An Introduction to Climate Change for Health Actuaries

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Although health actuaries work for a variety of employers, in this article the focus will be on health actuaries who work directly or indirectly for health plan sponsors, such as Medicare, Medicaid, employee benefit plans, provider groups, and insurance companies. Similarly, although health actuaries have a wide range of skill sets and responsibilities, the focus will be on projecting future health care costs, network analysis, care management program development, and various forms of risk analysis, including enterprise risk management. Each of these skill sets requires an understanding of the healthcare infrastructure including the legal environment, the underlying disease burden, and the delivery of healthcare.

As the impact of climate change becomes more apparent, health actuaries have an opportunity to provide actuarial services to other potential employers, such as state governments, municipalities, or communities attempting to adapt and mitigate climate change risks and outcomes. Health actuaries already have the basic quantitative skills to provide these services, but in order to provide them, they would have to learn more about the impact of climate change on the underlying infrastructure, like the budgeting process to maintain the infrastructure and the importance of building codes. This article will touch on these topics as well.

Background

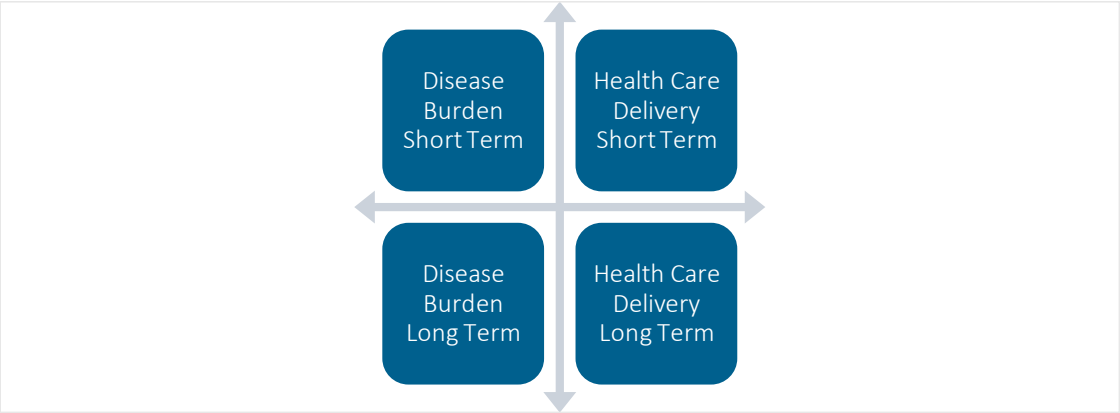
Although it may seem counterintuitive, initial health care spend tends to decrease somewhat whenever there is a major event like a hurricane.[1] Of course, there tends to be a slight increase in emergency care at that time, but those costs are usually offset by people forgoing needed care for both chronic diseases and preventive services during the event and immediately after. This may create the illusion that climate change is not important for those health plan sponsors. After all, health insurance is a short-term coverage product: Benefits are reviewed, premiums are set, and budgets determined on an annual basis.

The problem is, climate change has a major but slow-moving, cumulative detrimental impact on the health of individuals, especially those with chronic diseases like asthma, heart disease, and cancer. Currently, healthcare expense accounts for 18% of the GDP in the United States compared to 11% in comparable countries. Of that 18%, 90% is attributable to individuals with one or more chronic diseases. This means that in the long term climate change may well have a considerable impact on the affordability of healthcare and the economy in general. It may be in the best interests of health plan sponsors to get ahead of the curve by anticipating changes needed in care management programs for vulnerable members and network development. Similarly, communities may be well-served by implementing adaptation and mitigation programs needed to meet the needs of their constituents.

The Qualitative Analysis

As mentioned in the introductory article, the primary purpose of a qualitative analysis is to identify the risk and opportunities produced by climate change as that applies to the problem at hand. One common technique used in healthcare is to establish causal pathways. Causal pathways establish the link between a given risk, like a wildfire, to outcomes like property damage and negative health implications. Figure 1 illustrates one way to frame those risks and outcomes.

Figure 1
HEALTHCARE RISK AND OUTCOMES FRAMEWORK



THE DISEASE BURDEN

Many catastrophic events, especially wildfires, have a major impact on air quality. This results in many acute cases of asthma and wheezing. Over time, this results in an increase and prevalence of chronic diseases like asthma and chronic obstructive pulmonary disease (COPD) due to reduced lung function. Poor air quality also has a major impact on other diseases, including cardiovascular disease.[2] According to one study, 2.8% of all heart attacks can be attributed to a combination of hot weather and poor air quality in the form of fine particulate pollution.[3] Surprisingly, there is also a link between breast cancer and poor air quality.[4] Another area of concern is the long-term impact on mental health conditions as a result of direct and indirect exposure to climate events.[5]

The harm from climate change is more pervasive than that caused by major events. For example, crop damage may result from a number of slow-moving climate-related risks including drought, frosts, low temperatures, and even ocean acidification.[6] As shown in Figure 2, crop damage has a down-stream impact on health, especially for vulnerable populations.

Figure 2
IMPACT OF CROP DAMAGE ON HEALTHCARE

An emerging climate change risk is the expansion of vector-borne diseases, like Lyme disease and West Nile disease, as well as the migration north of tropical diseases such as dengue fever, zika, and malaria. These diseases are caused by pathogens carried by insects like fleas, ticks, and mosquitos which are even now thriving in areas of increased temperatures and humidity. Globally, vector-borne diseases account for 17% of all infectious diseases. Warm waters also foster waterborne diseases such as vibrio or E.coli as well as fungal diseases such as valley fever.[7]

THE DELIVERY OF HEALTHCARE

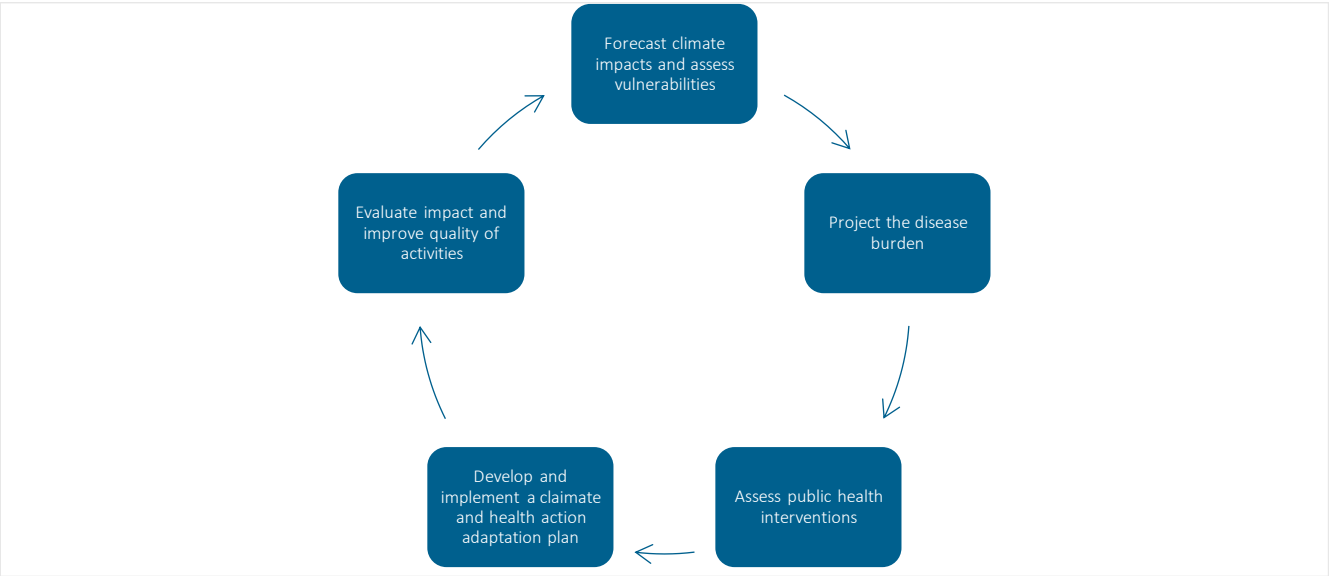
A major event always puts a strain on the delivery of health care. Emergency departments may be overcrowded or ambulances are in short supply. Nursing homes may have to find temporary residences for their patients, etc. Temporary, modular hospitals can ease some of the supply shock in the short term, but there is also a long-term risk that includes both a physical risk and a transition risk. The physical risk comes from the fact that hospitals, nursing homes, and doctor's offices may be destroyed or damaged by floods, hurricanes, and other events or that supporting infrastructure such as roads or electrical systems are not functional. Climate events can be especially impactful in areas with existing healthcare delivery system supply strains, such as rural or other underserved areas. KFF, formerly known as the Kaiser Family Foundation, reported that nearly half the municipalities in the USA have only one or two hospitals or health systems providing care rendering them vulnerable to loss of acute care if the sole hospital is damaged. There is also a significant risk caused by migration as people move from one area to the next in hopes of finding better living conditions. This was certainly the case after Hurricane Katrina in 2005 when over a million people left their homes in the aftermath of the hurricane. The loss of health workers—including those doing support roles—can hinder the return to full operating capacity. It is important to remember that the health system extends to more types of care than just clinics and hospitals. Care homes, home health workers, dialysis centers, pharmacies, and medical supply stores are also affected when a major climate event occurs.

Relocation of populations to adjacent localities can cause a resource strain in the new areas. A widely cited statistic is that there is a 38-day wait time to get an appointment in the U.S. (45 in one municipality), but rural areas are often more stretched.[8] The influx of new patients stretches already burdened locations.

RISK AND MITIGATION

In the U.S., the Centers for Disease Control and Prevention (CDC) has launched the Building Resilience Against Climate Effects (BRACE) program.[9] This program includes a 5-step framework for local communities to facilitate their efforts in preparing for climate change and some grants for use in implementing those changes as illustrated in Figure 3. The BRACE framework is a variation of an actuarial control cycle. One example of a BRACE success[10] is the Wisconsin Flood Resilience Scorecard (FRS), which reflects the social, institutional, and environmental factors creating a risk in a specific community, which allows decision-makers to make more informed decisions. Other success stories include developing emergency action plans, early warning systems, and even the "Be a Buddy" system in New York City to organize efforts to check up on residents who are older or disabled. In addition to BRACE, the World Health Organization has issued guidance for climate-resilient and environmentally sustainable health care facilities.[11]

Figure 3
THE BRACE FRAMEWORK



RISK AND OPPORTUNITIES FOR HEATH INSURERS

In many respects health insurance is like any other insurance: if a covered member incurs a covered claim, the claim is reimbursed. Unlike other forms of insurance, however, health insurers cannot underwrite the risk upfront. If a member in the U.S. meets the eligibility requirements, then they are covered under the plan with the same financial parameters regardless of their past or present medical conditions.

Risk, however, can be managed on the back end, using two primary mechanisms. The first mechanism is developing an optimal suite of care management programs. As the name implies, a care management program is designed to provide support to a member during their care journey. A care management program may be as simple as sending a postcard to a woman reminding her to take her mammogram or as complex as providing post-discharge counseling to a patient discharged from a hospital or nursing home. As the impact of climate change on personal health accumulates over time, the optimal suite now may not be the optimal suite in a few years.

The second element is developing and retaining adequate, cost-effective provider networks. A provider network is simply a group of providers, like doctors, hospitals, and therapists, who have signed a contract with a health plan to provide services to the insurer's members under agreed upon terms. The terms typically include both financial and quality considerations. In return, members are better off financially if they use a network provider compared to a non-network provider. These days, this is no easy task. About 30% of the U.S. population lives in a primary care professional shortage area, while nearly half of the counties have no cardiologist. This means that health insurers are going to have to be more creative in finding ways to meet the needs of their members, especially in high-risk climate areas and existing shortage areas.

The Quantitative Analysis

Using the risk framework shown in Figure 1, it may be helpful to think about the quantitative analysis in terms of short-term and long-term tasks. The specifics of the analytics are similar, but not identical for health plan sponsors and communities. Also, the terms "short-term" and "long-term" may have slightly different meanings when it comes to health versus other practice areas. The short-term impact is primarily just forecasting costs in the upcoming year

whereas long-term generally refers to the time it takes to implement an adaptation or mitigation initiative, which is usually two to five years.

SHORT-TERM ANALYTICS

For health plan sponsors, short-term analytics generally means projecting next year's budget and/or premiums or estimating claims liability for financial reports. An actuary may need to think if a climate event has disrupted claims utilization/payment patterns to an extent that there needs to be an adjustment in cash reserves for current claim obligations. For pricing applications, in its simplest form, that means applying a trend factor to the current year's cost per member per month (PMPM). The trend factor consists of core elements, like unit cost inflation or utilization increases, that happen every year and can usually be predicted using past patterns and non-core elements, like the impact of new legislation, new treatment methods, or climate change driven events, which are one-offs and must be calculated based on the circumstances at hand. One climate event related item that requires attention is trend bounce-back. As noted earlier, whenever there is a major event much of the typical healthcare use tends to be suppressed for a short period of time. If this care is deferred care, then it will likely "bounce back" to previous levels in the next year. An upwards adjustment needs to be made to account for that and depending on the nature of the deferred care, there may need to be an adjustment to reflect increased severity.

Community planners follow a similar pattern in trying to determine the budget for the upcoming year. Although there will likely be a need for an adjustment, in all likelihood fewer resources will be needed in the upcoming year.

LONG-TERM ANALYTICS

In most cases, the first step in an analysis is to identify the at-risk population applicable to your portfolio. In the United States, one way to start that analysis is to look at the Federal Emergency Management Agency's (FEMA) National Risk Index (NRI).[12] This database provides data and ranks risk at the community level based on 18 perils. While the NRI is a valuable starting point, it does not identify other types of vulnerabilities like food insecurity. The data in the NRI can be linked with proprietary, private, and federal government data sources to provide a more complete picture of the population at risk.[13] For more information about publicly available data sources and how to use them appropriately read "How Does Where You Live Impact Your Health?"[14] and/or "Social, Physical, and Cultural Determinants of Health: Their Incorporation into Actuarial Data and Workstreams."[15]

Another important question to consider is "What is the real cost of climate change considering both the short-term and long-term consequences?" We know that chronic diseases, like cancer, kidney disease, and heart disease, are major drivers of mortality, and we know climate change has an adverse effect on those diseases. For actuaries this begs the question, "How should I reflect this in my projections?" A similar question is "How will adaptation and mitigation measures impact my projections?" These questions can be answered using either a "bottom up" or a "top-down" approach. A top-down approach usually involves either AI or regression analysis. Under a "bottom up" approach, each situation is evaluated separately and then aggregated in the end. Some bottom up techniques include:

- *Before and after.* As the name implies, a before and after approach simply compares a key measure before an event and after an event. For example, one way to determine the impact of a hurricane on mortality rates would be to measure the excess deaths for a period following a hurricane compared to a base rate. From an actuarial perspective, there are two key considerations in using this method. The first consideration is determining the optimal period for the measurement. If the period is too long or too short, then there is a risk of understating the impact. The second consideration is determining if other factors may have an impact on the results. If this is an issue, then it may be useful to apply a regression analysis technique or some type of machine learning to make sure the comparison is on an "apples to apples" basis.

- *Cohort Comparison.* A cohort comparison is similar to a before and after approach, with a key difference being that two similar but different cohorts are being compared. This approach is especially useful in determining the impact of a mitigation or adaption effort. For example, one way to measure the impact of a strategy on mortality rates is to compare mortality rates for two regions with similar risk profiles, where one area has adopted the strategy and the other has not. Of course, this method only works if the profiles are really similar. This may require machine learning techniques like cluster analysis.
- *Risk Adjustment.* Risk adjustment, a technique commonly used in healthcare, is designed to compare costs on an "all other things being equal" basis by applying pre-determined risk factors to every member of a population. The advantages of this method are that it is already a widely accepted method in the healthcare community and it is relatively easy to perform the calculations. The disadvantage is the risk factors may not be relevant to the specific purpose of the analysis, nor reflect the specific risks due to climate events.

Once the risk factor has been identified, the next step is to project the results over time. For health insurance, this centers on projecting the trend for the next year. The trend calculation includes core factors, like inflation, and other factors like the expected impact of trend on the results. Longer term projections require some type of scenario analysis that reflects the expected impact of climate change and other relevant factors, like inflation. Techniques for scenario analysis include ad hoc techniques, economic scenario generators, and Bayesian techniques. As the understanding of climate impacts on human health become better understood, these methods will need to absorb this new information about vulnerable populations and regions.

Global Implications

In this paper the authors focused on the U.S. to illustrate key points about the effect of climate change on healthcare. That said, the essential challenges and solutions noted here apply to other countries to a greater or lesser degree depending on the country.

As noted above, the basic health issues associated with climate change are the same throughout the globe. That said, the degree to which an issue, such as droughts, varies considerably from region to region. Similarly, the ability of a region to adapt and/or mitigate varies by region. Although the key principles described above apply to any region, the specifics vary considerably. In dealing with other regions, one thing to keep in mind is that many areas outside the U.S. are at greater risk. Approximately 45%[16] of the world's population live in high-risk climate areas compared to 30% in the U.S. Globally, there are a plethora of studies being conducted to understand the implications of climate events and climate change on human health. It is useful for actuaries to examine studies from other countries to help identify what types of health impacts are associated with different types of climate events. The World Health Organization (WHO), as well as many nation-based organizations have extensive materials available for anyone who is trying to quantify the health costs of climate events. For example, the Australian government has the National Health and Climate Strategy Systematic Mapping Review of Australian Research on Climate Change and Health Interventions.

Another key consideration is data. Not every country or region has its own data sources, so there will always be some effort required to make the best use of the available data. Similarly, meaningful comparisons between countries can also be a challenge. Organizations that tend to be useful for this purpose include WHO, OECD, the Commonwealth Fund, the Kaiser Family Foundation (KFF), and the health system tracker.

One final thought. In other countries, medical underwriting may be allowed, thus providing an additional risk management option.

Keeping Current

The nature of healthcare delivery and healthcare insurance is changing rapidly. Actuaries who are interested in this topic may find themselves swamped with research papers and published studies in peer-reviewed journals, as well as a growing body of work from actuarial firms, the federal government, and think-tanks, not to ignore the volume of reports in the quality press. As a result, the SOA Research Institute (Institute) is constantly publishing research reports and articles on climate change and healthcare that seek to place an actuarial lens on the emerging science and filter out the best materials to help actuaries decide how, to what extent, and when to incorporate climate considerations into their work. Resources for healthcare actuaries include Institute publications such as Healthwatch and Institute research sponsored by the Health Care Cost Trends (HCCT) Steering Committee.

References

[1] Health and Hurricanes, Studying Disparate Health Impact of Extreme Climate Events, 2017-2020
[2] Air Quality and Health | Johns Hopkins Medicine
[3]Extreme Temperature Events, Fine Particulate Matter, and Myocardial Infarction Mortality | Circulation
[4] Link found between air pollution and increased breast cancer risk
[5] https://www.commonwealthfund.org/publications/explainer/2023/mar/how-climate-change-affects-mental-health
[6] Environmental Risk in Crop Insurance
[7] Vector-borne diseases
[8] In the U.S., wait times to see a doctor can be agonizingly long | Association of Health Care Journalists
[9] About Building Resilience Against Climate Effects (BRACE) Framework | Climate and Health | CDC
[10] Success Stories | Climate and Health | CDC
[11] World Health Organization, WHO Guidance for Climate-Resilient and Environmentally Sustainable Health Care Facilities, 9789240012226-eng.pdf
[12] Learn More | National Risk Index
[13] How Does Where You Live Impact Your Health?
[14] How Does Where You Live Impact Your Health? | SOA
[15]Social, Physical and Cultural Determinants of Health: Their Incorporation into Actuarial Data and Workstreams | SOA
[16] Climate change

Infectious disease
https://health.ucdavis.edu/news/headlines/experts-warn-climate-change-will-fuel-spread-of-infectious-diseases-/2024/03

Infrastructure
https://www.kff.org/health-costs/press-release/nearly-half-of-metro-areas-have-only-one-or-two-hospitals-or-health-systems-providing-inpatient-care/

Wait Times
New survey: Physician appointment wait times getting longer - Washington State Hospital Association

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