

Chapter 14:

Pathogen management strategies

Novel and emerging diseases

Consider Bill Gates' words from a 2015 TED Talk entitled 'The next outbreak? We're not ready.': 'If anything kills over 10 million people in the next few decades, it's most likely to be a highly infectious virus rather than a war. Not missiles, but microbes ... We've actually invested very little in a system to stop an epidemic. We're not ready for the next epidemic.'

In the light of the emergence of COVID-19, these words are eerily prophetic.

The growth in the number of emerging diseases, speed of transmission, and distribution of novel (new) diseases has increased rapidly in the last few decades. Outbreaks of disease that could previously have been contained within small areas or communities can now be transmitted quickly and can relatively easily become a global incident.

Novel and emerging diseases

Emerging diseases fall into one of the following three categories:

- diseases that have recently appeared in a population
- diseases that have occurred previously but till recently have affected only small numbers in isolated places
- diseases that have occurred previously but only recently have been recognised as being due to a newly identified pathogen.

Examples of emerging and re-emerging diseases:

- COVID-19
- Ebola
- AIDS
- Malaria
- Tuberculosis

How can we combat emerging diseases?

Prevention and early detection are by far the most effective strategies for management of such diseases, because most emerging diseases come from viruses for which we currently have no **vaccines**.

Management strategies may help control the spread of a disease, which may result in localised elimination of that disease, and may ultimately lead to its global and permanent eradication.

Control measures

Control measures refers to a set of strategies that reduce the incidence and duration of a disease. It involves meticulous preparation and rapid responses to outbreaks at community, state, national and global levels.

Australia has strict border control and quarantine strategies for the purpose of limiting an outbreak. When an outbreak occurs, response teams plan and carry out strategies that aim to minimise spread of the disease.

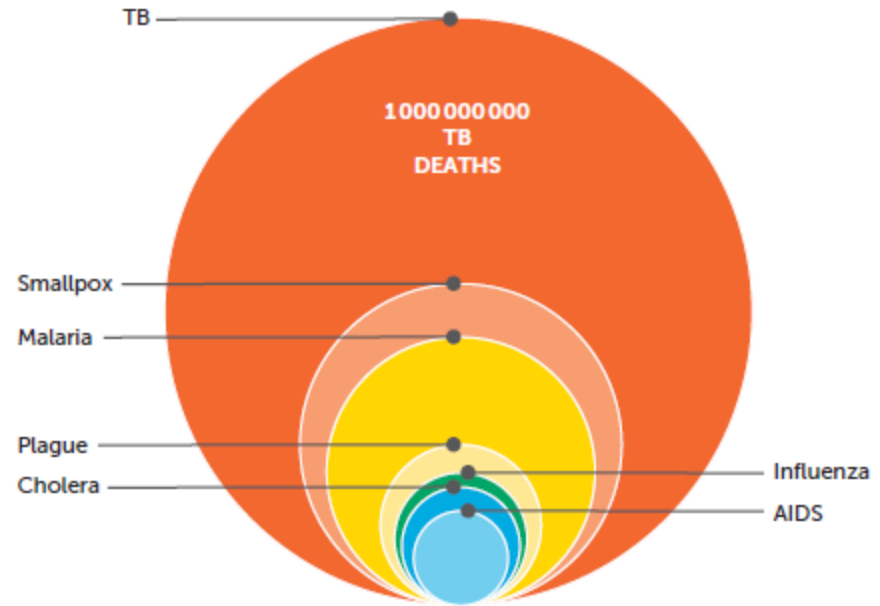
The World Health Organization (WHO) advises response teams with strategies aimed at:

- prevention (once the outbreak has happened)
- anticipation
- early detection
- containment
- control
- eradication.

Why are some controlled diseases still a threat?

Some epidemics have well-established control measures, yet they remain a threat for many individuals for a variety of reasons.

Influenza remains a threat because the pathogen rapidly changes strain. Tuberculosis (TB) bacteria have evolved to become resistant to antibiotics. Many people can't afford the testing needed to diagnose a disease, or its treatment. For many diseases, eradication awaits financial help, especially to increase health provisions.



Who studies diseases?

Epidemiology is the study of the occurrence of disease in populations.

Epidemiologists are professionals who work to prevent or minimise the impact of diseases in the population. Their work may include such activities as identifying outbreaks, determining the effectiveness of a vaccine, and calculating the cost effectiveness of various means of controlling disease transmission.

Occasionally, epidemiologists act as 'detectives' who track down the cause of an emerging disease, determine its reservoir and mode of transmission, and help organise healthcare workers to bring the disease under control.

Epidemiologists aim to describe patterns of disease, identify causes of disease, and provide data for management of a disease.

Quarantine

Quarantine is a period of isolation serving to prevent the spread of a contagious disease. Organisms suspected of carrying the disease are isolated from local, susceptible populations until at least the incubation period is finished and clinical signs and symptoms have passed.

Australia has strict quarantine laws that prohibit the entry of items that may carry an infectious animal or plant disease. When products are potential carriers of pathogens, biosecurity officers will enforce a compulsory period of isolation of the products.

Biosecurity

Biosecurity is a set of strategies that support the prevention of, response to and recovery from diseases that affect our economy, environment and health.

Biosecurity in Australia has maintained a disease-free status for many of the world's diseases. Our geographic isolation plays a major role in maintaining this status, but globalisation has diminished the geographical advantage.

Immunisation

Immunisation is the act of protecting someone from disease by the use of a vaccine, and also describes the process of developing resistance to a specific disease.

Vaccination is the administration of a vaccine into the bloodstream to cause immunity, usually by injection. Immunisation is what happens in your body after you have a vaccination.

A **vaccine** stimulates immunity, which is the production of specific antibodies in a susceptible host during its response to a specific pathogen. It helps develop immunity by imitating an infection, and promotes the formation of 'memory cells' that will remember how to fight the specific pathogen in the future.

Management strategies

Various types of immunity

ACTIVE IMMUNITY

Natural



Infection

Artificial



Vaccination

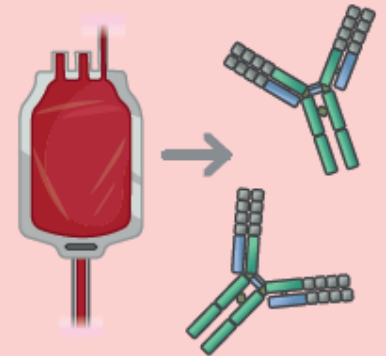
PASSIVE IMMUNITY

Natural



Maternal antibodies

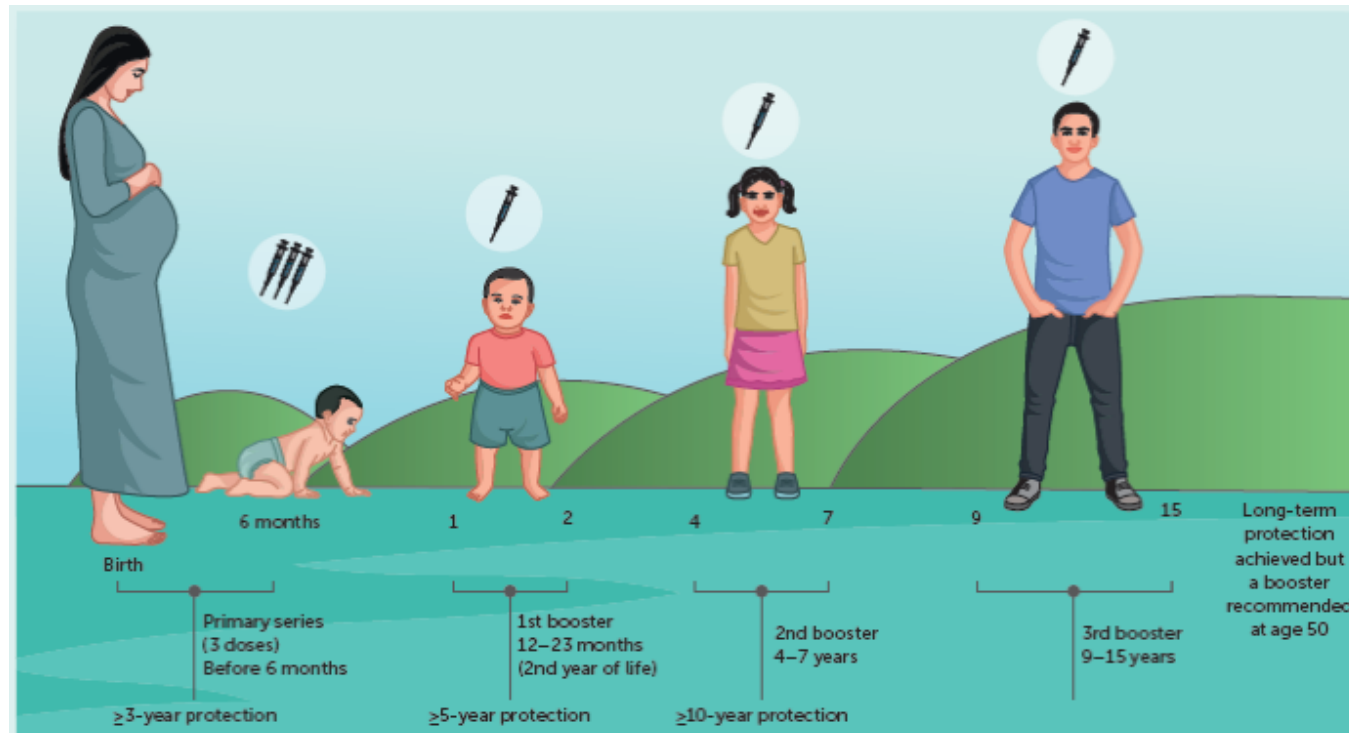
Artificial



Monoclonal antibodies

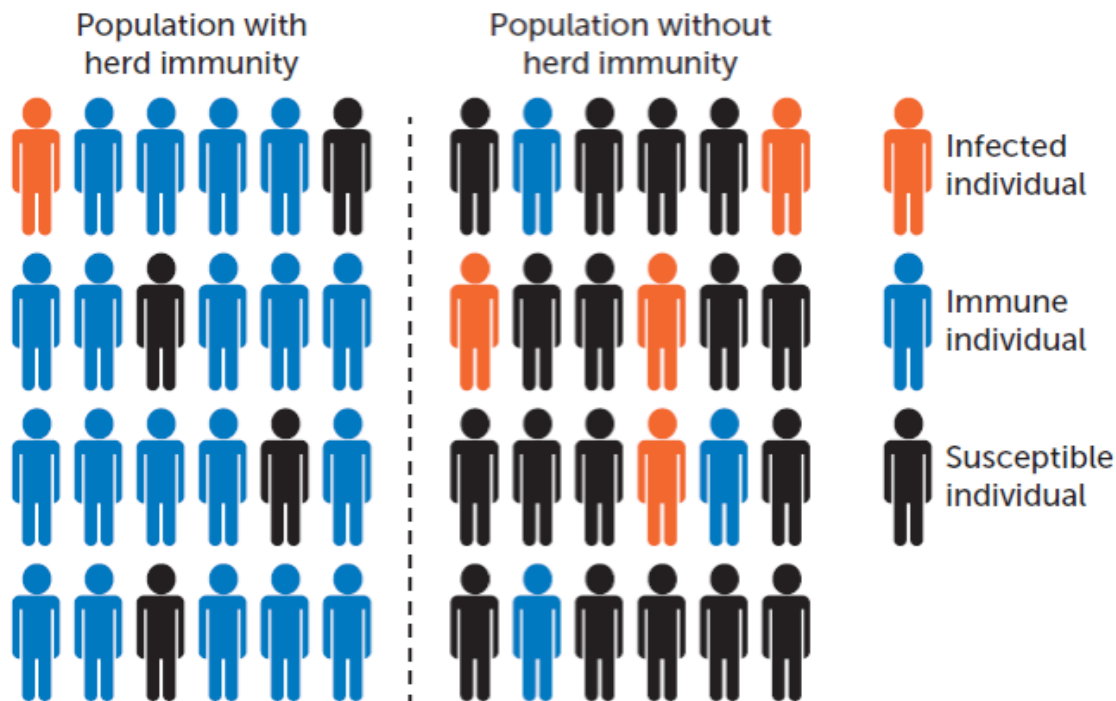
Long-term protection

Sometimes, more than one vaccination is required, as in the case of the infectious but not contagious disease tetanus. Three booster vaccinations should be administered during adolescence. Immunisation is then stimulated to last throughout much of adulthood. Boosters are required because memory cells decline over time.

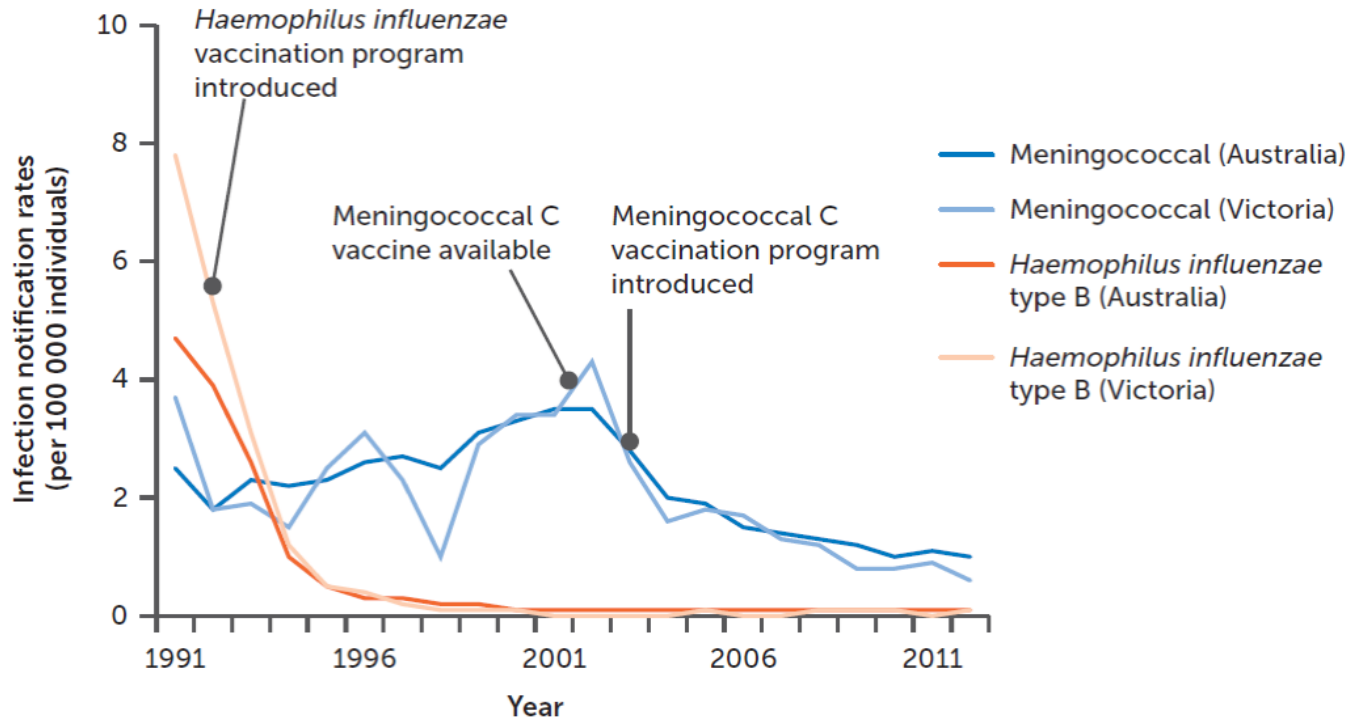


Herd immunity

When a high enough proportion of a population, the threshold proportion, is immune to an infectious disease, the fraction who are not immune are to a large degree protected from transmission. This is known as **herd immunity**.



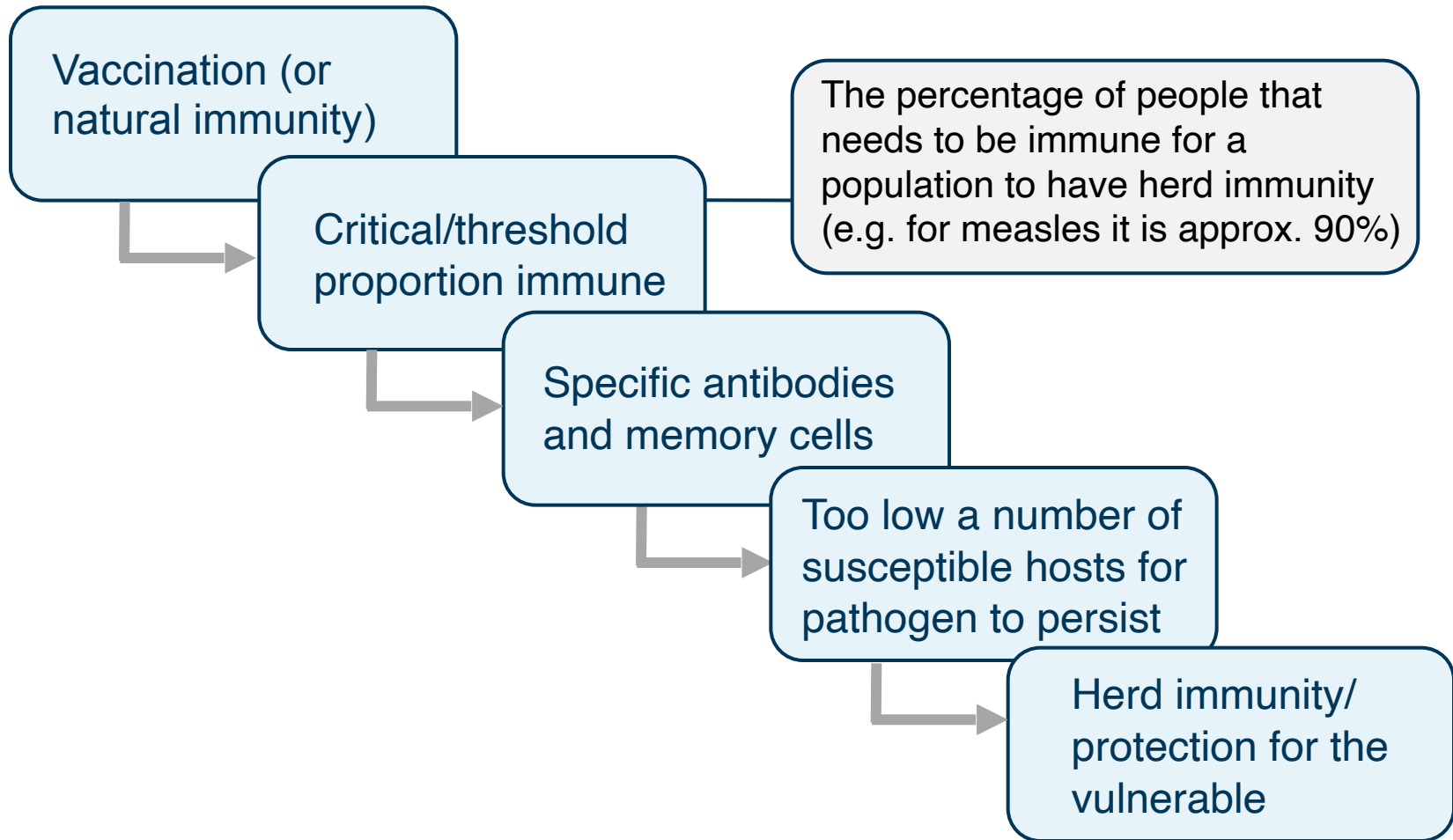
Herd immunity



Sources of data: National Notifiable Diseases Surveillance System (NNDSS) and Department of Health, Victoria

In Australia, children are routinely vaccinated against a large number of infectious diseases, including hepatitis B, pertussis, measles, tetanus and poliomyelitis. As new vaccines are developed, there are immunisation programs against an increasing number of diseases, with evident benefits to health.

Herd immunity: sequence of events



Disruption of a pathogen life cycle

Understanding the life cycle of a pathogen can help scientists work out how to prevent and control the spread of the disease it causes.

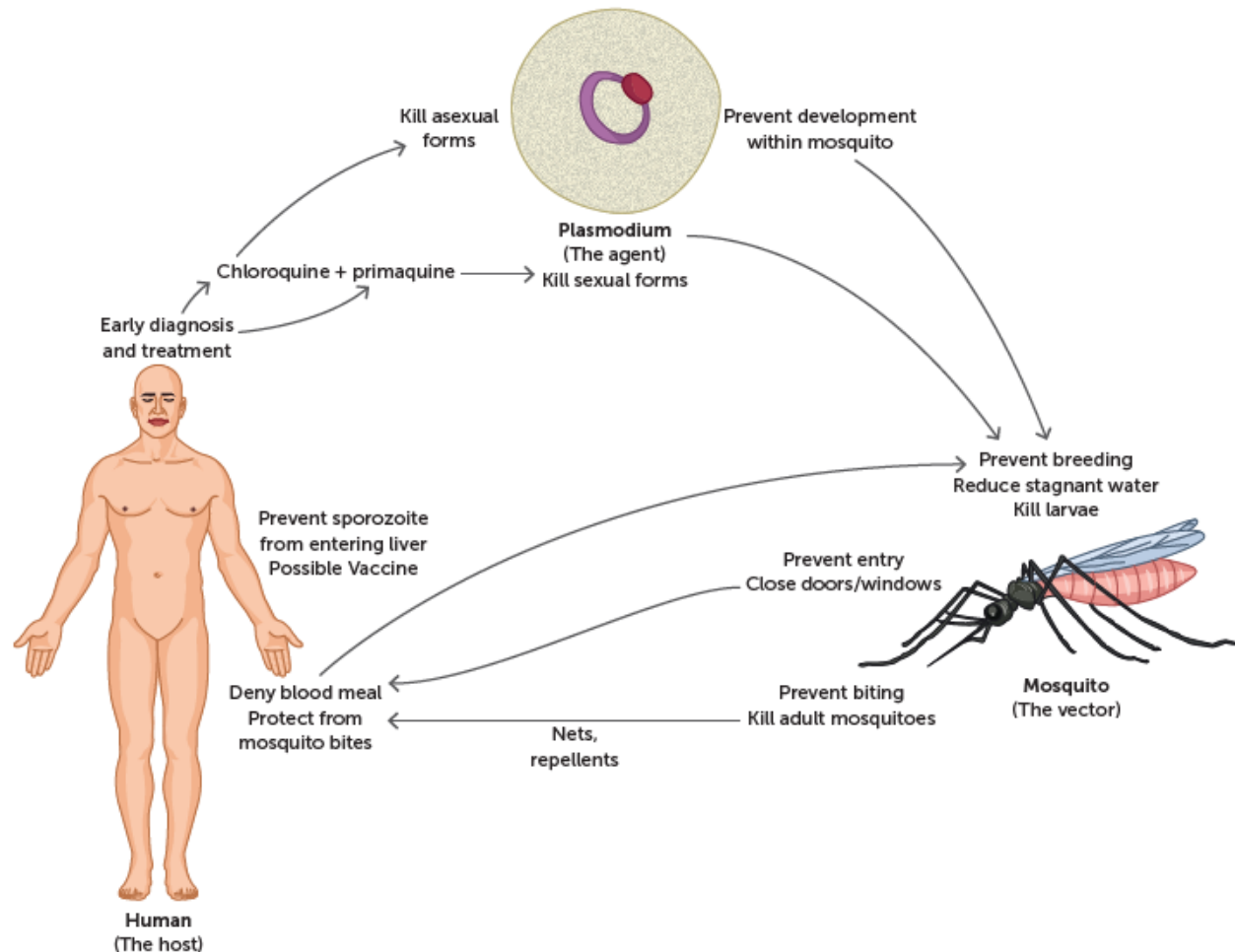
The life cycle of each pathogen is unique, but it generally involves a reservoir, a portal of exit from an infected host, a mode of transmission, a portal of entry, replication and a susceptible host.

Control strategies for disruption of life cycle example:

Plasmodium causes the disease malaria. This pathogen requires two types of hosts in its life cycle: the female *Anopheles* mosquito and the human. Control measures to disrupt the *Plasmodium* life cycle include targeting:

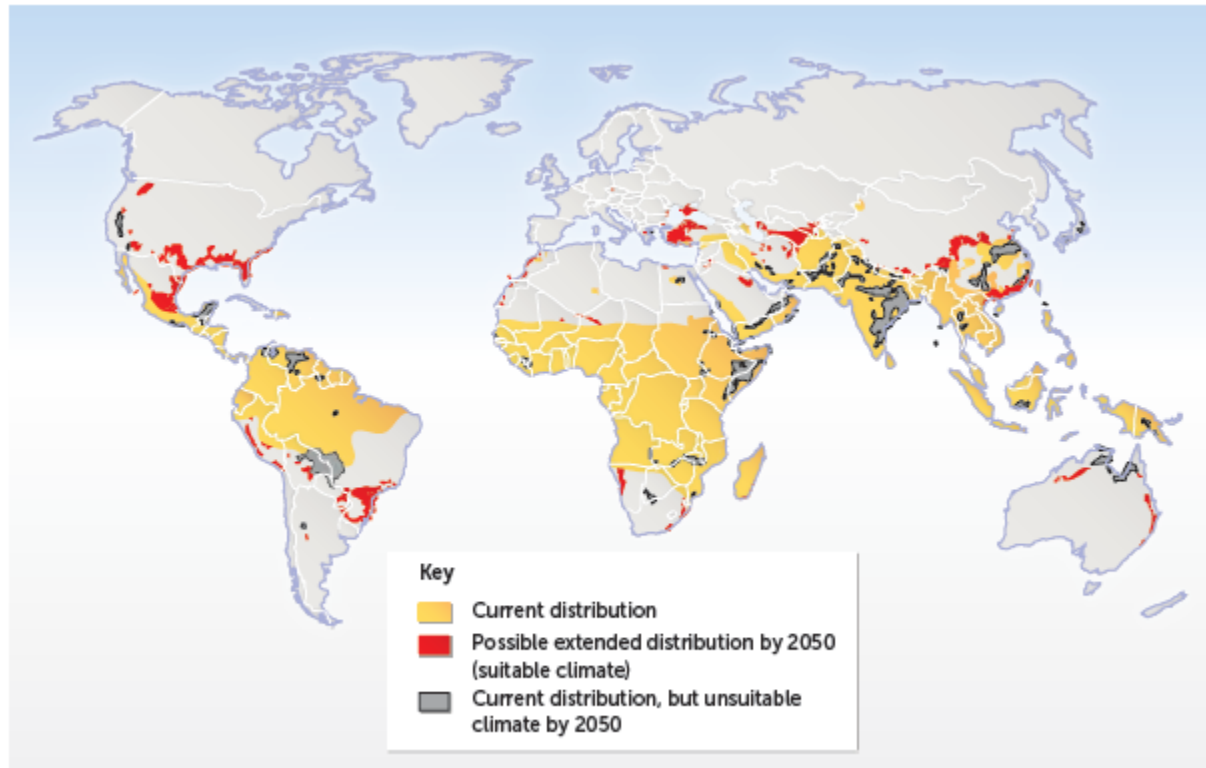
- mosquito larvae
- adult mosquitoes
- the human host, through early diagnosis and medication
- transmission sites (i.e. preventing blood feeds using barriers)
- potential human hosts, through use of preventative medication.

Control strategies at the various stages of the life cycle of *Plasmodium*



Disruption of a pathogen life cycle

Computer modelling can be useful in predicting climate change and distribution of a disease, such as this map showing the predicted change in distribution by 2050 of *Plasmodium falciparum* malaria, based on modelling data.



UNEP/GRID-Arendal/Hugo Ahlenius (<https://www.grida.no/resources/17718>)

Medications

Medications used to treat infectious diseases come in the form of **antimicrobial agents**. The type of antimicrobial depends on the type of organism that is causing the infection: whether the organism is a bacterium, virus, fungus or protist.

Antibiotics

treat bacterial infections

Antivirals

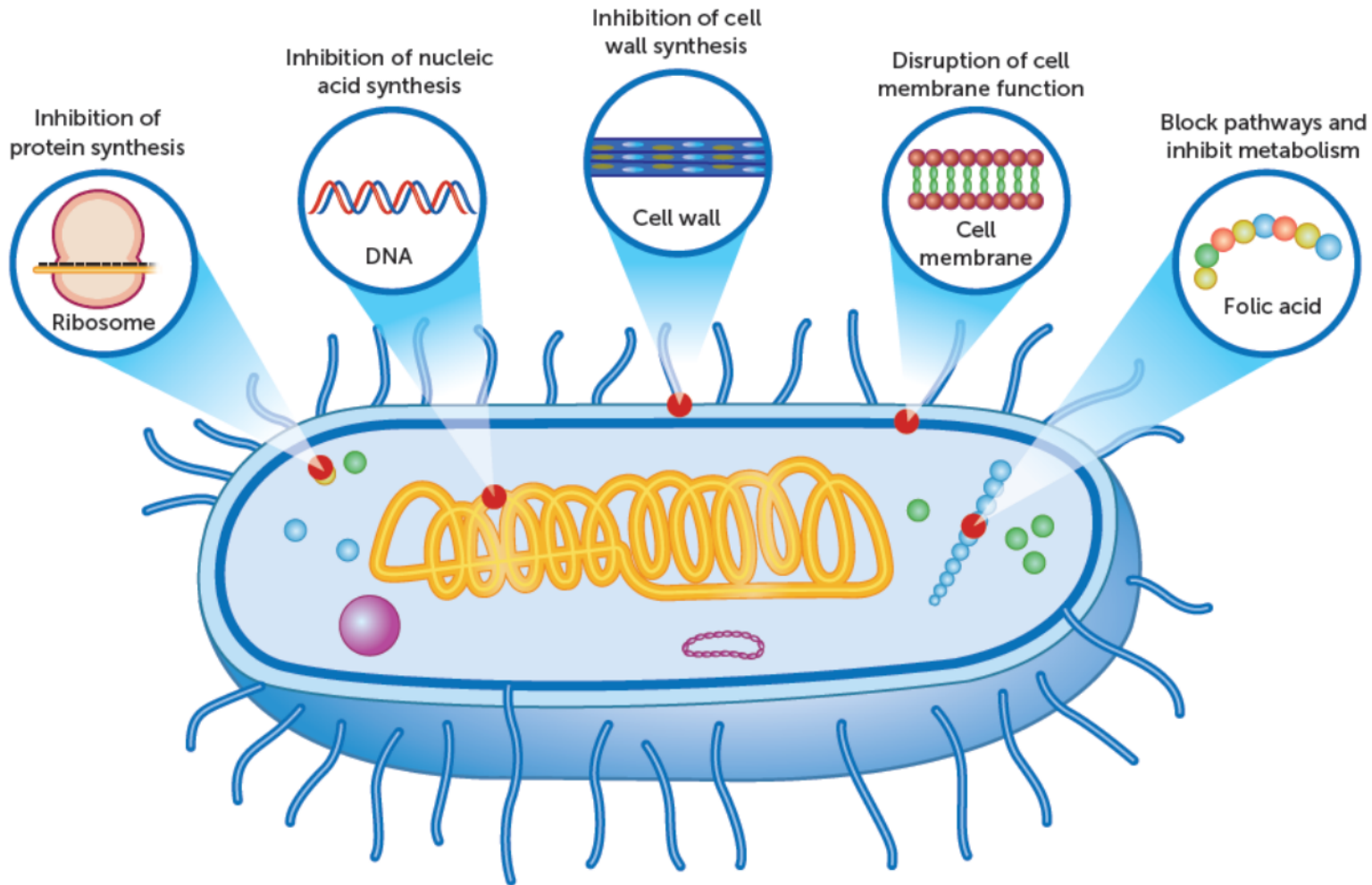
treat viral infections

Antifungals

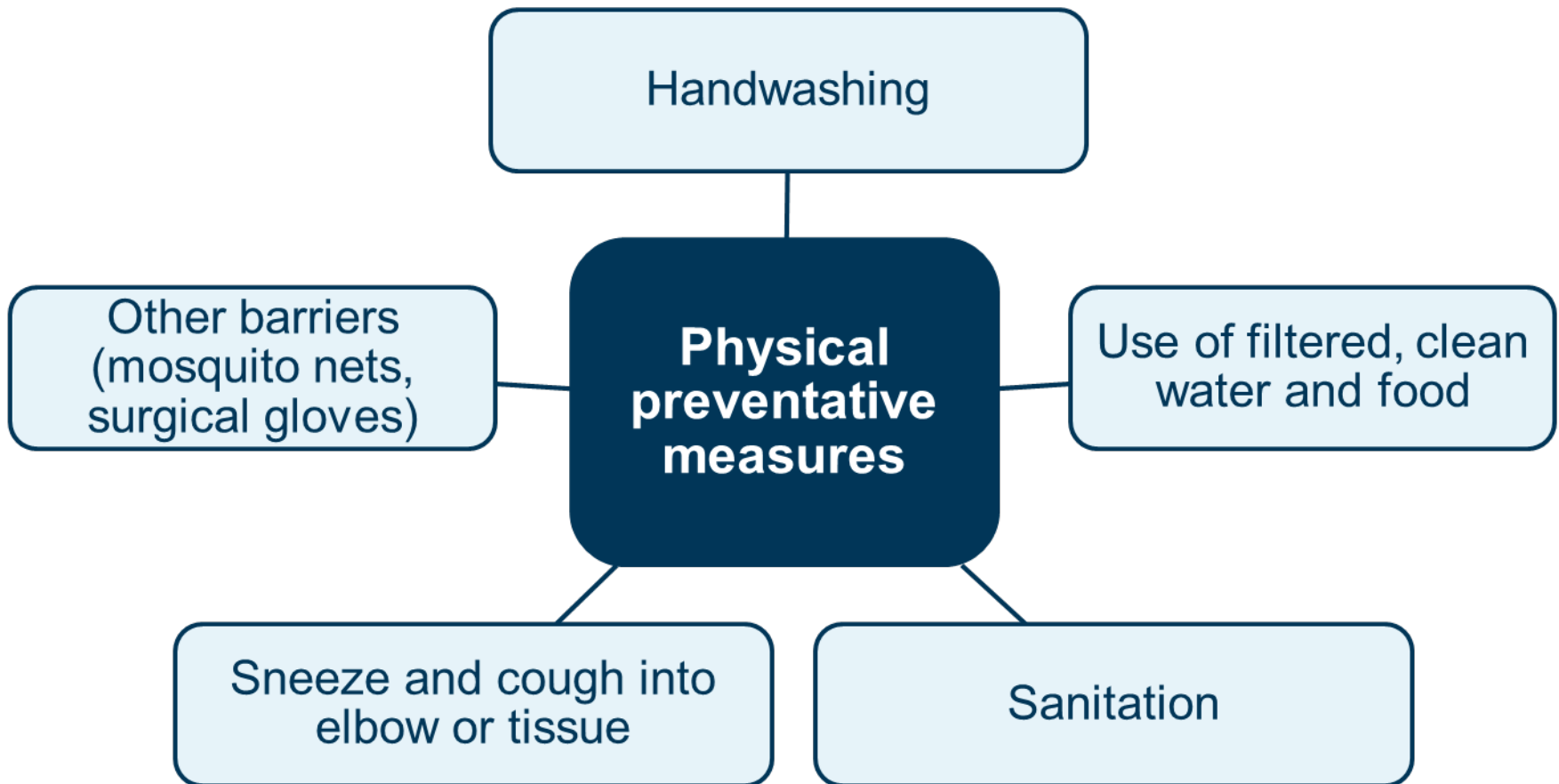
treat fungal infections

There are some antiprotozoal drugs (such as antimalarials) that treat protistan infections.

Modes of antibiotic action



Physical preventative measures against the spread of disease



Management strategies

Management of the spread of disease (COVID-19) example:

Creation of a vaccine for SARS-CoV-2, the virus that causes the disease COVID-19, is at the forefront of scientific research. Management plans for the spread of the virus include:

- testing/surveillance/rapid detection
- physical preventative measures such as handwashing, voluntary and mandatory isolation, social distancing, wearing face coverings and COVID Safe Plans for workplaces
- border biosecurity.



Fairfax Photos/Scott McNaughton

Management of the spread of a non-human disease (*Phytophthora dieback*) example:

Application of phosphite, a biodegradable fungicide, has been demonstrated to produce an increased resistance to *Phytophthora* infection. The phosphite is supplied agronomically, either by injection, which protects plants for up to 5 years, or by foliar spray, which protects plants for 2 years. It is safe, inexpensive and has low toxicity to animals. However, decreasing sensitivity of *Phytophthora* to phosphite has been documented.

Other strategies include:

- sterilisation of clothing/footwear,
- destroying all infected trees
- scheduling work in infected areas during dry seasons.

Monitoring disease activity

In order to define and control disease outbreaks, public health authorities need to know when and where particular infections are occurring.

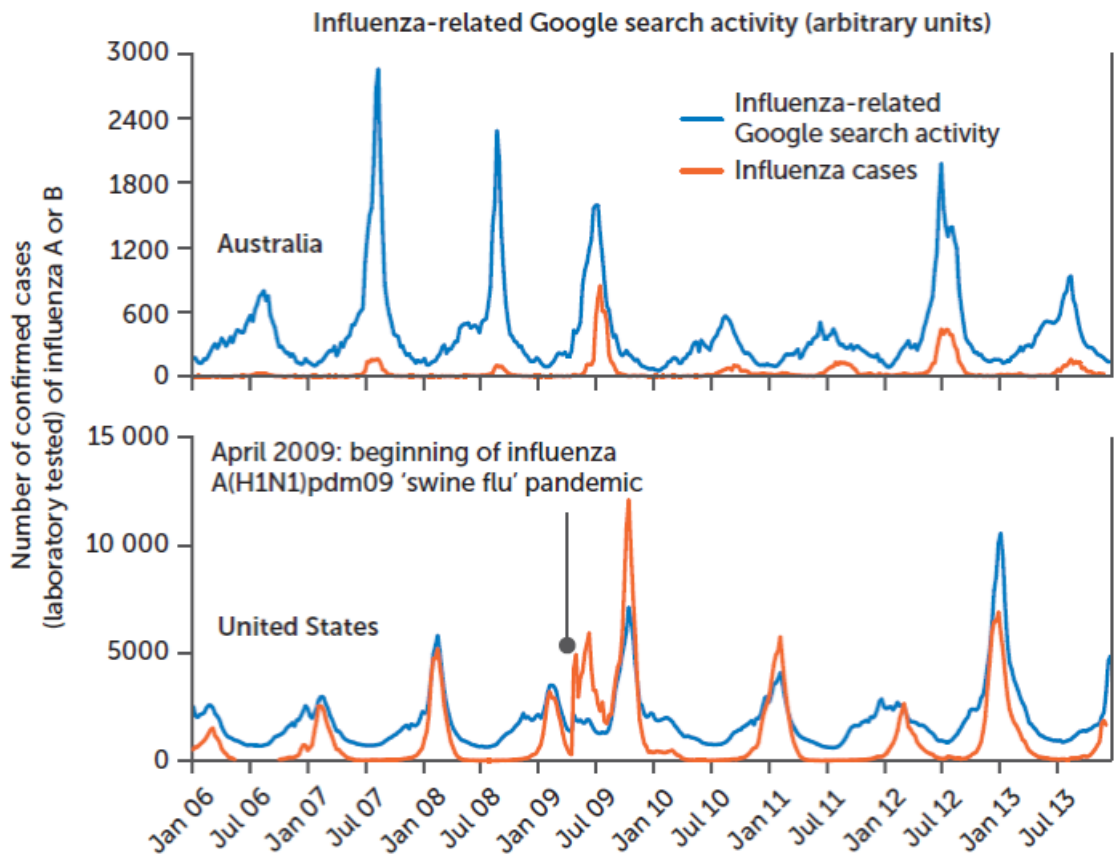
In Australia, the number of cases of a particular disease is monitored by health authorities in each state.

On a global level, the monitoring of diseases is conducted by WHO, the organisation that coordinates global responses to outbreaks that pose widespread threats.

Monitoring disease activity

Monitoring disease activity

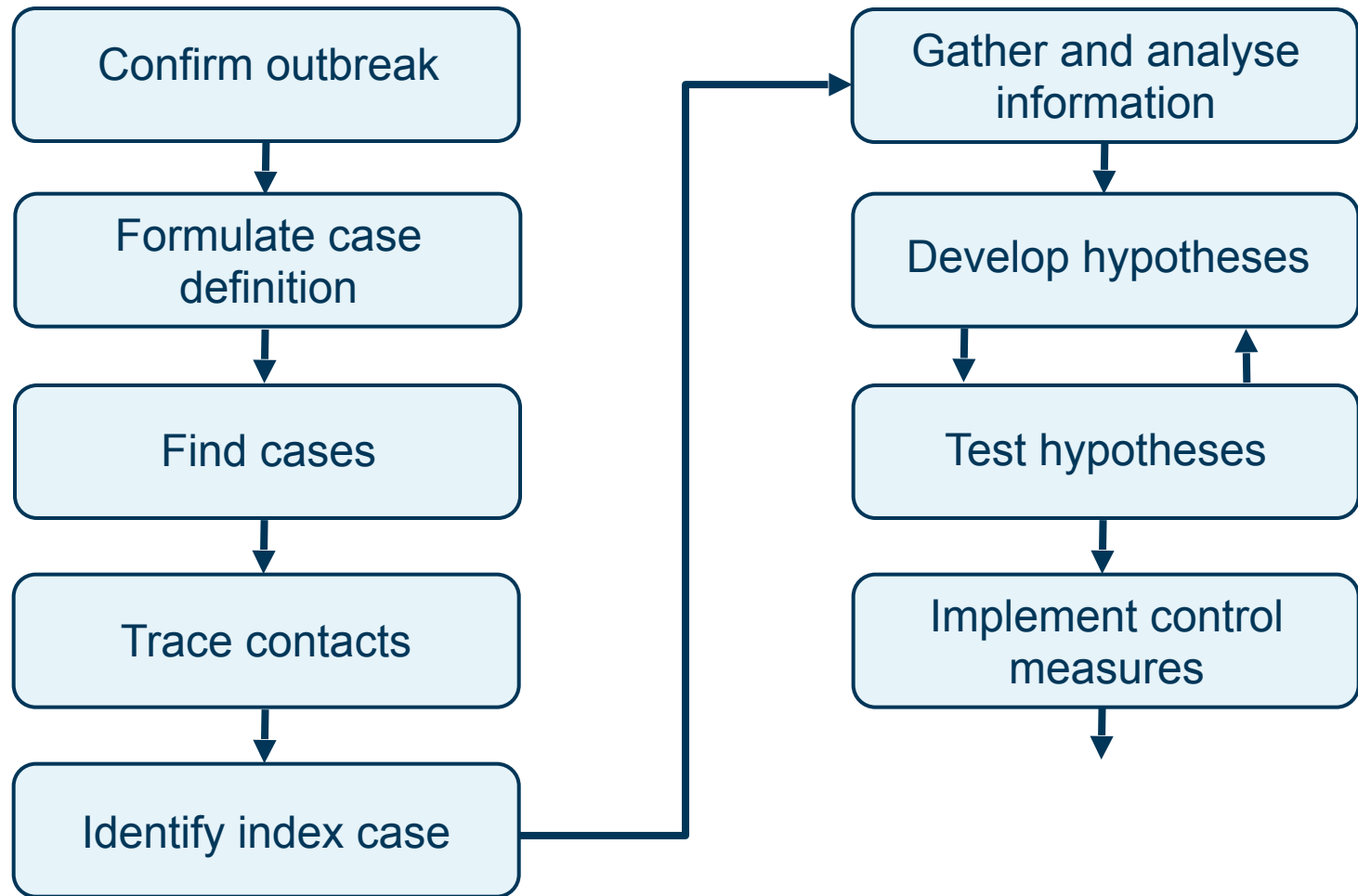
The widespread use of the Internet and social media provides a novel data source from which information about the frequency of different diseases can be extracted.



This image compares data obtained by this method with traditional reporting data. You can see that the spikes in Google search activity correspond with the peak influenza season.

Monitoring disease activity

Investigating a disease outbreak



Communicating findings and implementing control measures usually happen throughout the investigation.