Understanding Epidemics
Section 1: The basics

PART B: Epidemic Wave

Contents:

What is an epidemic wave?

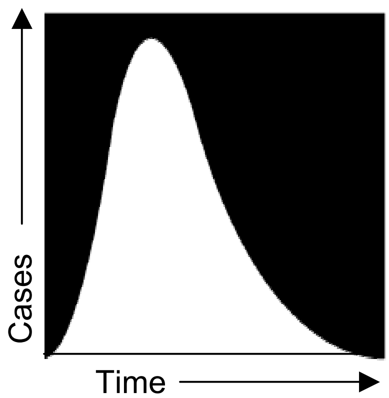
Think of a Mexican Wave created by spectators at a football match standing up and sitting back down again in unison and in sequence.

The effect is dramatic, but it does require the behaviour of individuals to be ordered in time and space. When and where are critical.

This is true for epidemics too.

An epidemic wave is a graph which traces the development of an epidemic over time and/or space.

To keep matters simple, let us begin by focusing on just the temporal dimension (time). The epidemic wave below plots new cases against time.



During an epidemic the number of new cases (infected individuals) increases rapidly to a peak and then falls more gradually until the epidemic is over.

Origins of the epidemic wave.

In the nineteenth century statisticians and medical scientists began to look for patterns and order in their data on epidemics. They noticed some distinct regularities.

One likened what he found to 'the waves on an enriged sea'.

This idea of an epidemic wave has proved to be particularly useful. Not only does it help to describe accurately the number of individuals who have been infected by the disease in question (new reported cases), but it also offers the possibility that the course of the epidemic may be predicted (when it will peak and when it will return to the original level, for example).

For this reason scientists drawn from many disciplines such as biology and mathematics, and not just specialist epidemiologists, have become interested in the subject.

South Pacific island case study

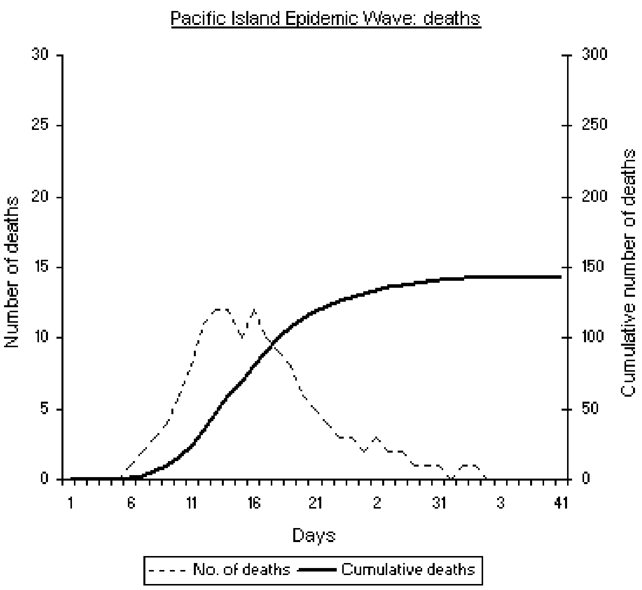
Suppose that we live on a beautiful, but small (population 400) and very isolated South Pacific island. One day a ship arrives bringing a new infectious disease previously unknown to the islanders.

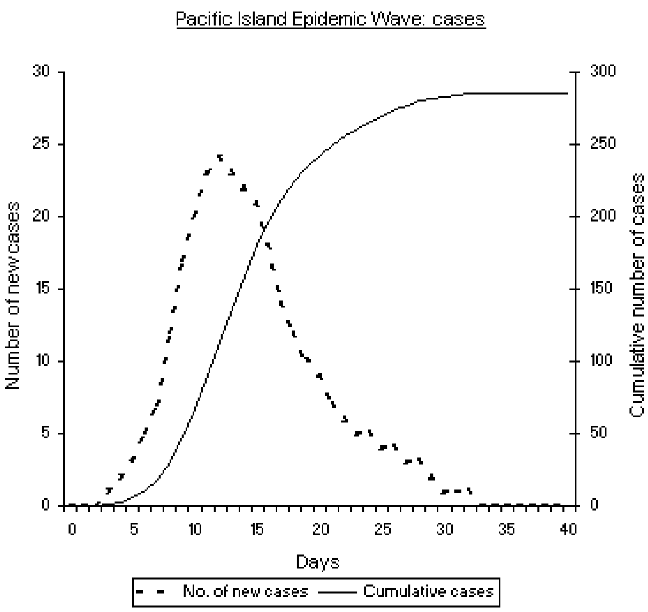
Infection of the susceptible population (those not previously infected by the disease) takes place rapidly and, because the incubation period for the disease is short, islanders quickly begin to infect each other.

Pacific Island epidemic wave

Of the 400 islanders 71% contract the disease and the death rate is 36%.

The graphs below show the epidemic waves for our island.





The graph on the left shows how the number of new cases (people infected by the disease) rises to a peak and then gradually falls off until the epidemics is over.

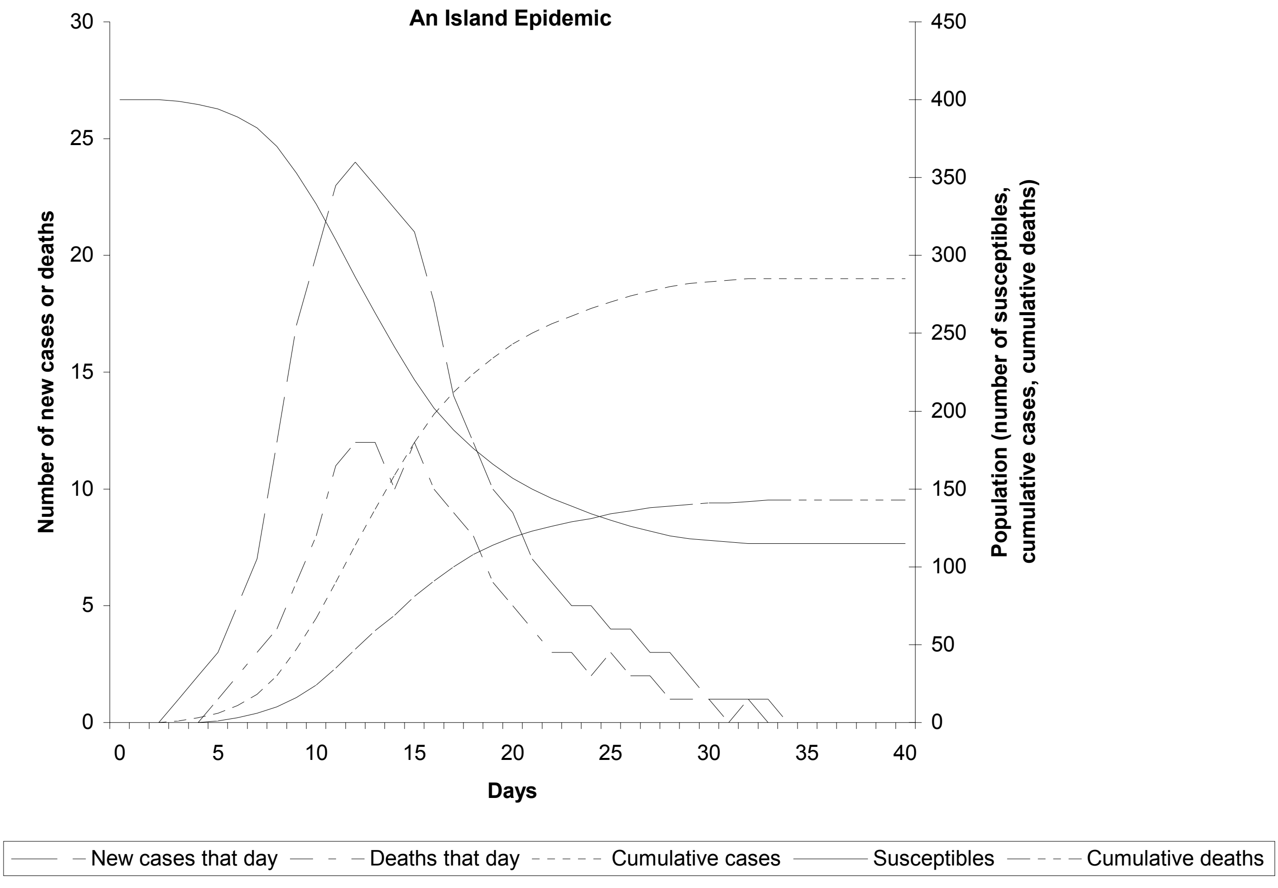
The graph on the right shows how the same happens for the number of people who die from the disease each day

The epidemic is over when there are no more new cases and no more reported deaths.

Time is shown along the horizontal (x axis) of each graph, and the number of new cases or deaths on the vertical (y) axis.

As well as this, both graphs have a second vertical (yy) axis which is on the right of each graph. These axes are used to show the cumulative (that is the total so far) number of deaths or new cases.

The graph below shows this data on the same graph and also has a line which shows the number of susceptibles (people who haven't caught the disease).



Explanation of the different lines on the graph:

New cases that day: This line shows the number of new cases per day. Read the number from the y-axis on the left. It rises at first, then falls as the number of susceptible people falls off meaning there are no new people to be infected.

Deaths that day: This line plots the number of deaths that day. Read the number from the y-axis on the left. Note how it follows roughly the same shape as the number of new cases, but is slightly less as not everyone who is infected will die. It also starts and ends after the new cases line as there is a time delay between infection and death. This will vary according to disease.

Cumulative cases: This line plots the cumulative number of cases. Read the number from the yy-axis on the right hand side. This is the total number of cases so far - i.e. if you add the new cases per day you will get the cumulative number of cases. As the cumulative number of cases rises, note how the number of susceptibles falls. As more people contract the disease, there are fewer susceptible people left who have not been infected.

Susceptibles: This line shows the number of susceptibles. Read the number from the yy-axis on the right hand side. The number of susceptibles is the number of people who could catch the disease but who haven't been infected. As our island's population is 400, the number of susceptibles at the beginning is 400. As the number of people who are infected increases, the number of those left uninfected (susceptibles) falls. The final number of susceptibles is 115. This means that 115 of our 400 islanders were not infected by the disease.

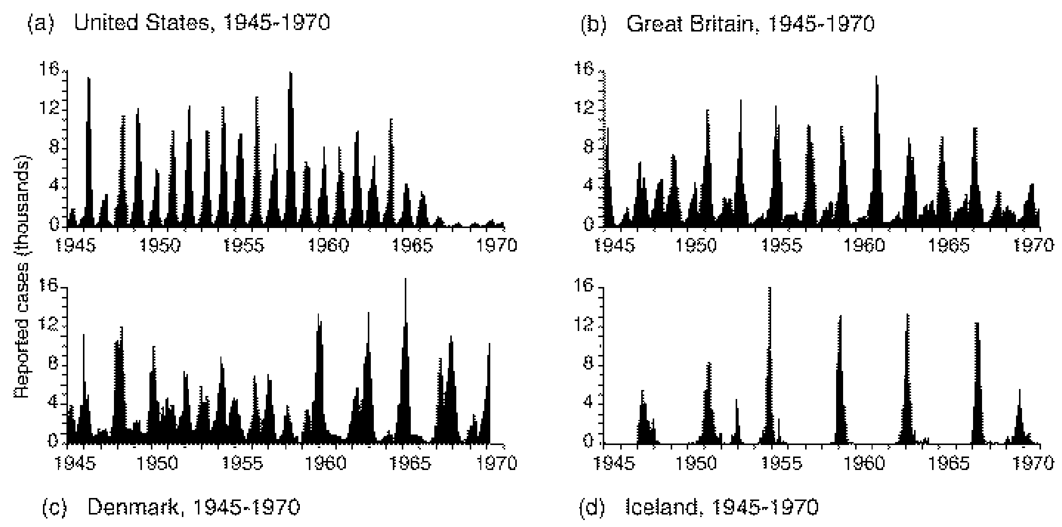
Cumulative deaths: This line shows the cumulative deaths. Read the number from the yy-axis on the right hand side. This line shows the total number of deaths so far - i.e. if you added up the number of deaths per day you get the cumulative deaths. Note the difference between the cumulative number of cases and the cumulative number of deaths. This means that not everyone who is infected dies. This would be different for different diseases.

Repeated epidemic waves

Each of the four time-series curves shown in the graphs below follows a characteristic signature shape now regarded as typical for an isolated epidemic.

Each epidemic disease has its own infection and case fatality rates which will influence the timing and effect of its spread in normal conditions. The typical patterns are captured by our Pacific island example.

It is often the case that the same epidemic disease returns at regular intervals to attack the new members of a population and those who are still susceptible to contracting the disease.



Before immunisation was introduced the common infectious diseases of childhood, such as measles, whooping cough, scarlet fever, German measles (rubella) and, to some extent, smallpox, reappeared in epidemic form to target those children born during the previous two, three or four years since the last outbreak.

The most dramatic illustrations of these repeated epidemic waves are provided by measles. Examples from the USA, the United Kingdom, Denmark and Iceland appear above.

It is easy to see that while all four graphs show repeated epidemics, the curves of which are similar in shape, there are clear differences between the four countries.

Population

One clear difference is in the amount of time between epidemics (space between peaks on the graph).

This difference is because of the different population sizes of the countries.

Thinking back to the Pacific island example, the number of susceptibles (people who haven't had the disease, but who could get it) decreased as the epidemic progressed - as more people got the disease or died as a result of it.

For an epidemic to progress, there needs to be a supply of people who are susceptible, who then get infected and so the peak on the graph grows.

The gaps between the peaks on the graphs above show the amount of time it took for the number of susceptible people to build up again after an epidemic.

The increase in the number of susceptibles could be due to new people moving to the area, but in the case of measles it is most likely to be the number of people who are born. The gap between the peaks will therefore be smaller for places with more people (higher populations).

The populations of the four countries were: USA 210 million (peaks approx. every year); UK 56 million (peaks approx. every 2 years); Denmark 5 million (peaks approx. every 3 years); Iceland 0.2 million (peaks approx. every 8 years).

Public health

Another important influence on epidemics and so on the shape of the graphs above is public health campaigns.

This can be clearly seen in the case of the USA. The peaks get lower (fewer people are infected) at the end of the graph. This is a result of vaccination campaigns started in the mid-1960s.

The number of susceptibles was reduced as people who were successfully vaccinated could no longer be infected.