



We are seeing not only the potential return of epidemics from old infectious scourges but also the emergence of new threats.

Epidemics: past, present and future – what are the risks?

Did you know?

150

Of millions of microbes in existence only this many have the capacity to trigger a human to human epidemic.

Epidemics of infectious disease have killed more humans in history than any other cause; it is little wonder, then, that Pestilence (War, Famine and Death being the others) is considered the worst of the four dreaded horsemen of the apocalypse. Thanks to medical advances, particularly centred 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 explore why we are seeing not only the potential return of epidemics from old infectious scourges but also the emergence of new threats.

Microbial zoonoses

Microbial disease is an illness or ailment caused by the introduction or infection with one of four types of microbes (viruses, bacteria, protozoa or fungi). Of the millions of types that exist, only about 1,400 are pathogenic in humans¹ (but critically only 150 have both the capability of human-to-human transmission and the potential to cause epidemics)².

The emergence of pathogenic microorganisms appears to be accelerating with an average of 3 being identified every year³. Of all the agents that have been identified since 1980, 60% 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 blood⁴. 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.

¹ 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

² See WOOLHOUSE, M., & GAUNT, E: Ecological origins of novel human pathogens. *Crit Rev Microbiol.* 2007; 33(4):231–42.

³ See MORSE, S.S., ET AL: Prediction and prevention of the next pandemic zoonosis. *Lancet* 2012; 380: 1956–65

⁴ See KARESH, W.B ET AL: Ecology of zoonoses: natural and unnatural histories. *Lancet* 2012; 380; 1936–45.

Table 1: Historic and recent epidemics/pandemics⁵

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

Table 2: An example of human pathogens with animal sources that have emerged since 1945⁶

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?

⁵ See BENFIELD, E. & TREAT, J.: As Ebola death toll rises, remembering history's worst epidemics. National Geographic, October 25 2014.

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

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 (an 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 body 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 (but carriers) 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 including how pathogenic or virulent the underlying organism is. This refers to how capable the microorganism 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 R_0 . This essentially calculates the average number of new people an infected person will spread the disease to. If the R_0 is greater than 1 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 1 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 5–10% of those infected get clinical disease.

Table 3: The R_0 or infectivity of selected diseases⁷

Disease	R_0
Measles	15
Tuberculosis	4–5
Smallpox	3–11
HIV	2–5
SARS	2–4
Ebola	2
Pandemic Flu	1–2

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

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 organise 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 never before seen in human history. Take SARS, for 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 passengers⁸. Contrast this to the Black Death, which took a year to reach England from Italy⁹. 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 fever¹⁰.

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 Europe¹¹.

⁸ See Howard & Fletcher

⁹ See Crawford

¹⁰ See Howard & Fletcher

¹¹ 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>

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.

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.

Contact



Paul Edwards

Manager, Medical Risk Research
Tel. + 44 20 3206-1736
paul.edwards@hannover-re.com

Sources

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

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

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>

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

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

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

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

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