses on their implications for the human health and life of insureds and annuitants in North America and actuaries who practice in this space.

Significant changes in climatic conditions can result in changes in both the frequency and severity of certain natural hazards and extreme events. These perils, especially when compounding or cascading,[*] encompass a range of events and conditions that can adversely affect human health and life. Although these changes have been the subject of scientific discussion for over half a century, the adverse effects on human health and life have sometimes seemed inconsequential compared to other health-related risks. In fact, some actuaries believe climate change might improve overall mortality in some geographic regions because winter deaths could decrease more than summer deaths increase. However, this assertion will be challenged later in this article.

First, it is important to recognize that reliable and relevant data in this area are limited, mainly because of attribution issues and the relatively significant number of deaths that arise indirectly from or with a lag between exposure from a climatic hazard and death. For example, when a hurricane (tropical cyclone) hits or a heat wave strikes, the media focuses on the number of deaths reported by hospitals as being directly due to the extreme event. However, there may be even more deaths that occur that are reported as being due to another cause or on a lagged basis, such as cardiovascular or pulmonary disease or another pre-existing condition. The number of deaths whose primary cause is a climate-related hazard thus typically understates the true number of consequential deaths.

Despite the warranted attention given to mortality risk due to changes in the climate, some of the deaths of the most vulnerable discussed here may occur shortly thereafter in any case. It can also be difficult to distinguish between mortality due to the weather, climate, climate change, and other environmental factors such as air pollution. Thus, although the focus here is the growing effect of climatic change, it is also useful at the same time to study the overall mortality impacts of the environment on mortality risk.

Assessing the mortality risk of those vulnerable to these hazards is particularly important. This vulnerability can arise when a person whose health is sensitive to the effects of one or more climate-related hazards is exposed to these hazards. As illustrated in Figure 1, mortality risk arises from the intersection of these two factors: exposure and sensitivity. For example, people are especially vulnerable to mortality risk if they live in an area in which a lengthy heat wave occurs, and they are individuals who are of advanced age with pre-existing heart disease without working air conditioning.

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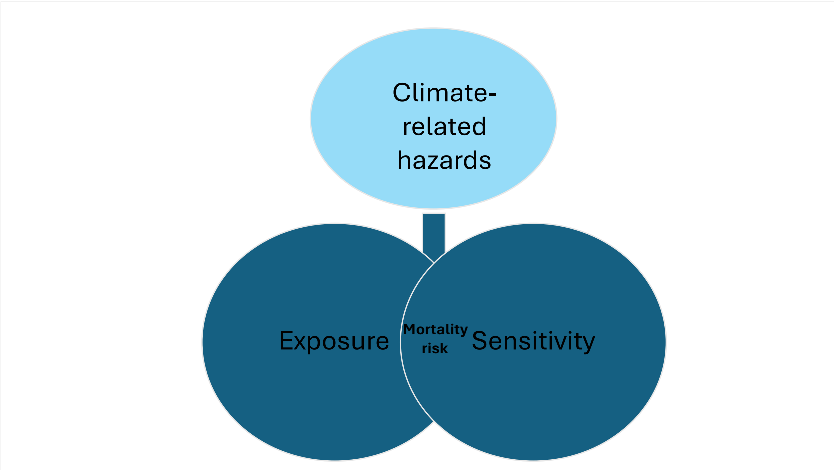
[*] These factors often involve two or more extreme events occurring simultaneously or successively, combinations of extreme events with underlying conditions that amplify the impact of the events, or combinations of events that are not themselves extreme but lead to an extreme event or impact when combined.

Figure 1
MORTALITY RISK



A population segment's exposure and sensitivities to a climate-related hazard differ, sometimes dramatically, because of the segment's risk profile determined by its (socioeconomic and demographic) risk characteristics, location, extent of adaptation, and severity/volatility/timing of the hazard. This sensitivity can also differ by climate hazard. For example, a person's sensitivity (and exposure) can differ from excessive heat and flood risk. In addition, the timing of the risk or assessment can also be a significant factor. Each of these is discussed below.

- Risk characteristics. Risk characteristics that are more sensitive to adverse effects of climate risk include people's physical condition and environment. These characteristics can include age, healthiness, disability, and socioeconomic status. For several types of hazards, such as temperature extremes or adverse air quality, the elderly and young children tend to be most at risk. For others, the extent of mortality risk depends on the existence or extent of one or more comorbidities such as asthma, cardiovascular or pulmonary disease, or willingness or ability to avoid extreme heat or other climatic events or conditions due to such factors as lack of affordability of air conditioning or inability to avoid working outside.

- Location, even within a state or city, can significantly affect the extent of exposure to the consequences of climate risks. Avoiding high-risk areas represents one approach to reducing mortality risk. For example, moving away from flood zones or areas especially prone to excessive heat, hurricanes, wildfires, or protracted droughts may reduce overall risk. However, due to a lack of affordability, these areas may be all the household can afford; nevertheless, this may prove short-sighted. For instance, in one part of a state, there may have been a severe drought for years, creating extremely dry conditions, while on the other side of a mountain range under adverse wind conditions, there can be flooding or extreme wind. Risk assessment and regional planning may prove beneficial.

  In some cases, people are moving toward this risk. For example, many high-income people are moving to the ocean's edge or next to a wildland-urban interface area. Not only can this result in property loss, but in extreme cases, it can also result in loss of life, independent of socioeconomic status.

  An example of extreme differences due to location can be illustrated by the case of diarrheal disease, which can represent a catastrophic mortality condition for children in a tropical area in Asia in contrast to the United States where there are fewer than 1,000 annual deaths from this disease. In some cases, an adverse weather event or condition may arise due to pure luck. Nevertheless, although some believe climate-related risks primarily affect low-income countries, the overall mortality risks remain for all of us.

- **Extent of adaptation**. A household, community, or region can build resilience against climate-related mortality risk over time or prepare itself for a potentially adverse event or condition. For example, an effective and timely early warning system can reduce exposure to a quickly moving hazardous situation or reduce the risk of simply heeding a warning for evacuation or staying indoors. In addition, some population segments or areas may incur fewer additional deaths because the population has become used to the hazard; for instance, more additional deaths tend to occur in more temperate regions, such as Canada, for the same temperature in Florida where the population is more acclimatized to that temperature.

  An effective and tested emergency-response system can reduce excess deaths. A quality and accessible healthcare infrastructure and resources can reduce health and mortality risks during or immediately after a climate-related hazard event. For example, unavailable emergency transportation or lack of a nearby healthcare facility or staff in rural areas can increase the time until emergency services can be accessed. One approach to assess this risk is to assign a low, moderate, or high degree of adaptation categorization to a particular location or population segment and plan accordingly.

  As important as adaptation can be to reducing the impact on mortality from a climate-related event or condition, effective mitigation of greenhouse gas emissions may be viewed as being even more critical, that is, to reduce the build-up of atmospheric or ocean temperatures. An insurance company can contribute to this mitigation through its own (and its employees') carbon or methane footprint or by encouraging its insureds to reduce their footprints and their exposure to health harm.

- **Severity and timing of the hazard**. Of course, a Class 4 hurricane or a month of 110°F days will likely result in more severe health consequences than a Class 1 hurricane or an extremely hot weekend, respectively, and the flood risk in an area that has previously suffered from sea level rise can be more dangerous than one that has implemented shore protection against a storm or sea surge.

Analysis of the Effect of Climate Change on Mortality

The following four-step process can be used to develop estimates of the impact of climate risk on expected mortality experience.

1. **Climate projections.** Almost all climate risk projections are based on one or more emission scenarios, representing a key driver of climate change. Since many greenhouse gases remain in the atmosphere and oceans for a long time, historical emissions will affect climate for many decades, if not centuries. In addition, the future emission trajectory will also have a lasting impact.

   Most actuaries will not develop their own climate projections. Instead, several publicly available climate projection scenarios can be identified and selected for sensitivity testing. These can help guide actuaries to specify a likely range of conditions, enabling the development of best-estimate and extreme-risk scenarios.

   One set of commonly used climate scenarios has been developed by the Intergovernmental Panel on Climate Change (IPCC), each of which reflects a different set of scenario-specific factors, including population growth, mean and extreme temperatures, precipitation, wind speeds, and sea level rise. They developed four primary Representative Concentration Pathways (RCPs), RCP8.5, 6.0, 4.5, and 2.6, corresponding to 3.4°C, 2.8°C, 2.4°C, and 2.0°C above preindustrial global temperature levels. Their naming is based on the radiative forcings measured in terms of W/m^2 (watts per square meter). The sixth assessment in this IPCC series[4] describes five Shared Socioeconomic Pathways (SSPs) that are intended to capture global and local effects, incorporating factors including population, economic growth, education, urbanization, and the rate of technological development. These were designed to illustrate possible global trajectories and how alternative levels of climate change mitigation could be achieved when the mitigation targets of the RCPs are combined with the SSPs (1-2.6).

2. **Relation between climate outcomes and mortality risks.** Many studies[5] have explored the relationship between climate outcomes (e.g., heat waves), mortality, and health. The mortality risk associated with all relevant hazards can be derived by assessing the mortality impact from each applicable climate-related hazard. This step aims to identify sources that can be used to quantify this relationship in a way that supports actuarial risk analyses. These studies have often decomposed their aggregate findings by projection year, geographic region or area, extent of adaptation, and age group.

3. **Mortality risks applicable to a particular population**. In many cases, because of location or other risk characteristics, the mortality risks from overall population mortality may not apply to the specific population being assessed. Such adjustments may reflect its risk characteristics, location, and expected level of adaptation practiced. It can be easy to shrug one's shoulders and claim that, compared to other mortality uncertainties, the additional mortality due to the mortality risks discussed here is marginal, at best. However, this may only be true if an insurer's life insurance or annuity portfolio is highly selective, young, has low concentration risk, and is expected to primarily cover a relatively short future period. If, for example, a set of successful agents sold many large life insurance policies to those in the Pacific Palisades in California before its 2025 wildfires or if the insurer's book of business consists primarily of older individuals with a higher-than-expected vulnerable population with relevant pre-existing conditions, additional mortality may be experienced.

4. **Mortality assumption/projection for a particular application**. The selection of an assumption for a mortality projection may depend on the application. The degree of prudence in the assumption or scenario selection may depend on whether the projection is, for example, for a life insurance or annuity portfolio (holding similar size groups of life insurance and payout annuity policies whose insureds have a similar risk profile can act as a perfect mortality risk hedge); however, deviations from such a hedge, for example, with a very different age profile or location, may lead to material mortality risk. In many cases, the adjustment would be made to the rate of mortality improvement rather than the mortality rate itself.

   For internal planning purposes, a range of scenarios may be selected to demonstrate the range of likely outcomes. Alternative assumptions could encompass multiple climate hazard possibilities and/or alternative assumptions regarding the sensitivity of mortality to the future estimated climate scenario over the period projected. However, pricing may demand a best estimate reflecting market conditions, with the liability for a portfolio incorporating a risk adjustment that reflects the inforce population under a somewhat conservative scenario to be used for valuation under International Financial Reporting Standards (a larger mortality improvement for life insurance and a smaller mortality improvement for annuities), with a more extreme scenario for sensitivity testing, ORSA reporting, or economic capital assessment.

Although the first and possibly the second steps may be common to all mortality risk analyses, the third and fourth steps will be particular to the assessed risk portfolio and application. In any case, conducting an in-depth evaluation of each major climate hazard to which the portfolio appears particularly vulnerable may be appropriate.

The Effect of Climate Change on Mortality

Before developing mortality scenarios, a separate analysis of the specific hazards to which the population is expected to be exposed should be assessed. Table 1 provides examples of the connection between key climate-related hazards and health-related diseases or outcomes that can arise due to adverse climatic factors and hazards. Multiple climatic factors, illustrated in the leftmost column, often contribute to a higher likelihood and severity of direct or indirect hazards through intermediate hazards. These, in turn, result in an increased incidence of immediate or delayed increases in adverse health conditions that can lead to increased mortality.

Several of the indicated health conditions can be particularly life-threatening when a disease or adverse health condition already exists. For example, if a person already has an adverse cardiovascular or pulmonary condition, a climate hazard will more likely contribute to premature deaths. Thus, climate risks accelerate deaths that would otherwise have occurred later.

Table 1

EXAMPLES OF CLIMATIC FACTORS, RESULTING HAZARDS, AND RESULTANT ADVERSE HEALTH

Climatic factors – one or a combination	Hazard	Examples of intermediate hazards	Adverse health condition
Temperature – heat High humidity	Excessive heat	Vector[†] spread Uninhabitable outdoors	Heat stroke Heart attack Cardiovascular
Temperature - heat Dryness - extreme Heavy wind High air pressure	Wildfire	Fire	Injury/suffocation
		Smoke – air quality/pollution	Cardiovascular Pulmonary Cancer
		Flood (post-wildfire)	Drowning/injury
Temperature – heat Precipitation - heavy	Vectors, such as mosquitoes	Vector spread	Vector-spread infectious disease Zoonotic transfer[‡]
Precipitation - heavy Water temperature – high Deglaciation	Inland/river flood		Injury/drowning Water and food-borne diseases
Precipitation - heavy Ocean temperature – high Sea level rise Wind High air pressure	Tropical cyclone Coastal flood Storm surge Land/mudslides Land subsidence	Food insecurity Loss of land and homelessness	Injury/drowning Mal/undernutrition Water and food-borne diseases
Temperature – high Precipitation - limited	Drought Reduced agricultural output	Food/water insecurity	Famine Mal/undernutrition

Several observations regarding the relationship between climate change and mortality risks follow.

- Time lags. The time between exposure to a climate-related event or condition can differ widely. For example, deaths due to injury or drowning are often immediate, while deaths that are partly due to cardiovascular or pulmonary disease can take a long period to happen. Many studies have not adequately included premature deaths that do not occur shortly after exposure.

- Excessive warming. Mortality due to excessive heat has been addressed in numerous studies. These deaths are highly likely to increase over time as temperatures continue to rise. However, some studies have also observed that cold-related deaths are similarly expected to decrease. Because in most areas the number of winter deaths is greater than summer deaths, it is easy to conclude that global warming may reduce the total number of deaths in generally cooler areas with a large number of cold-weather deaths.[§]

  For example, one study[6] projected that, with no further adaptation to excessive heat, the increase in heat-related deaths in Europe between 2015 and 2099 will consistently exceed the corresponding decrease in

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† Vectors include insects such as mosquitoes and ticks.

‡ Zoonotic transfers are transference of a pathogen, such as a virus or bacteria, from an animal to a human.

§ For example, through effectively communicated heat advisories, affordable air conditioning, or public cooling facilities.

cold-related deaths across all considered scenarios. However, its projections showed large regional differences indicating a slight net reduction in death rates in Northern European countries with high vulnerability to those in the Mediterranean and Eastern Europe areas.

However, a wide range of estimates have been made. In fact, cold-related direct mortality rates more than doubled in the United States between 1999 and 2022,[7] mainly in the last five years of this period, suggesting that the mortality savings from fewer cold-related deaths may not be as significant as overall season patterns suggest. It has been asserted[8] that there is no longer a strong association between the extent of cold temperatures and excess winter deaths because of housing and health care improvements, higher incomes, and increased awareness of cold-weather risks.

Another study[9] found that older adults in the United States living in areas prone to extreme heat (90ºF and above for 140 days or more a year) showed accelerated aging at a molecular level compared with those in areas less prone to extreme heat. According to the study's authors, this suggests that rising temperatures from climate change could chemically modify people's DNA, and age these people up to 14 months faster than those in an area with fewer than ten extreme heat days a year. This is driven by elevating stress and anxiety due to frequent sleep disruptions and physical discomfort and reducing physical activity levels, which tends to accelerate mortality. Interestingly, this study did not provide strong evidence for heightened vulnerability for those in lower sociodemographic groups measured by wealth.

- Other hazards. Unlike deaths due to extreme heat, there is no corresponding offset when assessing other climate-related hazards; that is, no other factors provide beneficial effects from climate change. As indicated in Table 1, other causes of death include increased cardiovascular and pulmonary deaths due to poorer air quality due to wildfires, increased infectious disease deaths, and increased cancer deaths. It may also exacerbate the mortality risk associated with those with pre-existing conditions for which climate-related factors will contribute to earlier premature deaths. Thus, even in areas with a larger decrease in cold-related deaths than increases in heat-related deaths, overall deaths due to climate risk may increase.
- Infectious diseases. Because of warming, the geographic reach of certain infectious diseases, including Lyme disease, West Nile virus, and Valley fever, has been extended and thus are affecting more people. For example, climate change is making it easier for infectious diseases to spread in the United States by vectors such as mosquitoes. Even Dengue fever has recently been found in the southern United States.
- Population aging. The population of most high-income countries is experiencing an aging of its population. If actuarial modeling is conducted in an aggregate rather than age-specific manner, the effect of population aging should be reflected, particularly if the climate-risk-related hazard studied is significantly age-related.
- Incremental effects. As in any mortality study, it is important to determine the base period from which mortality experience is gathered and a set of improvement factors is applied. To the extent that the base period contains climate-related mortality, the additional mortality included in the projected period should not double-count the base period's mortality. Consideration should also be given to the lumpiness of climate events, that is, occur in the same or immediately subsequent period of a climate event, and it is likely that climate-related deaths are underreported or not identified at all.

The type of application will determine the scenario(s) studied. For example, if the results are to be used in a stress test, a relatively conservative climate scenario and mortality sensitivity scenario may be appropriate. A weighted stochastically developed assumption may be appropriate for pricing purposes. Alternatively, if a risk margin/adjustment is included, a moderately adverse scenario might be selected.

Caution is needed in interpreting the results of any mortality risk assessment associated with climate change, particularly regarding the projection period. For instance, additional mortality due to climate change may increase over time since climate-related risks are expected to increase over time.

Summary

Climate change affects both a life insurer's investments and mortality experience. This article focused on the latter as it affects life insurance and annuity portfolios. Understanding the potential range of impacts and supplementing current modeling practices through a four-step process described in this article can help actuaries develop a range of possible scenarios that, in turn, can lead to more informed mortality assumptions and forecasts. The extent of these effects will depend on the exposure and sensitivity of each insurance portfolio's geographical and other risk characteristics. Actuaries can enhance their analysis by assessing climate-related hazards and their expected consequences on applicable causes of death. It also must be recognized that mortality data attributed to climate and environmental risks tend to underestimate the number of these deaths.

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Society of Actuaries Research Institute
8770 W Bryn Mawr Ave, Suite 1000
Chicago, IL 60631
www.SOA.org