Mathematical models

The attack rate is the probability of contracting the disease. The attack rate is calculated as the number if people who became ill divided by the number of people at risk for the illness. The attack rate is difficult to measure as it is difficult to accurately determine all the people who are infected.

The basic reproduction number (R0) is the average number of infected cases produced by each infectious case in a totally susceptible population. Disease incidence; is static if each case leads to one new case (R=1), increases is each case leads to more than one infective secondary case (R>1), and decreases if each case leads to less than one infective secondary case (R<1) which will result in disease control and eradication. The basic reproduction number depends on the duration of infectiousness of the case (D), the number of contacts per unit time (K), and the transmission probability (B): R0=D*K*B. This formula shows that the basic reproduction number is not specific to an infectious agent only, but also to a specific host population at a particular point in time. Different diseases have different reproductive rates. A completely susceptible population is unusual. More commonly, a population consists of susceptible and immune individuals. The net reproduction number ® is the average number of secondary cases in a population where not all individuals are susceptible. The net reproduction number depends on the basic reproduction and the proportion of susceptible individuals (x): R=R0*x. The lower the proportion of susceptible individuals in a population, the lower the probability that an infectious individual will be in contact with a susceptible individual. Thus, if the proportion of susceptibles (x) is small enough, R will be less than 1 and the disease can be eradicated. The proportion of the population immune to infection is called herd immunity (H): HI=1-x. The herd immunity threshold is the proportion of the population that needs to be immune in order for a disease to eventually die out (R<1): HI=R0-1/R0. Susceptible individuals become immune once they are vaccinated with a highly effective vaccine. The basic reproduction number allows us to estimate the vaccination coverage which needs to be achieved in order to control an infectious disease. K and B are modifiable factors, K can be altered by changing people's behaviour, B can be changed by vaccination. B is determined by susceptibility of people in the population to that disease. For self-limiting, non-fatal, diseases, can allow natural immunity to develop with the population. However, where case fatality is high to where the carrier state is likely to develop with long term consequences, public health organisations will consider interventions to change B.

Hepatitis B virus (HBV) infection is an example of an infectious disease in which interventions have been implemented to change the basic and net reproduction rate. In the UK, HBV vaccines are included in routine childhood immunisation schemes. Other at risk populations are also routinely vaccinated. Vaccination lowers the B value for HBV.