RMS

# Infectious Disease Modeling: The Science of Pandemic Assessment

RMS insights

In today's interconnected world, with the ease of global travel driving greater opportunities for exposure to infectious diseases, the risk of pandemic has never been higher. In fact, a recent study found insurance executives believe the most important extreme risk facing the industry today is pandemics[1]. The Ebola epidemic in West Africa, alongside outbreaks of SARS and avian and swine influenza, underscores the fact that infectious diseases come in many varieties. Preparedness and responsiveness are critical in determining their outcome.

In spite of these facts, pandemic risk is commonly assessed today by using data from a single event that occurred a century ago—the 1918 Spanish Flu. While there is no doubt as to the severity of this event—considered the deadliest pandemic in modern history, in which an estimated 50 million worldwide died—reproducing this single scenario in today's environment raises questions for today's insurers and reinsurers with life exposure, such as:

- **What is the relationship between age and mortality in a pandemic?**
- **Could a vaccine be discovered, tested, produced and delivered quickly enough to have a meaningful impact on the disease?**
- **How would we have fared in a repeat of the 1918 event if we could have treated secondary infections with antibiotics?**
- **What might the global economic impact be from a pandemic other than flu?**
- **Would a healthy underwritten portfolio have a better chance of survival in a pandemic?**

## Capturing the full scope of pandemic risk

Using mortality from a single historical scenario makes it impossible to adequately address such critical questions, and avoiding them may result in required capital being far from the optimal level. To better answer these questions and more accurately assess pandemic risk, RMS has developed probabilistic infectious disease modeling built on two critical factors: modeling that correctly reflects the science of infectious disease, and a software platform that allows firms to address questions using their exposure and experience data.

RMS' predictive infectious disease modeling takes into account the many careful considerations (age profile, portfolio experience data, vaccines, pharmaceuticals) that are required of an accurate pandemic model.

[1] Poll of 30,000 industry executives by Towers Watson in December, 2013

The RMS Infectious Disease Model is built using fundamental principles of epidemiology to develop an event set containing 4,536 pandemics to capture the full scope of viral characteristics and potential interventions.

Historical events provide useful insight into what mortality shocks are possible, but overreliance on one or even a few events introduces a heavy bias into these analyses, as many judgment calls must be made by individuals with limited expertise in the spread of disease. RMS has combed through historical records and used every recorded pandemic of the past three centuries to inform our pandemic model. Epidemiological modeling enabled us to embed this collective knowledge into the RMS Infectious Disease Model. Here is what we discovered:

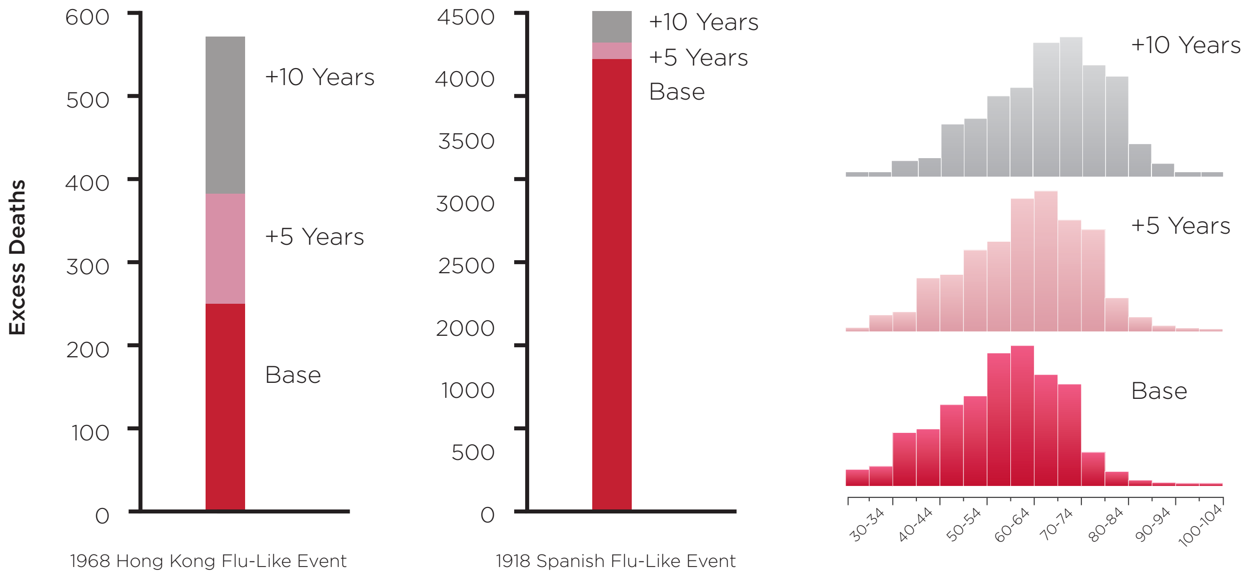
## 1. Age Matters

Insured portfolios have very different age profiles to the general population—begging the question: how does the age profile of an exposed population impact pandemic risk?

We know that certain infectious diseases are more dangerous for specific age groups, such as the heavy mortality suffered by the 65+ populations during the 1968 Hong Kong Flu. The impact of this is demonstrated in Exhibit 1, where the excess loss doubles as the age profile is shifted up by ten years. Contrast this with the 1918 pandemic, where the heavy death toll on the working-age population meant shifting the age profile had a far smaller impact.

Other diseases, such as Ebola, can be equally deadly to all ages. The age impact of an event is, to a large degree, dependent on virulence. In different parts of the severity distribution, people at different ages will be vulnerable. As the graph below demonstrates, taking age-mortality into account has a large impact on risk estimates.

Exhibit 1: Age Mortality by Pandemic, 1968 v. 1918




*Many commonly used scenarios in the industry today show wide variation in sensitivity to the age profile of the insured population. Source: RMS Infectious Disease Model, 2015*

## 2. Your Underwriting Matters

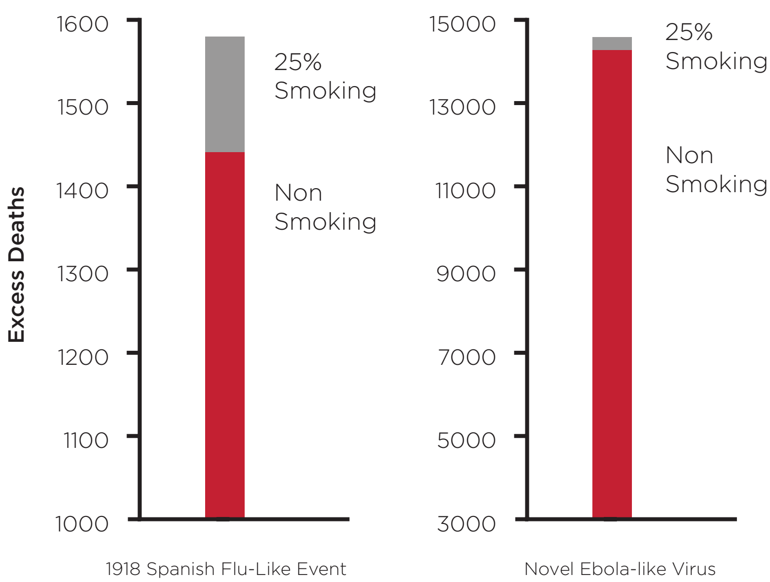
The discrepancy between the health of an insured population and the general population is an institutionalized observation, and the mortality table associated with a specific portfolio provides critical insight into this difference. Generally, sick people are more likely to suffer complications when infected by a pandemic disease. This can be captured at the portfolio level using mortality experience: a healthier population with lighter mortality will typically have lighter mortality during a pandemic.

A further consideration is pandemic severity; differences in starting health status become less significant for more deadly pandemics. In the extreme case of viruses that kill many people they infect, such as Ebola and H5N1, the relative health between the insured and general population has a lesser impact. RMS has accounted for these effects in our model.

## Relative Health Has Meaningful Impact on Losses

Even when comparing two insured populations, the relative health of the group in question will have a meaningful impact. This is demonstrated in Exhibit 2, where the two exposures differ only in their smoking rates – a non-smoking population versus a population with 25% moderate smokers. In the case of a 1918 Spanish Flu type of event, the exposure with 25% smokers suffers 9.5% more excess deaths. If we instead consider a novel Ebola-like virus with airborne transmission, the losses proceed irrespective of the population's starting health status.

Exhibit 2: Smoking vs. Non-Smoking Mortality Rates




*The health of the underlying portfolio is a non-trivial consideration that varies by virus type. Source: RMS Infectious Disease Model, 2015*

## 3. Vaccines Matter

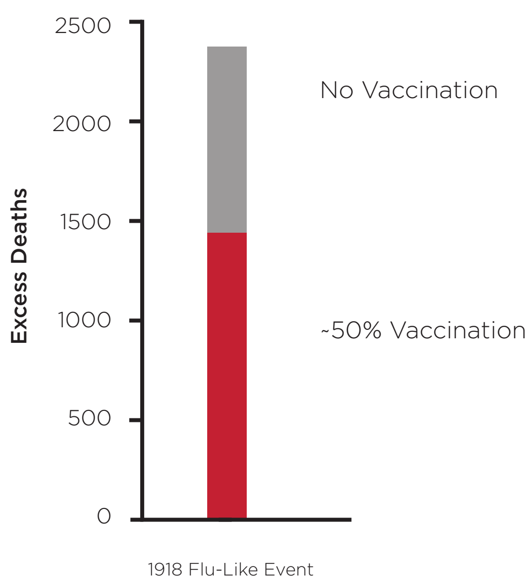
Vaccines have saved more lives than any other pharmaceutical in history and are among the primary tools for mitigating the impact of a pandemic, particularly in the case of influenza, which has the greatest frequency of pandemic outbreak. Some pandemic risk models make the simplifying assumption that during a pandemic there will be insufficient time to produce a vaccine, but two observations undermine this assumption:

1. Deaths during a pandemic often come in waves that can be separated by weeks or even months

2. Surveillance has made it possible to develop influenza vaccines in the early stages of a potential pandemic, an observation supported by experience in the 2009 H1N1 pandemic

RMS has incorporated a range of factors that influence the overall efficacy of vaccines and models a spectrum of vaccine scenarios. In Exhibit 3, we address the limitations of making this simplifying assumption and compare the resulting losses of a 1918-like event with and without vaccination.

Exhibit 3: Losses Of 1918-Like Event With and Without Vaccination




*Vaccines can have an enormous impact on the death toll of a pandemic. Source: RMS Infectious Disease Model, 2015*

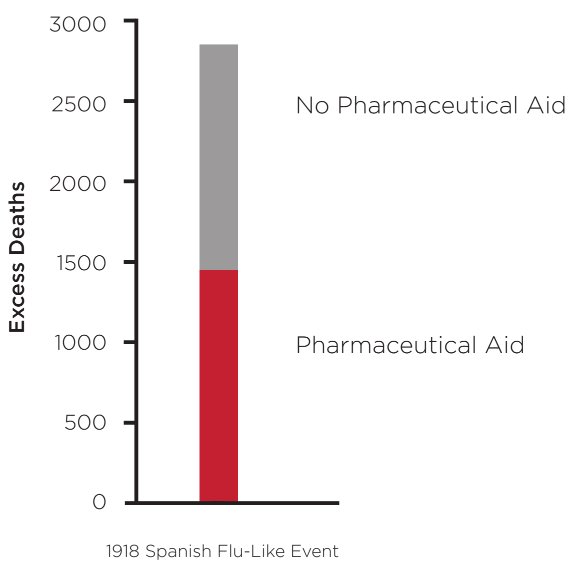
Incorporating modeled distributions of the potential timeliness and effectiveness of vaccine production is central to understanding the uncertainty associated with pandemics, and that uncertainty is part of the risk associated with pandemics to insurers.

## 4. Pharmaceuticals Matter

Going beyond vaccines, other pharmaceuticals are often a highly effective intervention available during a pandemic. This is particularly true when the pandemic virus is not the primary cause of death, but merely leaves infected individuals with weakened immune systems. In such cases, secondary bacterial infections drive the loss of life, and antibiotics provide a powerful means to intervene.

RMS models multiple 1918 Spanish Flu-like scenarios and accounts for cases where the primary cause of death can be the virus or secondary infection. When antibiotics are an effective treatment, the death count can be cut in half, as demonstrated in Exhibit 4. The RMS Infectious Disease Model accounts for both the impact and the likelihood of this scenario among many others to build out the full spectrum of possible pandemic losses.

Exhibit 4: Mortality With and Without Pharmaceutical Aid




*When applicable, pharmaceutical interventions have an enormous impact on the severity of a pandemic. Source: RMS Infectious Disease Model, 2015*

## 5. The Risk to Your Portfolio

An outbreak of a virus similar to Spanish Flu would look different today. Many believe it would cause fewer deaths per head of population. On the basis of epidemiological modeling of the dynamics of infectious diseases and the way they are influenced by interventions, we agree.

This does not mean that your portfolio would fare better than the death rate seen in 1918. Indeed, it may do better if base mortality and age distribution are conducive to that, or it may do worse. Using a more realistic model of infectious disease pandemics – one that captures likely frequency and specific severity to your portfolio – makes it possible to make informed decisions about mortality shock risk.

## 6. The Risk to Your Enterprise

While it is true that many catastrophes have little impact on the global economy as a whole, this is most likely not the case for infectious disease events. Even relatively small or localized infectious events can have major economic repercussions, causing losses to an insurer's assets at precisely the time they are needed most.

Network models of economic interconnectedness can be used to assess the impact of an extraneous shock to the global economy. RMS has analyzed these effects and, in a moderately severe pandemic, we have found that a life or health insurer's losses to assets may be even greater than the losses incurred as a result of insurance policy payouts.

## Conclusion

RMS agrees with the poll of insurance executives: we can ill afford to fail to take seriously the risk of infectious disease pandemics. Every time the world experiences a new disease outbreak, we learn more about infectious disease in today's population and more about our preparedness to respond to that disease. The global population is much healthier now than it was in 1918. The habits, behavior and movement of that population has also changed, and medical technology, pharmaceuticals and interventions are all different too.

RMS has monitored the way these features played out during recent events, such as with the Ebola outbreak, and have encoded that knowledge with mathematical models of the biology of infectious diseases to produce a realistic pandemic model. RMS probabilistic infectious disease modeling takes into account the many careful considerations (age profile, portfolio experience data, vaccines, pharmaceuticals) that are required of an accurate pandemic model.

To learn more about RMS Life Risk modeling scenarios, in particular scenarios of excess mortality, visit us at
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