Government
Office for Science

Emerging Infectious Diseases Guidance Note

Purpose

This document is intended to assist the Government Chief Scientific Adviser (GCSA) and the Scientific Advisory Group for Emergencies (SAGE) during the 'golden hour' of an emergency involving an emerging infectious disease.

During the early phases of an emerging disease outbreak there may be a lack of information on many key issues. Not every question can be answered at the start of an outbreak but they should still be asked.

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The attached annexes focus on the different modes of transmissions. This document includes:

- A brief introduction to emerging infectious diseases
- A list of the initial impacts that could result
- Key questions and contact details of experts at relevant science agencies

Emerging Infectious Diseases

Infectious diseases are caused by pathogenic microorganisms (a microorganism capable of harming its host) including bacteria, viruses, fungi and protozoa. They can take a variety of forms and their impacts will vary considerably. In general, with the possible exception of malaria, epidemics important enough to merit a SAGE will be viruses, or occasionally bacteria.

An emerging infectious disease is a disease that has recently been recognised, or an existing disease which has spread geographically or caused an increase in cases over the last 20 years. An emerging disease may be: completely novel (it has newly jumped the species barrier from animals to humans), or it may be a known disease behaving in unexpected ways (appearing ~~moving into~~ in a new territory, such as ~~did~~ ~~like~~ Ebola in West Africa in 2013, or a bacteria becoming drug-resistant, for example). Emerging infectious diseases of note in the last few decades include Zika, Ebola, SARS, MERS, Monkeypox, ~~HIV~~, multidrug-resistant tuberculosis, and new strains of influenza.

An emerging disease is most likely to be zoonotic in origin (a disease that normally exists in animals but can infect humans), moving from an animal reservoir to humans through direct or indirect contact, usually in rural areas where the population may have more frequent exposures to animals. Often, humans are dead-end hosts (or 'incidental' hosts), meaning they cannot pass the pathogen to other susceptible hosts (and therefore do not play a role in continuing the transmission cycle). Occasionally, zoonotic pathogens can recombine or mutate ~~within a human~~ and can subsequently become a novel strain which primarily affect humans. This facilitates further spread amongst human populations ~~(facultative zoonoses),~~ and could potentially result in ~~leading to~~ epidemics or pandemics. For example, H1N1 influenza, ~~Ebola, MERS~~ and SARS ~~all~~ both originated in animals before spreading rapidly amongst human populations.

Novel ~~diseases~~ pathogens can often be virulent and have a high case fatality rate (15% for SARS, and 50% for Ebola) due in part to the lack of natural immunity within affected human populations, and that new diseases tend to attenuate over time. Emerging zoonotic diseases are most likely to become established in human populations in rural areas outside of the UK. However, globalised transport networks can rapidly propagate the disease. For example, the SARS index case occurred in November 2002. WHO was notified in February 2003 of an unknown contagious disease. A month later, SARS had spread to 19 countries in Asia, Europe, North America and Australasia.

There are several elements of an infectious epidemic which are needed to understand its likely course and possible countermeasures, but probably the most important is the route of transmission. ~~Broadly there are 5/6~~. Most infections have a primary route of transmission~~,~~ and may also have a secondary ~~one~~route. ~~These~~ Routes of transmission are, with an example of a recent epidemic:

1) Airborne. Influenza H1N1.
2) ~~Touch~~Contact. Ebola.
3) Vector-borne (mosquitoes, ticks, midges etc). Zika.
4) Sexual. HIV
5) Faecal~~e~~-oral (ingestion). Drug-resistant typhoid.
6) Bloodborne. Hepatitis C.

Examples of a primary and secondary routes are: HIV (sexual, bloodborne); plague (vector, airborne), influenza (airborne, ~~touch~~contact), Zika (vector, sexual).

Once the route of transmission is known a countermeasure can be designed.~~ For example, isolation worked for Ebola (touch) but would have almost no impact on HIV or influenza.~~

Useful definitions

Outbreaks: a sudden increase in the number of cases of a disease within a particular localised setting or community, beyond the number of cases which may typically be expected in that community at that point in time.
Example: 200 cases of influenza in a single school in winter over two weeks. Based on previous years, typical incidence for that school for the same period is 30 cases.

Epidemics: an increase in the number of cases over a region or country, above the number of cases normally expected in that region or country at the same point in time.
Example: 2014 West African Ebola epidemic. Occurred primarily in Guinea, Sierra Leone and Liberia~~, but did not successfully reach other regions in Africa or transcend continental boundaries~~ with linked cases in other African countries, Spain and the United States of America (USA).

Note that outbreak and epidemic are sometimes used interchangeably.

Pandemics: epidemics which occur over a very large area of the globe, usually transcending continental boundaries.
Example: 1918 influenza pandemic. Spread across the globe, resulting in at least ~~n estimated 20-~~50 million deaths. Also SARS, H1N1

Reproductive number (R0) is the number of secondary cases caused on average by a single primary case, in an entirely susceptible population. By definition an expanding epidemic has R of over 1; getting R below 1 is a key outcome for most outbreaks and epidemics.

Effective reproductive number (R) is the number of secondary cases caused on average by a single primary case, in a population of susceptible and non-susceptible people. As a population will rarely be entirely susceptible, *R* is often of more practical applicability than *R0*.

Incubation period is the time between exposure and symptom onset. Some diseases can be contagious during the incubation period (eg influenza); this makes control less easy.

Serial interval, or *generation interval*, is the time between symptom onset in a primary case and onset in a secondary case. It may sometimes be used to refer to the time between infection of a primary case and secondary case. It's useful in indicating the rate of spread.

Add latency as for HIV?

How outbreaks and epidemics work

Each emerging disease epidemic will vary based on the specific disease. N epidemic ~~A typical emerging infectious disease epidemic may follow the~~ In the case of SARS~~epidemiology of a coronavirus (a~~ acoronavirus ~~species~~ which affects the respiratory tract and is~~are~~ spread by droplet transmission) ~~like MERS-CoV and SARS. SARS was spread~~ it is spread through inhaling large contaminated respiratory droplets or touching a surface where droplets have landed. It may also be airborne.

The **incubation period** (the time between exposure and symptom onset) for SARS was 2 to 7 days, which is typical of many diseases. Influenza has a shorter incubation period, between 1 and 3 days. SARS is not contagious during the incubation period, but some diseases are, which will make identifying contagious cases and preventing spread considerably harder.

The **serial interval** (the time between symptom onset in a primary case to onset in a secondary case) of SARS was 8.5 days. The serial interval may be taken as indicative of the rate of spread. If the effective reproduction number (*R*) [the average number of secondary cases per primary case in a population of susceptible and non-susceptible people] is greater than 1, the number of cases will increase over time and, without effective mitigation, an epidemic may occur. *R* can be calculated using contact tracing, which identifies all persons a probable or confirmed case has had close contact with during the period of infection.

In the early stage of the SARS pandemic, *R* was 3 across affected countries, and decreased to 0.7 following implementation of control measures, except in Canada. Modelling work suggests the efficacy of mitigation strategies in reducing *R* is highly dependent on the timing of implementation; a one week delay was found to increase the epidemic size by a factor of 2.6, and prolong the duration of the epidemic by a month.

SARS originated in China, likely from close contact with bats. Globalised transport networks meant it spread in rural China before reaching Hong Kong, whereby it was transferred to Vietnam, Singapore and Canada. The ease of spread was facilitated by late notification and lack of awareness, which subsequently led to an absence of screening at major transport hubs during the early stages of the pandemic.

Consequences

The range and scale of the consequences of emerging infectious diseases will be dependent on the type of disease, its mechanism of spread, speed of spread, its virulence and its contagiousness. Highly contagious and virulent emerging diseases may lead to a large number of cases, rapid spread, and a high case fatality rate. A case fatality rate (CFR) over 10% may be considered 'high'. SARS had an estimated CFR of 15% ~~in Hong Kong, 14% in Singapore, and between 15 and~~ to 19%~~ in Canada~~. Ebola has~~d~~ a CFR of 50%. CFR also changes between age cohorts. The CFR of SARS in those aged below 24 years was 1%, compared to 15% in those aged 45-64 years, and over 50% in those aged above 65 years. ~~Ebola had a CFR of over 60% and~~ HIV pre-treatment era of 100%.

Health Impacts: Health outcomes can range from being asymptomatic, to severe illness or death. Different demographics will be more affected than others; the very old, young or immunocompromised are usually most at risk. There is often a lack of vaccine or treatment ~~remedy~~ for emerging infectious diseases which may increase the severity of an outbreak.

Economic costs: Epidemics and pandemics can lead to substantial economic costs due to travel disruption and behavioural responses. For instance, only 8,098 people worldwide were infected with SARS, of whom ~~ich~~ 744 died, yet the cost to the global economy was between $30-100 billion. The World Bank estimates that if a global pandemic lasted over a year it could trigger a major global recession. A pandemic similar to the 1918 influenza pandemic could cost over US$3 trillion, and cut global economic output by 4.8%.

Behavioural responses: Public perception of infectious disease risk is often greater than actual risk. During the 2014 Ebola epidemic, a RAND survey found that almost 17% of Americans felt they were more than 10% likely to contract Ebola, and a further 17% felt they were between 2% and 10% likely. In total, there were four laboratory-confirmed cases diagnosed within the USA, of which two were imported from an affected country, and two were healthcare workers in direct contact with ~~an index~~ one of the imported cases. ~~, two returned from affected countries~~.

There is evidence to suggest that the case fatality rate, transmission mechanism, symptoms, lack of treatment or prevention options, and sudden increases in prevalence all affect the level of panic within a society undergoing, or at risk of, an epidemic or pandemic. Civil panic is likely to be substantial if a likely outcome is death or disablement, there is no effective vaccine or treatment option, or if prevalence in affected areas is high. Additionally, societies often fear diseases which are spread via airborne transmission or close-contact with cases (e.g. droplet transmission), for which they feel a lack of control over the point of exposure, which is not felt for other transmission mechanisms (e.g. sexual transmission). People have been shown to exhibit greater avoidant behaviour during epidemics, and there is likely to be school and workforce absenteeism. Businesses and schools may consider closing~~e~~ as a response to any suspected severe epidemic. Prompt scientific advice is necessary to support individuals~~, and~~ businesses and other service providers to make informed decisions in response to an epidemic.

Service Infrastructure: Transportation can both act as a facilitator of spread and be disrupted by epidemics, and especially pandemics. Transport can catalyse geographic spread, with cases travelling during the incubation period. Cases with no noticeable symptoms at the time of travel are unlikely to be detected by symptom-based screening mechanisms. SARS was able to reach 32 countries after reaching Hong Kong, due to air transport. Freight disruption can lead to substantial economic costs.

Key Questions

During the early phases of an emerging disease outbreak there may be a lack of information on many key issues. Not every question can be answered at the start of an outbreak but they should still be asked.

- What are the symptoms?
- What is the transmission mechanism/route
- How virulent is the disease? What is the case fatality rate?
- What is the R and R0 value?
- What are the treatment options and how might they mitigate spread?
- Is there a known preventive countermeasure like a vaccine?
- When does a confirmed case start and stop being infectious?
- What is the incubation period and serial interval?
- Demographics of probable cases.
- What is the current geographical spread of the outbreak?

- If vector-borne, what is the vector? What is the ecology of the vector?
- Can we model how the disease might spread?
- What does the epidemic curve look like?

Contacts

PHE:

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