## IQ4: How can the spread of infectious diseases be controlled?

**4.1** *investigate and analyse the wide range of interrelated factors involved in limiting local, regional and global spread of a named infectious disease*

### FACTORS AFFECTING SPREAD OF INFECTIOUS DISEASE

- Human movement (transfer of pathogen locally, regionally or globally)
- Human behaviour (poor sanitation habits increase spread)
- Farming practices (facilitates transmission of disease e.g. Avian flu from chickens to humans
- Land clearing
- Environmental/geographic factors e.g. natural disasters
- Pathogen factors (virulence, adaptations, resistance)

### DISEASE MONITORING AND CONTROL

- Because of the ease with which humans can travel, disease monitoring and control are carried out at three levels:
  - Local
    - Usually related to a neighbourhood, town or city
    - Sanitation is a major factor in spread of disease, especially after natural disasters
    - Poor communication networks and roads may limit access to medical treatment, hospitals, medical info etc.
    - Overcrowding increases host to host transmission
  - Regional
    - UN-5 region in world (Africa, Americas, Asia, Europe and Oceania)
    - Geography influences transmission e.g. highly mobile populations have increased exposure to infection than isolated ones
  - Global
    - Increased movement of people globally because of travel/work/migration introduces difficulties in limiting spread of disease
    - Internet increases up-to-date information about outbreaks of disease as they occur

### EXAMPLE: LIMITING THE SPREAD OF MALARIA

- Local and regional measures
  - Drainage programs to get rid of stagnant water → cannot breed
  - Reduce contact with infected mosquitoes e.g. wear protective clothing, bug spray, use mosquito nets in house
  - Screening for disease to prevent spread across regions
- Global measures
  - Vaccination programs
  - Global insecticides
  - Global communication about outbreaks of disease and information on how travellers can protect themselves

**4.2** *investigate procedures that can be employed to prevent the spread of disease, including but not limited to:*

- hygiene practices

- Infectious diseases are transmitted between people through direct or indirect contact.
- Disease control can be aided with measures including improved hygiene practices, quarantine and immunisation programs.
    - Factors that limit the effectiveness of these include poverty, high density accommodation and access to quality medical services.

**HYGIENE**

- Personal hygiene
    - Thorough + frequent hand washing (kills and removes bacteria present on hands)
    - Protection during sex (prevents pathogens transferring through bodily fluids)
    - Cover mouth when sneezing or coughing (prevents pathogens transferring through droplets)
- Government regulations
    - Public services that help prevent the spread of disease
        - e.g. disposing of sewage, household/medical waste, and providing CLEAN WATER
    - Temporary infrastructure in the case of a natural disaster
        - e.g. portable toilets, bottled water
- Safe food practices
    - Legislation is in place to avoid the spread of pathogens by food handling e.g. salmonella
        - Hand washing and wearing gloves
        - Cooking food thoroughly and storing food correctly

- quarantine

- Quarantine refers to all the measures taken to minimise the risk of infectious diseases caused by pathogens entering and establishing in Australia.
- Measures may include isolation or hospitalisation of infected people, closing schools or workplaces, and surveillance of people, animals & goods moving across borders
    - e.g. collection of passenger and cargo information at airports
- Australia has strict quarantine laws e.g. eradication of foot & mouth disease in farm animals
    - Illegal to bring meat/dairy products to Australia without a permit
    - Heavy penalties apply for illegal movement of these items which is de-incentivising, protecting the population and economy

- vaccination, including passive and active immunity public health campaigns

**VACCINATION**

- Vaccination is a method of providing artificially acquired immunity without the need for a person to have suffered the disease initially.
    - Highly effective e.g. smallpox = WHO created global vaccination program and eradicated the disease in 1980
- Immunity is active or passive depending on the origin of the immune response.

- Problems with implementing vaccination include lack of monetary funding, poor health resources and lack of public health education.

**RECOMBINANT VACCINES**

- A recombinant vaccine is a vaccine provided through recombinant DNA technology.
    - Involves inserting the DNA encoding an antigen (such as bacterial surface protein) that stimulates an immune response into bacterial or mammalian cells, expressing the antigen in these cells and then purifying it from there.
    - DNA cut with enzymes → new DNA inserted → recombinant DNA placed into something that replicates quickly e.g. yeast cell → fermentation tank → antigens are detached, extracted and put into vaccines

**ACTIVE IMMUNITY**

- Stimulates production of antibodies without need to suffer disease initially
- Person does not acquire disease but memory cells are manufactured and stored = future immune response is faster and more effective if infection by same antigen occurs
    - e.g. tetanus or diphtheria injections

**PASSIVE IMMUNITY**

- Protection provided to an individual by the transfer of antibodies produced by another organism
- Immediate but only short-term = does not activate immunological memory
    - e.g. antibodies present in mother kangaroo milk provide protection to its joey, as their immune system develops after birth

**HEALTH CAMPAIGNS**

- Health authorities and government promote healthy behaviours through public health campaigns.
- Information is distributed through media outlets/schools/mail etc.
    - e.g. after the Giardia water crisis in Sydney - immediate campaign was launched:
        - Educating the public about the pathogen
        - Information about treatment of water supplies
        - Bans on drinking water + instructions on boiling water
        - Information about where/how to seek medical help if needed.

**HERD IMMUNITY**

- For immunisation to be successful, enough people need to be vaccinated (usually 90% and above) – this is called herd immunity
    - The more people who are vaccinated, the less chance there is of an infectious agent spreading throughout a population because there are fewer potential carriers.
- Herd immunity is essential for the protection of those who cannot be vaccinated or have suppressed immune systems e.g. newborn babies or the elderly

- use of pesticides

- Pesticides are chemicals used to prevent the spread of infectious plant and animal diseases.
    - May also help control insect vectors e.g. mosquitoes → malaria

- May be used as sprays/baits, in irrigation water or as dips for farm animals (baths containing insecticides)
- However, because of the overuse of pesticides, genetic resistance has developed among many pests → e.g. 90% of sheep parasites are now resistant to farming pesticides, meaning that new pesticides must constantly be developed

- genetic engineering

- Genetic engineering is used to modify the genetic structure of an organism using biotechnology
- Helps prevent spread of disease by producing plants/animals resistant to common pests/diseases, vectors with a diminished capacity to spread disease, and transgenic animals for harvesting biomedical products.
    - e.g. genetically engineered plant = BT cotton (transgenic cotton) → BT bacteria has a gene for making pesticides.
    - The gene from BT bacteria is removed using enzymes and inserted into the cotton plants via a plant infecting bacteria, allowing the cotton plants to gain natural pesticide
        - Less pesticide used has a good effect on ecosystems, however this creates less variation in the crop.

**4.3** *investigate and assess the effectiveness of pharmaceuticals as treatment strategies for the control of infectious disease, for example:*

- antibiotics

- One way of controlling pathogens and their spread is to reduce the number of them in the outside environment - e.g. many bacteria are pathogens and can be treated with antibiotics
- Disinfectants are used to kill pathogens on surfaces such as door handles and hospital equipment e.g. chlorine and hydrogen peroxide.
- Antiseptics, such as ethanol, iodine and some detergents are used to kill pathogens on the body → reduces chances that infection will occur

- Successful antibiotics kill bacteria without damaging the cells of the organism being treated.
- Should target biochemical pathways and molecules specific to the microbe e.g. bacterial cell walls → makes cell burst
- Antibiotics that slow bacterial growth = **bacteriostatic,** those that kill bacteria = **bactericidal**
- Narrow spectrum antibiotics only act on specific bacteria and broad-spectrum act on a wide variety (when identity of bacteria is unknown)
- <u>Disadvantages</u> include:
    - They kill good bacteria (flora) residing in the body
    - Antibiotic resistance can develop e.g. MRSA (golden staph) and methicillins
        - Can be acquired through mutation, intrinsic resistance or DNA transfer

- antivirals

- Viruses are non-cellular pathogens that must be inside living cells to replicate
- Antiviral drugs fight infection by either inhibiting a virus' ability to reproduce, or strengthening the body's immune response to the infection – includes:
    - Preventing virus from entering cell by binding to receptors that allow virus to enter
    - Inhibiting enzymes that catalyse reproduction of virus genome
    - Blocking transcription and translation of viral proteins
    - Preventing viruses from leaving cell and so preventing infection of other cells
- Good targets for antiviral drugs are capsid proteins and envelope proteins

- Narrower range of organisms – viruses treated by antivirals include influenza, HIV, herpes, hepatitis B.
- However viruses can develop resistance like antibiotics – implications include:
  - Death from treatment failure
  - Economic impacts e.g. costs of care/drugs

**4.4** *investigate and evaluate environmental management and quarantine methods used to control an epidemic or pandemic*

- Preventing the transmission of pathogens in a serious epidemic requires the use of procedures and protocols called controls
  - These include environmental and quarantine measures.

| Method | Description |
|---|---|
| **Standard precautions** | Hand hygiene, use of PPE e.g. gloves, eyewear, gowns, safe handling and disposal of sharps, routine cleaning of surfaces and equipment, and using aseptic techniques in in handling body fluids to prevent/control infection and reduce the possibility of an epidemic. |
| **Water supply** | The transmission of many pathogens occurs due to the use of contaminated water e.g. diseases such as cholera, typhoid, and dysentery. Clean water supplies are essential to prevent and control infectious diseases and a potential epidemic. |
| **Sanitation facilities** | The transmission of many pathogens occurs when water, food, or utensils are contaminated with faeces e.g. hepatitis A and salmonella.<br>The treatment and disposal of sewage dramatically reduces the risk of disease epidemics. |
| **Food supply** | Poor quality control of food supplies, food preparation, cooking procedures and disposal of wastes can lead to the transmission of an infectious disease and cause an epidemic e.g. mad cow disease with infected beef |
| **Reducing transmission** | Environmental controls can reduce disease transmission e.g. interrupting the life cycle of a vector such as removing stagnant water where mosquitoes breed. |
| **Contact tracing** | When an outbreak occurs all infected people and the people they have contacted need to be traced and tested for the disease. If necessary these people may need to be quarantined for the required incubation period. |
| **Quarantine** | Keeping infected individuals isolated and in quarantine is one of the most important controls in reducing further transmission of the disease. |
| **Public health infrastructure** | Quality public health infrastructure provides the means to diagnose, treat and care for infected individuals. Isolation in proper medical facilities provides the greatest possibility of survival for an individual and restricts further transmission. |

**4.5** *interpret data relating to the incidence and prevalence of infectious disease in populations, for example:*
- mobility of individuals and the portion that are immune or immunised Malaria or Dengue Fever in South East Asia

**INCIDENCE**

- The incidence of disease is the rate of occurrence of new cases, which indicates the risk of people contracting the disease. Incidence is expressed as a fraction of a population within a period of time.
    - E.g. during the years 2000 to 2011 there were 990 new cases of measles in Australia. Therefore, the annual rate was 0.4 per 100 000 population.

**PREVALENCE**

- The prevalence of disease measures the proportion of cases in the population and a given time, which indicates the spread of disease.
    - E.g. on 1 January 2017, out of 10,000 people in Town A, 40 have measles.
    - Population ÷ cases = 0.4%.

**MOBILITY**

- The increase of globalisation and as air travel facilitating fast movement of people across geographic areas increases the risk of exposure to infectious disease
    - e.g. prevalence of Dengue in Asia increased following WW2, when ecological/demographic changes led to the transport of Aedes mosquitoes and an increase in the number of hosts
        - Post-war, the rapid urbanisation of SE Asia meant that infrastructure such as sewage systems were inadequate and left population susceptible to infectious disease

**4.6** *evaluate historical, culturally diverse and current strategies to predict and control the spread of disease*

**JOHN SNOW – CONTRIBUTION TO DISEASE CONTROL (CHOLERA)**

By mapping the location of local water pumps on the spot map, he identified the relationship between prevalence of cholera and water supply. After successfully identifying the source of the outbreak, area officials removed the water pump and the epidemic ended. Snow successfully identified that water could act as a reservoir for disease and that epidemiological studies could inform public health strategy and action. A John Snow pub

**MONITORING, CONTROLLING AND ERADICATING RABIES**

- Sri Lanka and Thailand have recorded a sharp decrease in the no. of rabies deaths after mass dog vaccination and improved access to human pre- and post-exposure vaccines
    - Also helps prevent the spread of disease to other countries by mobility e.g. rabies does not exist in Aus despite travel and trade links to SE Asia

| Strategy | Description | Evaluation |
|---|---|---|
| Historical | In the Middle Ages infectious diseases and parasites, e.g. head lice, worms were common. Poor hygiene meant cuts on the skin easily became infected and developed tetanus or gangrene. Leprosy was common and leper colonies (or lazer houses) were widespread. It was believed the body had four 'humours' – blood (sanguine), yellow bile (choleric), black bile (melancholic) and phlegm (phlegmatic). These humours needed to be balanced, e.g. by bleeding with or without leeches and causing purging or vomiting. As many people believed that disease, e.g. Black Death was caused by horrible smells they believed that by removing the bad smell, e.g. by using the pleasant scent from a pomander they could repel the disease in the air. The pomander was a hollow container filled with spiced wax which people wore around their necks, at their waist or around their wrists. Malaria was named from the medieval Italian for 'bad air' (had formerly been called ague or marsh fever). | The isolation of lepers into leper colonies is a form of quarantine which is a suitable strategy to control the spread of the disease. However, the lack of proper hygiene and sanitation meant there were many possible routes for the transmission of pathogens, e.g. the Black Death killed around 40% of the population of Europe. Thus these historical strategies were ineffective. |
| Another culture | Traditional Chinese medicine (TCM) involves many strategies, e.g. acupuncture, herbal medicine, maintaining a specific diet, massage and tai chi and qigong practices. Classical Chinese medical books provide many herbal formulas to treat and control many types of illnesses. 'Warm' diseases which went from one person in a household to another then from street to street were treated with bitter and cold herb formulas and 'cold damage' diseases were treated with heat. The ancient Chinese doctors realised that the cause of these warm diseases had no smell, shape or shadow. Modern analyses of these formulas show some have notable antibiotic properties. Traditional Chinese herbs include ginseng, honeysuckle and *Forsythia suspensa*, *Gentiana*, *Astragalus propionquus*. The ancient Chinese also advocated bathing, oral hygiene, washing hands before eating using steam heated cloths and advised not to drink contaminated water. | By careful observation the ancient Chinese doctors identified strategies that would help treat and control disease, e.g. using particular herbal formulas for particular diseases and understood there were different modes of transmission, e.g. 'warm' diseases spread from person to person within a household. Combined with better hygiene practices these strategies helped control the spread of disease. |
| Current | Many strategies are currently being used to predict and control the spread of disease, e.g. immunisation programs, public health campaigns, provision of fresh water, good sewage treatment and disposal, garbage disposal, applying good hygiene practices in all situations, quarantine and vector control measures. The Australian government has a National Framework for Communicable Disease Control that was developed with the assistance of the states and territories and provides strategies for communicable disease prevention, detection and response with improved organisation and delivery of communicable disease control. If a person shows symptoms of a notifiable disease the medical practitioner must register the case with the Notifiable Diseases Surveillance System (NNDSS) Once diagnosed and confirmed the case is investigated and the situation contained as much as possible to prevent further transmission. | Modern strategies cover a diverse range of activities that help predict and control the spread of disease. Thus if an outbreak does occur these strategies aid a fast and efficient response that helps contain the outbreak and prevent further illnesses and loss of life. |

**4.7** *investigate the contemporary application of Aboriginal protocols in the development of particular medicines and biological materials in Australia and how recognition and protection of Indigenous cultural and intellectual property is important, for example:*

- bush medicine
- smoke bush in Western Australia

**PATENTS/INTELLECTUAL PROPERTY**

- Indigenous Australians have made and passed down observations and inferences about how Australian plants could be used to help treat diseases for centuries.
- Many modern products have been developed using traditional knowledge of bush medicine
    - e.g. the Bundjalung Aboriginal people from NSW used crushes tea-tree leaves to treat wounds and sore throats - since 1920s tea tree oil is used in many products and is shown to have antiseptic properties
- Protecting Indigenous intellectual property is critically important to protect their culture from commercialisation - therefore legalisation must be established in order to recognise them for their discoveries for fairness and equity.

## EXAMPLES OF BUSH MEDICINE

**TABLE 13.5.1** Australian flora species are used in many Indigenous Australian bush medicine applications.

| Common name | Scientific name | Ailment being treated | Application |
|---|---|---|---|
| kangaroo apple | *Solanum laciniatum/Solanum aviculare* | swollen joints | poultice |
| goat's foot | *Ipomoea pes-caprae* | pain caused by marine stings | leaves crushed, heated and applied to skin |
| sticky hopbush | *Dodonaea viscosa* | ear ache | boiled and applied |
| digging stick tree | *Pemphis acidula* | toothache | tip of the stick burnt and applied to teeth |
| lemongrass | *Cymbopogon* sp. | fever<br>diarrhoea<br>ear ache | boiled, cooled, applied to skin<br>liquefied and consumed<br>direct contact with ear |
| snake vine | *Tinospora smilacina* | headaches and arthritis (acts as an anti-inflammatory) | crushed and applied |
| eucalyptus oil | *Eucalyptus* sp. | aches, pains, fevers and chills | leaf infusion |

## SMOKE BUSH

### Smokebush licencing

The Australian native smokebush (*Conospermum* sp.) (Figure 13.5.10), grown in coastal Western Australia, is used in traditional Indigenous Australian bush medicine because of its healing properties. From the 1960s to the 1980s, the USA's National Cancer Institute was given licensing rights to collect specimens of smokebush for research into its effectiveness in treating cancer and HIV. Research discovered that the smokebush plant contained Conocurovone, a property which has the potential to destroy low concentrations of HIV. The Institute subsequently gave the Victorian pharmaceutical company, Amrad, a global license to patent a product from Conocurovone. Should the product be commercially successful, the Western Australian government and Amrad would earn billions of dollars in profits and royalties. Meanwhile, Indigenous people, who originally discovered the healing properties of this plant, would receive no acknowledgment or financial return.