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AIRCURRENTS: MODELING A MODERN-DAY SPANISH FLU PANDEMIC

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EDITOR'S NOTE: *The 1918 influenza pandemic killed tens of millions of people around the world, making it one of the deadliest infectious disease outbreaks in modern history. In this article, Nita Madhav, a Principal Analyst in AIR's Research and Modeling Group, characterizes the historic 1918 pandemic and estimates the effects of a similar pandemic occurring today using the AIR Pandemic Flu Model (scheduled for release in Summer 2013).*

THE ARTICLE: Explores the effects of a modern-day influenza pandemic caused by a virus identical to the 1918 "Spanish flu" pathogen, and estimates the mortality rates and life insurance losses this event would inflict.

HIGHLIGHTS: The AIR Pandemic Flu Model reveals that the "Spanish flu" pandemic would have a much less dramatic impact today (in terms of mortality rates) than the actual Spanish flu pandemic did in 1918. However, the 1918 pandemic does not represent a worst-case scenario for pandemic losses.

The 1918 "Spanish flu" pandemic was one of the greatest public health catastrophes of the past century. Although the start location is unknown, the first known cases appeared in Fort Riley, Kansas in February of 1918. By the end of the pandemic, millions of people worldwide had been killed. Global estimates of deaths range from 20 million to more than 100 million, at a time when the global population was approximately 1.8 billion.

In the United States, the 1918 pandemic caused life insurance losses of nearly USD 100 million (The Insurance Press, 1919), which corresponds to USD 19.9 billion today.[1] In fact, during the seven-month height of the pandemic, one of the largest life insurance companies in the United States reportedly experienced a 96% increase in claims (totaling USD 24 million in 1919, which is nearly USD 4.6 billion today) due to pneunomia and influenza compared to a more typical seven-month period.

WHY WAS THE 1918 PANDEMIC SO DEVASTATING?

Compared to other flu viruses, the virus that caused the 1918 pandemic was highly transmissible (as measured by the basic reproduction number, R_0, the number of new infections generated by an infected person entering into a population with no immunity to the disease). For seasonal flu, the average R_0 value is around 1.30, but the median R_0 for the 1918 pandemic was much higher, ranging from 1.80 to 2.48. In some regions, the R_0 of the pandemic pathogen even soared to 4.50. The notably high transmissibility of the 1918 pathogen may have been due, in part, to genetic factors that amplified the virus's replication ability.

In addition to being highly transmissible, the 1918 virus was highly virulent, as measured by the case fatality rate (CFR), or the percentage of sick individuals that later die of the disease. During the 1918 pandemic, the CFR ranged between 2.0% and 5.0%, while seasonal flu today typically has a CFR of 0.2% in developed countries. Recent research has shown that certain mutations in multiple genes of the 1918 virus contributed to its marked virulence.

Another factor that increased the deadly effects of the 1918 pandemic was World War I. Living in close quarters under wartime conditions increased the spread of influenza, and the limited supportive health care available at the time was diverted to the war effort. Finally, many countries censored news reports about the pandemic to keep up morale as WWI drew to a close; unfortunately, this censorship prevented people from knowing the severity and extent of the pandemic so they could take precautions to mitigate the infection.

Unique among historical influenza pandemics, the 1918 event caused high excess mortality in younger adults, especially those aged 25–34. Typically, influenza strikes the very young and very old, resulting in a "U"-shaped CFR profile, such as that shown in Figure 1 for the 1928–1929 flu season. However, the 1918 virus exhibited a unique "W"-shaped profile (Figure 1), indicating increased mortality among young to middle-aged adults.

AIR

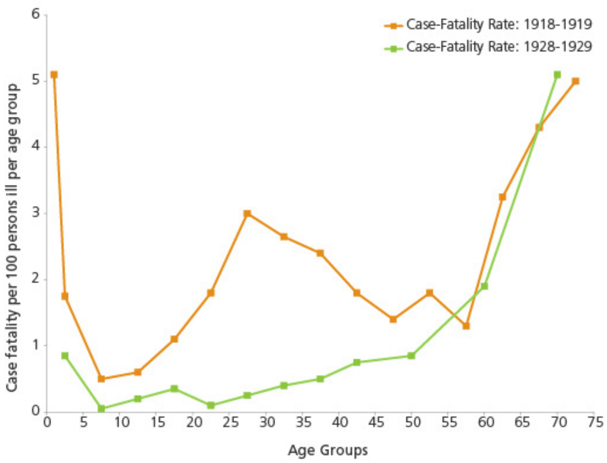

Figure 1. Comparison of the CFR profile of a typical influenza outbreak (1928–1929 flu season; shown in green) and the CFR profile of the 1918 pandemic (shown in red). After Taubenberger and Morens (2006).

While the cause of this unique CFR profile has not been fully resolved, two contributing factors have been identified. First, the 1918 virus's high virulence triggered a "cytokine storm" overreaction of the immune system, which often leads to pneumonia and death in certain victims by suppressing the body's antiviral responses and promoting increased inflammation. Young, healthy adults are more likely than other age groups to suffer a cytokine storm because their immune systems are robust and, therefore, more prone to overreaction. Second, bacterial co-infections such as pneumococcal pneumonia and tuberculosis were much more widespread in 1918, especially among young adults. Because the interaction of influenza virus infection and bacterial infection can cause severe illness, widespread bacterial co-infections led to increased mortality.

Pandemics are low frequency events with a potentially high impact for which there is a limited historical record. For these reasons, assessing pandemic risk can be challenging.

Probabilistic modeling enables a more robust understanding and management of pandemic risk than relying on the historical record alone. The AIR Pandemic Flu Model supplements traditional epidemiologic modeling with explicit modeling of population movement to yield a complete catastrophe modeling solution, allowing risk managers to fill in the gaps in the historical data.

The AIR Pandemic Flu Model also accounts for medical and technological advancements, incorporates the very latest in influenza research, and has been externally peer-reviewed by leading experts.

THE ROLE OF TECHNOLOGICAL AND MEDICAL ADVANCES

Many treatments[2] are now available for influenza that were unknown in 1918. The discovery of the influenza virus in 1931 made it possible to develop vaccines that prevent infections. (Figure 2 is a timeline showing the discovery of the virus and other relevant scientific advances, along with past pandemics.) Today, antiviral drugs are available to treat influenza infection. In addition, the use of antibiotics and vaccines has reduced the rate of bacterial co-infections such as tuberculosis and pneumococcal disease, which cause complications in influenza patients. Furthermore, greater supportive care measures are now available, including state-of-the art hospitals and intensive care units; in fact, studies suggest that many patients who died of influenza in 1918 might have survived if modern medicine had been available. Heightened national and international planning and preparedness efforts have also improved the ability for the world to respond to an imminent influenza pandemic threat.

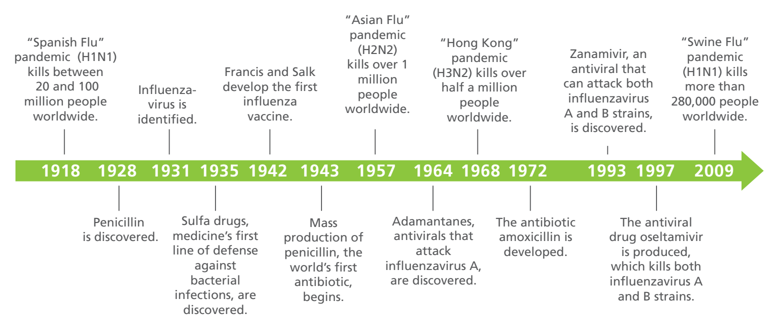

Figure 2. A timeline of influenza pandemics and medical advances during the past century.

ESTIMATING THE EFFECTS OF A MODERN-DAY "SPANISH FLU" PANDEMIC

To estimate the effects of a modern-day "1918 pandemic," AIR's epidemiologic model was run for a range of events using initial parameters consistent with the historical pandemic. These parameters included R_0 values of 1.80–2.48, and a range of CFRs (0.90%–1.25%) that have been adjusted to account for medical and scientific advances since 1918. Other initial parameters included when and where the pandemic originated. The pandemic was then propagated through the AIR model to estimate mortality and life insurance losses.

It is important to note that the model explicitly incorporates the application of mitigation measures such as antivirals, vaccines, and travel restrictions, and makes realistic assumptions for each. For example, the model assumes that vaccine production and deployment takes about six months; in contrast, antivirals are assumed to be available immediately. In the model, the availability of both vaccines and antivirals varies according to each modeled country's stockpile size, resource levels, and distribution capabilities. The model also accounts for variation in the efficacy of these pharmaceutical interventions by patient age, with an average efficacy of 40%–60%. Finally, the model accounts for worldwide population movements through air travel and local commuting. Global air travel will likely decrease as the pandemic becomes more widespread because of government-mandated restrictions and because people are likely to avoid traveling due to concerns over contracting the virus.

The AIR Pandemic Flu Model estimates that a modern day "Spanish flu" would result in between 21 and 33 million deaths globally. Developed countries would experience the lowest mortality rates, with population-level mortality rates in the range of 0.08%–0.09%, as shown in Figure 3. In fact, the AIR model suggests that, due to medical and technological advancements, case fatality rates would be almost 90% less than what was experienced during the actual 1918 Spanish flu. However, the AIR model also finds that increased global travel and an aging population would raise the death rate of a modern day "Spanish flu" pandemic by 30% and 8%, respectively, compared to the actual mortality rates in 1918. Taken together, these modeling results suggest that dramatically fewer excess deaths—nearly 70% fewer than actually occurred in 1918—would result from a "Spanish flu" event today.

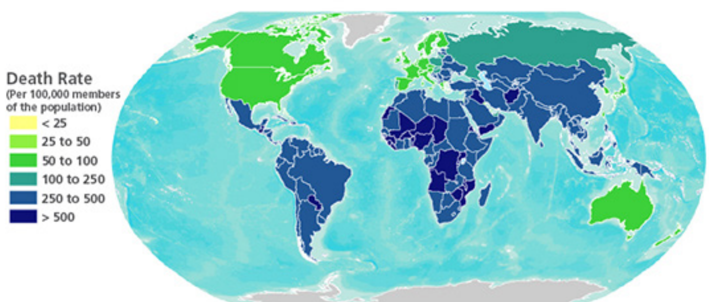

Figure 3. Mortality rates caused by a modern-day recurrence of the 1918 Spanish Flu pandemic, as estimated by AIR (Source: AIR)

The stochastic "modern day Spanish flu" event generated for the AIR model produces an age CFR profile similar to that of the actual 1918 pandemic. Specifically, the stochastic pandemic event exhibits increased mortality rates among young- to middle-aged adults (25–34 years of age), yielding a "W"-shaped mortality profile very similar to the mortality profile of the actual 1918 pandemic. This "W"-shaped profile can be attributed to the ability of the simulated virus to cause a cytokine storm, demonstrating the model's ability to capture the effects of this complex syndrome.

Table 1. Mortality and life insurance losses estimated by AIR for seven countries due to a modern-day recurrence of the 1918 influenza pandemic (Source: AIR)

COUNTRY	NUMBER OF DEATHS	INDUSTRY LIFE INSURANCE LOSSES (USD BILLIONS*)
Australia	15,000 – 26,000	0.8 – 1.4
Canada	20,000 – 37,000	2.1 – 3.8
France	36,000 – 62,000	2.1 – 3.7
Germany	48,000 – 85,000	1.8 – 3.3
Japan	83,000 – 145,000	8.9 – 15.2
UK	36,000 – 64,000	3.1 – 5.5
U.S.	188,000 – 337,000	15.3 – 27.8

*All losses converted from local currency to USD using exchange rates as of 12/31/2012.

The AIR model estimates that a modern day "Spanish flu" event would result in additional life insurance losses of between USD 15.3– 27.8 billion in the United States alone. According to the American Council of Life Insurers, benefits paid to beneficiaries in 2010 amounted to more than USD 58 billion (ACLI, 2011). Therefore, losses from a modern day "Spanish flu" would represent close to a 48% increase in the total benefits paid by the life insurance industry.

PUTTING THE SIMULATED PANDEMIC IN CONTEXT

The AIR Pandemic Flu Model features a 500,000-year stochastic catalog of more than 18,000 simulated pandemics. Based on this stochastic catalog, AIR can estimate exceedance probabilities for a modern-day recurrence of the 1918 pandemic from various perspectives. Exceedance probabilities vary by country and, within those countries, the probabilities also vary by age group. The AIR Pandemic Flu Model shows that, for the U.S. and UK, the observed population-level mortality from a recurrence would have an exceedance probability between 0.5%–1.0%, corresponding to a 100–200-year return period. This return period holds true for most age categories, with a few exceptions. For example, the mortality level for the 25 to 34-year-old age category is associated with a return period of around 200–400 years, which arises from the pandemic's atypical "W"-shaped mortality profile. Conversely, for the 65+ age category, the estimated level of mortality would have a return period around 50–100 years.

Insurance and reinsurance companies should, however, realize that a modern day "Spanish flu" pandemic does not represent a worst-case scenario in terms of pandemic risk. For example, an emergent pandemic strain could be resistant to antiviral drugs; in addition, it may prove impossible to manufacture a vaccine in a timely fashion due to production difficulties. Hospitals may also be overwhelmed by the influx of the sick and the "worried well" and may be unable to provide care to everyone who needs treatment. For these reasons, and due to the threat of highly pathogenic avian influenza, the AIR stochastic catalog also includes extreme events with CFRs as high as 25%–30% in developed countries. Events this severe have the potential to cause hundreds of millions of deaths globally, including millions of deaths in the United States alone.

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[1]AIR TRENDS HISTORICAL LIFE INSURANCE LOSSES TO MODERN-DAY DOLLARS USING THE SHARE OF GDP METHOD (THE SHARE OF GDP REPRESENTED BY A HISTORICAL LOSS VALUE IS CALCULATED, AND THIS PROPORTION IS APPLIED TO THE CURRENT GDP).

[2]WHILE ALL OF THESE TREATMENTS ARE AVAILABLE IN DEVELOPED COUNTRIES, THEIR AVAILABILITY IN OTHER PARTS OF THE WORLD VARIES.

ABOUT AIR WORLDWIDE