From 9/11 to COVID-19: The Unthinkables, Call for Essays
Mortality: Well-behaved, chaotic or unpredictable?

Catastrophe and Climate

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December 2021

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Mortality: Well-behaved, chaotic or unpredictable?

There are many references to ‘unknown knowns’, ‘unknown unknowns’, and ‘known unknowns’ risks. In reality, the boundary or uniqueness among these types of risk can be unclear. The same risk can take on wildly different characteristics and dimensions (for example, a black swan in Australia is common and it is no surprise that a virus causes a pandemic, although its timing and severity can be). Some drivers of risk come at us from left-field, that is, were not thought about of before; but these are rare – and will continue to be rare. In most cases, the general areas of risks are known, although their specifics may not be.

So, if I am not a wild advocate of the Rumsfeld allocation of risks, what is better? I often opt for the classic actuarial split – focusing instead on the quantification and modeling of risks:

- Process risk. Purely statistical or random.
- Parameter risk. One or more model parameters for which the precise likelihood, severity, or timing are uncertain.
- Model risk. Uncertainty regarding whether the right variables have been identified, how they interact, and the structure of the model itself. This can include chaotic elements or variables, which can be incorporated as a residual unexplained or unexplainable component.

The example that I will use in this short essay is the seemingly mundane actuarial risk of mortality. Nothing is more certain than death itself, but its timing, drivers, and circumstances are far less certain, especially on a personal level. This uncertainty can apply to a population segment or to an entire population. Although the law of large numbers can reduce the level of uncertainty, uncertainty remains.

Several decades ago, mortality rates seemed well-behaved and could be reduced to and were reproducible by one or at most a few formulas or statistical distributions. Mortality improvement seemed predictable, although often containing a random element or error term. Even when a change emerged, many actuaries felt that the mortality level or rate of improvement could be depended upon to return to pattern after a while.

Is this still the case? I don’t think so – around 2010 mortality improvement slowed down around the world and in a couple of recent years in the United States it deteriorated, while during the COVID-19 period the rates for all adult ages took a nosedive. Were these twists and turns predictable? Certainly, many predicted that a pandemic was inevitable, although few got its severity or timing right. Even looking backward, some of the drivers of recent mortality patterns are difficult to discern. How can the risks that face societies’ health be predicted?

In general, I look at mortality patterns in terms of:

- Level. The level of expected mortality can be specific to a population segment or an individual, affected by a myriad of factors, which might be discernable given the proper data. A permanent shift in level can occur, possibly because of a medical breakthrough, a pandemic’s endemic period, or a permanent change in culture, behavior, or law.
- Trend. Actuaries have often assumed a relatively small annual mortality improvement (often between 0.5% and 2.0%), based on the improvement of mortality over the last several centuries. This is quite a long track record, but why should it increase at about the same pace, given what may be drastically different conditions. Remember, some actuaries have been thought of as only looking backwards to project forward. In some cases, especially evident in the slowdown in improvement over the last decade (mostly, but not exclusively due to cardiovascular mortality), following this approach may produce biased results.
- Spike. Several types of spikes, that is, temporary discontinuities, can occur. Although a sharp, even catastrophic spike (i.e., one-time change) can emerge over a brief period such as a day, month, or year (e.g., as a result of a terrorist attack or a short-lived epidemic), other spikes can become endemic or hang around for a long time. For instance, the AIDS pandemic with long-term adverse consequences is still with

us after fifty years. The actuary should recognize both its initial shock period, as well as its plateau or decline.

- Cycle. It can be easy to conclude that what comes up will inevitably come down. But unfortunately, this may not always happen. In some cases, the driver of the cycle may be difficult to discern, or society can periodically loosen its mitigation focus to enable conditions to worsen multiple times. For example, there remains limited understanding of the mortality cycle of those in their nineties over the last several decades evident in heat maps.
- Chaotic (including random) elements. Often these consist of unrecognized, offsetting, or minor causes. They have often been grouped together as the residual or unexplained portion of changes.

Multiple processes may be involved, either favorable or adverse. Cause-and-effect (direct consequence), association (indirect or uncertain relationships), confounding (feedback loop), and cascading (accumulative set of risks) can be involved in the possibility of risk, uncertainty, or catastrophe. Time lags between the driver onset and outcome, such as in the case of smoking or obesity, can be decades long, resulting in unexpected adverse premature mortality results, making analysis challenging. Their lack of identification can contribute to terrible results. Even the identification of their underlying drivers can take a long time, e.g., the adverse effect of air pollution, climate change, smoking, and weight gain from excessive intake of high fructose sugar drinks.

Although many factors can drive changes in mortality, their mix in a specific population segment can be in constant flux, including changes in human behavior or external factors such as advancement in medical treatment, law or regulation, terrorist attacks or infectious diseases. A better understanding of these drivers, their ultimate consequences, and possible mitigation actions will enable more rapid anticipation and more effective management of their consequences.

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