# Epidemics: Past, Present and Future—What are the Risks?

By Paul Edwards

The uncontrolled, rapid spread of infectious disease still causes alarm in society today. In Medieval times it was called "Pestilence" and perceived as a mythical character firing poisonous arrows on victims as it rode alongside its companions War, Famine and Death. Indeed as epidemics have killed more people in human history than any other cause, it is little wonder it continues to hold such dread in our societal psyche.

Thanks to medical advances, particularly centered on vaccination and antibiotics, combined with efforts to improve the urban environment in the mid-20th century, it seemed that the era of widespread epidemics had passed. Yet, at the start of the 21st century we face a return to that era, made worse by both environmental degradation and overpopulation. In this article we will explore why we are seeing not only the potential return of epidemics from old infectious scourges, but also the emergence of new threats.

Table 1
Historic and recent epidemics/pandemics[1]

| What | When | Where | Deaths |
|---|---|---|---|
| **Black Death** | 1347–51 | Europe | 50,000,000 |
| **HIV** | 1980 | Global | 39,000,000 |
| **Spanish Flu** | 1918–20 | Global | 20,000,000 |
| **Asian Flu** | 1957–61 | Global | 2,000,000 |
| **Seventh cholera pandemic** | 1961 | Global | 570,000 |
| **Swine Flu** | 2009 | Global | 284,000 |
| **Ebola** | 2014 | West Africa | 4,877 |
| **Measles** | 2011 | Congo | 4,555 |
| **SARS** | 2002–3 | Global | 774 |

## MICROBIAL ZOONOSES

Microbial disease is an illness or ailment caused by the introduction or infection with one of four types of microbes, namely (viruses, bacteria, protozoa or fungi). Of the millions of types that exist, only about 1,400 are pathogenic in humans[2] (but critically only 150 have both the capability of human-to-human transmission and the potential to cause epidemics).[3]

The emergence of pathogenic microorganisms appears to be accelerating with an average of three being identified every year.[4] Of all the agents that have been identified since 1980, 60 percent have zoonotic origin, i.e., pathogens that have spread from animals to humans, either as a result of interaction with a carrier or vector (e.g., the mosquito carrying Plasmodium protozoa or rat fleas carrying Yersinia pestis) or as a result of direct contact with the microbe, either through the air (influenza), from bites (rabies) or through contact with contaminated body fluids such as blood.[5] For example, HIV, which is now a purely human disease, probably evolved from a simian counterpart and SARS (Severe Acute Respiratory Syndrome) likely from a palm civet cat virus.

Table 2

An example of human pathogens with animal sources that have emerged since 1945[6]

| Year | Pathogen | Origin |
|---|---|---|
| 1952 | Chikungunya virus | Mosquito |
| 1959 | Zika virus | Mosquito |
| 1977 | Ebola virus | Bats? |
| 1977 | Hantaan virus | Rats |
| 1977 | Legionnaires' disease (Legionella pneumophila) | Unknown |
| 1982 | Lyme disease (Borrelia burgdorferi) | Deer, sheep, cattle, horses, dogs |
| 1983 | HIV | Chimpanzees |
| 1993 | Hanta virus | Deer mouse |
| 1994 | Hendra virus | Fruit bat |
| 1997 | H5N1 flu | Chicken |
| 1999 | Nipah virus | Fruit bat |
| 2002 | SARS | Palm civet cat |
| 2009 | H1N1 flu | Pigs |
| 2012 | MERS | Camels? |

## EPIDEMIC VS. PANDEMIC

In the widest sense of the term, an epidemic is the presence of any disease in a large number of people, hence, for example, diabetes or heart disease can be said to be present in "epidemic proportions." In a stricter sense, however, it means the rapid spread of an infectious disease to a large number of people over a short timeframe.

Epidemics strike when and where microbes find a susceptible group of people to infect and have a means (or "agent") to pass from one person to another. In natural conditions an epidemic usually ends when all possible victims have been infected and either have become immune or, in the most lethal examples, have died. Epidemics can be classified as being "common source" outbreaks where those who get infected do so because they have been exposed to an infectious agent from the same source (e.g., Cholera usually occurs from an infected water supply) or "propagated" outbreaks where the infection passes from one person to another. The latter are the diseases that are perhaps most feared, and transmission can be directly contagious (e.g., through blood or other bodily fluids, touch or breathing in particles), vehicle-borne (e.g., needles) or vector-borne (mosquitos, fleas, etc.).

An epidemic does not necessarily have to cause death to be problematic; for example, while symptomatic infection by the Zika virus causes a relatively mild illness, the major cause for concern with Zika is the effect that it can have on the development of babies during pregnancy.

A pandemic differs only in that the epidemic disease has spread beyond its initial hot zone, i.e., it has become international or even intercontinental. All epidemics display a spectrum of effects—ranging from patients being asymptomatic carriers of infection or displaying mild illness to the extreme of catastrophic disability or fatal disease.

## PATHOGENICITY, VIRULENCE AND INFECTIVITY

The severity of an epidemic's impact is determined by a number of factors, especially how pathogenic or virulent the underlying organism is. This refers to how capable the micro-organism is of making a person ill and in the worst instances it is expressed as the case fatality rate.

In addition, when an epidemic strikes, epidemiologists will try to estimate the size and infective nature of an outbreak. One method for doing this and for monitoring the outbreak over time is to calculate the basic reproduction rate—the R0. This essentially calculates the average number of new people an infected person will spread the disease to. If the R0 is greater than one, it indicates that the number of infected cases will rise, and the higher the number the more contagious the pathogen. If, however, it is less than one, the infection is not sustainable.

While these two measures—virulence and infectivity—overlap, they are not the same thing. You can be infected but not ill. Polio, for example, is highly infectious yet only 5 percent to 10 percent of those infected get clinical disease.

Table 3

The R0 or infectivity of selected diseases[7]

| Disease | R0 |
|---|---|
| **Measles** | 15 |
| **Tuberculosis** | 4–5 |
| **Smallpox** | 3–11 |
| **HIV** | 2–5 |
| **SARS** | 2–4 |
| **Ebola** | 2 |
| **Pandemic Flu** | 1–2 |

## RECENT HISTORY AND WHAT HAS CHANGED

The speed and regularity of new epidemic disease threats that have emerged in the last 25 years is both concerning and, at first glance, bewildering. Of course, in part, this apparent rapid emergence masks successes; these include the ability of modern microbiology to quickly isolate and identify new pathogens and the achievements of the World Health Organization's Global Alert system, which is designed to organize


a rapid response and improve biosafety and biosecurity across the world.

However, other changes have also influenced the risk of epidemics and pandemics in less positive ways. The interconnected fast transportation links of the modern world now facilitate the rapid spread of disease in ways not previously seen. Taking SARS as an example, it spread from China to 17 countries across two continents in a mere week, with one infected individual passing on the disease to 22 of his fellow 119 airline passengers.[8] Contrast this to the Black Death, which took a year to reach England from Italy. [9]

One of the main tools in medicine's arsenal defending against epidemic outbreaks has been immunization against pathogens through vaccination. Vaccines expose the immunized person to a weakened or harmless version of the pathogen and thereby trigger the body's own immune system to create antibodies. However, for a vaccine to be effective, certainly against those diseases which are highly infective, a very large proportion of the population needs to be immunized. This is in order to create "herd immunity" where so many people in a community (or herd) are immune that it affords a degree of protection to those who are not. With measles for example, if 92 percent to 95 percent of a community has been vaccinated, it has a protective effect on infants, the immunocompromised or those born pre-vaccination. The last few decades have seen the rise of "anti-vaxx" movements, often spurred on by perceived infringement of personal liberty caused by compulsory vaccinations or by reports of (usually spurious) serious side effects, e.g., the Measles, Mumps, Rubella (MMR) autism debate. Subsequently, in some countries we have seen outbreaks of disease epidemics, long thought controlled re-emerge, such as the Californian and Italian measles epidemics of 2014 and 2017. [10,11]

Other very important factors are climate change and overpopulation.

The El Niño-Southern Oscillation (ENSO) cycle events in the 1990s and 2000s have triggered severe droughts in the Southern United States, and conversely heavy floods in South America. Consequently, the drought-hit zones have seen explosions in the populations of rodents with the appearance of Hantavirus, while the number of mosquitos in flooded areas has increased with epidemics of Dengue fever.[12]

Mosquito-borne diseases are particularly influenced by weather and climatic patterns, since most require humidity and moderate to warm temperatures to propagate. With global temperatures rising, it is easy to anticipate the spread of different mosquito species; indeed, we have already seen the incidence of Chikungunya and Dengue rise in Europe.[13]

Finally, poverty and overpopulation pressures mean that humans are increasingly moving to areas previously seen as impenetrable wildernesses. As a result of our invasion of new environments we become exposed to microorganisms against which we have little or no immunity. The tropical rainforests of the world are the prime example, and it is from these areas that HIV and Ebola emerged.

Governmental policies at the regional, national or international level can have a positive or detrimental effect in mitigating or worsening these factors. As ever, preventative measures, whether they are offering free mosquito nets, condoms or vaccinations, are much cheaper than the huge efforts required to combat an outbreak once it has started. In the case of Ebola, for example, the economic impact on the three countries effected (Guinea, Liberia and Sierra Leone) has been enormous and is estimated to have caused a reduction in their economies of USD 1.6 billion or 12 percent of GDP, and would require a staggering USD 4.5 billion spend to recover.[14] During the height of the Ebola outbreak of 2015, international contributions to combat the disease were USD 3.6 billion with the two largest contributors being the U.S. (65 percent) and the U.K. (10 percent). It is uncertain whether, following the political tsunamis of 2016 and the rise of more nativist sentiments in these countries and subsequent pressures on international aid budgets, such contributions would be made available again.[15]

## CONCLUSION

The trend in the emergence, or re-emergence, of infectious diseases that could cause epidemics is likely to continue. While an apocalyptic pandemic causing millions of deaths is unlikely, one causing widespread disease inflicting deaths in the thousands is more probable. Indeed, reinsurers do "price" for such events in their reinsurance rates. As an industry, we need to be vigilant in monitoring this risk and ensure that guidance to underwriters is clear and up to date. At Hannover Re, as a global reinsurer with a variety of underwriting manuals and tools at our disposal, we stand ready to assist our clients in this regard. ■

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### ENDNOTES

1 See BENFIELD, E. & TREAT, J: As Ebola death toll rises, remembering history's worst epidemics. National Geographic, October 25 2014.

2 See HOWARD, C.R & FLETCHER, N.F.: Emerging virus diseases: can we ever expect the unexpected? Emerging Microbes & Infections (2012) 1, e46; doi:10.1038/emi.2012.47

3 See WOOLHOUSE, M., & GAUNT, E: Ecological origins of novel human pathogens. Crit Rev Microbiol. 2007; 33(4):231–42.

4 See MORSE, S.S., ET AL: Prediction and prevention of the next pandemic zoonosis. Lancet 2012; 380: 1956–65

5 See KARESH, W.B ET AL: Ecology of zoonoses: natural and unnatural histories. Lancet 2012; 380; 1936–45

6 See CRAWFORD, D.H.: Deadly companions: How microbes shaped our history. 2007 Oxford University Press

7 See LAMB, E.: Understand the measles outbreak with this one weird number. The basic reproduction number and why it matters. Scientific American on January 31, 2015

8 See HOWARD, C.R & FLETCHER, N.F.: Emerging virus diseases: can we ever expect the unexpected? Emerging Microbes & Infections (2012) 1, e46; doi:10.1038/emi.2012.47

9 See CRAWFORD, D.H.: Deadly companions: How microbes shaped our history. 2007 Oxford University Press

10 See THE GUARDIAN, 17th March 2015, California measles outbreak fuelled by parents who failed to vaccinate children – study

11 See THE GUARDIAN, 19th April 2017 Italy experiencing measles epidemic after fall-off in vaccinations

12 See HOWARD, C.R & FLETCHER, N.F.: Emerging virus diseases: can we ever expect the unexpected? Emerging Microbes & Infections (2012) 1, e46; doi:10.1038/emi.2012.47

13 See EUROPEAN CENTRE FOR DISEASE PREVENTION AND CONTROL: Mosquito borne diseases in Europe, Retrieved February 8 2017 from: http://ecdc.europa.eu/en/healthtopics/vectors/infographics/Pages/infographic-mosquito-borne-diseases-in-Europe.aspx

14 See MULLAN, ZOE, Editorial - The cost of Ebola, July 9, 2015, 15: 825-32

15 See CDC - Cost of the Ebola epidemic Retrieved July 17, 2017, *http://www.cdc.gov/vhf/ebola/outbreaks/2014-west-africa/cost-of-ebola.html*

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