Bio Factsheet

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Infectious Diseases

In 1900 life expectancy was 40-45 years, by 2000 the average life expectancy was around 75 years. Advances in the prevention and cure of infectious diseases largely achieved this improvement. Tuberculosis was the most common cause of death in the UK in 1900. However in some developing countries life expectancy is still as low as 45. The impact of medical advances, education and improved sanitation has not reached across the globe and diseases that are rare in the Developed world are endemic in poorer countries.

What is infectious disease?

An infectious disease is one that can be passed from person to person. The invading organisms are known as **Pathogens**. Key to preventing the spread of infectious disease is to identify the **method of transmission** of the pathogen.

Methods of Transmission

There are **four** basic methods of transmission of infectious disease.

- **Droplet (airborne)**. The infected person exhales the pathogens in small droplets of water or mucus, often whilst coughing or sneezing. These are then inhaled by another person and the pathogen has a potential new host. Diseases spread in this way usually infect the throat or lungs (e.g. colds and influenza) but they can use this method to enter the body before migrating elsewhere (e.g. meningitis)
- **Food and Water**. The pathogen enters the body through the mouth, either within the person's food (e.g. *Salmonella* food poisoning) or in infected water (e.g. Cholera). Infection of the food is very often linked to undercooked meat or meat that has started to decompose and to shellfish which tend to feed on untreated or partially treated sewage. Infected water is usually the result of the water supply being untreated or contaminated by sewage. This is often referred to as the "**fecal-oral route**". Often the two are combined: uncooked foods such as salads are washed in untreated water; or people with poor hygiene handle food after defecating.

  The body's response to detecting pathogens of this type in the digestive system is to try and remove them before they are able to cross into the bloodstream – pathogens detected in the stomach are vomited out and those further along the alimentary canal are "flushed out" by not absorbing water in the large intestine (diarrhoea). In areas of overcrowding and/or poor sanitation this can further the rapid spread of the disease. In extreme cases the person actively adds water to their digestive tract to try and remove the pathogens. This can very quickly lead to death or serious illness due to dehydration (e.g. Amoebic dysentery).

- **Contact**. This may be direct or indirect. "Contagious" diseases spread in this way usually enter the body through breaks in the skin or infect the skin. **Sexually Transmitted Diseases** such as HIV/AIDS and *Chlamydia* clearly fall into this category. The (mostly fungal) infections that we associate with shared towels and changing room floors are obvious examples of indirectly transmitted contagious diseases
- **Animal Vectors**. Parasites that use another, non-human, species to carry them from person to person often have extremely complex life cycles and are amongst the most difficult to eradicate. Examples include Hydrophobia (Rabies), spread by other mammals (the pathogen needs a warm blooded host at all times); and many insect-borne diseases such as Malaria (spread by mosquitos) and sleeping- sickness (spread by tsetse flies).

Defence against infection

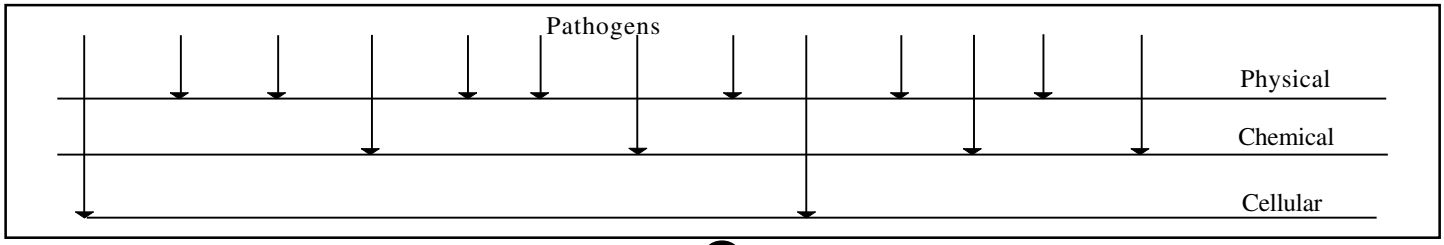
Of course our bodies do not simply allow pathogens to infect us. We have 3 natural lines of defence to try to prevent them entering or to eliminate them (Fig 1).

1. PHYSICAL
- SKIN is a protective barrier; if it remains unbroken pathogens must enter through openings (orifices).
- If you cut yourself the blood clots quickly to prevent pathogens entering.

2. CHEMICAL
- Mucus – air is filtered upon entering the body and any pathogens are trapped
- Sweat/Tears – contain anti-bacterial enzymes e.g. Lysozyme. Sebum from the sweat (sebaceous) glands also helps to keep the skin supple, stopping it "cracking".
- Stomach acid – pH2 acid kills most pathogens in food and/or water .

3. CELLULAR
- White blood cells - Phagocytes and Lymphocytes
- Symbiotic bacteria in the intestines (gut flora) and on the skin kill or prevent division of other micro-organisms

Fig. 1. Lines of defence against infection



Examples of important infectious diseases

Table 1. Four Important Infectious Diseases

Disease	Type of pathogen	Name of pathogen	Means of transmission
Tuberculosis	Bacterium	*Mycobacterium tuberculosis*	Droplet
Cholera	Bacterium	*Vibrio cholerae*	Water and food
HIV/AIDS	Virus	Human Immunodeficiency Virus	Contact
Malaria	Protoctist	*Plasmodium vivax & other plasmodium species*	Animal vector - female mosquito, *Anopheles*

These four diseases are major killers in many parts of the world. They have serious social and economic effects, particularly in developing countries.

Tuberculosis (TB)

Tuberculosis was the most common cause of death in the UK in 1900, when it was commonly known as "Consumption" – it literally seemed to be eating away at the sufferer's lungs. It was once thought to be almost eradicated, but new, antibiotic resistant strains and the increase in worldwide travel have seen a resurgence in developed and, particularly, developing countries – especially where HIV/AIDS is also prevalent. There are now 7,000 cases of Tuberculosis per year in the UK, requiring treatment with high doses of highly specialised antibiotics for over 6 months.

It is also a serious disease of cattle (caused by another species of *Mycobacterium – M. bovis*) and some believe that it is spread from farm to farm by badgers. This has led to serious controversy as badgers are a protected species in England but permission is often sought to cull the occupants of entire setts if TB arises in local herds. The sale of unpasteurised milk has been stopped to prevent the spread of the disease to humans.

Table 2. Tuberculosis – the key points

Incubation period	Several weeks
Tissues attacked	Lungs, then spreads throughout body
Symptoms	Vigorous cough, usually including blood; breathlessness & chest pain; 'flu - like symptoms such as fever & sweating; severe weight loss
Annual global incidence (WHO) - new cases	9 million show symptoms, up to 30% of world population infected but show no symptoms
Mortality rate per year	20%
Global significance	Ranges from 81in every 100,000 deaths in Africa to 6 in the Americas (8 per 100,000 deaths in Europe). 1.7 million total deaths

Tuberculosis is very closely linked to **overcrowded housing conditions** and poor diet. For this reason it is quite common in inner cities of Developed countries. People with the inactive form of the disease (no symptoms) may become ill if they are weakened by other diseases or become malnourished

Treatment in the past consisted of spending up to a year in an isolated sanatorium, being exposed to as much cold air as possible (beds were often pushed outdoors after it had snowed!). 50 years ago the antibiotic Streptomycin was developed. This is effective against the original strain of the disease when administered for a long period, but there are increasing numbers of resistant strains, some of which are multiple drug resistant (MDR-TB). Many people stop taking antibiotics before they have had the full course allowing the disease to redevelop.

In the UK, children were inoculated at school in their early teens against TB using the BCG vaccine, which was developed from *M. bovis*. However in some areas of the country this is no longer routinely carried out.
In countries of the developed world, many people who have migrated to the cities in search of work live in severely overcrowded conditions. The cost of drugs to treat sufferers is impossibly expensive and the availability of trained medical practitioners to diagnose the disease is restricted.

Cholera

Cholera is most closely associated with contaminated water supplies, allowing the bacterium to spread from the faeces of sufferers – the "fecal-oral" route. It is most closely associated with countries of the developing world, where the infrastructure to provide a clean water supply & remove sewage are lacking; and when natural disasters such as flooding and earthquake occur, causing sewage to enter the water supply.

Some estimates suggest that over half the world's population have never sat on a toilet! In many parts of the world people travel to the towns and cities looking for work and live in "shanty towns" where there is great overcrowding and no sanitation ;often sewage is seen running between dwellings. This provides ideal conditions for pathogens to spread quickly. Other people live in relatively isolated areas where it would be impossible to provide the pipe work to bring in clean water and take away sewage. The easiest, relatively cheap, solution is to bore deep wells to provide a supply clean water. This is often funded by charities such as "Comic Relief".

Table 3. Cholera – the key points

Incubation period	1-5 days
Tissues attacked	Walls of small intestine
Symptoms	Very severe diarrhoea leading to dehydration and loss of vital salts
Annual global incidence 2004 (WHO) - new cases	101,300 cases in 56 countries notified to WHO, probably up to 5 million cases in total
Mortality rate per year	2.50%
Global significance	Over 90% of global total in Africa, mortality rate as high as 40% in worst hit areas. Some outbreaks in Asia (e.g. after flooding in Bangladesh) & South America

If bacteria successfully reach the small intestine, they secrete a toxin that causes water & salts to leave the blood causing very severe diarrhoea called "rice water" because of its appearance. Some people pass as much as 20 litres per day and die within 24 hours.

As with all water & food borne illness, treatment involves **oral rehydration therapy** and rapid introduction of good hygiene. Oral rehydration therapy consists of clean water and dissolved glucose & salts. The amount provided should add up to the volume of urine and faeces lost. Antibiotics are largely ineffective against cholera.

When outbreaks occur it is vital that all water is boiled thoroughly and food is well cooked. The area is often isolated - a process known as "cordon sanitaire". The population must be educated about the need for good hygiene.

Exam Hint: *In questions about food and water borne disease, you may well be asked to write about* ***preventative*** *measures such as clean water & good hygiene. Remember that, in addition to stopping transmission of the pathogen, this is often much more cost effective than* ***treatment****. This is particularly important in Developing countries.*

HIV/AIDS

Acquired Immune Deficiency Syndrome was identified in the early 1980's. People were not recovering from infections that their immune system would normally deal with. The cause was quickly identified as a virus which attacks the **T helper cells.**

These **lymphocytes** inform the B-lymphocytes to divide and produce antibodies, so if the numbers of T helper cells are reduced the body is less able to defend itself against pathogens. The symptoms of AIDS are a combination of the effects of these "opportunistic infections". By the end of 2005, the World Health Organisation (WHO) estimated that a total of **25 MILLION** people have died from AIDS since its first discovery.

HIV is passed from person to person so the patient's immunodeficiency is said to be "acquired" – there is a much rarer inherited form of Immune Deficiency Syndrome. HIV is a **retrovirus** and contains RNA in its protein core along with **reverse transcriptase.** Once inside the host T helper cells this enzyme uses the RNA as template and produces DNA.

HIV can only be transmitted by direct exchange of body fluids such as semen and vaginal fluids, infected blood (which may be on contaminated needles) and from mother to child across the placenta or in breast milk. It is most often thought of as a Sexually Transmitted Disease (90% of HIV positive cases) and in many parts of the world is associated with homosexual men. However the pandemic has been most virulently spread by heterosexual intercourse in sub-Saharan Africa, where over 80% of deaths from AIDS occur. In countries such as Zimbabwe & South Africa, life expectancy dropped significantly in the second half of the 1990's as AIDS spread. There are many millions of children who have been orphaned by the disease in this part of the world – a large proportion of them are HIV positive. Linked very closely to this are cultural issues involving the attitude of men towards women. This is hindering attempts to reduce the transmission of HIV by educating people about reducing promiscuity and the use of condoms.

Table 4. – HIV/AIDS – the key points

Incubation period	A few weeks to become HIV positive, up to 10 years for AIDS to develop
Tissues attacked	T helper cells
Symptoms	Some 'flu like symptoms associated with HIV infection. Prolonged symptoms of opportunistic infections such as TB, pneumonia, cancers when AIDS develops
Annual global incidence 2005 (WHO) - new cases	4.9 million new cases, producing a global total of over 40 million cases
Mortality rate per year	8% of total sufferers
Global significance 2005	3.1 million people died from AIDS, of whom over 0.5 million were children under 15

There is no vaccine against HIV and no cure for AIDS. There is evidence that a small number of people with HIV have developed immunity. The main drugs used for treatment are **Antiretroviral** drugs such as Zidovudine, which binds to the reverse transcriptase in HIV and blocks replication of viral DNA. However these are very expensive. The supply of such drugs to Developing countries at an affordable cost was a major issue at the World Summit in Johannesburg in 2002. Until drugs and vaccines are developed, individuals are responsible for preventing spread from person to person by their own behaviour – this puts the onus very much on Education.

Malaria

The mosquito (various species of *Anopheles*) is a notorious **vector** of disease, spreading West Nile virus in the west of the USA and Canada for example. However the most notorious and feared killer disease spread by mosquitoes is Malaria. The **female** mosquito needs a regular meal of blood in order to produce its large number of eggs. If it feeds on an infected person, the ***Plasmodium*** in the blood meal migrates to the salivary gland of the mosquito. When the mosquito punctures the skin of another victim, it injects saliva containing an anti-coagulant and an anaesthetic. The *Plasmodium* enters the new host in the saliva. In this way many people are infected very quickly.

Fig 2. Spread of Plasmodium by mosquito

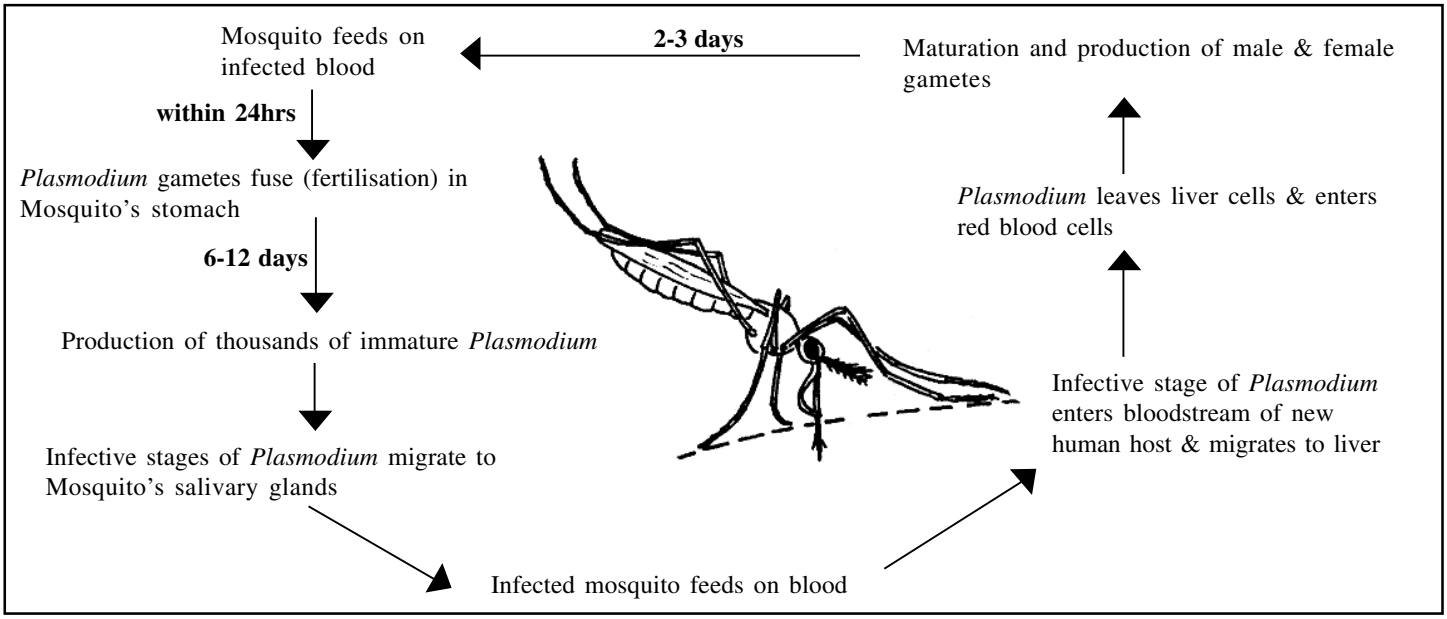


Table 5. Malaria – the key points

Incubation period	1 week to 1 year
Tissues attacked	Liver, red blood cells, eventually brain
Symptoms	Flu like fever, shivering, sweating, headache, nausea, anaemia, enlarged spleen
Annual global incidence 2004 (WHO)	Approx 400 million
Mortality rate per year	0.3% - small percentage of very large number!
Global significance 2004	Well over 1 million deaths per year. 90% of deaths from malaria in Africa are children under 5

Over 40% of the world population live in areas where malaria is endemic. People who are continually reinfected and survive for 5 years tend to become immune to malaria. People who are heterozygous for the sickle cell anaemia gene are immune to malaria; as a result the recessive sickle cell allele is most common in people of African descent.

There is no real treatment for malaria, the key is prevention. The major focus for the WHO and aid organisations is to reduce the number of mosquitoes and break the life cycle of *Plasmodium.* There are several ways of doing this:

- Mosquitoes lay eggs in water. People are encouraged to cover containers of water and to stop pools & puddles developing if possible. Some pools can be drained.
- Oil can be spread on water to stop mosquito larvae breathing at the surface.
- Ponds can be stocked with fish that feed on the larvae – an example of **biological control.**
- A bacterium, *Bacillus thuringiensis*, which kills mosquito larvae but is otherwise harmless, can be sprayed.
- Batches of male mosquitoes can be sterilised using radiation, then released. Females they reproduce with lay in fertile eggs.

Another way of stopping transmission is to stop people being bitten by mosquitoes. This requires costly insect repellents and/or mosquito nets. This is advised for visitors to Malaria endemic areas, but the WHO estimates that only2.5% of children in Africa sleep under a mosquito net.

The third preventative measure is the use of **prophylactic** drugs. These stop the development or reproduction of Plasmodium inside the human host and are taken for a period before travelling to a risk area until about a month after leaving. The 19th century British colonials developed the gin and tonic as a way of getting bitter-tasting quinine into their bodies for this purpose! Unfortunately, resistant strains of *Plasmodium* have evolved and new anti-malarial drugs are ever more powerful and have increasingly unpleasant side effects. Increasing numbers of people return to the UK having contracted malaria (over 2000 per year); many did not take the prophylactics for long enough after their return and a lot are put of by their high cost – most Health Authorities will not provide the drugs on NHS prescription.

Infectious diseases are still the major cause of death and suffering in the poorest parts of the world where the lack of finance and organisation and, often, civil unrest mean that the situation will continue for the foreseeable future. We take successful prevention and treatment for granted in Developed areas such as Western Europe as the key requirements are all available:

- Clean water,
- Sanitation,
- Education on health and hygiene,
- Health provision.

Practice Questions

1. Explain why relatively small numbers of pathogens need to be dealt by the white blood cells.

2. a) What is the name of the organism responsible for Tuberculosis?

   b) Explain why TB is common in inner city areas of developed countries.

   c) Some tourists contract Tuberculosis on the Airplane journey home. Suggest why.

3. Outbreaks of food & waterborne diseases such as Cholera are often associated with filter feeding seafood, such as oysters & mussels, which live in areas where semi- and un-treated sewage are pumped into the sea.

   a) Explain how and why the disease is transmitted from person to person.

   b) What is the name given to this route of infection?

   c) What is the name of the organism responsible for Cholera?

4. a) In major sports such as soccer and rugby, all participants who are bleeding must leave the field. Explain how this could help to prevent the spread of HIV.

   b) Why does HIV cause the immune system to fail?

   c) Why is HIV described as a retrovirus?

5. Explain the role of the female mosquito in transmitting Malaria.

Answers

1. Most pathogens are prevented from entry to the body; by physical barriers; skin; blood clotting; or chemical barriers; in sweat; tears; Most pathogens entering through orifices are dealt with by chemicals; mucus; stomach acid; cilia moving mucus; mutualistic bacteria in gut; only pathogens progressing beyond these need white cell response.

2. a) *Mycobacterium tuberculosis*:

   b) Overcrowding; bacterium spread in droplets; more likely to infect new host:

   c) Crowded airplane; air recirculated; droplets from 1 infected passenger easily transmitted

3. a) People with cholera pass pathogen (Vibrio) in faeces; sewage not treated; oysters/mussels remove *Vibrio* when feeding on faeces; Oysters/ mussels not properly cooked; *Vibrio* enters human when oysters/mussels eaten:

   b) fecal-oral route:

   c) *Vibrio cholerae*

4. a) Participant may be HIV positive; HIV carried in blood; open wounds of participants may touch during game; HIV transmitted from one to other:

   b) Attacks T-helper cells; B-cells not informed of any antigen presence; B-cells don't divide & produce antibodies;

   c) Has RNA in protein core; uses reverse transcriptase; to make DNA; from RNA template.

5. Female mosquito (*Anopheles)* needs blood meal to make eggs; has proboscis to penetrate skin; *Plasmodium* in infected blood; sucked into mosquito stomach; fertilises; multiplies; in mosquito; migrates to salivary gland; enter new host; in saliva.

Acknowledgements:
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