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Influenza Pandemics: Are We Ready for the Next One? What Actuaries Can Learn From 1918

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This article summarizes a presentation given at the 2004 ERM Symposium by the author along with David Ingram. Opinions expressed are those of the author and not his employer or any other organization he is affiliated with. It is not a refereed paper and does not substitute for doing your own research on the topic. The author is indebted to the researchers who wrote the books referenced, to SOA librarian Ellen Bull (an underutilized but wonderful resource for actuaries) and to David Ingram, whose interest in the subject and initial research helped to jump-start this project.

Introduction

Tail risk has gotten the actuarial profession's attention. With supposedly 10 Sigma events occurring almost every year and contagion risk consistently underestimated, best estimate assumptions using a single economic scenario are not sufficient. Many practitioners have known this for years, but technology now allows actuaries to model and manage these risks. These models generally use a combination of stochastic and deterministic scenarios. Interest rates and equity returns are often modeled deterministically to address specific risks and stochastically to cover the universe of possibilities. Risks as diverse as earthquakes and anthrax attacks can be similarly modeled.

Mortality risk is generally tested deterministically, with specific concerns stress tested. For life insurance products, stresses of 110 percent of base mortality are commonly used for external projects like asset adequacy testing. Recent discussion has focused on the very real risk of bioterrorism, with geographical concentrations of exposure creating the risk. Hopefully there will never be enough "data points" to fit a distribution for these risks, but some hypotheses can be modeled. Either a dirty bomb or water poisoning are examples that could present a major disruption to a state, province or other geographical region, but it is unlikely that such an event would be either national or worldwide in scope. Even a natural disaster like an eruption of Mt. Rainier or a large earthquake in California would impact a limited region. Only an outbreak of a disease that is both highly contagious and lethal could affect global populations materially. One might think, with today's medical tools and research labs, that such an outbreak could be easily contained. While medical knowledge has improved greatly since then, in 1918 such an outbreak of disease occurred that remains untreatable even today. It was influenza.

This article, while not a formal book review, takes much of its information from three books. All are very readable and provide slightly different perspectives. *America's Forgotten Pandemic*, by Alfred W. Crosby and first published in 1976, follows the story through America's cities as the virus spread and mutated. It was the definitive book on the topic until recently. The second book, *Flu: The Story of the Great Influenza Pandemic of 1918 and the Search for the Virus that Caused it*, by Gina Kolata (science editor for the *New York Times*) and published in 1999, describes the pandemic but also tells a true detective story. Several groups, working independently, raced to isolate the virus that caused this particularly virulent strain of influenza and their stories are told here. The third book was released in 2004 by John M. Barry, titled *The Great Influenza: The Epic Story of the Deadliest Plague in History.* It includes both advances made in the past 30 years as well as some new investigative work that convinced me that this virus originally presented itself in the United States. It will quickly become the standard bearer for this topic and a must read for anyone determined to learn from the mistakes made in the past.

Actuarial Interest

What makes the 1918 influenza pandemic (epidemic is within a country or region, pandemic is worldwide) so interesting to actuaries is the excess mortality curve. While the other epidemics of the 20th century were lethal to the old and most, but not all, caused extra mortality for the very young, only in 1918 did those aged 20-40 experience material excess mortality. When a whole life policy is several years old and the pol-

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icyholder's attained age is high, reserves have built up and the net amount at risk (NAAR) is much smaller than the face amount of the policy (face amount = reserve + net amount at risk). With group life, sold as annual renewable term (ART) to all employees at many firms, the net amount at risk is a large percentage of the face amount. And reinsurers generally provide ART coverage to direct writers. As a profession we spend a lot of time studying tail risk of equity-based and casualty products. However, the greatest tail risk of all for insurers might be a product most life insurers and reinsurers have been happy selling for years as a core product, life insurance.

How it could happen

Several months ago the Extreme Values Subgroup of the SOA's Risk Management Task Force had a contest to describe an extreme event. In my entry I described a college all-star soccer camp held in the Midwest over semester break in late December. One of the campers isn't feeling well, but this camp increases his chance to make the U.S. National Team and it is worth playing even while feeling a little sluggish. The campers sleep in bunk beds set up in a gym. They spend all their time together, making many new friends. After the camp everyone flies back to his home to finish the rest of break, and then returns to their respective universities. No one realizes that all of them are now infected with influenza and contagious. Before anyone knows it an influenza outbreak has occurred. How can society stop this scenario? It can't, and that is what is so scary about influenza.

Pandemic Basics

Every year approximately 30,000 Americans die from the flu. Most are very old or very young, with immune systems that are either not as strong as they once were or as they will become. Many get sick and spend a few days in bed to rest and recover. Few in the prime of life die from it. The general pattern is high morbidity and low mortality. Occasionally, perhaps five times per century, the virus mutates into a form that is either more contagious or experiences higher mortality. About once every century or two it takes a form that history remembers. This last happened in 1918, when 600,000 Americans and up to 100 million people worldwide died, most over the course of less than three months. While history is very likely to repeat itself, and the odds seem to increase over time, the more we know about the last pandemic the better we can deal with the

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In listening to Chairman Greenspan I found so many insights and applications of his comments to my work that I thought you all might feel the same. In trying to summarize what I take from his comments, here's the Top Ten:

1. Risk management is a conceptual framework.
2. Use your models as tools, as means to an end, not the end.
3. The simpler the better.
4. But the world's complex so even the simplest models might need to be complicated.
5. Robust is better than precise.
6. Rules help, but judgment matters too.
7. Know what you know and know what you don't know and never confuse one with the other.
8. Don't confuse the future with the past.
9. Avoid a big mistake from which you can't recover.
10. Never stop learning.

Now, I'm not going to run out and campaign to be the next Federal Reserve Chairman. But if that's your dream, go for it. ✦

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next one. Unfortunately, when I speak with practicing physicians they have only cursory knowledge of the 1918 outbreak, often referred to as Spanish flu, and seem to assume that today's available technology and drugs make it unlikely to return.

Influenza pandemics repeat periodically. Records are not always accurate, and other diseases are sometimes confused with influenza. Pandemics were recorded in 1510, 1580, 1688, 1693 (all ages were impacted), up to six in the 1700s and at least four in the 1800s. The 1889-91 pandemic was especially strong and the most notable in the past three centuries except for 1918, which also returned in less virulent form in 1919-20.

Influenza can be very contagious. In the air after being exhaled, it can infect someone else up to a day later. On a hard surface it can remain potent for two days. Door knobs and remote controls become inadvertent killers. The only effective measures, even today, are isolation and quarantine. Doctors and nurses put their lives at risk when taking care of these patients and, to their credit, very few shirked their duties in 1918. Keep in mind that many of the top medical professionals had been called to duty for the war effort and there was a shortage of qualified practitioners at the time. This fact wasn't helped when national nursing organizations refused to support curriculums to develop practical nurses. Only recently has the medical profession developed knowledge about this particular virus and is starting to understand what made it so lethal. In 1918 they knew little more than when plague spread centuries earlier about how to treat it.

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Are influenza pandemics like earthquake risk that increases with time since the last one, or is pandemic probability completely random with the likelihood just as high in the year following the most recent outbreak? Since antibodies created in one pandemic give some protection against the next one, it seems more like earthquake risk, building over time. As the last major pandemic happened over 80 years ago, it is appropriate to allocate resources to better understand influenza today.

Waves

The 1918 flu was active for several years, but mutated its form over time and created several “waves” that each traveled across most of the globe. The first wave in spring 1918 was very contagious, especially for young and healthy adults, but not very lethal, and was given little notice outside of the U.S. military camps where it thrived. It required few contacts with others to spread and took only four months to cover the globe. Africa, South America and Canada were initially spared. Those who were victims of the first wave showed resistance to later mutations of the virus, although little preparation anticipated future waves.

Author John M. Barry has traced the origins of the first wave to Haskell County, Kansas. This small farming community in southwest Kansas was missed in earlier research as a starting point for the pandemic because of an incorrectly published date of the local epidemic. Barry's research of local newspapers allowed him to track each of the outbreaks from this local epidemic, advancing to what is now Ft. Riley in Kansas, then on to other military bases and beyond.

The second deadly wave occurred in the late summer and fall of 1918. Since the “hosts” either died quickly or recovered with antibodies to fight off future contacts with the disease, in a given city the flu arrived, flourished and was gone. In cities this took six to eight weeks, while in military camps the overcrowding compressed it to three to four weeks. Within a region, the virus appeared to grow weaker over time. If a community could delay its arrival or slow the contact rate just a bit it had a material impact. As an example of the intertwined histories of the war and pandemic, the Armistice Day celebrations recognizing the end of hostilities in November 1918 touched off a second wave of the flu in many cities.

U.S. troops in Europe had half the rate of death from influenza as those in the United States. It is likely that they were exposed to the first wave and had developed some immunity. While the deaths in the western world were staggering, those in other parts of the world that had not previously been exposed to influenza were horrific.

It is estimated that 20 million deaths occurred in India alone.

The third wave started in December 1918 and had mutated such that schoolchildren were most impacted.

Life in 1918—Dominated by World War I

The times surrounding 1918 were dominated by World War I, once thought to be the war to end all wars. Influenza likely impacted this concept, but I'll get back to that later. After the United States entered the war and troops started to travel across the Atlantic Ocean to the front lines, the country quickly mobilized. This transition was helped by laws to improve morale. In effect, you could not criticize the federal government run by Woodrow Wilson. Media fell in line, supporting "our boys" and the Liberty Loan bond drives that pressured all citizens to buy government bonds to pay for the war effort (war funding was outside the regular budget at the time and required funding from other sources). Meetings, rallies and door-to-door solicitations raised money for the war effort while unknowingly spreading the virus. Any negative event was downplayed or ignored. Information regarding the influenza epidemic was suppressed, causing concerns to be downplayed and the media to lose the trust of their customers. The virus moved very quickly. With an economy shifted to war production, there was limited lasting impact on the economy. Since the virus hit both sides it does not appear to have impacted the outcome of the war, although the fall elections in the United States were very close and Congress was divided evenly between parties.

The name "Spanish flu" seems to result from the lack of information reported by media in countries involved in the war. Spain, as a neutral party, had a relatively free press and reported the impact. Other countries reported the impact in Spain even as they ignored their own outbreak.

American medicine had progressed rapidly in the early years of the 20th century and, for the first time, had become as capable as the research facilities in Europe. In Europe, researchers were busy trying to combat gas attacks from the war and did not have resources available. As it turned out, the medical profession was helpless beyond common sense techniques of hydration and rest, which made public policy even more important. The lack of honest information allowed fear to run rampant. Some family members refused to enter homes where simple care would have saved the patient. The army's surgeon general, William Gorgas, warned of a high pneumonia risk in the military because of overcrowding, especially in the winter when heat became a luxury. He suggested a 10- to 14-day quarantine of troops arriving in Europe, shorter than Canada's 28-day isolation period. He was ignored. Even when quarantines were set up by the U.S. military, officers were often exempt. Unfortunately for the doughboys, the influenza virus can't read the bars on their shoulders. An incomplete quarantine is little better than no quarantine at all.

As war production ramped up, workers descended on cities. Crowding became worse in these cities, with shift workers often sharing rooms (and beds) with workers from other shifts.

Historical Perspective

Politics played several roles in the 1918 flu pandemic. No major player in world politics died. This is one reason why the pandemic escapes many history books of the era and is likely caused by the nature of the mortality curve. While normal influenza outbreaks cause excess mortality primarily at very young and very old ages, in 1918 the primary group afflicted was aged 20-40. Few people have distinguished themselves enough by this young age to merit inclusion in a history book. We know, because he survived and accomplished much later in life, that Franklin Roosevelt, as assistant secretary of the Navy, became very sick with flu during a trip to Europe. Had he died we would not know this today. Who knows how many future world leaders were lost? Several members of the Paris Peace Conference delegations died. The most notable American death was Willard Straight. When he died he received three columns on the front page of the *New York Times*. Both President Woodrow Wilson and General John Pershing became sick.

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The other role of politics did little to minimize the pandemic's impact. President Wilson never mentioned influenza publicly; not once. While 600,000 Americans died at home from the virus, he focused on the war effort and ignored the war against disease being fought by the civilian population. It is interesting to note that he tried to keep the United States out of the conflict, but once America entered he seemed to become obsessed by it.

Woodrow Wilson arrived at the Paris Peace Conference driven by strong principles. He was reportedly so frustrated with the negotiators, particularly those from France, that he was ready to leave the negotiating table and return to America when he became ill. While there is still some debate on the matter (some think he had a stroke), his symptoms were consistent with influenza. After this time, future President Herbert Hoover, also in Paris, thought his mind lost "resiliency." Wilson suddenly had new and strange ideas. For example, he thought there were French spies in his residence. He suddenly abandoned principles he had previously insisted upon and yielded to France on everything of significance. Four months later President Wilson suffered a major debilitating stroke. Many think that the seeds of World War II were planted in the treaty that ended World War I. Would history have turned out differently if Wilson had not encountered flu in early 1919? We will never know.

Other reasons for the lack of historical perspective include the passage of time and the fact that flu is common, with a person rarely dying from it. I think a separate reason is bringing this devastating event back into the forefront—research into the cause is starting to be successful. In the 1920s much research was attempted, and side benefits included penicillin and genetics, but the solution never came. The scientists were not able to identify what made so many so sick in 1918.

Although sanitation had improved enough so that large cities like London could support their own population without immigration from the countryside for the first time, epidemics were not rare in the early 20th century. As recently as 1911 a measles epidemic had broken out in the U.S. Army that killed 5 percent of those who caught it. Various forms of plague had also broken out since 1900 around the globe. The entry of the United States into war drove leading scientists of the day to predict that travel and crowded conditions would lead to some form of epidemic. Their goal was for this war to be the first where more died from battles than from disease by lowering the number of disease-related deaths. Little did they know that war conditions, especially troop ships, would accelerate the pandemic.

Funeral homes and cemeteries were quickly overrun, even as life insurance agents were placing ads encouraging business (apparently improperly aligned incentives are not a new phenomenon). Fear and sickness caused many of the people who normally performed these burials to stop or run away. Often there was no one left to pay the funeral bills, and wood for coffins became scarce. Women of "society" often took over when the government proved ineffective. Volunteers too quickly abandoned the task. Families had to dig their own graves and police often had to collect the bodies using wagons reminiscent of plague.

In some families everyone was wiped out. Large numbers of orphans and single-parent families were created in late 1918. Although the impact on servicemen is well documented, young women were also heavily impacted. Pregnant women proved especially vulnerable. Some thought it might be the end of the world based on biblical references in Revelations to a deathly pale horse.

Reactions

Since medical researchers at the time had not identified the virus and how tiny it was, many cities passed laws requiring that masks be worn when out in public. They did not help. As long as the masks were replaced frequently there was no harm done, but the masks themselves started to breed germs when moist for long periods. Not surprisingly, the supply of masks ran low, creating shortages and encouraging people to wear them for longer periods. Another rumor had it that chewing tobacco decreased your odds of contracting influenza.

> **While originally thought to be purely a human disease, influenza actually passes back and forth between humans and several species of animals.**

In late September 1918, the surgeon general provided advice to avoid influenza. It included general common sense suggestions like avoiding needless crowding and washing your hands, but also to chew your food and avoid tight fitting clothes.

Victor Vaughan, head of the Army's Division of Communicable Diseases, said "If the epidemic continues its mathematical rate of acceleration, civilization could easily disappear…from the face of the earth within a matter of a few more weeks."

The draft was canceled in the United States—not to reduce the impact of influenza, but because influenza had so impacted the military camps that no training for deployment could occur. It was the right thing to do, but for the wrong reason. Many lives were likely saved nonetheless.

Children are often a good barometer of the nation's pulse, taking a serious subject and putting it in their terms. A jump rope verse heard across the country reflects this.

I had a little bird
And its name was Enza.
I opened the window
And in-flew-Enza.

The Virus

Pigs, ducks and humans

While originally thought to be purely a human disease, influenza actually passes back and forth between humans and several species of animals. Each one reacts differently to a specific strain of the virus. Since farmers are in regular contact with pigs and birds (primarily ducks and chickens), they are one of the conduits between human and animal influenza. Another is markets where live animals are sold. It is thought that if an animal (or human?) catches both human and animal flu at the same time that it mutates into something that can be more lethal to one or the other species. The 1918 swine flu was new to the species, has been present ever since and was initially deadly to pigs. It was recently shown to have originated as an avian, or bird, flu, adding to the confusion. The virus strain itself is mild to pigs but, as happened in 1918, in combination with B. influenzae as a secondary invader it becomes highly lethal. Antibodies from humans have been used to protect pigs from the virus. An old wives tale that just might be true is that an outbreak of flu among horses often is a leading indicator of human flu epidemic.

Several recent influenza outbreaks have originated in China. Live animal markets have been involved in many of these epidemics, but farmers also live in a high-risk environment. For example, farmers in China use ducks to grow rice. When the fields are flooded, the ducks eat insects and weeds while leaving the rice alone. The ducks are removed while the rice grows, returning to clean the fields after the harvest. Having served their purpose, the domesticated ducks are then slaughtered for dinner. These farmers also raise pigs. This combination of swine, birds and humans has historically believed to have been the source of the worst influenza outbreaks. The viruses are able to combine between species and sometimes create a lethal cocktail.

Medical Basics

While this paper is not being prepared for a medical journal, some basic information will provide background.

Influenza consists of eight genes made of ribonucleic acid (RNA). Other viruses in this family include HIV and coronaviruses (SARS and many colds). Viruses have no means to replicate themselves. They use their genes to subvert and direct host cells. Influenza moves in and out of these cells using sharp protein shards, hiding from the immune system while in the cell. The virus requires a specific enzyme found in humans only in the lungs. Birds are the natural and original homes for influenza, existing in their gastrointestinal tract. It is often found in their droppings. While a human can catch avian flu from birds directly when exposed to massive amounts of bird droppings, it can't spread to other humans because the binding process between virus and host cell differs between species. The virus must first adapt to humans, using an intermediary animal like

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pigs. When deoxyribonucleic acid (DNA) copies itself, it works very hard to do so correctly. There are redundancies to make sure the copy is correct. When RNA copies itself, very few copies are exact because no redundancies are built in. Because the influenza virus is a segmented genome, the genes can reassort themselves, allowing the virus to move between species. It is much easier for RNA to mutate and find a form that helps it to survive than it is for DNA to do so. This "mutant swarm" process makes it inevitable that new forms of the influenza virus will emerge. It is very hard to create a vaccine, trying to hit a moving target as the virus mutates. In addition, influenza mutates very quickly to become drug resistant, often within days. While not meaning to detract from the seriousness of AIDS, the cumulative total deaths from HIV is lower than those recorded by the 1918 influenza virus. Since research is continuing on both and they are similar, perhaps joint efforts will help control both viruses.

The virus contains two proteins: hemagglutinin (H) that helps flu to enter cells and neuraminidase (N) that helps flu escape from the cell. As these proteins mutate, they are identified by shape (each shape is identified by number). H1N1 identifies the 1918 Spanish flu, along with epidemics that occurred in 1976, 1977, 1986 and 1988. Other epidemics included 1956 (Asian flu—H2N2), 1968 and 1993 (Hong Kong flu—H3N2), 1995 (H7N7), 1997 (Chicken flu—H5N1) and 1999 (H9N2). The influenza virus is unique in that, as a new virus takes hold, it seems to drive old forms of the virus to extinction. There are 15 known shapes of hemagglutinin and nine of neuraminidase.

The 1997 virus generated another concern. Influenza vaccine is grown in eggs, and this particular one was so strong that it killed the eggs. It took a year to overcome the problem. In a pandemic you don't have a year.

The similarities to the 1918 virus created the swine flu scare in 1976, where the United States encouraged immunizations for all. Unfortunately, the vaccine proved to have some negative side effects. Luckily the influenza outbreak did not occur. This highlights a very difficult issue for public policy makers. They use the prior year's flu, especially those mutations that appear in the spring, to make the next year's vaccine. If they successfully reduce a pandemic's impact they are open to criticism for crying wolf. Resources and time are both limited, so they have to focus their efforts. Stockpiling vaccine doesn't work because the virus mutates quickly, making such efforts fruitless.

Moisture appears to play a part in the influenza story, as it appears to die quickly in high humidity. One story I heard referred to the 1988 Kansas basketball team, led by Danny Manning and coached by Larry Brown. Apparently flu was going around campus and Coach Brown had his players sit in a humid environment every day to breathe in the moisture and kill any flu virus. While you still have to play the game, that team won the NCAA tournament as a number six seed.

Symptoms

There are stories of people that appeared to faint, collapse and die during the pandemic. Soon-to-be patients would leave for work, seemingly healthy, and die the same day. In one to two hours a person could become prostrate with fever up to 105 degrees, general weakness and severe headaches. Their eyes would burn and their ears would ache, with blood coming from ears and eye sockets. So much pressure would build up that blood would sometimes spurt several feet from a patient's nose. Severe aches in their muscles, joints, backs and heads made them feel as if they had been beaten all over by a club. Kidneys, liver, adrenal glands and testes all were impacted. Nurses reported that air pockets beneath the skin caused patients to crackle like a bowl of Rice Krispies when they were rolled over.

When autopsies were completed, the heart had often been impacted. There was often an inflamed pericardium, the sac around the heart, and the heart muscle itself was flabby.

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Acute Respiratory Distress Syndrome (ARDS) was not identified as a specific sickness until after 1918, although the doctors of the time would be very familiar with it because of its common occurrence among influenza deaths. It is caused by an extreme stress on the lungs. This can be caused by near drowning, smoke inhalation, inhaling toxic fumes (or poison gas) or influenzal viral pneumonia. The immune system burns the insides of the lungs, followed by secondary invaders that attack the weakened defense systems. Someone diagnosed with ARDS today has a 40-60 percent chance of survival. Without intensive care units, this rate dwindles to near zero. There were no ICUs in 1918. The army found what is now called ARDS in half the autopsy cases it reviewed from 1918. As the virus mutated it became less prevalent and was rarely found in the comparable 1919 autopsies.

As a comparison, bacterial pneumonia following influenza has 7 percent mortality rate. Antibiotics are used to treat these infections. Over 35 percent of pneumococcal infections are resistant to the antibiotic of choice. For staphylococcus aureus bacterium, which is very resistant to antibiotics, the death rate is over 40 percent.

Lasting Effects

The 1918 influenza strain appears to have left residual effects on many who recovered, leaving them tired and susceptible to heart and neurological problems. Many who had flu died early in 1919 of secondary causes and were not recorded as flu deaths.

The influenza virus is hosted in the human body by the lungs. Yet the virus also appears to have impacted the neurological system, causing paralysis and mental illness. Hysteria, melancholia, delirium and insanity with suicidal intent were not uncommon. Some of this was temporary. A study that followed influenza patients that suffered from schizophrenia showed that most recovered completely within five years.

There appears to be a link to the brain as well, with those infected having a higher rate of Parkinson's disease a decade later.

Worst Case—Death

Many of the worst cases resulted in what was essentially drowning. As the lungs filled with reddish fluid, less oxygen was transported to the extremities. Nurses could tell which patients were not going to make it by looking at their feet. If they were black it was as if a death sentence had been given. Faces turned a dark brownish purple and patients coughed up blood while gasping for breath.

Research

Over the years much research time and effort was devoted to Pfeiffer's bacillus, a bacterium often present with influenza as a secondary invader. In some locations it was found in nearly all of the cases and was thought to be the cause of influenza. This is partly because of the stature of the scientist who discovered the correlation, Richard Pfeiffer of Germany. Many researchers were so sure of themselves that, if no influenza bacilli were found, then the disease present could not be identified as influenza. But this was a bacterium, and the true cause of all influenza is known today to be a virus.

While little success was achieved in discovering the source of the virus, lots of good research was performed and some important discoveries were made. Penicillin was found to kill bacteria, and Oswald Avery made the key observation that DNA carried genetic information when he determined how a weak pneumococcus could be made strong by adding a capsule around its structure.

Several individuals worked for many years to isolate samples of the virus. Since the Civil War, standard autopsy procedure for military doctors has been to take thumbnail samples of tissue, soak it in formaldehyde and store it in paraffin wax. The Armed Forces Institute of Pathology then stores these samples. Several of these samples survived from 1918, and Dr. Jeffrey Taubenberger painstakingly dissected them until he had sequenced the genome. Dr. Taubenberger continues to be a principal researcher of this topic. Dr. Johan Hultin, while studying at the University of Iowa, also became involved in the issue. The Swedish-born scientist made trips to Alaska to find bodies buried in the permafrost

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where the virus might have been frozen. Eventually the science caught up and he was able to bring back small samples to study. Several other researchers have been involved as well, but these two have been more focused on saving lives than personal glory.

The mystery that still stymies scientists today is the 1918 strain's lethality. What made so many people die from this influenza and not from another one? Once this is identified, vaccines and other methods can be used to lessen its impact. Since flu shots create antibodies in a person, does getting an annual flu shot help to protect you from the next pandemic? It is currently thought that a mild flu earlier than the pandemic of 1889 provided those older than 40 with some immunity to the 1918 virus.

Similar Topics Today

SARS

Severe Acute Respiratory Syndrome (SARS) first appeared in late 2002 in China. It was not reported to the World Health Organization (WHO) for several months, which allowed it to get a foothold and spread through international travel. While it is more lethal than influenza, it is less dangerous. It requires close contact to spread. It also lives primarily in the upper respiratory tract, so is spread via coughs and sneezes up to a week after symptoms develop. This makes it much easier to isolate and quarantine. Nevertheless, the ease of its spread to Toronto shows how important it is to react quickly to any outbreak.

Bioterrorism

It is difficult to read about influenza in today's environment and not think about the possibility of terrorists discovering the secrets of influenza before "the good guys" do. There are many historical cases of bioterrorism, mostly involving hurling infected animals over the wall of a town. In recent times the Japanese spread bubonic plague in China during World War II, in 1984 an Oregon cult infected salad bars in a restaurant with salmonella, in 1995 a cult group released the nerve gas sarin on commuter trains in Tokyo, and in 2001 anthrax was spread through the mail in the United States. Smallpox was used against Native Americans, both accidentally and on purpose (millions of Native Americans lived along the Mississippi River until a messenger carrying news of the Spanish arrival also carried smallpox). The risks today are anthrax, plague, smallpox and botulinum toxin. All can be countered with either antibiotics or antitoxin. Poison gas has been used more frequently, notably in World War I and more recently in Iraq.

Actuarial Involvement

The Numbers

The resulting mortality curve for 1918 looked like a W, with some additional deaths at early ages and little excess mortality at older ages. The unusual characteristic of this pandemic was the high number of deaths among those in the prime of life. Other flu outbreaks have had fewer than 10 percent of the deaths at ages 16-40. In 1918 over half the deaths occurred in this age range, with ages 21-30 the worst hit.

Specific industries that featured overcrowding and moist conditions were particularly susceptible. In 1918 Met Life reported that 6.21 percent of all insured coal miners and 3.26 percent of all insured industrial workers died. Overall estimates of worldwide deaths have ranged from 20-100 million, with the higher numbers now considered more credible. The high end of the range translates into 5 percent of the world's population dead from influenza within about three months. Based on population increases, today as many as 350 million would die. Population morbidity was less than 30 percent, which is toward the high end but still within a normal range for influenza. Slightly higher percentages were found in the military, likely caused by the overcrowded conditions. In the army, one in 67 died over a 10-week period starting in mid-September 1918.

In the United States, the consensus is that 25 percent of the population became infected with influenza and, of these, 2.5 percent died. This resulted in .06 percent of the population dying from the virus (.25 * .025 = .00625). This left 600,000 Americans dead and reduced the ex-

pected lifetime (taking the probability of surviving 1918 for each attained age and multiplying the results) from 51 to 39. More Americans died from the 1918 influenza pandemic than from all 20th century combat deaths. Up to 10 percent of the world's young adults died. One can only imagine the impact these lost lives could have had, for better or worse, during their lifetimes. Could World War II been prevented, or did a brilliant German soldier die that would have changed the outcome of the war? We will never know.

Looking at U.S. population trends shortly before 1918, the average annual increase was about 1.4 million (average of 1915-1917). In 1918 the population decreased by about 60,000. One could conclude that excess mortality from all causes was 1.5 million (an alternative could be fewer children being born—this was not the case in 1918 but did reduce in 1919). War deaths are listed as over 50,000 in battle and over 60,000 other deaths, which would include those caused by influenza. It appears that a strong argument can be made that the 600,000 deaths from flu estimate in the United States is low, especially since the number also includes deaths from 1919 and 1920 when a less virulent form of influenza created later waves.

Remote Areas

Areas not readily accessible and without domesticated farm animals were especially vulnerable since many had not previously been exposed to milder forms of influenza. The visiting postman wiped out some Alaskan villages, delivering flu along with the mail. In Tahiti over 10 percent of the population died within a month of a ship's docking with flu aboard. Samoa provided an interesting case study. In Western Samoa, 20 percent died after a boat docked with flu. In American Samoa, the governor quarantined boats with the flu and there was limited impact. The locals still sing a tribute song to the governor for his strong and prompt action. Native Americans were also susceptible, with 2 percent mortality. In Russia and Iran it is estimated that 7 percent died. In India it was 5 percent. Funerals in India use cremation and return ashes of the deceased to the rivers. When they ran out of firewood, corpses soon clogged the rivers.

Models

This paper is based on a presentation given in April 2004 at the Enterprise Risk Management Symposium. Dave Ingram also presented at a session titled "Pandemic History and Financial Implications: Focus on Flu Epidemics." Dave's focus was to present a simple teaching model that he developed while working on SARS. Such a model can help someone cut through the hysteria and understand where an outbreak may be heading. Parameterizing and modeling an emerging epidemic allows the modeler to provide a leading indicator of the epidemic's strength while it is still early enough to put measures in place that reduce the impact.

Dave trued up his model to the 1918 U.S. pandemic using the following parameters: population 100 million, contact rate 12 per day, transmission efficiency (probability of infection per contact) 2.5 percent, recovery rate 25 percent per day and mortality .64 percent per day. This is consistent with the 25 percent morbidity and 2.5 percent mortality data described earlier that resulted in a reported 600,000 U.S. deaths. With a population at year-end 2002 of 289 million, proportionate results would be 1.8 million deaths today in the United States. It is easy to think of adjustments to the contact rate based on today's global industrialized society that would quickly increase these results even if mortality resulting from secondary infections were reduced. Adding inoculations to the model and reducing the contact rate even slightly has a major impact on the results. Dave's model can also be adjusted to include an initial number of infected persons in case the epidemic has already started.

The Centers for Disease Control and Prevention (CDCP) has built a model to project a pandemic in the United States. It uses an average of the 1918, 1957 and 1968 outbreaks. While these numbers are large, if they were to use only the 1918 statistics the deaths would be four times as great as those modeled and the shape of the excess mortality curve will not match that of 1918. Users of this model should be careful to understand its limitations.

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“The Centers for Disease Control and Prevention (CDCP) has built a model to project a pandemic in the United States. It uses an average of the 1918, 1957 and 1968 outbreaks.”

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Insurers

Actuaries had their hands full in 1918. For those policies where the attained age was older and the policy had been in force for several years, reserves had built up and the net amount at risk was lower. For younger policyholders, where little reserve had been set up, the hit was harder. About three quarters of the companies either omitted or reduced their dividend.

As a result of the 1918 pandemic, the Committee on Statistical Study of the Influenza Epidemic created an opportunity to show what statistics and their methods could do for preventive medicine. Insurers also began funding research on the flu. Insurance applications picked up, not surprisingly, as there were many examples where life insurance would have helped families cope with their losses. Underwriters were aware of the heart based after effects of this flu and included this in their analysis.

During a June 1919 American Institute of Actuaries conference, the dynamics of the time were discussed. In addition to the mortality increased by the influenza pandemic, the war also took its toll. There were other repercussions from the war effort. Some added to mortality, some encouraged a healthy lifestyle. They included dietary improvements in the general population as they planted "war gardens", a switch from wool to cotton based clothing (higher mortality assumed from the change, not because one was better than the other), landlords cutback of coal during the pandemic to "support" the war effort, lengthened work hours and higher accidents caused by skilled workers entering the armed forces.

Before the end of 1918, President of the Actuarial Society of America Henry Moir estimated that the pandemic had cost 400,000 American lives having an average age of 33. The average age at death prior to 1918 had been 55-60. He estimated that 25 years were lost per victim and a total of 10 million person years were lost to mankind.

Fast-forward to today, where many individual policies and most group life insurance are designed using annual renewable term features. Many reserves are ½ cx for these policies, a statutory accounting convention that treats each policy year as an independent event. In addition, reinsurance is often designed using ART. A company might determine that it can survive 5 percent excess mortality due to offsetting in-benefit annuity mortality, but what if (like in 1918 when older ages did not experience higher mortality) the offset did not appear? And what about the counterparty risk of the reinsurer? What if the reinsurer pays 50 cents of every $1 it owes the direct writer? Even these reduced payments could be delayed, especially if a bankruptcy results for the reinsurer. My opinion is that the life insurance industry will survive the next pandemic only if there is wide spread securitization of term policies. At least life reinsurers and companies with large ART concentrations should strongly consider this option.

"As a result of the 1918 pandemic, the Committee on Statistical Study of the Influenza Epidemic created an opportunity to show what statistics and their methods could do for preventive medicine. Insurers also began funding research on the flu."

Summary

Why the next pandemic may be mild

There are several reasons why the next influenza pandemic may not be as serious as occurred in 1918.

- Today's health teams have developed Intensive Care Units and other means of caring for patients that are much advanced from 1918. Many deaths at that time were from secondary invaders that can be better treated today. An example is bacterial pneumonia, which can be treated with antibiotics.

- There was a World War going on at the time, with nearly all regions of the world impacted. This made countries unwilling to impose travel quarantines.
- Germ theory has advanced to where the next virus can more easily be analyzed.
- Antiviral drugs are now available.
- International cooperation has improved dramatically, partly because of the 1918 pandemic. Countries, cities and towns created new departments of health, including the U.S. National Institute of Health. The World Health Organization (WHO) coordinates surveillance of mutations to adjust each year's vaccine.
- Many emergency hospitals created in 1918 were converted into permanent ones.

Why the next pandemic may be worse

There are also several reasons why the next influenza pandemic may be more serious than occurred in 1918.

- Travel—it is the primary concern. It is so easy to travel internationally that any contagious virus would appear to hit everywhere at once. A quarantine of one region would likely come too late, as it did with SARS. It took only two weeks for the influenza virus to travel from Boston to Seattle in 1918. This virus would have covered 90 percent of the earth in that time period today.
- Time—it has been a long time since the last major influenza pandemic and few are still alive with antibodies in their system.
- Medical advances have not yet identified the virus completely and don't know why it was so lethal, let alone how to counteract it. Within the next few years, additional research may turn this into a reason the next pandemic will be mild. Offsetting this is the ability of the virus to quickly mutate to a drug-resistant strain.
- ICUs will quickly be overrun with patients. Many hospitals have downsized as they privatized and are not capable of supporting the needs of 30 percent of the population simultaneously. There will be a shortage of beds when they are needed most.
- Many bacteria are building resistance to currently available antibiotics, making secondary infections more dangerous.
- Regional conflicts throughout the world are constantly flaring up. Some could expand.
- Influenza is showing signs of building resistance to antiviral drugs.
- More countries do not participate with the WHO than do, so coverage of future influenza mutations is not complete.
- Politics and the courts—try to imagine telling everyone that they can't leave a state. The courts would be flooded with cases to allow freedom of travel and might have to allow it if laws are not enacted in advance to allow and enforce a quarantine. The quick challenges to the Patriot Act provisions are good examples where the proper balance is a debatable question among reasonable people.
- More people live in urban areas. This means there are more contacts per person per day. On the flip side, there is also greater probability of previous exposure to a similar virus that provides partial protection.
- There will be a greater impact on the economy, as relatively more people less than 40 have key positions in the information-based global economy. The financial markets are also likely to react quickly to an outbreak.
- A population exists today with compromised immune systems. Those with HIV, being treated with radiation/chemotherapy and transplant recipients will all be susceptible to influenza and its secondary invaders.

In May 1919, the Actuarial Society of America published, in *Transactions* (Vol. XX, Part 1 No. 61), a paper by James D. Craig and Louis I. Dublin titled, "The Influenza Epidemic of 1918. "Their lead paragraph included a statement that could be made today, and I will include it here. "With the recent development of hygiene and sanitation as marked as it is, the world felt safe against the possibilities of any new conflagration from influenza. But the experience of the last two years has demonstrated that we are not so far advanced in our knowledge of this disease, of its cause and of the methods of its control as we thought we were. Epidemics may still occur with sufficient virulence to test the resources and stability not only of life insurance companies but also of civilization itself." Will history repeat itself?

Overall, if the scientists can develop countermeasures that can be quickly implemented this will be a great weapon in the battle against an influenza pandemic. If not, public policy will drive the results. Closing down public meeting places like schools and shopping malls, limiting contact with others and temporary telecommuting will all help.

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What can we do to protect our families?

This is a tough question, and one that I have thought a lot about over the past year as I researched this topic. Until Dr. Taubenberger and his extended team solve the riddle of why this particular strain of influenza was so virulent and develop the tools to create countermeasures quickly, there is little beyond common sense. Getting a flu shot every year will help, even if just to ease identification of similar viruses like SARS. I have to wonder if flu shots might have antibodies that will also help protect from future, similar, strains. Perhaps something that seems odd today, like getting a transfusion from someone who lived through earlier mutations of influenza, will be found to add the proper antibodies. The most difficult challenge will be political. It is difficult to determine as an outbreak is occurring how bad it will be. Will our leaders have the nerve to quarantine large segments of the population in a democracy? And even if they have the nerve, will the courts allow it to happen (Tom Clancy's fictional work *Executive Orders* addresses the quarantine issue when the Ebola virus is released.) As the models show, reducing the contact rate even slightly has a major impact on how bad a pandemic will become.

> **History often repeats itself, and influenza pandemics are no exception. The key to dealing with them is for politicians to treat them seriously and not just hope they will go away.**

Risk to the Life Insurance Industry

According to the 2003 ACLI Life Insurers Fact Book, which cites data from 2002, the total net amount at risk in the life insurance industry is $15.5 trillion and statutory surplus is $198 billion. Surplus as a ratio of NAAR is 1.28 percent. Excess mortality, beyond conservative statutory based assumptions of 1.28 percent would bankrupt the industry if it were just one company. This, of course, does not include life insurance benefits designed into a product like a variable annuity. The 1918 pandemic reportedly killed .6 percent of the population and had limited excess mortality at high ages. There appears to have been underreporting of this cause of death in 1918 even in the United States, let alone elsewhere in the world. Even so, the estimate is 5 percent dead worldwide, much higher than in the United States. There are a number of reasons that likely account for this anomaly. Sanitation matters greatly when secondary diseases attack. So does poverty, since it leads to overcrowding.

Each year companies report results such as asset adequacy tests (U.S. regulators) and dynamic capital adequacy tests (OSFI in Canada). These require deterministic scenarios, and most companies include at least one based on higher mortality for life business. Companies should consider the risk to their block if the 1918 influenza pandemic recurs. Even with U.S. data, which is lower than most of the world, the risk to insurers writing mainly group life or other ART-based products is high. Insurers should also stress their counterparty risk. What if the reinsurer pays less than 100 percent and/or the payments are delayed? Can the insurer survive?

This naturally occurring catastrophic risk seems logical to be considered for a government backstop, much as the man-made terrorism payback coverage. Without it, the industry will not survive the next influenza pandemic in its present form. Another possible solution would be to tap into the financial markets. Securitization of mortality risk into a financial instrument, similar to catastrophe bonds, would spread the risk across a diverse group of investors that could absorb a large loss occasionally, if paid for taking the risk in the other years.

History often repeats itself, and influenza pandemics are no exception. The key to dealing with them is for politicians to treat them seriously and not just hope they will go away. Any reductions in contact rate can have major benefits for a region. It likely will take at least one more major outbreak for scientists to get their hands around this disease, but in the future lies hope of treatment and vaccine. In the meantime actuaries should consider various scenarios and determine the expected impact of each. Only through analysis can you determine the interactions between product lines to various levels of mortality and shapes of the mortality curve. It's time to do that analysis. ✦