ANALYSIS ON THE RISK OF EBOLA

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This paper has been produced by Health Committee of the IAA and has been approved by that committee.

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This is an analysis on an evaluation of the mortality and morbidity risk of Ebola to life and health insurance companies[1]. The actuarial profession has played an active role in developing models and advising on the impact of epidemics on mortality and morbidity risks, particularly in the context of the HIV/AIDS epidemic in the 1980s and beyond. Whilst this does not go into the same level of detail or sophistication, the aim of this high-level analysis is to assist actuaries working for or consulting with life or health insurance companies on evaluating the risk of an Ebola epidemic to their companies or clients. It is for information purposes only: the principles set out here are meant to be general and high level, and should not be regarded as actuarial advice. Every actuary should determine whether these principles are applicable to their specific circumstances.

What is Ebola?

The Ebola virus disease, or simply Ebola, is a severe and often fatal disease in humans. The virus is transmitted to people from wild animals, such as fruit bats. Ebola then spreads through human-to-human transmission via direct contact (through broken skin or mucous membranes) with the blood, secretions, other bodily fluids or organs of infected people, and with surfaces and materials (e.g., bedding, clothing) contaminated with these fluids [1]. Quarantine is usually effective in interrupting or decreasing the spread of the disease [2].

The time from virus transmission to the onset of illness (incubation period) is two to 21 days with an average of eight to 10 days [3]. Humans are not infectious until they develop symptoms. The usual initial symptoms are the sudden onset of fever, fatigue, muscle pain, headache and a sore throat. This is followed by vomiting, diarrhoea, a rash, symptoms of impaired kidney and liver function, and in some cases both internal and external bleeding [1].

Symptoms of Ebola are treated as they appear. The following basic interventions, when used early, can significantly improve the chances of survival:

- Providing oral rehydration solutions or intravenous fluids and balancing electrolytes;
- Maintaining oxygen status and blood pressure; and
- Treating other infections if they occur.

If the infected person does not recover, death due to multiple organ dysfunction syndrome occurs within seven to 16 days (usually between days 8 and 9) after first symptoms [4]. The death rate for past epidemics have been estimated at between 25% and 90% [1].

Experimental vaccines and treatments for Ebola are under development, but they are still being tested for safety or effectiveness. Recovery from Ebola depends on good supportive care and the patient’s immune response. People who recover from Ebola infection develop antibodies that last for at least 10 years, possibly longer. It isn’t known if people who recover are immune for life or if they can become infected with a different species of Ebola [5].

[1] We do not attempt, in this note, to evaluate the economic and social impact of a potential Ebola epidemic, or any other aspects not related to morbidity and mortality risks, such as the possibility of medical malpractice liabilities.

The 2014 West African Outbreak

Cases of Ebola were first reported in 2014 in the West African country of Guinea. This has subsequently spread to the neighbouring countries of Liberia and Sierra Leone. As of January 11, 2015, there were 13.460 confirmed laboratory cases reported with 8,429 associated deaths. This puts the current average death rate for this epidemic at 62%. This is the largest outbreak in history [6]. There have also been infections of local and foreign healthcare workers during the epidemic.

There are several factors that have contributed to the spread of the virus in West Africa [7]:

- The countries where the outbreak has spread are some of the poorest in the world. Consequently they have very weak health systems lacking basic healthcare infrastructure and supplies such as running water, hand hygiene products, gloves, and other protective equipment. Fear of the virus has resulted in an exodus of healthcare workers with few returning to continue to care for infected patients.
- Traditional burial rituals are believed to be responsible for a large part of infections, as much as 60% in Guinea, for example [8]. In many of these societies customs dictate that embalming occurs at home. This leads to further infections as family members and other caregivers often come into contact with bodily fluids of the deceased that are highly infectious.
- Fear and mistrust of government officials and healthcare workers also play a major role. Officials were also unaware of the potential scale of an outbreak.

The spread has initially continued, given the difficulty of achieving effective quarantine and treatment of infected individuals. However, over the last couple of months, the bed capacity has increased dramatically in the most affected countries (Liberia and Sierra Leone) along with improved contact tracing and case finding.

Ebola in other countries

It is not certain if and how the Ebola virus could spread to other countries. There have been isolated cases of infected individuals travelling from West Africa to the United States and Europe while still asymptomatic or not being detected by the screening systems in place. A similar situation could occur in other countries.

Many countries have better public health infrastructure than the West African countries currently affected, and in many of those, infected patients would not be treated in private facilities but in public highly-specialized settings. Where health insurers operate, their liabilities in respect of such treatments may vary. The extent of any outbreak in a country is dependent on the number of infected individuals that cross its borders and also the speed of outbreak control. This is achieved by moving patients who are being attended to at home, with no effective isolation, to isolation wards in hospitals to ensure that there is a reduced risk of disease transmission.

In countries not affected yet, government departments of health would typically have implemented the following interventions to contain the risks:

- Advice on travel restrictions to affected countries for all citizens;
- Travel restrictions for foreigners from affected countries;
- Local financial support to affected countries;
- Assistance with setting up testing laboratories in affected countries;

- Setting up isolation facilities;
- Training of laboratory staff in affected countries; and
- Supporting volunteer programmes for healthcare workers to support affected countries.

There are typically further internal control plans implemented by individual countries, such as:

1. Entry screening for all international travellers entering the country at all international airports.
    a. Any suspicious cases (based on specific clinical risk criteria) are further screened, and passage into the country is managed by government.
    b. Governments would co-ordinate the transfer and care required by each individual patient.
2. All public health facilities and (possibly) private hospital facilities will have been tasked to appoint designated areas where patients would be admitted.
    a. This would include design and development of standard operating procedures for identification (triage), isolation and treatment, and designated trained staff to look after such patients; and
    b. Inter-hospital transfer of patients would have to be authorized by the relevant government body.
3. Each suspected, probable and confirmed case of Ebola would be reportable to government authorities (i.e., it would be classified as a notifiable condition).

Countries with similar national response plans would be better placed to contain the epidemic to focal areas and prevent widespread dissemination. Governments would be careful with widespread communication, and would attempt to inform the public adequately without causing panic.

The private sector might be expected to:

- Collaborate with governments for the national preparedness and response plan; and
- Provide financial support.

There may be a role for insurers to play in this.

Modelling the impact on an insurer

It is possible to do modelling to determine the expected impact of Ebola on an insurer. A company could develop a multi-state model and feed in assumptions on transitional probabilities and mortality rates based on available information—although data and information on this are scarce. (See the appendix for a short summary on a potential modelling approach.)

In general, it is worth pointing out that Ebola, as an epidemic, has the general form of high mortality rates and low transmission probabilities. Because of the lower transmission probabilities such an epidemic is typically therefore easier to contain, and typically has a less significant population mortality impact than an epidemic with lower mortality rates and higher transmission probabilities, such as a full-blown avian flu epidemic.

The result is that even if the actuary makes extreme assumptions about herd immunity[2], and large influxes of Ebola positive people into a country, the modelling will typically not indicate an extreme population impact.

For actuaries working in countries where there are good national preparations for Ebola, as mentioned above, the results of the multi-state model would typically indicate that the risk to an insurer is fairly limited.

In general, for any health insurer offering some form of medical expense insurance, there are two mitigating factors even in the case of a widespread epidemic:

- There would typically be limited private hospital capacity to isolate patients, which means that insurers typically won't be liable for most of the costs[3], as governments would step in to isolate and treat patients.
- If there is an epidemic, hospital admission rates will most likely decrease dramatically. This is because everyone who can, will postpone any form of elective surgery until the epidemic has passed. In short, no-one would want to be in hospital due to the perceived risk of contracting Ebola, and would only go if they cannot postpone their admission.

For a life insurer, of course, a general widespread epidemic would have big implications. For the reasons set out above, and for actuaries working outside of the currently affected regions, actuaries may consider whether there are grounds for a view different from the one that the likelihood of a widespread Ebola epidemic is low. It also seems as if some progress is being made in bringing the epidemic under control in West Africa.

We would welcome any comments or suggestions on this analysis. Please send them to Karla Zuniga at karla.zuniga@actuaries.org.

[2] The probability of a virus encountering a susceptible host, propagating the infection and sustaining a pandemic depends on the proportion of susceptible hosts in the herd (or population). As the pandemic passes through successive hosts leaving them immune, progressively higher proportions of the population become immune to the virus, and the pandemic subsides and eventually ceases (this is herd immunity). The proportion required to reduce susceptibility to a level where a pandemic cannot be sustained depends on many factors, such as the properties of the population (e.g., whether vaccinations are available), the environment (e.g., factors encouraging or preventing transmission) and the virus itself (e.g., transmissibility and virulence).

[3] This is the case in countries where private medical expense insurance covers treatment in private hospital facilities, and not in public facilities. In the US, for instance, insurers may well be liable as most care is provided in private facilities. However, some insurance policies may exclude costs associated with widespread epidemics. In other countries, insurers will carry some liability for treatment in public facilities. Even where some of the treatment does occur in a private facility, some of the costs, such as the preparation of isolation wards, the cost of protective clothing, and so on, may also not be for the account of the insurer. Of course, in the case of HMOs, the insurer may be liable. Actuaries should consider the circumstances pertaining to the insurance contracts that they advise on.

References

1. World Health Organization. Ebola virus disease.

2. Sompayrac, Lauren. *How Pathogenic Viruses Work*. Boston: Jones and Bartlett Publishers. 2002.

3. Centers for Disease Control and Prevention. Ebola signs and symptoms.

4. Simpson, D. I. H. Marburg and Ebola Virus Infections: A Guide for Their Diagnosis, Management, and Control. WHO Offset Publication No. 36. 1977.

5. Centers for Disease Control and Prevention. Ebola treatment.

6. Centers for Disease Control and Prevention. 2014 Ebola outbreak in West Africa: Case Counts.

7. Sun, L., B. Dennis, et al. "Out of Control". *The Washington Post*. October 4, 2014.

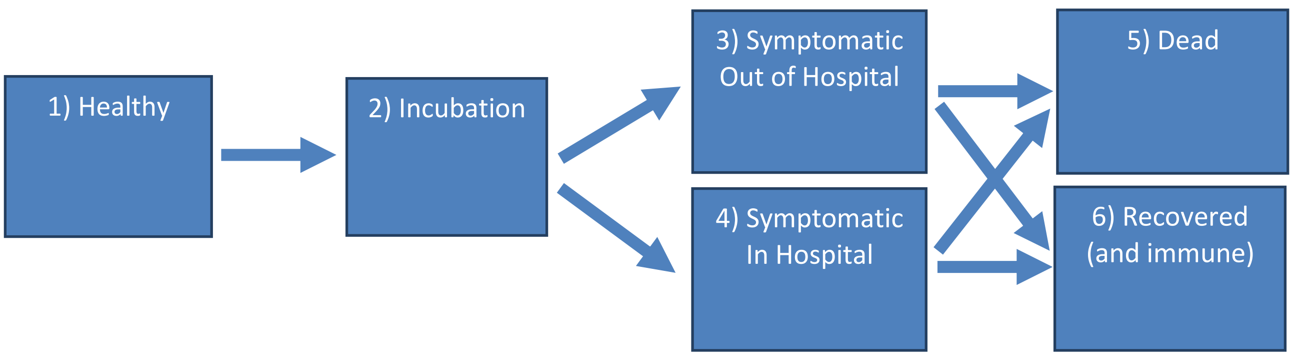
8. Chan, M. "Ebola Virus Disease in West Africa—No Early End to the Outbreak". *The New England Journal of Medicine*. August 20, 2014.

Appendix – An Approach to Modelling the Potential Impact of Ebola

An example of a simple model for evaluating the potential impact of Ebola in a particular country is described in this appendix. Several simplifying assumptions are made – more complex models, not relying on such simplifying assumptions, are possible. However, very little is known about transition probabilities in different countries and different contexts, and hence a more practical and simpler model would probably be sufficient for most actuaries.

A Markov chain can be used to construct an epidemic model, which represents the epidemic by calculating the probability that a person in a given population is in one of six states in a given week. Weekly intervals are appropriate as incubation lasts roughly one week, with symptoms and death occurring in the following two weeks.

This can be represented by the following diagram:



The fundamental structure of this epidemic model is that movement occurs only in one direction. A person can only stay in their current state or move forward to the next state. This means that the following implicit assumptions are made for the purposes of simplifying the model:

- Death can only happen due to Ebola, and not due to other causes.
- All persons infected will show symptoms of the virus.
- No reinfection occurs should a person recover from Ebola. This does seem to be confirmed by the medical literature – please see below for further detail on this assumption. Also, it is assumed that once a person has fully recovered from the disease, they are not able to infect others.
- Patients are only infectious once symptomatic.

As mentioned at the outset, this is a model with several simplifying assumptions. For instance, a person may in practice transfer from state 3 to 4 if he/she has symptoms and does not seek treatment at a hospital immediately, and only gets admitted later. A separate transition matrix may be needed to take into account different transmission probabilities for people who are quarantined versus those who are not, depending on the relevant conditions and capacity in the local healthcare sector. In practice, it may also be necessary to update the model and particularly the transition probabilities regularly, as more data emerges on the epidemic.

Population vector

The population vector contains the state of the population at the start of the epidemic. At the outset it is assumed that there are no cases reported in a particular country. Therefore this vector represents 100% of the population in the Healthy State 1.

$$\begin{array}{cccccc} 1 & 2 & 3 & 4 & 5 & 6 \\ \end{array}$$
$$[\,1 , 0 , 0 , 0 , 0 , 0\,]$$

Probability matrix

A probability matrix is then constructed to govern the movement between the six states. The columns represent the state at the start of each week. Different scenarios should be modelled, using different transition probabilities – not much is known about probabilities of infection, time of incubation, and probabilities of recovery and death in, for instance, developed countries.

	1) Uninfected	2) Incubation	3) OH Infectious	4) IH Infectious	5) Recovered	6) Dead
1) Uninfected	1-A	A	0%	0%	0%	0%
2) Incubation	0%	0%	B	1-B	0%	0%
3) OH Infectious	0%	0%	50%	0%	10%	40%
4) IH Infectious	0%	0%	0%	50%	40%	10%
5) Recovered	0%	0%	0%	0%	100%	0%
6) Dead	0%	0%	0%	0%	0%	100%

Some points to note about this particular matrix are:

- It represents the likelihood that a healthy person is infected in a given week. This is one of the main assumptions to vary for different scenarios. A is dependent on the initial number of infections in the population and the number of persons hospitalized. For instance, an actuary may assume that, on average, a hospitalized person who is effectively isolated is likely to transmit the virus to 0.12 people and a person not quarantined will transmit it to 1. people [9]. (This is just one example of assumptions based on a specific case – other assumptions may well be justified.)
- B is the likelihood that an infected person is not admitted to hospital. This is a key factor in determining the likelihood of successfully containing the epidemic.
- For simplification, it is assumed that patients infected are either hospitalized when showing symptoms, or not hospitalized at all. There is no movement modelled between OH and IH infectious states in this particular model.
- Infected individuals are likely to remain in treatment (IH or OH) for another week 50% of the time.
- In this model, the probability of moving from State 3: OH Infectious to State 6: Dead is 40% in a given week. Over two weeks this amounts to mortality of 64%, which is within the range of mortality rates observed in past Ebola outbreaks.
- The model thus simulates death after one or two weeks of infection.
- In this model, designed for a country with high-quality hospitalization services, mortality is reduced once a person is hospitalized but it is not eliminated completely. The

assumption in the above model is 10% mortality per week. This is difficult to verify as very few patients have been treated in hospitals in developed countries.

- The recovery and death states are terminal states. Upon recovery, after 90 days of testing negative, it is accepted that a person has recovered completely and that they would not continue to infect others. They will also not be re-infected again themselves.

By varying the above assumptions, different scenarios can be constructed, indicating a range of possible outcomes.

Reference:

9. Centers for Disease Control and Prevention. Estimating the Future Number of Cases in the Ebola Epidemic—Liberia and Sierra Leone, 2014–2015. Morbidity and Mortality Weekly Report, September 26, 2014.