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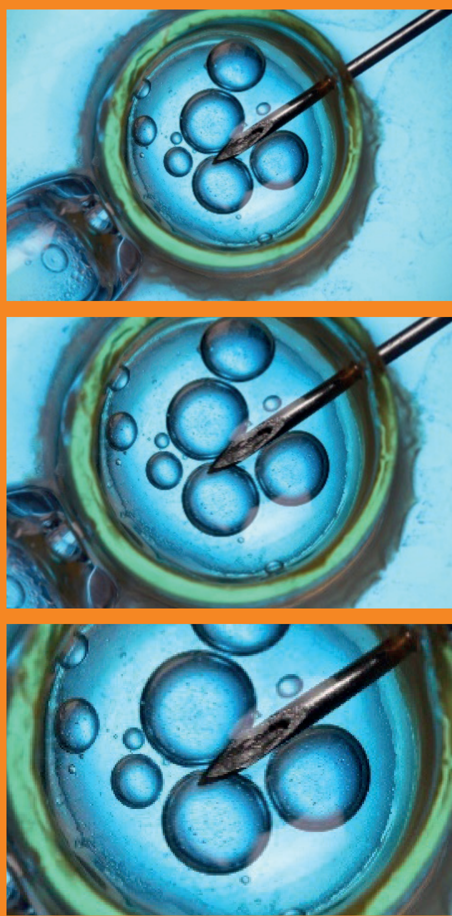
Pearson BTEC Level 3 National Extended Certificate in

Applied Human Biology



Unit 3

Human Biology and Health Issues

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How to use this document

Welcome to your Applied Human Biology course.

A BTEC National in Applied Human Biology will give the opportunity to develop a range of skills that will prepare you for the world of work, or for continued study at a higher level.

The number of units in your BTEC National qualification varies depending on the size of qualification you are doing.

This document supports the specification and associated assessment guidance, it does not replace them and should not be used in place of it. Teachers should use their expertise and judgement regarding the teaching and delivery of this course and ensure that all areas of content are taught to learners in sufficient depth in preparation for the external assessment. Every effort has been made to cover as much of the specification as possible. This document **does not** indicate topics, question types or activities that may come up in the external assessment and no member of the examination team has been involved in its creation.

Features of this document

There are a number of different features throughout the document, designed to help you learn about the topics in your course in different ways and understand it from multiple perspectives. Together these features:

- explain what your learning is about
- help to build your knowledge
- help you to reflect on and evaluate your learning
- make you think beyond what you are reading about
- help you make connections between your learning and real-world workplace environments.
- In addition, each feature has a specific purpose designed to support your learning.

Features that explain what your learning is about

Getting to know your unit

This section introduces the unit and explains how you will be assessed. It gives an overview of what will be covered throughout the unit.

Features that help you build your knowledge

Worked example

The worked examples show the process you need to follow to solve a problem, such as a maths or science equation. This will also help you to develop your understanding and your numeracy and literacy skills.

Key points

Concise and simple definitions are provided for key words, phrases and concepts, allowing you to have, at a glance, a clear understanding of the key ideas in the unit.

Features connected to your assessment

Assessment practice

These features give you the opportunity to practise some of the skills you will need when you are assessed on the unit. They do not fully reflect the actual assessment tasks but will help you prepare for them.

Features to help you reflect on and evaluate your learning

Pause point

Pause points give you the opportunity to review and reflect on your own learning. The ability to reflect on your learning is a key skill you will need to develop and use throughout your life.

Hint and Expand
These points also give you suggestions to help cement your knowledge and indicate other areas you can look at to expand it.

Case study

Case studies are used in the unit to allow you to apply the learning and knowledge from the unit to a scenario from the workplace or industry. Case studies include questions to help you consider the wider context of a topic.

Think future skills

This section includes a case study of someone working in the industry. They talk about their job role and the skills they need. This comes with a Focusing your skills section, which gives suggestions for how you can begin to develop the employability skills and experiences that are needed to be successful in a career in your chosen sector. This is an excellent opportunity to build up your employability skills.

Getting to know your unit

Assessment	
You will be assessed through a 3-hour supervised task worth 60 marks, which is set and marked by Pearson.	Medical science has come a long way in the past 100 years or so. Nowadays we can treat, cure, or prevent, illnesses and diseases that would have often been fatal even 50 years ago. Despite the many advances in medicine that the world has seen in the last century, human beings still suffer from a huge number of health complaints. In Units 1 and 2 you will have learned about how the human body functions in both health and disease, and how microorganisms can make us unwell. Unit 3 will help you to understand how scientists and healthcare workers use that knowledge to promote good health, to treat illnesses when they occur, and to monitor and control the spread of disease worldwide. You will also learn more about how to critically analyse and interpret scientific articles, allowing you to draw your own conclusions from literature. aimed at a variety of audiences.

How you will be assessed

This unit will be assessed under supervised conditions. The supervised assessment task will assess learners' ability to understand health issues covered in a scientific article.

The supervised assessment task must be completed in a single session of three hours, on a day timetabled by Pearson. During the supervised assessment session, learners will be given stimulus material in the form of a scientific article. Learners will analyse and interpret this article in the context of how the health issue is being reported.

Pearson sets and marks the task. The number of marks for the unit is 60.

Sample assessment material will be available to help centres prepare learners for assessment.

Unit 3 has four Assessment Outcomes (AO), which will be included in the external set task. These are:

AO1 Demonstrate knowledge and understanding of health issues and associated initiatives and reporting

AO2 Apply understanding of health issues and associated initiatives and reporting

AO3 Be able to interpret, analyse and evaluate different sources of scientific information

AO4 Be able to synthesise different sources of scientific information.

A Contemporary health issues

This section builds on topics from *Unit 1: Principles of Applied Human Biology* and looks in more detail at cells, tissues, human body systems and their functions, and the immune response and genetics. From *Unit 2: Practical Microbiology and Infectious Diseases*, microorganisms and infectious diseases are explored. Every country has some way of managing the health and wellbeing of its citizens.

In the United Kingdom, there are a number of government, non-government and global organisations that influence how the health and wellbeing of the nation is monitored and managed and these will be explored. It is also important to explore the impact that individuals such as service users, patients, advocates and champions can have on shaping the way forward for research and initiatives designed to improve health outcomes.

A1 Understand health issues and associated initiatives and research

Modern healthcare systems can diagnose and treat many different health issues, from infectious diseases to genetic problems. In many areas of medicine, the focus has shifted from treating diseases as they occur to preventing diseases before they affect people. Using laboratory tests or imaging such as mammography to screen for diseases like cancer, heart disease and diabetes can help to prevent people from developing these diseases or can treat a condition in its early stages, before complications arise.

However, these advances have brought with them their own problems. We are now capable of keeping people alive and healthy for far longer than ever before. An ageing population requires increasing levels of care, which in some cases means that they will need long-term and complicated treatments, sometimes for more than one medical condition. There are often fewer people who can provide informal care to older age adults. Overuse of antibiotics has led to increasing levels of antibiotic resistance worldwide, meaning that simple infections are once again becoming harder to treat. Changes in sexual habits have meant that sexually transmitted infections (including infections resistant to antibiotics) have become increasingly common; and obesity is an increasing problem among the population, which can lead to an increased risk of many different health problems.

In addition, whilst medicine can now treat many different conditions, we still cannot cure everything. Some problems – such as genetic disorders – cannot be cured, and some diseases cannot be treated if they are detected too late. Increasingly, research is looking at how we can change our own genetic code through genetic modification and reprogramming to help reduce the burden of some of these conditions – and even to treat problems such as addiction to alcohol and other substances.

Infections

Many diseases are caused by infecting agents or microorganisms, such as viruses, bacteria, protoctists, fungi or larger parasites such as worms and insects (lice and fleas). Infecting agents live in or on the body, and if they cause disease, they are described as pathogens.

Key points

Infecting agents – organisms that infiltrate another living organism (the host) and cause an infectious disease – this could be a virus, bacterium, fungus or parasite.

Microorganism – microscopic organisms that include viruses, bacteria, fungi and some protoctists.

Parasites – organisms that live in or on another organism (host), obtaining nourishment and shelter from the host, while causing harm.

Viruses occur in all types of ecosystem and can affect all living organisms. Among the infectious diseases they cause in humans are HIV/AIDS, measles, mumps, influenza, herpes and Ebola. Some viruses cause cancer, such as cervical cancer which is caused by the human papilloma virus (HPV).

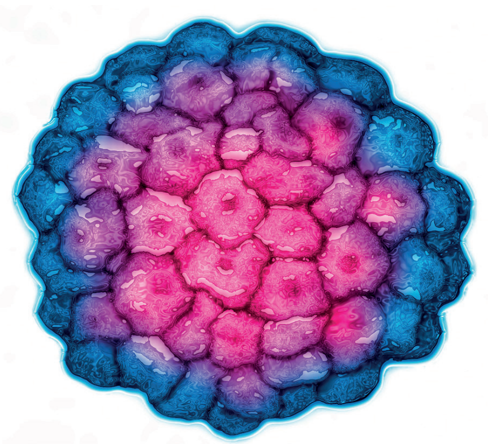


Figure 3.1: Transmission electron micrograph (TEM) with colour added of HPV, the diameter of the virus is about 50 nm

Bacteria are single celled **prokaryotic** organisms. Many inhabit the intestines of animals, including human intestines. Many types of bacteria are essential to us; however some types of bacteria are **pathogenic**. Bacterial diseases include cholera, bacterial pneumonia, meningococcal meningitis and whooping cough.

Figure 3.2: Scanning electron micrograph (SEM) with colour added of a variety of bacteria from the human intestine, x8000

Fungi are **eukaryotic** organisms. While some fungi support ecosystems by breaking down dead matter to recycle nutrients, some fungi act as parasites and infect other organisms. Yeast is one such type of fungi that can infect humans, these infections include:

- candidiasis (thrush)
- ringworm and athlete's foot (tinea)
- farmer's lung (aspergillosis).

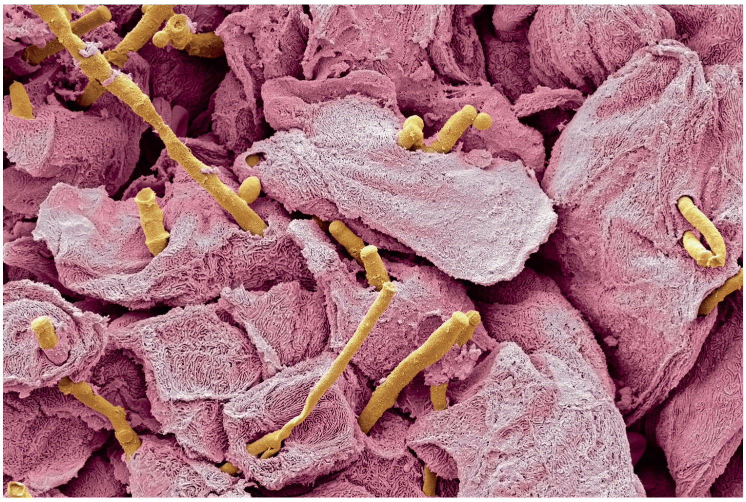


Figure 3.3: SEM with colour added of the surface of a human tongue infected with Candida fungus, x1000

Protoctista are species that do not fit into the other categories of microorganisms. All members of this species kingdom are eukaryotic and include:

- protozoa – infecting agents that cause malaria, sleeping sickness and amoebic dysentery
- slime mould and water moulds.

Key points

Virus – an infective agent, consisting of a protein coat and nucleic acid – either DNA or RNA, but not both.

Prokaryotic – cells that have cell surface membranes, cytoplasm and a cell wall but do not have a proper nucleus containing DNA. Their DNA floats free in the cell cytoplasm.

Pathogenic – capable of causing disease.

Eukaryotic – cells that contain a nucleus and membrane-bound organelles; organism made of eukaryotic cells.

Pause point

Use annotated diagrams to compare the structures of viruses, bacteria, fungi and protoctists.

Hint
State whether the microorganism is eukaryotic, prokaryotic or akaryotic. Explain these terms.

Extend
Discus whether viruses are living or non-living entities. Which features seem to indicate they are living or non-living?

Infectious diseases are also called communicable diseases as they can spread from person to person, or from animals to people, and, in some cases, people to animals. However, all microorganisms require certain conditions for their cell numbers to grow by replicating. These conditions include:

- a source of energy
- nutrients
- suitable temperature
- host organism
- suitable oxygen concentrations.

Some examples of communicable diseases and their method of transmission (how they enter a host) are shown in Table 3.1 below.

Table 3.1: Transmission routes of infectious diseases

Method of transmission	Infectious disease
Direct or social contact –fomites are objects or substances that can carry infecting agents and transfer them from one person to another. Examples include shaking hands, physical touching, and sharing of items such as towels, bedding and money.	Athlete's foot, influenza, colds, measles, mumps, MRSA and hospital acquired infections, norovirus and chicken pox
Airborne – the infecting disease is carried in droplets and released via breathing, coughing and sneezing; the droplets are breathed in by another person.	Measles, colds, influenza
Contaminated food and water.	Typhoid, salmonella, campylobacter, hepatitis A, Ebola and cholera
Bodily fluids, for example blood to blood, or via sexual intercourse.	HIV, AIDS, syphilis, hepatitis B and the human papilloma virus (HPV) (which causes cancer of the cervix)
Insects and tick bites.	Malaria, dengue fever, lyme disease and sleeping sickness

For many of the identified infectious diseases across the world, how they are spread and how they are cured using medicines such as antibiotics is known, and ultimately how they are prevented using vaccinations and other health-related policies and procedures. However, there are important public health issues in the prevention and control of infection, including the general health of the public, living conditions, sanitisation and cleanliness, housing, and water supply. These issues influence the level of infectious disease in a community and can lead to outbreaks of a previously unknown, or previously contained, infectious disease.

Key points

Formites – objects or substances that carry infecting agents and transfer them from one person to another.

Droplets – tiny drops of moisture produced when a person breathes out/sneezes/coughs. If that person is infected, these droplets may contain bacteria or virus particles that could infect another person.

Epidemiology

Epidemiology is the study of the distribution and determinants of diseases and health problems, and the factors that affect their spread in specific populations (groups of people in rural or urban areas for example). Epidemiologists gather information about the distribution of specific diseases throughout the population, and, using the evidence they gather, identify the risk factors for the disease. This evidence helps to shape public policies that try to reduce or eradicate the infectious diseases. Epidemiologists gather data on how many people fall ill and how many people die as a result of the infectious disease. They then use data to look at the incidence (number of new cases in the population) and prevalence (number of people with the disease in a population at any given time). They use this data to make comparisons across days, weeks, months or years.

This data informs the preventative and treatment regimens that any nation may need implement to control an infectious disease.

Endemic

If an infectious disease is always present in a particular area or population, it is described as endemic. Chicken pox is endemic in most parts of the world, particularly among young children.

Epidemic

A sudden outbreak of an infectious disease, for example influenza or measles, affecting many people in an area or population group is an epidemic.

Pandemic

If an epidemic spreads across a very large area, such as a continent or the whole world, it is called a pandemic. SARS-CoV-2, also known as Covid-19 (coronavirus disease 2019), is an example of a pandemic.

In Britain, local health authorities must report any outbreak of a disease in the area they are responsible for. This data is generated from GP reports, private health agencies and health-related charities. This data is then passed on to the Department of Health and Social Care (DoHSC) to review over a period of time. If they detect a serious outbreak of a disease, this is reported to the World Health Organisation (WHO) who track the data further and decide if medical assistance or resources are needed to prevent a serious epidemic.

Reducing the transmission of infectious disease

Infectious diseases still cause millions of deaths around the world every year – from malaria and schistosomiasis in tropical areas, to influenza and norovirus outbreaks in the more temperate regions of the world. They affect all age groups, from new-born babies to the elderly and cannot always be stopped from spreading from one person to another.

Different pathogens have different routes into the body or infective sites. Respiratory pathogens are usually airborne, intestinal pathogens are usually food or waterborne, or spread via the faecal-oral route (faeces to hands to food via preparation or eating).

Where possible, health professionals take preventative measures against infections that are common in particular age groups, or those that occur on a seasonal basis. For example, people vulnerable to infectious disease, such as the elderly, or those with underlying health conditions such as diabetes or respiratory issues, are offered a flu vaccination on a yearly basis. Babies and infants are immunised against communicable diseases such as measles, mumps and rubella to prevent them spreading.

Antibiotics and vaccination programmes are only a small part of how governments and healthcare workers help to reduce the burden of infectious disease on individuals and on society. The case study below looks at some different ways of reducing the transmission of a particularly deadly infectious disease.

Case study

The Ebola epidemic

In late December 2013, a deadly disease started to spread through villages in Guinea, West Africa. Sufferers complained of high fevers, headaches, vomiting, and diarrhoea. These symptoms rapidly progressed, and victims of the disease soon started to bleed from all of their orifices. The disease worked quickly – many who contracted it died within a week. The first victim, a young boy from an isolated village, died two days after he first became unwell. Several of his immediate relatives fell ill with similar symptoms shortly afterwards. They too died quickly, but not before they had attended a local hospital with their symptoms. Several members of staff at the hospital then started to display similar symptoms – and, again, many of them died.

In January 2014, local public health officials were informed of a rapidly fatal illness, and investigations began into its cause. Initial examination of samples from sufferers suggested that cholera was to blame. By this time, cases had already spread from the small villages where the disease had initially begun. One of the first victim's relatives had travelled to the capital of Guinea, where he started to suffer with the same symptoms. He was treated at a local hospital, where staff were unaware of the outbreaks of disease in the countryside., As a result no measures were taken to protect them against possible infection. From this central hub, the disease began to spread across the country.

By mid-March 2014, public health officials, including staff from the World Health Organisation (WHO) and the organisation Médecins Sans Frontiers (MSF) (see section below) had begun to investigate the links between these cases. Samples from people suffering from the infection were sent to laboratories around the world to try to identify the cause. Finally, on the 22nd of March 2014, a laboratory at the Institute Pasteur in France confirmed the causative agent was the Ebola virus. The local government alerted the WHO to a "rapidly evolving" outbreak of Ebola.

Ebola is easy to spread. It is transmitted in the bodily fluids of those infected with the virus, meaning that anyone who comes into close contact with an infected person is at risk. This includes family members, healthcare workers, and even mortuary workers who may encounter the body of someone who has died from the disease. The outbreak quickly spread to neighbouring Liberia and Sierra Leone.

Travel restrictions were put in place in all three countries. Healthcare and mortuary staff were issued with appropriate personal protective equipment (PPE). Additionally, education programmes were developed to help people understand how to avoid contracting the infection. These programmes advised the public about symptoms, and what to do if they became unwell with suspected Ebola. Eventually, these efforts (instigated by the WHO, the Centre for Disease Control, local governments and other groups) would control the outbreak – but by that time the disease had already claimed over 11,000 lives and infected over 28,000 people. The WHO states that the true toll from the outbreak may never be known, as accurate data is difficult to collect in the more rural areas of West Africa.

Figure 3.4: Ebola virus under a microscope

Case study

Check your knowledge

1. What is the organism that causes Ebola?
2. Under what circumstances today, do Ebola epidemics occur?
3. What is the treatment for Ebola?

Pause point

Without copying from Table 3.1 make a table summarising the main ways infectious diseases can be transmitted from one person to another.

Hint
Think about direct, person-to-person contact as well as indirect means such as food and water contamination.

Extend
Find out about the risks to pregnant women from contracting toxoplasmosis from cat litter trays.

Controlling the spread of antibiotic resistance

Bacteria can quickly develop resistance to antibiotics. In fact, bacteria have been developing antibiotic resistance for millions of years as a defence mechanism against naturally occurring antimicrobials, and against antibiotics secreted by other bacteria. This ongoing "evolutionary arms race" has only been accelerated by the overuse of antibiotics in medicine, veterinary care and agriculture. Some fungal and protozoal infections have also evolved to become very challenging to treat. The WHO has previously stated that "antibiotic resistance is one of the biggest threats to global health, food security, and development today".

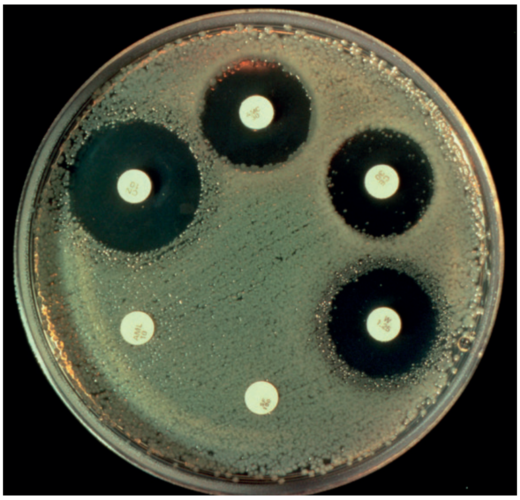


Figure 3.5: Antibiotic resistance in E. Coli bacteria – the bacteria are sensitive to four antibiotics, shown by the clear zones around them, but are resistant to two of them, shown by the absence of clear zones around the bacteria

One way of getting around antibiotic resistance is, of course, to develop new antibiotics. This, however, is far more difficult than it sounds – it can take many years of research to identify a chemical with antimicrobial properties, and many years more to determine whether or not it can be made into a drug which is safe and effective in humans. New antibiotics cannot currently be developed quickly enough to deal with the problem of antibiotic resistance, and so doctors and scientists have been forced to look for other methods of reducing resistance.

One of the most important of these is through what is known as "antibiotic stewardship" – only prescribing antibiotics for proven bacterial infections, and then only using them for as long as they are needed. Educating both doctors and patients about this concept is hugely important to reduce the long-term over-prescribing of antibiotics that can be seen throughout the world today. Figure 3.2 below demonstrates one way of trying to explain to people why they are not being prescribed an antibiotic for their viral infection.

As modern medicine discovered more antibiotics through the second half of the 20th century, some older antibiotics were replaced with more modern ones. Another approach to reducing antibiotic resistance has been to "rotate" the prescription of antibiotics – using different antibiotics in sequence over months or years. If an antibiotic is not used for a long period of time, then bacterial resistance to it is likely to diminish, in favour of resistance to drugs currently being used. Even this measure, however, isn't likely to be enough to combat the antibiotic resistance crisis.

There are some other possibilities being examined by scientists as ways of combating antibiotic resistance. Bacteriophages (viruses specifically designed to infect and destroy particular bacterial strains), bacteriocins and immunotherapies are all showing some promise – but it is likely that there will need to be a combination of approaches to combat the problem. Vaccination is another way to help reduce the overuse of antibiotics.

Vaccines work to stimulate the memory cells in our immune systems, meaning that our bodies can respond quickly if exposed to the same microorganisms again in the future. This allows us to prevent an individual becoming infected in the first place, even if those around them contract the disease. The case study below shows just how effective a vaccination programme can be.

Key points

Antibiotics – medication that treats bacterial infections, either by killing bacteria, or by inhibiting their ability to reproduce.

Antimicrobials – substances that act to kill or disrupt the growth of microbes. Antimicrobials may be effective against bacteria, fungi, protozoa, or other organisms.

Case study

Eliminating smallpox

Smallpox is the first example of an infectious disease that has been wiped out by effective vaccination programmes. In 1980, the World Health Organisation (WHO) declared that smallpox had officially been eradicated from every country on Earth.

Smallpox is an ancient virus – thought to date back to at least the 3rd century BCE. It causes a deadly disease – killing 30% of those infected with it, and often scarring or blinding survivors. Those infected suffer from severe blisters on the skin, which are extremely painful. If they burst, each blister contains millions of virus particles (or virions), which are then easy to spread to other people. Smallpox used to be found almost everywhere in the world – slowly being spread throughout human history by traders and explorers – meaning that eradicating the disease was in everyone's best interests.

In the 1950s the WHO began a programme to vaccinate against smallpox, with the aim of eliminating the disease from every country in the world. This first effort was underfunded and suffered from a lack of commitment globally. There were also issues with supplies of the vaccine. By 1967, however, momentum had gathered again. Laboratories around the world had found ways to manufacture large amounts of high-quality freeze-dried vaccine, and international large-scale immunisation programmes began to take off. In addition, better health surveillance allowed teams of healthcare workers to target their efforts more effectively.

The last case of "wild" smallpox worldwide was reported in 1977. Unfortunately, in 1978 Janet Parker, a medical photographer in England, contracted the disease from a laboratory on the floor below where she was working. As smallpox was so rare by this stage, it was not immediately recognised by the doctors who were treating her, and she tragically died from the infection. However, by 1980 there had been no further cases reported, and the WHO officially declared that the disease had been eradicated. Only a few samples of the virus have been kept, in secure laboratories, for research purposes. The extinction of smallpox remains one of the greatest success stories of public health.

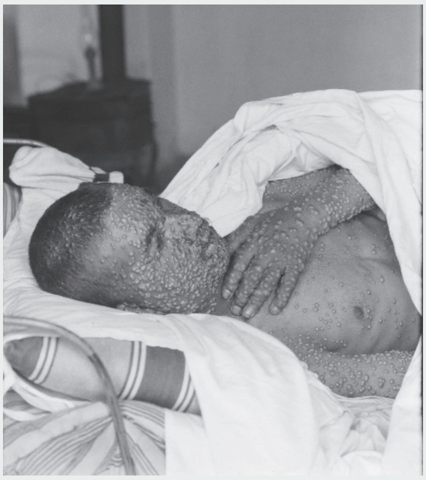


Figure 3.6: A patient with severe, painful blisters which occur in smallpox infections

Check your knowledge

Why do you think, despite the success of smallpox eradication, that global eradication of other common infections through vaccination has not been successful?

Vaccination programmes and disease prevention

Vaccination is the deliberate exposure of a person to a specific type of pathogen that has been killed or treated to make it harmless, or to its antigens, to stimulate an immune response. As a result, the person's body makes memory cells that remain, giving long-term **immunity**. Vaccination involves active immunity where the immune system is activated to make its own antibodies.

- Active immunity is the body's immune response in which it makes antibodies to a specific antigen. It may be natural, as in having the disease, or artificial, following a vaccination.
- Passive immunity is where you are given ready-made antibodies. This happens naturally when antibodies pass from mother to foetus before birth, or after birth in the first breast milk (colostrum). It may be artificial when antibodies are injected into a person, for example an anti-tetanus injection.

Pause point

Why do you think active immunity lasts a long time, but passive immunity is fairly short lived?

Hint
Think about what happens during an immune response, and what remains in the body to make someone immune.

Extend
Explain how the structure of antibodies makes each type specific for a particular antigen.

In order for vaccination programmes to be successful and to protect the greatest number of individuals possible, large proportions of the population must be vaccinated. This helps to prevent the disease from spreading easily amongst those who either haven't received adequate protection from the vaccine or who cannot be vaccinated. This concept is called **herd immunity**. Children in countries with established vaccination schedules rarely suffer from potentially serious diseases such as polio, measles, meningococcal meningitis.

In the UK there is a vaccination schedule that:

- offers all children vaccination against specific diseases at appropriate ages, such as whooping cough, mumps, measles and rubella
- offers vaccinations through the NHS against influenza and pneumonia to all people over 50, who have certain health conditions, are pregnant, frontline health and social care workers, or who care for or live with someone at significant risk of contracting influenza. However, because influenza has a high mutation rate, each year the vaccine is adjusted to the three types predicted to most likely infect people in that specific period.

In addition to planned schedules, people travelling abroad can request and pay for certain vaccinations, and people with specific health conditions can ask for vaccines against hepatitis B, TB and chickenpox.

Key points

Immunity – the ability of an organism to resist an infecting agent, due to the presence of memory cells.

Herd immunity – protection of a population from infectious disease that occurs following a large percentage of the population being made immune to the infection.

Different infectious diseases have different levels at which herd immunity is said to have been achieved. This is based not only on how effective the vaccine is at immunising each individual, but also how infectious the disease is. For example, measles is extremely infectious – and so herd immunity cannot be guaranteed unless at least 90-95% of the population has been vaccinated. Polio, on the other hand, is harder to spread, and only requires 80-85% of the population to be vaccinated before herd immunity is deemed to have been achieved.

Pause point

Think about how treatment and prevention of infectious disease has changed over the past century.

Hint
What differences are there now in healthcare practice, compared to 30 years ago?

Extend
How do you think it might change in the future?

Health and lifestyle initiatives

Cardiovascular disease (CVD)
Cardiovascular disease (CVD) includes all the diseases of the heart and circulation such as coronary heart disease, angina, heart attack, congenital heart disease and stroke. Diseases of the **cardiovascular system** are some of the biggest killers globally, causing an estimated 31% of deaths worldwide – most of which are from heart attacks and strokes. It is estimated that over 1 billion people around the world suffer with **hypertension,** which puts them at a greater risk of having heart attacks and strokes. In addition , hypertension increases the risk of conditions such as peripheral vascular disease – (damage to the blood vessels usually caused by a combination of hypertension, smoking, and high cholesterol) which can result in chronic kidney damage, and the loss of limbs or eyesight due to damage to the tiny blood vessels in these parts of the body. Modern medicine, combined with public health approaches, has to implement a wide range of approaches to reduce the effects of cardiovascular disease on an individual and on society.

Key points

Cardiovascular system – also known as the circulatory system. The heart and network of blood vessels supplying the body.

Hypertension – raised blood pressure.

Pause point

Create a table explaining the different conditions that CVD covers. What factors cause each condition?

Hint
Think about age and other genetic and lifestyle factors.

Expand
What are the possible consequences of not treating CVD? Describe how each condition could be avoided and the support someone might need if they develop symptoms and complications.

As an individual ages they have an increased risk of CVD due to narrowing of the arteries and other blood vessels as a result of fats being deposited in the walls of the blood vessels. This process of the arteries being ‘clogged up’ is called **atherosclerosis**. Atherosclerosis can result in higher blood pressure putting the person at risk of stroke and heart attacks. It can also result in the heart having to work harder to pump blood around the body, which raises blood pressure, and deposits can break away from the blood vessels and block an artery. If this happens, a person may experience chest pains and breathlessness, potentially leading to angina, or if there is a significant blockage, this is experienced as a heart attack.

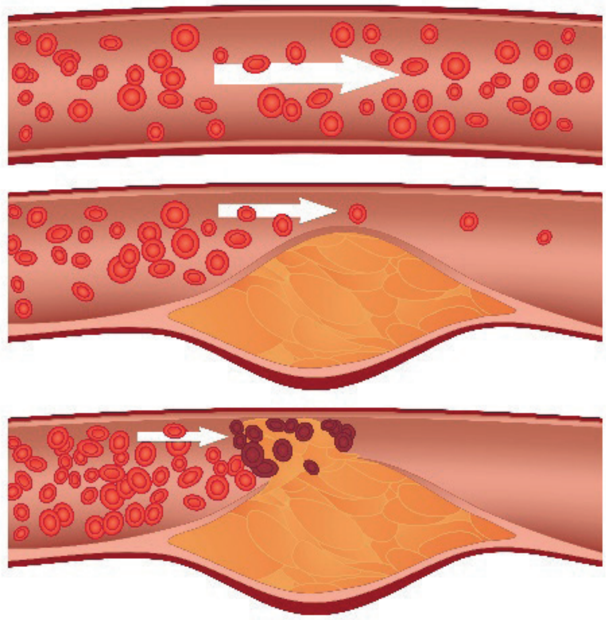


Figure 3.7: The evolution of coronary artery disease – one of the conditions that can lead to a heart attack

Key points

Atherosclerosis – the build-up of deposits in the arteries. These deposits consist of cholesterol, calcium and other substances found in the blood.

Primary prevention

Primary prevention involves trying to prevent medical emergencies such as heart attacks and strokes before they occur. This involves looking at populations who might be at risk of these conditions, such as people with high blood pressure, high cholesterol, or other pre-existing medical conditions. Primary prevention often involves both lifestyle changes and medical intervention, although this depends on why an individual is at risk of cardiovascular disease. Primary prevention methods might involve:

- reducing high blood pressure by exercising more, reducing dietary salt intake and reducing stress levels
- reducing high cholesterol levels by changing diet and reducing alcohol intake
- improving diet by reducing ready-made meals and processed convenience foods which are typically high in sugar, salt and saturated fats, resulting in higher calorie intake
- stopping smoking (to reduce high cholesterol levels, high blood pressure, and to reduce the risk of other diseases as well)
- using medication such as statins or antihypertensives to reduce high cholesterol or high blood pressure.

Intervention

However effective primary prevention may be, some people are still going to be unfortunate enough to suffer from a cardiovascular event – whether that is a heart attack, a stroke, or sudden damage to a blood vessel from a blood clot. If this happens then immediate treatment is needed. Without rapid intervention these conditions can be fatal or lead to lasting disabilities. Interventions in cardiovascular disease may involve:

- thrombolysis – using medication (usually delivered through a vein) to break up a blood clot and restore blood flow to an area of the body. This intervention may be used in strokes, heart attacks, or peripheral vascular disease
- angioplasty – a wire is inserted into the affected blood vessel under X-ray guidance, and dye is squirted into the blood vessel so the location of the thrombus can be identified. It may then be possible to break up the thrombus, or to place a stent to open up the blockage.

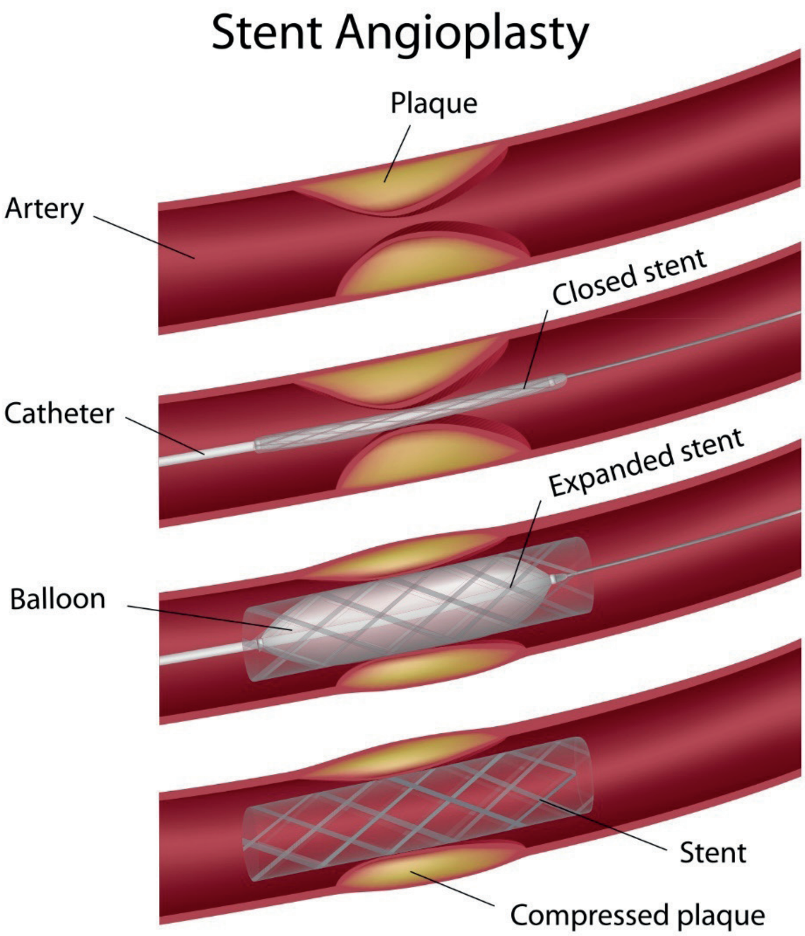


Figure 3.8: An example of how angioplasty and stenting works to open up a diseased blood vessel

Key points

Thrombus – blood clot.

Stent – a mesh tube, used to open up a blood vessel to restore blood flow.

If the blood vessel is too diseased for thrombolysis or an angioplasty to be effective, then bypass surgery may be required. This involves taking a healthy blood vessel from another area of the body (usually the leg) and using it to bypass the area of blockage or narrowing. Alternatively, artificial material is sometimes used to construct the bypass if no suitable blood vessels can be found.

Secondary prevention

Where primary intervention involves prevention, and interventional management involves treatment, secondary prevention focuses on trying to reduce the likelihood of a health problem recurring. In cardiovascular disease, this involves looking at people who have already suffered from a heart attack, stroke or other cardiovascular condition, and trying to reduce the risk of this happening again. Like primary prevention, this often takes multiple approaches. This may include both health and general lifestyle measures, such as:

- stopping smoking – this is probably one of the most important lifestyle changes that people can make after a heart attack or stroke
- improving diet to help reduce salt and cholesterol, and to include healthier fats
- increasing levels of exercise to help to reduce high blood pressure and improve cardiovascular fitness. This may need to be as part of a rehabilitation programme following a stroke or heart attack
- taking medication to lower blood pressure, reduce cholesterol, and reduce platelet activity to lower the risk of a further thrombosis. Other medication may also help to preserve the function of the heart muscle after a heart attack.

Key points

Thrombosis – a blood clot which may form in the heart, brain or other blood vessels.

Pause point

Research the following antihypertensives: thiazide diuretics, calcium channel blockers, beta blockers. Create a table describing what they do, and the advantages and disadvantage of each.

Hint
Think about who they are suitable for, and who they may unsuitable for, and whether they have any side effects.

Expand
If medication fails to prevent CVD, what's the potential next step to ensure a patient's survival? What risks are associated with this?

Respiratory diseases

Whilst not causing as many deaths worldwide as cardiovascular disease, respiratory diseases still affect many millions of people every year. The most common respiratory diseases are asthma, **COPD** and lung cancer, although there are many others in addition to these.

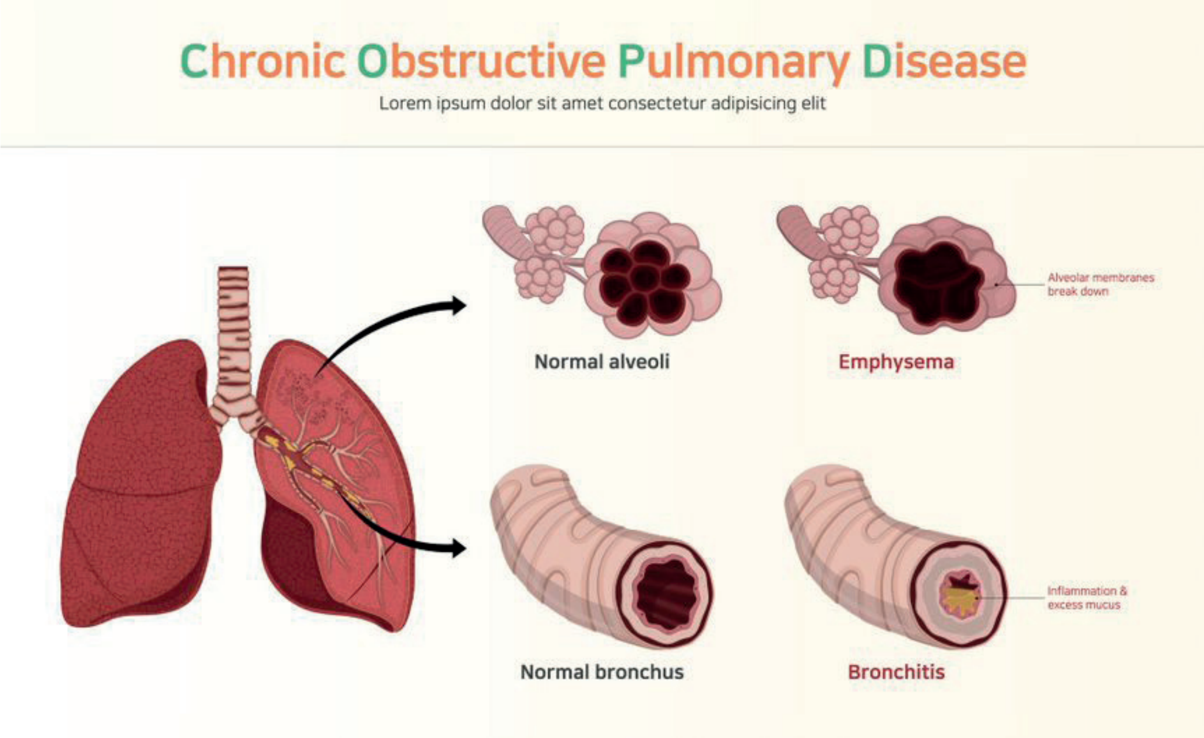


Figure 3.9: Chronic obstructive pulmonary disease

Key points

COPD – Chronic obstructive pulmonary disease, a disease mainly caused by smoking.

Treating respiratory diseases often focuses on managing the symptoms, as conditions such as asthma and COPD cannot be completely cured. This usually involves the use of inhaled medication to help keep the airways open and reduce symptoms such as coughing or breathlessness. Inhaled medications are usually used because they are easier to deliver directly to the lungs and will often work more quickly than taking medication orally. Treatment may also involve using oral medication to treat specific aspects of the condition – such as the use of oral medication to reduce the thickness and stickiness of mucous secretions in COPD sufferers. Sometimes, in very severe cases, surgery might be considered – to remove sections of diseased lung (in some COPD cases and lung cancers), or even to perform lung transplants.

Figure 3.10: Inhalers are used to treat a variety of different respiratory diseases.

Some lifestyle measures can be extremely important when treating respiratory diseases. Exercise remains very important and can significantly improve symptoms in some asthma sufferers by increasing their respiratory fitness. However, even people who are very limited by their respiratory conditions will often benefit from some regular exercise. In many areas, local pulmonary rehabilitation classes are held to help people exercise safely, within the limits of their conditions. Sometimes physiotherapy can be helpful for sufferers of respiratory conditions – helping them learn how to breathe more effectively or working with them to loosen and cough up sticky secretions from their lungs. Perhaps the most important intervention for anybody with a respiratory disease is to stop smoking – even in people with severe COPD, this can help to slow any deterioration in the disease.

An ageing population

Thanks to modern medicine and other significant social changes, the population of the world is gradually getting older. The WHO estimates that by 2050 the proportion of the world's population over the age of 60 will have doubled to 22% – almost 2 billion people.

With the average life expectancy in the UK at more than 80 years of age, as the population ages, new challenges arise for individuals and society. As a result of living longer, people are now affected by a wider range of diseases, particularly those that are slow to develop. Dementia and cancer, for example, are more prevalent in older age. Diseases that previously led to death are now successfully managed with medication and have become chronic rather than acute diseases.

Additionally, as people age, they tend to depend more on others for care and support as their independence and quality of life declines. Informal support can be difficult to obtain as people are tending to have fewer children, and their families are often scattered – meaning that traditional family support networks cannot always look after a relative as they become older and frailer. This means that many older people depend more on health and social care services to provide them with carers, or an environment where they can be cared for (such as a residential or nursing home).

It takes years to develop new health and social care services that met meet the demands of the population and this often requires years ahead of the new services being needed so that sufficient time is given to develop new drugs and build new hospitals, for example. Gathering data regularly on the population to monitor the incidence of different diseases and disorders is the only way for the government and health and social care providers to predict the needs of society in the future.

One of the ways in which society can try to reduce the impact of an ageing population is by encouraging people to look after their bodies throughout their life, to reduce the number of people suffering from multiple comorbidities in older age. Health services need to understand the health needs of the older population and understand what separates those who remain active and maintain good health, from those are who physically less active and may experience more health problems.

There are a number of ways that local authorities, charities and other health and social care groups promote health and wellbeing by providing resources:

- leisure centres having free or reduced cost membership for the over 60s
- fitness clubs in community centres offering free exercise activities
- promotion of walking and cycling activities as well as running
- providing exercise classes with adapted and inclusive workouts for those who are physically less able.

Obesity

Key points

Malnutrition – when a person does not receive enough nutrients to be able to function, caused by having too little food, or too little types of the food necessary for good health.

Obesity – when a person is more than a third over the normal weight for their age, height and body type.

Osteoarthritis – a painful condition caused by wear and tear on the joints of the body.

Eating a healthy diet requires the balance of nutrients to be right. This requires eating the right amounts, or portions, of food stuffs. A person can have a poor diet in two ways, either they are eating less than the amount of nutrients they need to be healthy, this is known as **malnutrition**; or they are repeatedly eating excessive amounts of the nutrients they need, this is referred to as **obesity**. Obesity can also be caused by a lack of physical exercise, or a combination of poor diet and lack of physical exercise. The WHO reports that globally there are more people who are obese than underweight in most regions, and that obesity is linked to more deaths globally than being underweight.

Obesity is currently a significant concern to health services globally. The prevalence of being overweight and obesity among children and adolescents aged 5-19 has risen dramatically from 4% in 1975, to just over 18% in 2016 globally. For adults, the figure is estimated that around 13% (650 million) of the global population is obese, and 39% (1.9 billion) is overweight.

Obesity can lead to serious health problems, such as:

- diabetes
- osteoarthritis
- coronary heart disease
- some cancers, including breast and bowel
- diseases of the liver, gallbladder and bowels
- stroke.

Obesity can also lead to psychological problems such as depression, low confidence and feelings of isolation.

Tackling obesity is difficult – healthcare professionals and governments cannot control how much people choose to eat, and how much exercise they choose to do. Fast food is cheaper and more readily available than ever before, and many people lead busy lives that do not leave much time for cooking or exercising. Sometimes encouragement from a healthcare professional is enough for people to make the lifestyle changes needed to reduce their weight – but often the habits and patterns that have led to someone being overweight in the first place are quite complex, and resistant to change. Governments often run public health campaigns encouraging people to make diet and lifestyle changes (such as Figure 13), and initiatives like the sugar tax imposed on sugary soft drinks in the UK aim to guide people towards healthier choices.

Occasionally, other methods are needed to get people to lose weight. In people who are severely obese and who have tried dieting and exercise without success, medication is sometimes used to help with weight loss. In order for someone to remain on this medication, they must demonstrate that they are continuing to lose weight on a regular basis. In exceptional circumstances, surgery may be offered to reduce the size of the stomach – either by placing a removable band around the stomach, or by physically bypassing most of the stomach. After the operation, only very small portions can be eaten, and people usually lose significant amounts of weight. However, this operation is only performed as a last resort, and people need support from a specialist dietician and weight loss team to ensure that they get the appropriate nutrients from their more limited diet, and that their weight loss is carefully managed.

Smoking, alcohol and substance misuse

Tobacco and alcohol are both legal drugs in the UK but are responsible for causing significant amounts of harm. They are both physically and psychologically addictive, are strongly related to higher rates of cancer, liver and lung disease – but are still seen as socially acceptable drugs.

Smoking

It was only after the Second World War that scientists began to make the link between smoking and disease, and longer still before governments worldwide started to take action to reduce smoking-related harm and deaths. The ONS report the number of people in the UK who smoke has fallen continually – in 2015, only 17.2% of adults smoked, compared to 46% in 1974.

Smoking is a risk factor for many diseases throughout the body – from throat, lung and stomach cancer, to heart attacks, strokes, peripheral vascular disease, erectile dysfunction, lung diseases such as COPD, and even dementia. However, preventing smoking-related diseases and deaths is challenging. Often, by the time somebody realises that smoking has damaged their body, it is too late to reverse the disease process. This means that healthcare workers and governments have to tackle the act of smoking – either by convincing people to stop smoking or ensure that they never start in the first place.

In the UK, this has taken many different forms. In the 1960s, cigarette advertising on television was banned. This was followed by heavier taxation on cigarettes and tobacco products in the 1980s, health awareness campaigns detailing the harm caused by smoking and the establishment of "help to quit" services in the early 2000s, and the banning of billboard and magazine advertising for cigarettes in 2003. Smoking in all enclosed workplaces became illegal in 2007, and in recent years all cigarettes and tobacco products are sold in unbranded packaging. Shops have stopped displaying tobacco products, instead keeping them hidden from sight behind the counter.

Alcohol

It is possible to drink alcohol at a "harmless" level, which is not associated with any particularly increased risk of disease. However, excessive alcohol misuse, over sustained periods of time can lead to:

- heart disease
- stroke
- liver disease
- liver cancer
- mouth cancer
- pancreatic cancer.

Alcohol misuse can also lead to social problems, such as unemployment, divorce, serious crime and prison sentences, and homelessness. Alcohol addiction has been linked to road deaths, domestic abuse, violent assault and physical and emotional problems in children living with parents with alcohol problems. Even low levels of alcohol intake by a pregnant woman can damage her developing foetus.

Efforts to curb alcohol excess often take a slightly different approach to smoking cessation. This is usually in the form of public health campaigns and education. By educating people about harmful levels of alcohol abuse, governments hope to encourage people to cut down on levels of harmful drinking. Doctors and nurses are encouraged to ask people about their levels of alcohol consumption, and offer patients help to reduce their drinking, or even stop entirely. Organisations such as Alcohol Concern (in England and Wales) and Alcoholics Anonymous (UK) aim to offer non-judgemental counselling, support, and assistance for people who are addicted to alcohol, and who want to stop excessive use.

Substance misuse

Substance misuse isn't limited to the use of illegal, or illicit, drugs, such as cocaine, cannabis, and heroin. Antibiotics, or similar drugs, have been misused over decades as a means to combat infections, leading to antibiotic resistance in many cases, and the creation of so called 'superbugs' as a result. This can also include sleeping pills, tranquillisers, and other drugs that have been prescribed, sometimes over prescribed, long term.

Any substance can be addictive, while they may make a person feel relaxed initially, they can quickly lead to people feeling sick, sleepy, paranoid or to panic attacks. This is in addition to the potential issues of debt and even possibly crime to finance ongoing substance misuse.

Illegal or controlled drugs, sometimes called recreational drugs, are taken to alter behaviour and mood. Taken once, they can be extremely dangerous, and if taken regularly they can quickly become addictive, often leading to long-term physical and mental health problems.

Addiction and overreliance on drugs, of any kind, causes long-term damage to the body, in particular the liver and kidneys. The liver clears the blood of drugs by breaking up the chemicals, and the kidneys excrete the waste in urine. Over time, these organs are vulnerable to damage. All drugs have side effects associated with them, these can include rashes, digestive issues, and blood disorders.

Table 3.2: Health risks commonly associated with illegal substances

Misused drug	Method of use	Possible health risks
Cannabis	Usually smoked but can be eaten.	Mental illness, raised blood pressure, memory loss.
LSD	Eaten in various forms.	Disorientation, depression and anxiety.
Heroin	Injected, sniffed, or smoked.	Heart and lung disorders, HIV/AIDS, vein thrombosis, septicaemia (blood infection).
Ecstasy	Swallowed.	Heat stroke, collapse, cramps.
Cocaine	Sniffed or injected.	HIV/AIDS, vein thrombosis, septicaemia (blood infection).
Amphetamine	Swallowed, sniffed or injected.	HIV/AIDS, vein thrombosis, septicaemia (blood infection).

Illicit drugs are more challenging to tackle, for both governments and healthcare workers. People will often not want to admit to a healthcare professional that they are using illicit drugs and are often resistant to seeking treatment. The harm from these substances can occur in several ways, depending on which drug is used and how it is taken. Smoking substances like cannabis or crack cocaine, for example, can cause similar health problems to smoking tobacco – damage to the lungs and airways. Snorting drugs such as cocaine can cause damage to the nose, and the delicate tissues in the nasal passages. Injecting drugs such as heroin can cause long-term damage to blood vessels, and lead to severe infections throughout the body. In addition, the drugs themselves may cause psychological issues amongst users. If somebody overdoses on a drug, it can even kill them.

Different governments take different approaches to dealing with illicit drugs. Some ban them entirely, and impose harsh sentences for anybody found carrying drugs, whether for their own use or for supplying to others. Other countries, such as Portugal, have decriminalised all previously illegal drugs. This means that, instead of arresting drug users, they are offered help to manage their addiction, or to stop taking drugs entirely. In the UK, drugs are classified as class A, B, or C, according to their perceived level of risk. Class A drugs are most likely to cause harm – and being caught whilst carrying these carries a much greater likelihood of prosecution and prison than class C drugs. In the UK, educational campaigns aim to make people are of the possible risks behind drug abuse, as well as the potential legal consequences.

Sexually transmitted infections (STIs)

Sexually transmitted infections may be caused by a huge variety of pathogens – viral, bacterial and fungal. They cause many different symptoms – from itchiness or soreness in the genital region, right through to suppression of the immune system, and even death. Many sexually transmitted infections are treatable with modern medicine – but not all of them can be eliminated entirely.

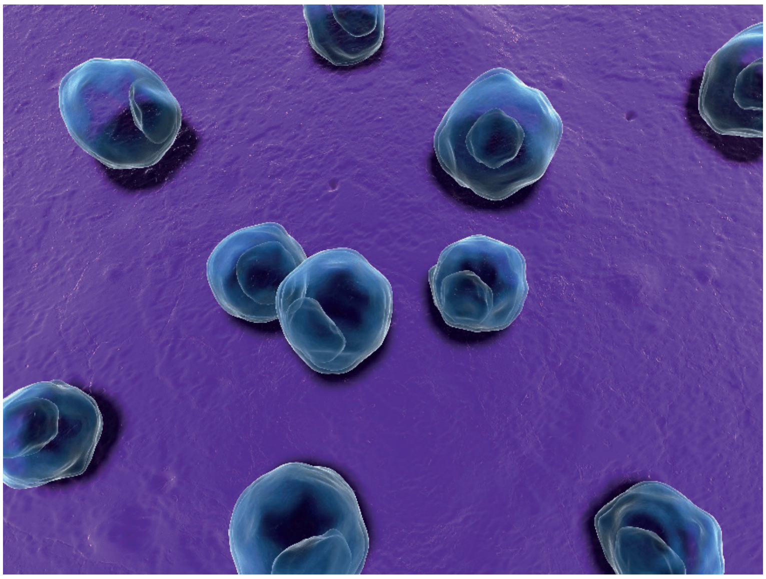


Figure 3.11: Representation of chlamydia cells

Chlamydia is perhaps one of the most common sexually transmitted infections, accounting for around 46% of all STIs diagnosed in the UK (source: https://www.fpa.org.uk/factsheets/sexually-transmitted-infections). Caused by the bacterium *Chlamydia trachomatis*, it may cause symptoms such as discomfort on urinating and genital soreness – or it may not cause any symptoms at all. It is relatively easily treated with a course of oral antibiotics – but if left untreated, it can go on to cause serious womb or testicular infections and can even cause infertility in both men and women.

Other bacterial infections like gonorrhoea can also usually be treated with antibiotics – but the rise of antibiotic resistance means that scientists are now starting to see a rise in strains of gonorrhoea that are very resistant to antibiotic treatment.

Viral infections such as the herpes virus, the wart viruses (which have many different subtypes), and Human Immunodeficiency Virus (HIV) are much harder to treat. None of these infections currently have a treatment that cures them – although HIV can now be effectively controlled in most cases using a range of different drugs, preventing it from developing into the much more severe Acquired Immunodeficiency Syndrome (AIDS). The herpes virus may lie dormant for long periods of time, before flaring up and causing painful blistering of the genitals. When this occurs, antiviral medication may sometimes help to reduce the severity of the attack, but it cannot eradicate the virus from the body – and so sufferers may continue to have outbreaks of herpes for the rest of their lives.

If an STI cannot be treated, then preventing people from contracting the infection in the first place becomes tremendously important. Public health campaigns encourage people to get tested regularly and remain aware of the risks of transmission. Encouraging people to use condoms and to test regularly can help to reduce the spread of untreatable infections.

In addition to disease prevention campaigns, vaccination campaigns can be an effective way of treating some STIs. In the UK there is now a national vaccination campaign for Human Papilloma Virus (HPV) – an STI with many different viral subtypes, some of which are responsible for cervical, penile, and anal cancers. Other subtypes of HPV are responsible for genital warts – and some of the vaccines developed for HPV are effective against both the cancer-causing strains of HPV and the wart-causing strains. In the UK all girls and women from age 12 to age 18 are vaccinated against HPV, with plans to extend this vaccination programme to men and boys in the near future. It is hoped that this campaign will help to eradicate cancers caused by HPV, as well as significantly reduce the rate of genital wart infection.

Genetic initiatives

Genetic screening

Many different diseases have genetic risk factors, even if they are not conditions that we might ordinarily think of as genetic disorders. Illnesses like diabetes, COPD, and even addictions to alcohol or substances, may all have a genetic component. One way of improving the health of the nation, and the health of individuals at risk of certain conditions, is to check a person's health status by offering them health screening.

A good example of genetic screening in the UK can be found as part of the testing offered to some pregnant women. If a foetus is felt to be at a high risk of genetic abnormalities (due to problems picked up on routine ultrasound scans during pregnancy, or due to a family history of genetic disorders) then the mother may be offered a test of either the amniotic fluid inside the womb, or of a sample of tissue taken from the placenta. This fluid or tissue can then be examined for any genetic abnormalities, either by performing a full examination of the foetus's genetic code, or by checking specifically for certain genetic conditions, such as Down syndrome. Screening can lead to difficult decisions in some cases.

Genetic screening in later life is often offered to people with a strong family history of a disease – particularly conditions like cancer, as some cancers have significant genetic risk factors. If a woman has a strong family history of breast or ovarian cancer, for example, she may be offered genetic screening for the BRCA genes (BRCA1 And BRCA2) – which are strongly associated with these types of cancer. If a family is identified as being BRCA-positive, then men in the family may also be offered the genetic testing – as BRCA also increases the risk of male breast cancer and prostate cancer. If someone is diagnosed as being BRCA-positive, they will need to be closely monitored for any signs of these diseases developing. They may even be offered preventative surgery to remove the breasts or ovaries.

Genomic research aims to map and understand the entirety of human genetic code, and to unravel which genes may increase the risk of cancers and other diseases. With improved understanding of these risk factors we may be able to screen for faulty genes with increased accuracy, and perhaps prevent many diseases from occurring.

Genetic diseases

Several thousand genetic disorders are known in humans. Some are extremely rare, but others such as cystic fibrosis and sickle cell anaemia are more common and better known. Genetic diseases may be extremely severe, or they may cause few symptoms. Some genetic conditions – such as Down syndrome and haemophilia – are present from birth, and others – such as Huntington's disease – only become obvious later in life. This huge variety in genetic disorders is due to the vast number of genes found in the human genome. Around 30,000 different genes make up the genome, and they can be switched on and off at different times to add more combinations. Some genetic disorders are the result of just a single faulty gene. Other diseases are due to combinations of many gene variants.

Genetic screening, and an increasing understanding of the human genome, are crucial in order to further understand genetic diseases, and perhaps learn how to prevent them in the future. The technology that makes this possible is becoming faster, smaller and cheaper all the time. Techniques such as CRISPR (clustered regularly interspaced short palindromic repeats) is a technology that can be used to edit DNA. Targeting faulty genes may one day allow for successful treatment of genetic diseases. For now, although genetic conditions can often be diagnosed successfully and early on, it is not possible to reverse the genetic changes responsible for diseases, instead the focus has to remain on treating the symptoms of the disease as far as possible.

Pre-implantation genetic diagnosis

Genetic diseases are often impossible to cure. This means that people with a strong family history of a known genetic disease, such as cystic fibrosis or haemophilia, often want to reduce the risk of their children being born with the disease. Pre-implantation genetic screening aims to determine the risks of a specific genetic disease before the fertilised embryo is implanted in the uterus (womb).

Because pre-implantation testing must take place before the embryo is implanted in the uterus, testing can only take place using *in vitro* fertilisation (IVF). This involves removing an egg (ovum) from a female and combining it with sperm from a male outside the human body, in a scientific environment.

When the embryo is at the eight-cell stage, one cell can be removed without damaging the embryo. The DNA can be extracted from this cell, amplified and then tested for specific alleles that lead to genetic disorders. The result is that only healthy embryos are implanted into the uterus. It can also be carried out on embryos to see if they can be an umbilical cord stem cell donor for a sick sibling.

In the UK, in order for someone to qualify for pre-implantation genetic diagnosis, they must:

- have a strong family history of a specific genetic disorder, or
- have a child with a specific genetic disorder and want to avoid it happening again, or
- have terminated previous pregnancies for a specific genetic disorder, or
- have a family history of chromosome problems.

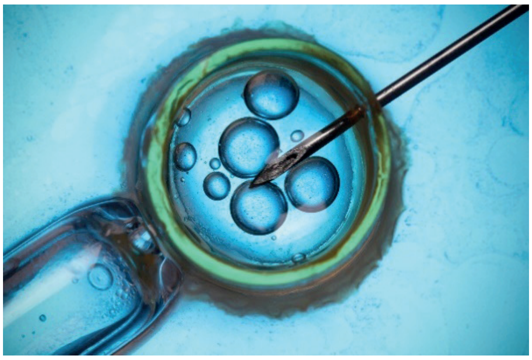


Figure 3.12: IVF involves the fertilisation of an egg with sperm in a laboratory

Pre-implantation genetic testing has its limits, however. It is expensive, and involves IVF, and therefore cannot be offered to everyone, which is why the criteria above are applied when deciding who is entitled to be tested. Each test is only designed to look for a single, specific genetic condition, based on the family history of the people being tested – and so it is not normally practical to screen for lots of different conditions at once. There are around 400 different conditions that can be tested for – but this does not include all genetic conditions, and therefore some people may be excluded from testing. IVF has its own health risks, is time-consuming and often very stressful for the people involved and is not always successful. Despite these potential complications, pre-implantation genetic diagnosis remains an important resource for people who meet the criteria.

Medical prevention and treatment

Cancer screening

Cancer has links to genetics and environmental and lifestyle factors and can affect any organ system in the body, from the skin to the bowels. There are over 200 types of cancer, but the basic mechanism of disease remains the same. As part of the body's normal repair mechanisms, cells are constantly dividing, using mitosis to replace old, dead or dying cells. Older cells, and cells damaged beyond repair, will undergo **apoptosis** – programmed cell-death – as they approach the end of their useful lifespans. There are complex signalling pathways involved in this process to ensure that old or abnormal cells do not continue to reproduce themselves, and that new cell production does not exceed the need for new tissue.

In cancerous processes, these mechanisms that regulate cell growth and death do not function as they should. Cells divide too quickly, and do not develop properly. The mechanisms that would ordinarily cause apoptosis in these abnormal cells do not function properly, and the cluster of abnormal cells continues to divide, growing without regulation or control. This cluster of cells continues to grow, becoming a tumour.

Some types of cancer are localised and do not spread further but cause significant problems because of where they are based – for example brain tumours. However, depending on the original type of cells involved in the process, other growths are invasive, spreading through the bloodstream or the lymphatic channels of the body to other sites in the body where they continue to grow into secondary tumours (sometimes called metastases). You can see how this process occurs in the Figure below.

Key points

Apoptosis – a deliberate process in which cell contents are packaged into small packets of membrane for programmed cell death**.**

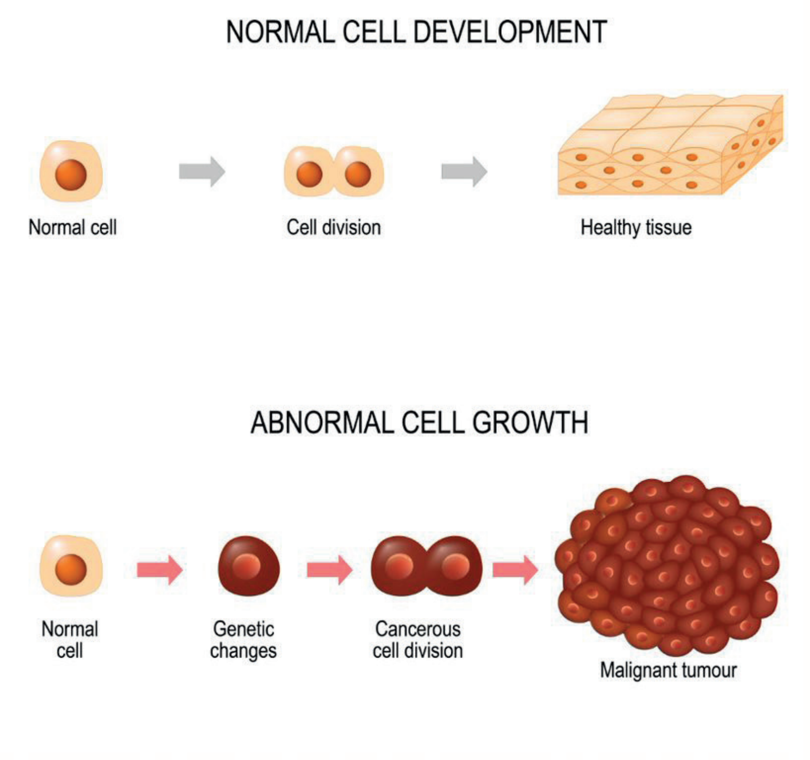


Figure 3.13: Cell division leading to cancer

Sometimes these cancerous cells release abnormal levels of chemicals which can be detected in the bloodstream. These chemicals are called tumour markers and may sometimes be tested for when cancer is suspected. However, these markers only become raised once the cancer has already started to grow – in some cases this may be too late for successful treatment.

Due to the way cancerous cells reproduce rapidly, early diagnosis of cancer is important for successful treatment. If a cancer can be diagnosed before it has spread, then it may be successfully removed with surgery, or treated with radiotherapy. If the cancer has spread before being diagnosed, then it becomes much more difficult to treat. It may even be impossible to cure, as it is very difficult to know whether all the cancer cells have been eliminated, even after treatment. This is why cancer screening is so important – because it may pick up signs of the disease even before someone has any symptoms.

In the UK, the main cancer screening programmes are for breast, bowel and cervical cancers. These are all common cancers and can be successfully treated if caught early enough. Equally importantly, there are reliable tests for all these conditions, which are highly accurate and do not provide too many **false positive** or **false negative** results.

Breast cancer screening is targeted at those assigned female at birth from the age of 50-70 – the age groups at which women are most likely to develop breast cancer. It takes the form of a mammogram – an X-ray examination of the breasts – which is then checked by a doctor for any signs of cancer. If there are any suspicious areas on the X-ray, then the woman will be called back in for further tests. Where a person has had surgery to remove the breasts, a small amount of breast tissue may remain, but not enough for a mammography to detect changes.

Bowel screening is offered every two years to all people from ages 60-74 in most parts of the UK, and 50-74 in Scotland. This screening test involves taking a stool sample and examining it for any traces of blood. The first part of the test is usually conducted by post, with people sending their samples back to a laboratory for examination. If any traces of blood are detected (which may be a sign of bowel cancer) then the person will be offered further tests, usually a colonoscopy, where a flexible fibre-optic camera is passed through the bowels to look for any changes that might be cancerous.

Finally, cervical screening is typically offered by the NHS to those assigned female at birth and are aged 25-64 in the UK. If a person has had an operation to remove their womb and cervix, they no longer need to be screened for cervical cancer. The screening test involves brushing the cervix (the neck of the uterus) and checking the sample of cells for any significant changes – either cancerous or pre-cancerous changes. If the test is positive, there is usually a follow-up appointment offered at a hospital clinic where the abnormal cells may be removed.

Key points

False positive – a positive test result in somebody who does not have the condition being tested for.

False negative – a negative test result in somebody who has the condition being tested for.

In order for a screening test to be effective, it must fulfil certain criteria. These were established by the WHO in 1968 but are still relevant today.

- The condition should be an important health problem.
- There should be a treatment for the condition – otherwise there is little point in screening for it.
- Facilities for diagnosis and treatment should be available – otherwise the disease cannot be screened for or treated.
- There should be a stage of the disease with few symptoms that is still detectable by screening methods.
- There should be a test or examination for the condition – otherwise it cannot be screened for.
- The test should be acceptable to the population – otherwise people are unlikely to attend for screening.
- The natural history of the disease should be adequately understood, so that it can be treated effectively.
- There should be an agreed policy on who to treat – at what stage of the disease is treatment necessary?
- The total cost of finding a case should be economically balanced – it cannot be too expensive to screen the population.
- Case-finding should be a continuous process – screening should be something that is undertaken constantly, not just on single occasions.

Deciding on which cancers are being screened for, and who is tested, can be a challenge. Ultimately, some cancers are not practical to screen for, or some population groups are not suitable for screening. Cervical cancer screening is not offered to women under the age of 25, for example, because the cells of their cervixes are still changing and growing. This would provide a large number of false positive results and mean that many young women underwent unnecessary investigation, and even surgery, for a condition they did not have. Similarly, prostate cancer screening (via a blood test) is not offered to men, because the blood test is not a reliable screening tool. It can provide false positive and false negatives, meaning that some men without the disease would have unnecessary investigations, and some men with the disease would be missed by the test. Despite these limitations, screening for cancer is an important part of disease prevention – and, as we grow to understand more about cancer as a disease, we may be able to develop more effective screening tools to detect it early.

Medical imaging

The ability to image the inside of the human body is a relatively recent one. The first **X-rays** were only used for medical purposes in the late 19th century – initially mainly by surgeons to guide their operations. Throughout the first half of the 20th century, X-rays became the only type of medical imaging available to healthcare workers – but following the Second World War, other types of imaging began to surface. Ultrasound scans were the first, emerging during the 1950s as a useful way to image soft tissue (which X-rays are not capable of doing). This was followed by CT (computed tomography) and MRI (magnetic resonance imaging) scanning in the 1970s – both accurately imaging soft tissue and bone in great detail.

Key points

X-rays – high energy electromagnetic waves that typically have wavelengths of around 10^{-10} m.

X-rays, ultrasound scans, MRIs and CT scans can give us an excellent idea about the structure of the body – and therefore any diseases affecting these structures. In addition to diagnosing diseases, they can be useful for planning surgery or other treatments inside the body (such as injections into joints, or radiotherapy for cancer), and can help us to monitor the spread and progression of disease.

X-rays

X-rays are part of the electromagnetic spectrum and have high frequencies, short wavelengths and high energies. X-rays are produced when high-speed electrons stop suddenly when they hit a metal target plate.

X-rays are slightly absorbed, or scattered, by the presence of atoms and molecules. X-rays penetrating the body experience this to various extents, depending on the composition of the organs or tissues and the wavelength of the X-rays. When X-rays enter the body, all tissues and organs absorb a particular amount, but the denser parts absorb the most. In the case of bone, it appears brighter on the image because it absorbs more X-rays than the surrounding tissue – which absorb significantly less X-rays.

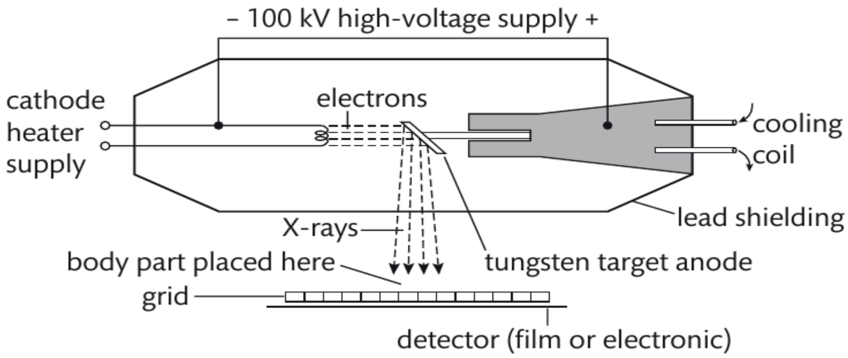


Figure 3.14: Production of X-rays

X-ray characteristics

X-rays have the potential to damage healthy tissue if a patient is exposed to them for prolonged periods of time. To reduce the **absorption** of lower energy X-ray photons by healthy tissue, X-rays are filtered through a thin metal plate before entering the patient. If the metal plate was not used, the tissues would heat up and become damaged.

X-rays can vary in energy to penetrate flesh and not bone, and also be absorbed by denser diseased tissue so it shows up clearly on film. Lower energy (longer wavelength) X-rays are more easily absorbed by body tissue than higher energy X-rays, which have more **penetration**.

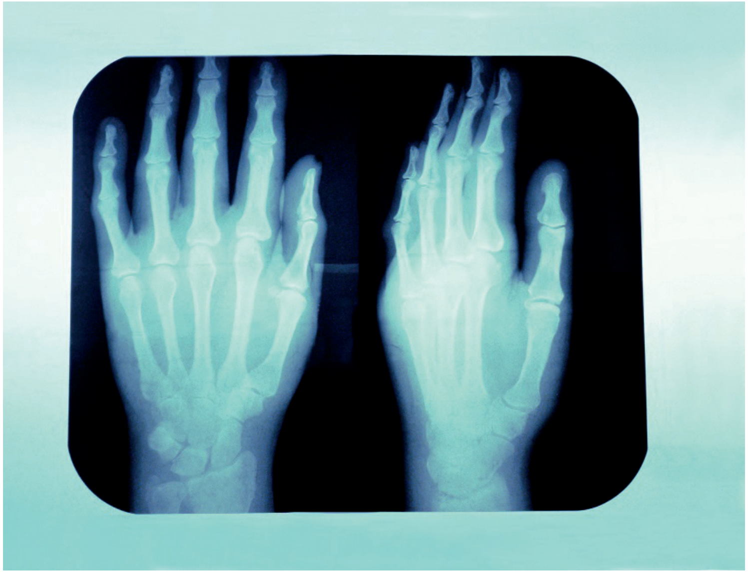


Figure 3.15: X-ray of hands

Key points

Absorption – the capacity of a material to take in external radiation.

Penetration – the capacity for radiation to pass through a material while giving up only a small amount of its energy.

X-rays can be used for diagnosis, as shown in Figure 3.16 below.

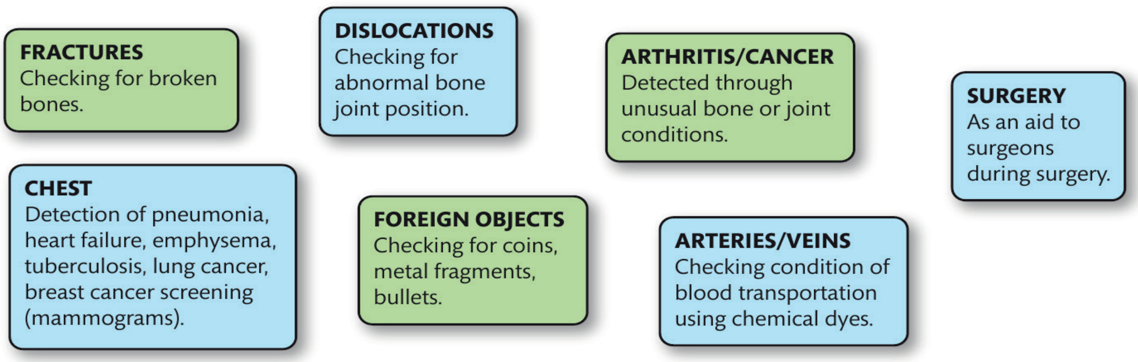


Figure 3.16: Use of X-ray in diagnosis

X-rays for treatment

High energy X-rays focus on the diseased area of the body in a process known as external radiotherapy. The X-rays destroy cancerous cells that cannot repair themselves following the dosage. Normal cells are damaged by the X-rays but can generally repair themselves.

Used in this way, X-ray treatment can be either curative – there is a good chance of destroying the cancer and preserving life; or palliative – there is a chance the treatment may relieve pain, but it won't destroy the cancer.

X-rays are used to:

- reduce the size of a tumour before surgery to reduce the amount of time and difficulty of the procedure
- kill remaining cancer cells and limit the possibility of follow-up surgery being needed after surgery
- reduce the size of a tumour and the level of pain when there is no possibility of a cure. The quality and length of a patient's life may increase as a result of reducing the pain
- kill cancer cells without the need for surgery.

Computerised tomography (CT)

Computerised tomography means that an image is put together by a series of thin sections or cross-sectional images produced by an X-ray scanner.

Key points

Computerised tomography – process by which a three-dimensional image of a body structure is produced from plane cross-section X-ray images along an axis.

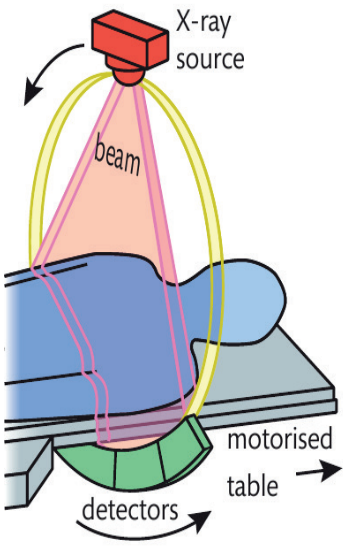


Figure 3.17: Principles of a CT scanner

There are eight steps to a CT scan.

1. The patient may be given an injection or meal of a contrast medium before the scanning procedure and then moved towards and into the CT scanner on a motorised table. How the contract medium is given, depends on the organs under investigation.
2. The X-ray source is rotated around the circular opening of the scanning machine. One rotation takes approximately one second.
3. The X-ray beam is spread out to irradiate the part of the patient's body. The beam covers an axial plane, many planes can be scanned to eventually produce a 3D image.
4. Many X-ray beams may be undertaken while the patient is in the scanner. The patient must remain very still while the table continues to move through the circular opening as this happens.
5. As the X-rays exit the patient's body, they are detected and recorded immediately, since the detector rotates directly opposite to the X-ray source.
6. The information from the scanner is processed by a computer that provides a cross- sectional image of the patient's internal organs and tissues. This cross-section represents one complete turn of the X-ray source, many rotations help to enhance and improve the image.
7. If multiple axial planes (at different angles) are scanned, the resulting X-ray scans can be used to create a 3D image, a valuable diagnostic tool.
8. The final images are analysed by a radiologist.

Pause point

The CT scanner scans thin slices, one at a time, through a patient's body. If the patient moves, even slightly, during the scans, what effect will this have on the resulting image?

Hint
If you take a picture using a camera, consider the effect that movement of your subject has on the quality of the image.

Expand
The image produced by a CT scan shows different body tissues as variations in brightness due to the number of X-rays that pass through them. Lighter areas will be tissues that absorb more X-rays. What effect will movement have on the image between tissue boundaries such as bone and a possible tumour?

CT for diagnosis and monitoring

A CT scan provides useful information for health professionals relating to a variety of conditions, and their potential treatments. A scan can provide information on the size and shape of a tumour anywhere in the body to help inform the appropriate treatment.

It is used to identify bone damage such as fractures or other problems as a CT scan can identify these issues much better than standard X-rays. The CT scan can also identify tissue damage around the bone.

CT scans have useful applications for diagnosing issues with organs, particularly any kind of damage, infection or disease. Heart disease can be detected by injecting a patient with an iodine solution that is highlighted by the X-rays to produce a clear image. A CT scan can also identify the levels of calcification in the arteries of the heart. The kidneys, liver and spleen also benefit from the detailed images that a CT images can produce in comparison to a standard X-ray.

If a stroke is suspected in a patient, a CT scan of the brain can detect where there is insufficient blood flow through the vessels so that immediate treatment can begin.

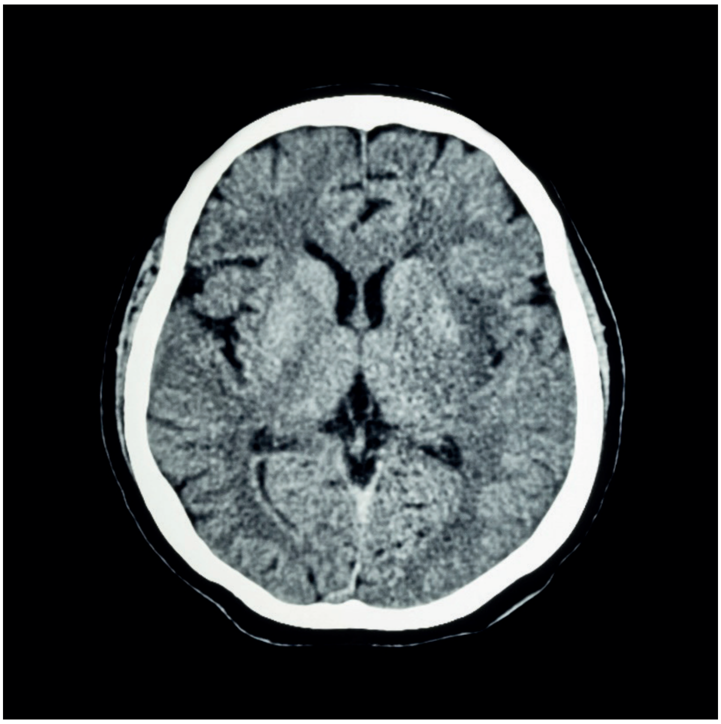


Figure 3.18: CT scan of a normal brain

Magnetic Resonance Image (MRI)

The human body contains hydrogen atoms and different tissues contain different amounts. The nucleus of a hydrogen atom consists of a single proton that acts like a small magnet and can be easily affected by a large magnetic field. An MRI scanner is a large piece of equipment that uses a large magnet and electromagnets to provide strong magnetic fields, which **polarise** nuclei.

An MRI scanner consists of the following:

- Main magnet – a large, permanent, superconducting electromagnet.
- MRI scanner coils – resistive electromagnets that produce a gradient field where different magnetic strengths over the body help to pinpoint the signals. When scans are being carried out and when the gradient field coils are switched on and off, a knocking sound can be heard.
- Radiofrequency coils – produce the input radio waves that excite the nuclei and result in the nuclear magnetic resonance (NMR) signal.
- Output signal receiver – tuning coils that pick up the output radio waves from the protons in resonance. There are many different types, and the one selected is based on the need to produce specific images, such as large volume areas or more focused tissues. The receiver is linked to a computer that processes the information.

Figure 3.19: An MRI scanner

Key points

Polarise – producing charged poles in an object that limit its vibrations to a single direction.

Field coil – a resistive electromagnet that produces a gradient field over the body, helping to locate the radiofrequency signals.

Nuclear magnetic resonance (NMR) – the absorption of specific electromagnetic frequencies by atomic nuclei which resonate and, after a short delay, re-emit a radiofrequency.

The process used in MRI, nuclear magnetic resonance (NMR), produces a detailed picture of tissues because the protons can be detected in their exact locations in the body. The process can also provide information about the type of tissue the protons are in as they realign at different speeds in different tissues, sending a signal that is particular to the tissue type. The resulting images are very detailed, as shown in Figure 3.20 below.

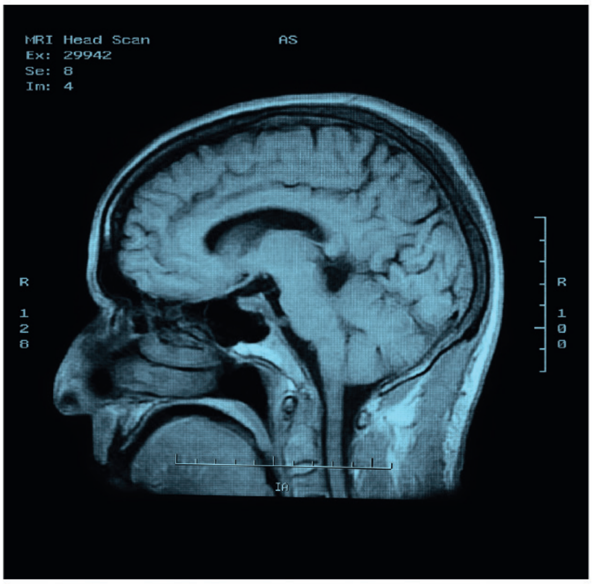


Figure 3.20: An image of a head using MRI

The highest concentrations of protons visible by means of MRI are in soft tissues, especially fat and water, making an MRI more suitable as a diagnostic tool for:

- the brain
- spine
- pelvis
- joints
- abdomen
- heart
- breast
- blood vessels
- other soft tissues and organs.

The images taken by an MRI scanner are clear and well defined, making them a useful diagnostic tool.

Pause point

In what ways are MRI scans less risky for patients than X-rays and CT scans?

Hint
Think about what X-rays can do to living cells.

Expand
Why do patients having an MRI scan need to remove all jewellery?

Another significant advance in medical imaging has been that of functional imaging. Instead of looking at a static image showing the structure of the body, functional imaging allows healthcare workers to look at changes in the body as a result of oxygenated and deoxygenated blood flow. This has been particularly useful when studying the brain and neural activity. A scan can look at parts of the brain to work out whether someone is suffering from a condition like Parkinson's disease or has experienced a stroke. It can also look for areas of high energy use within the body that might indicate a cancer. Functional imaging is also important in medical research, to help scientists better understand how parts of the body function in health and in disease.

Stem cell therapy, epigenetic modification and reprogramming

Stem cells are unspecialised cells that can differentiate to form specific types of adult cell. Stem cells are an important part of the normal repair and replenishment of organs and tissues within the body, but there is also the potential for them to be used as a medical treatment. There are three main types of stem cell.

- Embryonic stem cells – found in an embryo at the early stages of development after fertilisation. These cells are pluripotent – they have the potential to develop into almost every type of cell in the human body.
- Adult stem cells – found in many different body tissues in relatively low numbers. These 'somatic stem cells' are already partly specialised for the tissues where they are found. They are multipotent – they can only form a limited number of new adult cell types.
- Induced pluripotent stem cells (iPSC) – these are normal adult cells that are genetically modified and so reprogrammed to form pluripotent stem cells. They are currently used in research, drug testing and some other trial treatments.

Key points

Stem cells – undifferentiated cells that can develop into many different types of cell.

Pluripotent – referring to a stem cell with the ability to become almost any cell type in the body.

There are benefits and problems associated with stem cell research and treatment.

- Benefits – regeneration of cells and tissues for teeth, bones, heart, liver, eyes, pancreas, brain, trachea, blood and immune system. Blood and bone marrow transplants have been successful for 50+ years.
- Problems – ethical controversy and arguments around the use of embryonic stem cells, particularly as extracting the stem cells from the early embryo results in its destruction. Where stem cells are not directly matched to a recipient, rejection of the new cells can occur. Adult tissue stem cells are limited in their number, type, and effectiveness.

Case study 3.3 below explores one possible way in which stem cells could be used in the field of medicine.

Case study

Stem cells and skin grafts

During the Second World War, doctors began to see burn injuries in a way that had never been experienced before. Pilots were the worst affected – aircraft filled with extremely flammable fuel meant that, in the event of a crash, horrific burns across the entire body were common. Many men were permanently disfigured, but still more died from their injuries before the burns could heal. Two surgeons named McIndoe and Gillies pioneered treatments for these young men – initially saline baths to allow large areas of burns to heal, but quickly graduating to rudimentary plastic surgery, which had first appeared during the First World War. They would take skin from one area of the body and "graft" it to where it was needed, leaving a tube or "pedicle" to give the graft a blood supply. This partial reconstruction of the faces and bodies of men who had been severely burned was revolutionary at the time – and you can see the results of these surgeries in Figure 25 below.

These new surgical techniques were extremely successful and paved the way for successful skin grafting surgery in times of both war and peace. But skin grafts aren't perfect – they still leave significant scars, and the grafts themselves may fail and break down, requiring more surgery.

In the post-war years, plastic surgery became more and more advanced, with ever-greater possibilities for reconstruction. However, the inherent problems with skin grafts remained unsolvable. In the 1960s, the first work on stem cells was published and, by the early 1970s, scientists were looking into the possibilities of custom-growing sheets of skin using stem cell techniques. These techniques had limited success; sheets of keratin were relatively easy to grow, and sometimes hair follicles and other skin structures could also be grown. However, so far, it has not been possible to fully regrow skin – the structures embedded in the lower skin layers cannot be reliably reproduced. In the future, it is hoped that stem cells might be used to completely heal even the most severe burns and soft tissue wounds, reducing the need for skin grafts at all.

Check your knowledge

What challenges do you think doctors and scientists face in healing severe burns and open wounds?

Can you think of any problems might be common in people suffering from this type of injury?

Do you think that stem cells might help to improve these problems, as well as allowing the formation of more natural-looking skin?

Epigenetics

Epigenetics is the science of gene expression – how genes are switched on or off without changing the underlying genome. This occurs throughout a person's life and is responsible for changes such as the differentiation of cells into different types – but epigenetic modification can also be responsible for more damaging changes to the body, such as cancer. Epigenetics is particularly important during foetal development – studies have shown, for example, that if a mother is exposed to environmental pollution whilst pregnant, there is a significantly increased chance that her baby will suffer from asthma. Scientists are also starting to understand that epigenetics plays an important role in our adult lives, such as in conditions like alcoholism, addiction, and mental health problems like depression and schizophrenia.

The idea that external events can change these "genetic switches" for better or worse raises the possibility that we might be able to learn how to control epigenetic modification and "reprogram" our own genetic code. There is emerging evidence that lifestyle factors such as smoking, stress, and even our diets can affect our epigenetics, and ultimately significantly change our health over the course of our lives. If we can learn which genes are switched on or off by these environmental factors, then we may be able to better understand how to prevent some diseases from occurring at all, and drastically reduce the rates of others.

Developing new drugs

Although we can treat a vast number of different health complaints using medication, there is a constant demand for new drug treatments. As scientists continue to discover more about the mechanisms within the human body that cause disease, they also learn more about possible ways of treating those diseases. This requires a huge amount of research. It takes, on average, between 10 and 12 years, and around £1 billion for a medication to have undergone sufficient research to consider it safe to use in humans. The first step in developing a new drug is identifying an “active chemical” – a substance acting somewhere in the disease process being studied.

Figure 3.21: The Madagascar periwinkle, the source for two extremely important chemotherapy drugs, vincristine and vinblastine. Many other drugs also originate from the natural world

Historically, many of these active chemicals were found in the natural world – in substances produced naturally by plants and animals from around the globe. Nature is still an important source of active chemicals today (as you can see in Figure 3.21) – but researchers will now often use our increasing understanding of genomics and epigenetics to help identify chemicals acting at crucial stages of a disease process. Computer assisted design also allows scientists to simulate huge numbers of different chemicals and their possible actions.

Once an active chemical has been identified, then many slightly different forms of that chemical will be examined. Many hundreds or thousands of different forms of the active chemical may be trialled before the one which works specifically is found. The next step is to try to work out the **pharmacodynamics** and **pharmacokinetics** of the chemical to see how it will perform inside the body and whether it might eventually be safe to use in humans. -In order to gain as much data as possible at this stage, scientists conduct detailed computer models (*in silico* studies) and studies in the laboratory (*in vitro* studies).

However, in order to work out how a drug is likely to behave in living tissue, studies eventually need to be performed on a living creature. This stage is known as in vivo, and usually involves trials on animals.

Figure 3.22: It takes many years of experiments and trials before a drug reaches the shelves of a pharmacy

Key points

Pharmacokinetics – how a drug is likely to be absorbed, distributed, metabolised and excreted by the body.

Pharmacodynamics – how the potential drug acts in the body – its likely effects on the biochemistry of the body.

In vivo studies are strictly regulated to ensure that unnecessary testing does not take place, but it is still a difficult ethical area, and one that many people strongly object to. Laboratory and computer simulations are helpful but cannot always predict how a chemical will act in the complex systems of a living organism. If a drug appears to be safe after these initial stages (which usually take many years to reach after the identification of an active chemical) then some trials on human subjects may begin. Initially, these trials will be on healthy individuals who are not suffering from the disease that the drug aims to treat. This stage of testing is to attempt to make sure that the drug is safe to use in humans before researchers investigate whether it has any effect on the disease itself.

Finally, trials on humans with the disease are started – usually comparing the drug against an inactive compound called a placebo, to ensure that the new chemical is more effective than using nothing at all. If these trials are successful, then trials comparing the drug against the current most effective treatment are likely to occur. If the drug passes these trials, the feasibility of producing the drug on a large scale is considered, including whether it is economically viable. Then, the pharmaceutical company who has developed it will apply for a licence in each country that the drug is going to be used in. This dictates what the drug can be used to treat, how it is made available, and many other factors, many of which will have been discovered by the exhaustive trials throughout the drug's development.

Hormone therapies

Hormones are chemicals produced by the body that regulate the activity of the body's organs and organ systems. Hormones are usually produced by special glands, some of which produce a single hormone, and others several different ones.

Sometimes the body may become deficient in a particular hormone. This may happen due to a disease affecting the organ producing the hormone, or it may have other causes. A good example of this is hypothyroidism. The thyroid is a gland in the neck that produces two types of thyroid hormone. In some individuals, an autoimmune process damages part of the thyroid so it doesn't produce enough of these hormones. In healthy people, thyroid hormones help to regulate homeostasis – so if there are not enough of them, people may find themselves gaining weight, feeling tired, losing their hair, and suffering from constipation and skin problems. An underactive thyroid can also cause problems with the heart.

The treatment for low hormone levels is usually to replace the hormone. This might be a tablet, an injection, or even sometimes a cream or gel applied to the skin. This restores the hormone levels within the body – but it does not usually fix the disease process affecting the organ. For many people with a hormone deficiency, they must take replacement hormones for life.

At other times, we may want to block a hormone from acting. In prostate cancer, for example, the hormone testosterone is responsible for increasing the speed at which the cancer grows. Using medication to block testosterone can slow down the growth of the cancer. It can even shrink the size of the cancer – which means that testosterone blocking therapy is often used before surgery, to make the cancer smaller and easier to remove.

Perhaps the most well-known use of hormone therapy does not involve disease at all. The oral contraceptive pill, first developed in the 1960s, uses the hormones oestrogen and progesterone (sometimes both together, but more commonly just progesterone) to prevent pregnancy. Since the 1960s, hormonal contraceptives have become significantly more advanced, and are now used in a wide range of different forms – from pills, to injections, to an implant in the arm. Hormonal contraceptives allow people to decide if they want to become pregnant, giving them more control over their reproductive health. They are - when used properly - an extremely safe and effective form of contraception.

Assessment activity 3.1

1. Choose one of the contemporary health issues described in the above section.
2. Using what you have learned as a basis, produce a leaflet aimed at the general public, explain the key features of the health issue, along with how it can be diagnosed and treated.
3. Use appropriate language and terms. Your report should be no longer than two sides of A4.

A2 The influence of organisations and individuals on health issues

Government and global organisations

The role of local government organisations and global organisations can be critical in helping to identify and contain an outbreak of an infectious disease. Often, both national and international organisations will coordinate their efforts to research specific aspects, monitor outbreaks of diseases and promote healthy living to populations.

The World Health Organisation (WHO) – global monitoring
The WHO is one of the largest and most involved organisations in disease surveillance in the world. Working with local governments, it attempts to look for patterns in diseases, and to work out ways in which to prevent diseases before they can occur or spread. This includes infectious diseases (like Ebola, Case Study 3.1, Zika virus and Covid-19) and non-infectious disease such as diabetes, heart disease, or high blood pressure.

Monitoring outbreaks of disease at a global level takes two forms – passive and active surveillance. Passive surveillance involves monitoring reports from healthcare organisations around the world, looking for trends in reported data. However, this method relies on trained health professionals being available in all locations across the world, all with access to laboratories and scientific equipment, and being capable of confirming a diagnosis and then entering accurate data into reporting mechanisms used for local and global health monitoring. In some areas of the world, access to healthcare facilities is incredibly limited, and in some remote villages it may not be available at all. There is also the risk of misdiagnosis or misreporting of a disease with passive surveillance, particularly in areas where a lack of laboratories and scientific equipment means health professionals record a diagnosis based on symptoms alone, with no scientific confirmation.

The WHO also makes use of active surveillance, which is the deployment of personnel in areas where outbreaks of disease are suspected, or areas that are at a higher risk of significant diseases due to local risk factors. These personnel will visit local healthcare facilities and laboratories, review medical records and talk to local staff in an effort to identify people who may be showing symptoms of a particular disease. These people can then be fully investigated, and the infection can hopefully be confirmed or refuted based on clinical findings and microbiology samples.

Pause point

What limitations to active disease surveillance can you think of?

Hint
Think about the range of resources needed to perform active surveillance.

Expand
Using a recent example, explain how active surveillance may have contributed to monitoring an outbreak of disease.

A third kind of surveillance used by the WHO is termed sentinel surveillance. This involves selecting a healthcare provider (such as a hospital) in an area where cases of a particular disease are likely. The healthcare provider chosen must meet a number of criteria in order for it to function as an effective sentinel reporting unit.

- It must serve an adequately sized population who are able to access it.
- It must be willing to be a sentinel reporting unit.
- It must have healthcare staff trained in recognising, treating, and reporting the disease in question.
- It must have accurate, high-quality diagnostic equipment capable of performing tests to identify the disease under surveillance.

If all these criteria are met, then sentinel reporting units can be a useful indicator of local disease status; they report back to the WHO more accurately than simple passive surveillance, but they require fewer of the WHO's resources.

Once an outbreak of disease has been confirmed, the WHO will work with local healthcare and government, along with other organisations, to help track and control the disease. This may include gathering data from around the community, identifying those most at risk, utilising health surveillance programmes, and targeted education campaigns, for example posters and television and radio broadcasts, to promote health awareness and the consequences of not following the provided advice.

Pause point

Think about a time that you, or someone you know, wanted to find out information about a certain health topic. How easy was it to obtain the information?

Hint
Did you find the information at the GP surgery, in a public setting, or on the internet? List the places you found the information.

Expand
Find five different health promotion materials and find out who provided the information.

The WHO may also ensure that additional preventative measures are in place to control the outbreak of disease in healthcare and public settings, depending on how the infection is spread. This may include advising healthcare providers treating the disease to use antimicrobial agents (when this is possible) and directing local healthcare providers to issue their staff with personal protective equipment (PPE) such as face masks, gowns and eye shields. If there are significant concerns amongst the general public, equipment like face masks may sometimes also be recommended or mandated in public places. Patients suffering from suspected or confirmed cases of the disease will be isolated to prevent them from spreading the infection to others, and those who are clinically vulnerable to infectious may be asked to isolate, or shield.

Rigid **aseptic** techniques and antiseptic procedures will be put into place, to decontaminate areas where the infected individuals have stayed or been treated. Travel restrictions may be put into place, to prevent people from spreading the disease elsewhere in the country or even across the world.

Meanwhile, WHO and public healthcare officials will try to identify the original source of the infection and the pattern of cases as the disease spread, to understand how to better contain outbreaks in the future. All these measures can take many months, or even years, before the spread of infection is adequately slowed or stopped.

Key points

Aseptic – practices and procedures performed under carefully controlled conditions to minimise contamination by microorganisms.

Public Health Agencies

Of course, not all infectious diseases spread as a global pandemic. Many infections are limited to national populations, or even to small local areas. Most of these infections do not require any monitoring, even if they are relatively easily transmitted. The common cold, for example, is extremely infectious, and infects hundreds of thousands of people in the UK every year – but because it rarely has serious complications, it is not a disease that requires surveillance. However, there are infections which require monitoring, either because of their ability to cause significant harm or because they may indicate another public health concern, such as a contaminated water or food source, an area with a low uptake of vaccinations, or a particularly resistant strain of a disease-causing pathogen.

The countries of the UK each have their own **public health** agency in charge of **health surveillance**, such as monitoring infectious diseases and managing health and wellbeing:

- England -Public Health England (PHE).
- Wales - Public Health Wales.
- Scotland - Public Health Scotland.
- Northern Ireland - The Public Health Agency (PHA).

Like the WHO, the public health agencies in the UK work to prevent non-infectious diseases spreading, producing education programmes and resources to help educate people about conditions such as high blood pressure, heart attacks and diabetes. The organisations maintain a list of **notifiable diseases,** which local hospitals and healthcare workers are expected to report if they suspect a local case or outbreak.

This may be confirmed locally, or it may be further investigated by the public health agency as part of an active surveillance programme. If an outbreak appears to be spreading throughout the country then it may be classified as an epidemic– and, at this point, the WHO is notified about the possibility of a widespread outbreak. The public health agencies also regularly communicate with the WHO regarding outbreak data locally, to allow global patterns of disease to be examined as part of global passive surveillance.

Key points

Public health – organised strategies to prevent disease, promote health and prolong life in a population.

Health surveillance – a system of checks, which may be required by law, to detect ill effects and hazards to health, provide data, and monitor control systems (and check for lapses) to provide protection against hazards to health and wellbeing.

Notifiable disease – an infectious disease that must be reported to local public health officials when detected.

Public health agencies respond on a local level in a similar way to the WHO to suspected or confirmed outbreaks, first attempting to identify a causative pathogen, and then seeking to control the spread of an outbreak. Sometimes the cause of an outbreak of disease can be pinpointed to something quite simple – contamination of meat or salad items in a supermarket, for example. If this proves to be the case then public health officials will work with food suppliers to withdraw that particular food item from sale, contact customers who have bought the product and tell them not to consume it. They will also investigate where in the food processing industry the contamination has occurred. In this way, potential sources of contamination can be eliminated, and the food supply chain can be made safer for the future. Case Study 3.4 below outlines how PHE officials worked to eliminate a particular *E. coli* outbreak.

Case study

Loyalty cards and E.coli

In late 2017 PHE's passive surveillance identified 12 cases of a strain of the *E. coli* bacterium – *E. coli* O157 – over a short period of time. This particular strain is quite rare, causing only around 700 cases of disease per year in the UK, but it can make people extremely unwell. Twelve cases in such a short period suggested the cases were probably linked, but PHE needed to prove this without any doubt – and to find the source of the outbreak. Until recently the only way to do this was using traditional laboratory methods, which could take weeks to identify an individual strain – and sometimes missed the causative organism entirely. However, the PHE team were able to utilise a relatively new technique called Whole Genome Sequencing (WGS). This technique allows rapid sequencing of every part of the bacterium's genetic code, and rapidly compares all the samples from the 12 cases. Very quickly it became apparent that these cases had an identical genetic "fingerprint" – meaning that the infections had all come from the same source.

Interviews and investigations by local members of the PHE team suggested that burgers from a particular retailer might be the source of the outbreak. However, most supermarkets sell a large number of different burgers, and it is often difficult for people to remember exactly what it was they had eaten. PHE was able to ask the supermarket to examine the loyalty card records of the people who had contracted the *E. coli* strain – and this allowed them to identify the exact brand of burger that had been purchased by everyone who had become infected. The supermarket issued a recall of the brand, contacted customers to ask them to return any that they had bought, and PHE was able to trace the source of the contamination and control it, preventing any further cases of *E. coli* O157.

Check your knowledge

E. coli is a bacterium which lives in our intestines, and in the intestines of many animal species.

1. How do you think that this bacterium ended up contaminating the meat in this case study?
2. What mechanisms would you put into place to help reduce the risk of this contamination in the future?

Figure 3.23: E. coli bacterium - tiny, but potentially deadly

The National Health Service (NHS)

The National Health Service is a public sector service founded in 1948. It is funded primarily through taxation, and some small proportion of funds comes from National Insurance contributions. This method of financing has ensured that every person in the country could receive diagnosis and treatment of any illness regardless of their ability to pay. The NHS came into being to ensure that health services are accessible, fair and impartial to all, and, importantly, free at the point of access. The public sector health services and systems of the four countries of the United Kingdom generally work independently of each other. The four organisations are:

- National Health Service England (NHS England)
- Health and Social Care in Northern Ireland
- NHS Scotland
- NHS Wales.

As a direct provider of care, the range of services that the National Health Services in the four countries provides is immense. Services include:

Primary healthcare – accessed directly by members of the public when needed, examples include GPs, dentists and pharmacists.

Secondary healthcare – most hospital services including mental health services and community mental health services. A referral is usually required from a GP to access the majority of these services such as specialist consultants or psychiatric care. Members of the public have direct access to emergency services such as accident and emergency.

Tertiary care – specialist services usually accessed via a referral for complex needs, such as spinal injuries or hospice care.

Key points

Primary healthcare –directly accessed by members of the public, examples include GPs, dentists and pharmacists.

Secondary healthcare – care that includes most hospital services, typically accessed via a GP referral.

Tertiary care – specialist and often complex care services, for example spinal injury units.

The NHS has a key role in framing the aims of health policy and health initiatives in each country. The NHS has a duty to meet the health needs of citizens, and this requires health policy to be responsive to the future health needs of the nation. To meet the needs of a changing demographic, the government needs to gather data and commission reports into current trends in health within the nation as well as attempt to predict future developments in the health status in the nation.

In the 1970s the NHS took on responsibility for the majority of public needs. Due to the differences in health needs in rural and industrial areas and across social demographics such as lifestyle choices, unemployment and prevalence of disease, the establishment of local authorities was necessary and found to have a significant impact on the provision of appropriate health services.

The NHS in England and Wales also works with organisations such as NICE (the National Institute for Health and Care Excellence) to determine healthcare policy in the UK. NICE is responsible for providing guidance on current best practice in health and social care. It publishes guidance and advice that aims to control and improve health and social care provision.

For example, as part of its role, NICE provides:

- evaluation of whether procedures are sufficiently safe and effective to be used in health and social care services
- assessment of the cost and effectiveness of treatments
- recommendations for best practice, based on current research
- support for health promotion campaigns.

NICE recommendations are primarily for the use of NHS practitioners, local authorities and any organisation financed by the government to provide health and social care services.

Health Education England (HEE) – updating guidelines

The Department of Health and Social Care (DHSC) is responsible for health and wellbeing in England. It leads on health policies and is accountable to the government. The DHSC works with a number of public agencies and professional bodies, including HEE.

HEE is a part of the NHS, with the aim of ensuring that healthcare is delivered safely, in accordance with up-- to date guidelines and research. HEE oversees the training and education of NHS staff, clinical and non-clinical, through Local Education and Training Boards (LETBs) who make decisions on what that should include, according to their geographical area and the health and care needs of the population it serves.

Non-governmental organisations and associations

The General Medical Council (GMC)

The GMC is an independent organisation for the registration and regulation of medical doctors. All doctors must be registered with the GMC in order to work in the UK. The GMC sets out the guidelines and standards for acceptable medical practice in the UK and decides which doctors are qualified to work in the UK.

The GMC also oversees medical education and training, making sure that trainee doctors are practicing safely, and that fully qualified doctors (like GPs, surgeons, and medical consultants) are reskilling or upskilling every year to keep their practice stay safe and relevant.

If a complaint or concern is raised about a doctor, the GMC may investigate them. If the complaint or concern is upheld, the GMC may restrict their right to practice medicine, and in some cases it may remove the doctor from the medical register, effectively meaning that they can no longer practice medicine in the UK.

Nursing and Midwifery Council (NMC)

The NMC is responsible for the registration and regulation of all nurses and midwives in the UK. All nurses and midwives must be registered with the NMC in order to practice, whether they are in paid employment or voluntary roles. The NMC sets the standards for the education and training of nurses and midwives. It drives the curriculum for trainee nurses and midwives, and sets the requirement for continuing professional development, standards of professional practice, and standards of personal conduct for all registrants.

In order to remain on the register, nurses and midwives must meet a minimum requirement for continuing professional development and provide robust evidence to further support their engagement in training and education.

The NMC also sets a formal code of practice required of all nurses and midwives. In the event that a member of the NMC register is not meeting the standards of practice and conduct, the NMC will investigate them. The NMC has the power to restrict a nurse or midwife's practice, placing on them conditions of training and education, limitations on what level of care they can provide – and whether they have to be supervised, or what work areas they are permitted to work in. If a nurse or midwife is removed from the register, they are no longer permitted to practice in the UK.

Universities and research groups

Universities are vital for the future of healthcare. They provide education and training for the potential health and care workforce and the research they participate in often leads to direct shaping of education and practice curricula based on outcomes of research.

Universities are involved as partner organisations in a significant amount of research. Some of them lead the way on centres for research excellence in clinical specialisms, for example women's health and mental health. The research teams are typically formed of academic and research staff, often supported by doctoral students from a range of clinical and health backgrounds.

University research groups are often funded by research grants, consultancy and project work. This research may ultimately lead to new, innovative discoveries, paving the way for new diagnostic techniques or treatments and improving the quality of care given to patients.

The National Institute for Health Research (NIHR)

The NIHR is the UK's largest funder of health and care research. It is e primarily funded by the DHSC to improve the health of the nation through research. NIHR works in partnership with the NHS, universities and local government, private research funders, patients and the public, aiming to establish the NHS internationally as a centre of excellence for health and care research.

The NIHR is responsible for a complex health research system with multiple work streams including commissioning and funding research, providing clinical research facilities, providing specialist research employees, and committing to the development of integrated systems for research partners that allow for faster, easier clinical research programmes that benefit patients and the public more quickly.

The NIHR oversees multiple research programmes, supporting national research schools that bring together top academics and practitioners to conduct innovative research that aims to increase the evidence base for effective practice in health and care services to inform clinical professionals, NHS managers, patients and the public, and, where necessary, government and policy makers.

The NIHR also works closely with patients and patient leaders to establish easy access to UK clinical trials and to identify and establish priorities for treatments and innovations in local areas. This ensures that researchers and those who fund research are aware of priorities among local patient groups and clinicians.

Private and multinational organisations

Private companies and multinational organisations are often involved in healthcare. Multinational companies have gained increasing ground in areas such as diagnostics, pharmaceutical manufacturing and distribution and often lead the way in clinical drug trials. Most have areas of specialism, such as the production of consumer medical devices and specialist areas of care such as cancer care and cardiac and vascular treatments. Multinational companies are often able to invest in innovative and experimental technology for the purposes of diagnostics and treatments to improve patient outcomes.

There is also a UK market for completely privatised healthcare. The NHS contracts private health providers, notably in psychiatric services and the care of older adults. In most cases, private healthcare providers can see patients quickly, often significantly reducing waiting times for treatments and diagnosis compared to the NHS. Some businesses offer employees private healthcare as a part of their job contracts, which will often include quick access to a GP service and employee assistance programmes to promote mental wellbeing in the workplace. As a result, they may choose to be seen by a doctor working for a private healthcare organisation.

Many private healthcare organisations employ their own private healthcare professionals such as doctors, nurses, dentists, and have access to their own hospitals. Some people prefer to see private doctors because they can be seen more quickly and arguably feel they have access to a wider range of treatment options than may be on offer by the NHS. Others may feel that they get a better quality of care from a private healthcare service. Doctors and nurses working in private healthcare are still regulated by the GMC and the NMC, however, and must abide by the standards set by these organisations.

Private organisations also undertake significant amounts of medical research. Pharmaceutical companies, medical technology companies, and other multinational and national organisations all contribute towards the body of research into human health and disease.

Key points

Multinational organisation – a company with branches or facilities in multiple different countries.

Pharmaceutical companies

There is a significant cost to developing new prescription drugs, and this process has typically taken years to move from conception to having the drugs used in clinical practice. Pharmaceutical companies need to make a profit from the drugs they sell, to continue their research into potential new treatments.

Pharmaceutical companies will partner with organisations, such as the NHS, to support a variety of initiatives designed to bring benefits to patients, the NHS and the companies themselves. For a pharmaceutical company to break into the UK market, it needs to convince the NHS to use it. The private healthcare market is incredibly small by comparison to the NHS, which owns nearly 100% of the market share.

Historically, pharmaceutical companies have had a lot of influence over what drugs are prescribed in the UK. In recent decades, however, the way in which drugs can be marketed in the UK has been much more strictly regulated, and the influence of pharmaceutical companies has become significantly smaller. New innovative products are assessed by NICE for cost effectiveness and quality of life measures compared to existing treatments. If NICE considers the drug's effect on quality of life is not great enough to justify the price tag, then the drug is not recommended for use by the NHS.

Pharmaceutical companies will often donate funds to UK charities and patient groups who research and lobby for new treatments into specific conditions.

Charities and trusts

Charities and trusts tend to focus on particular diseases or groups of diseases. They don't receive funding from the government, instead they may raise funds to help research into a particular condition. Charities typically have areas they want to focus on. For example, Cancer Research UK centres its research on:

- helping to prevent cancer
- earlier diagnosis
- developing new treatments
- personalising treatments to meet individual needs.

Charities such as Age UK and the British Heart Foundation also act as pressure groups, using the data they collect in their research to persuade the government to change policies to fund particular causes. Age UK is the largest charity working for the benefit of adults over the age of 60, regularly conducting research into the health of this demographic. It uses the data and information it collects to persuade the government about health and care improvements that could be made for this age group. It uses the findings of research to support its policies when trying to influence national or international government decisions on health and care.

Individuals – pioneers and patients

Individual people may be able to make surprising changes to healthcare, whether they are pioneering scientists or patients. Below are just a few examples of individuals who have had a long-term impact on healthcare.

In the 1980s Australian doctor Barry Marshall conducted research with a pathologist, Dr Robin Warren. They investigated whether a bacterium called *Helicobacter pylori* could be partially responsible for causing stomach ulcers – which, at that time, were thought to be largely caused by stress, and often required a major operation to treat them. They discovered that the stomachs of many people suffering from stomach ulcers contained the bacterium – but the medical establishment remained sceptical that ulcers were directly caused by the bacterium.

In an effort to prove their theory, Dr Marshall underwent an endoscopy to prove that he was not already infected with the bacterium, and then drank a sample containing *Helicobacter pylori*. Within a few days he started to suffer from stomach pain, indigestion and vomiting. A repeat endoscopy showed significant inflammation in his stomach, and evidence of infection with the bacterium – proving his theory that *Helicobacter pylori* was related to stomach inflammation and ulcers. This changed the treatment of stomach ulcers worldwide – often, a dose of antibiotics cures the infection, and the sufferer's symptoms are resolved. Both Dr Marshall and Dr Warren were awarded the Nobel Prize for their work in 2005.

Dr Carlo Urbani, an expert in parasitic infections, was the first WHO officer to identify SARS as a new and lethal disease. Following a request from a hospital in Hanoi in 2003 to assist them in investigating 'a severe case of flu' that was highly infectious, lethal, and spreading rapidly, Dr Urbani's initial diagnosis was this was a case of an 'unknown contagious disease'.

Although at first thought to be an isolated case, Dr Urbani rapidly put in place isolation measures as staff and more patients became struck down with the disease, closing the hospital to new admissions and staff directed to wear PPE at all times. After further investigation, Dr Urbani and his team discovered that the disease had been circulating since 2002, and the man initially thought to be the first person infected with this disease had been staying in a hotel in China, on the same floor as a doctor who was infected with the disease. Having travelled by air from China to Vietnam, the disease had now crossed continents.

By alerting the WHO headquarters, experts from around the world were tasked with joining Dr Urbani and his team in Hanoi. A global public health response was triggered, with many new cases identified and isolated quickly saving the lives of thousands of people.

Francoise Barre- Sinoussi is a Parisian scientist, specialising in virology, celebrated for her discovery of HIV as the cause of the immunodeficiency disease AIDS during the height of the AIDS crisis in 1981-1984. In 1983, working at the Pasteur Institute in Paris, Dr Barre-Sinoussi, Luc Montaiger and their team discovered a retrovirus in patients with swollen lymph glands that attacked lymphocytes. At this early stage of the research, the retrovirus was named LAV for Lymphadenopathy Associated Virus, it was later renamed as HIV-1. She won the Nobel Prize in Physiology or Medicine 2008 for her work.

The research conducted by Dr Barre-Sinoussi proved HIV-1 to be the cause of the immunodeficiency disease AIDS. This discovery allowed for the development of rapid testing to support controlling the disease, and informed global health policy on the treatment of people with AIDS. Undoubtedly, her vital work has helped millions of people who are HIV-positive to live long, healthy lives. Since this initial discovery, Dr Barre-Sinoussi has continued to make contributions to the study of adaptive immune responses to viral infection, the role of innate immune defences in controlling HIV/AIDS and factors involved in mother-child transmission of HIV. From 2012-2014 she was President of the International AIDS Society, the world's largest association of HIV professionals, with members across the globe, in more than 170 countries.

Key points

Endoscopy – a flexible tube with a light and camera on one end that is inserted into the body to image the stomach and/or intestines.

Assessment activity 3.2

Choose one of the organisations or individuals described above. Prepare a report for a national newspaper, no more than two sides of A4, explaining the work of the organisation or individual, what the aims are/were, how funding is received, and any other information you feel is important.

You will need to conduct your own research into the organisation or individual of your choice.

B Interpretation, analysis and evaluation of scientific information

The collection of scientific data is only the first part of good research. Once a scientist has collected their data, they then need to analyse it appropriately, and evaluate the results before drawing any conclusions. This section will teach you more about how to interpret and analyse raw data collected from research projects, and how to evaluate the data to draw valid conclusions.

B1 Interpret, analyse and evaluate scientific information

Primary and secondary research

Primary research is also known as field research. This usually involves collecting new data from the world around us – whether by conducting a physical experiment, using a questionnaire to gather data from individuals, observation, or undertaking a trial of a new treatment. There are some practical and ethical difficulties with primary research in the field of health. It is usually costly due to the amount of time – sometimes years – experiments need to be conducted for their data to be of value. It can also interfere with individuals' treatment plans. Often you need to have specially trained researchers as well.

An alternative to primary research is **secondary research.** This kind of research involves looking at existing sources of information and data already published, and further analysing it to make new connections. Although this may not sound as interesting as field research, it is hugely important when looking at research in all scientific fields. A key element of a reliable investigation is that it gives results which are reproducible by anybody else who undertakes the same procedure. If the results are not reproducible, then that may mean there is something wrong with the way the experiment is designed, or with the way that the original results were interpreted. By analysing the results of lots of different investigations on a single topic, scientists can get a better picture of whether an individual research project's results are reliable or not. If the results from lots of different experiments all produce the same (or very similar) results, then the conclusions of all these studies are strengthened. If the results from lots of different experiments all give different results, then the strength of the conclusions from those experiments is weakened. Looking at lots of different research studies on the same topic is known as a meta-analysis – and is a crucial way of determining whether, or not, a particular medical intervention, treatment, or procedure is effective or not.

Key points

Primary research – research that is undertaken by carrying out an experiment.

Secondary research – research that reviews existing data from previously published sources.

Qualitative evidence

Qualitative evidence is descriptive evidence – it can only be described using words. This is usually obtained from surveys, administration records, or interviews with people – as you can see in Case Study 3.5 below.

Case study

Antibiotic prescriptions for children

One of the most common reasons for parents bringing their child to see a GP is a respiratory tract infection. This includes infections in the ears, nose or throat, as well as infections lower down in the chest or lungs. Determining whether an infection is caused by a virus or a bacterium can be challenging, as the symptoms will often be very similar. Historically, cautious treatment of respiratory tract infections has led to antibiotics being significantly over-prescribed.

There is some evidence that using information booklets can help to educate parents about the use of antibiotics in respiratory tract infections and reduce the number of antibiotic prescriptions given out by doctors. Scientists from Holland wanted to better understand how parents looked at these consultations, and whether the information booklets changed their views on the prescribing of antibiotics.

They interviewed 18 parents who had seen their GP and been given the booklet. Throughout the interviews, the scientists observed the following themes:

- reluctance to use antibiotics
- trust in their GP
- confirmation and reassurance by the booklet
- how to manage their child’s symptoms in the future.

Overall, the researchers found that parents were very enthusiastic about the booklet. They felt that it did not necessarily give them any new information, but that it helped to cement the knowledge that they already had and confirmed their reluctance to use antibiotics unless absolutely necessary. The parents generally trusted their GPs to determine when antibiotics were necessary and said that they would use antibiotics if their GP suggested it was appropriate to do so. You can read various statements from the parents below.

“I know you should be cautious using antibiotics, and that is of course also because bacteria can form a resistance against it.”

“I was not just going to administer antibiotics to my son without reason, only if it is really necessary. I was already sure of that, and with that attitude I went to see the GP.”

“I have a really good relationship with my GP, and the GP knows how I think about antibiotics. The GP will only prescribe if it is really necessary, you know. In cases where it wouldn’t work with just good care and no antibiotics.”

The data collected by the researchers during their interviews is qualitative evidence. It is not numerical, and describes the experiences, thoughts, and opinions of the individuals being interviewed.

Study source: https://bjgpopen.org/content/2/2/bjgpopen18X101553.full#sec-19

Check your knowledge

E. coli is a bacterium which lives in our intestines, and in the intestines of many animal species.

1. What do you think are the advantages and disadvantages of qualitative evidence?
2. Can you think of any types of study in which qualitative evidence could be useful to researchers?

Quantitative evidence

Quantitative evidence is numerical or statistical. This may be obtained from questionnaires, interviews, or scientific experiments in which data is gathered directly – for example cell counts and chemical analysis of body fluids carried out in a laboratory.

Quantitative evidence provides scientists with raw data, and quantitative studies are generally designed to test hypotheses, look at cause and effect, and potentially to make predictions based on the data gathered. Quantitative evidence tends to involve relatively large sample sizes, but to focus on specific elements of the sample group, rather than examining the group as a whole. This makes it much easier for scientists to perform large- scale quantitative studies. Once the data has been gathered, researchers will usually perform statistical analysis of the raw data, to determine whether their results are statistically significant, or whether they could possibly be due to random chance. Quantitative evidence is much more useful than qualitative evidence when examining the relationship between smoking and heart attacks, for example.

Displaying data

Both qualitative and quantitative data can be displayed in a number of different ways. When conducting research, it is important to select the most appropriate way of displaying your data, to make it easier and more appealing for others to read and understand.

The simplest form of data display is in a table. This can apply to both qualitative and quantitative data. The table should have the correct number of headings, and appropriate units applied for quantitative data. Data can also be represented in a graph or chart-based format. The type of graph will vary depending on how many variables need to be plotted – but usually, data will be represented in a pie chart, a bar chart or a histogram plot. Table 3.3 outlines which formats are most appropriate for displaying different types of data.

Table 3.3: Features of different formats for presenting numerical data

Format	Features of the format
Tables	• Suitable for quantitative and qualitative data. • Enables systematic and compact presentation of data. • Enables sequencing in ascending or descending order, especially is entered onto a spreadsheet. • Useful for recording measurements as they are made or presenting several different measures in a systematic and compact format.
Line graphs	• Only suitable for plotting continuous data. Each point on the graph can be joined by a straight line. • Useful for identifying trends, especially over time.
Bar charts	• Used for discrete data. Each bar is separate from other bars, with identical widths, they only differ in height (or length if presented horizontally). • Useful for presenting data relating to different groups (e.g. age).

Format	Features of the format
Pie charts	• Used to present proportions of a whole e.g. a population and its subgroups. The size of each segment is proportionate to the percentage of the 360o circle (pie).
Histograms and distribution curves	• Histograms are only useful for plotting continuous data. Plots a frequency distribution, where each measure is categorised into a class representing a specified range of measures e.g. 0-4.9, 5-9.9, and so on. Each bar is presented with no gaps (unless none of the measures fall into one of the classes). • In a distribution curve, the frequency values are represented by a curved line. A normal distribution will have a 'bell' shape. • Both provide a visual presentation of an 'average' value, showing the range or spread of values in a data set.

Statistical analysis

Once researchers have collected their data, they need to work out whether what they have collected is meaningful or not. This point in a research project is where the use of statistics is usually necessary. Using statistical analysis can help scientists to:

- test the predictions (the hypothesis) made at the beginning of the experiment
- work out whether their data is cohesive and relevant
- look at any key points from the data collected
- determine whether any trends in their data could have occurred through chance
- make future predictions are based on trends in the existing data.

Using a statistical test like the t-test or the chi-squared test can help to determine whether the results of the experiment are statistically significant. If the statistical analysis indicates that the results of the experiment are statistically significant, this implies that the results are extremely unlikely to have occurred by random chance alone.

When running data through a statistical test, scientists will usually end up with a single number, which can then be compared against a value called a P value. This P value is the likelihood that the statistical results have arisen purely by chance. Usually scientists will use a very low P-value – less than 0.05 – to indicate that their results have a low probability of having occurred due to random chance.

Accurate and reliable sources of information

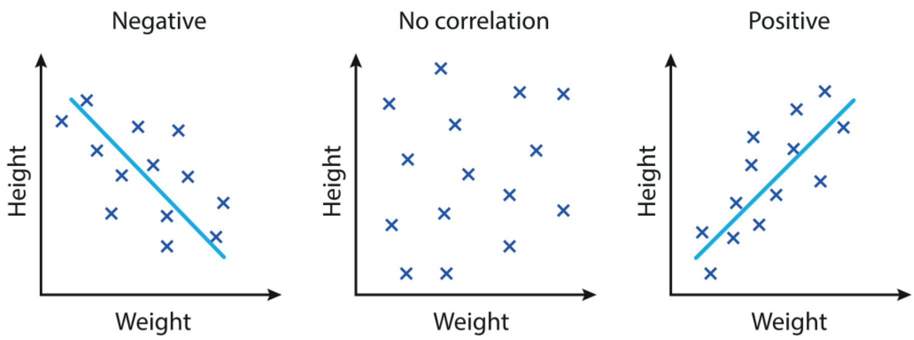
Finding a source for any information used in a research project is essential. While it is very easy to find huge amounts of information on almost any topic with an internet search, scientists must also verify that any information that they use is both reliable and accurate – otherwise it would be easy to make false claims or mislead people. When considering the accuracy and reliability of sources of information, it's useful to consider the following points of reflection:

- How old is the source? While older research is not necessarily less reliable, it may have been disproven by newer studies, or there may be more recent sources to support the original findings.
- Who has written the source? What are their scientific credentials? Could they be in any way biased towards a particular point of view? Sources written by scientists who are experts in the area they are writing about are likely to be more accurate than sources written by people with no scientific expertise, for example.
- Who paid for the source? Could whoever paid for the source possibly influence the point of view of the writer?
- Has the source been peer-reviewed? If so, who has reviewed it? Generally, the more scientists and experts who have reviewed and approved of the source, the more reliable it is – although that still doesn't mean the source is free from bias.

Trends, patterns, and anomalous data

After graphical or statistical interpretation of their data, scientists must then decide whether there are any key patterns or trends in the data – along with any significant anomalies, and why these might have occurred. In some simple experiments, it may be possible to perform a correlation analysis – to look at what happens to the outcome of the experiment if you change one variable. This can produce positive correlation, negative correlation, or no correlation at all. You can see examples of this in Figure 3.24 below.

If the results show positive correlation, then this implies that increasing the independent variable (along the x axis) causes the dependent variable (on the y axis) to also increase. Negative correlation suggests the opposite – when the independent variable is increased, the dependent variable decreases. If there is no correlation, then increasing the independent variable has no effect on the dependent variable.



The points are close to a straight line which shows a decrease (negative). This shows that as one variable increases the other decreases, e.g., as a person is taller they are lighter.

There is no pattern here to points. There is no relationship between the two variables, e.g., some taller people are heavier while others are lighter.

The points are close to the straight line which shows an increase (positive). This shows when one variable increases so does the other. There is a relationship between height and weight, e.g., as the person grows taller they are heavier

Figure 3.24: Graphical representations of positive, negative, and no correlation

Anomalous data is when a result differs significantly from the rest of the collected data. You can see an example of what this might look like in Figure 3.25 below.

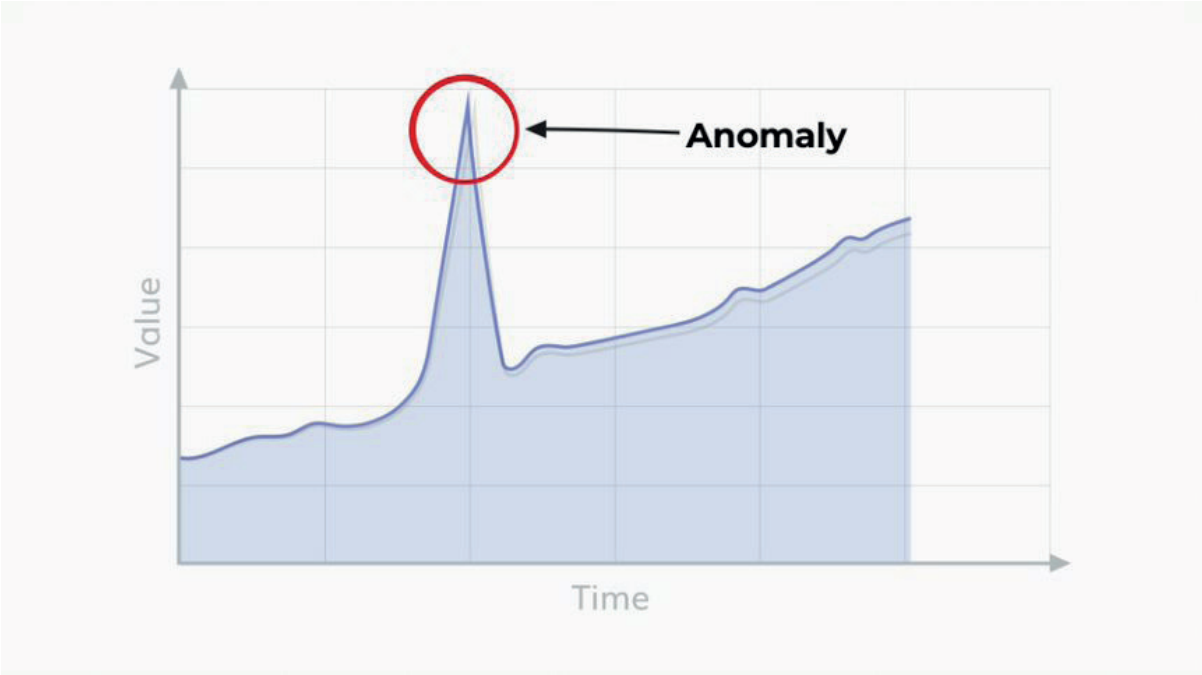


Figure 3.25: Anomaly illustration

Just because a result appears to be anomalous does not mean that it should be discounted entirely. If an experiment appears to have produced an anomalous result, then it should be repeated – as many times as is reasonably possible, and ideally by different groups of scientists – to help work out whether the result is truly anomalous, or whether it is reproducible.

There are many different sources of error that can produce anomalous data. The commonest sources of error can be broken down into random and systematic errors.

- Random errors are those errors occuring due to chance. This may be due to changes in the environment during the experiment, slight fluctuations in the instruments used to measure results, or small differences in the way that each result is measured. Random errors do not produce the same error each time. By taking large numbers of measurements, including taking the same measurement several times, scientists can reduce the impact of random errors on an experiment.
- Systematic errors are more consistent. These may be due to inaccuracies in equipment, or in the experiment procedure itself. Systematic errors may also occur if important variables have not been considered when designing the experiment. By carefully designing experiments, and by using properly calibrated equipment, the likelihood of systematic errors can be significantly reduced.

Primary and secondary data

Primary data is information generated by the scientist themselves through direct experimentation or observation. It may also be called "first-hand" or "raw" data. Secondary data is data that has already been collected elsewhere, which the scientist then bring together and analyses. There are advantages and disadvantages to conducting research using either kind of data.

Primary data gives up- to- date, current measurements, which are specific to the researcher's needs. However, collecting this data often takes quite a long time, and can be expensive. This also means that the sample size for primary data collection is often limited by both money and time – and so the scientist may not be able to collect as much data as they would like to.

Secondary data takes much less time to gather and is also usually significantly cheaper than primary research-– as the results are already available, and new experiments are not being planned or carried out. This means that far larger sample sizes can be used, and results from lots of different studies can be grouped together, reducing the likelihood of errors. However, this data is likely to be older than that gathered by primary research, and therefore may not be as relevant. It is also unlikely to be completely tailored to the needs of the researcher – which may affect the relevance of conclusions drawn from the data.

Validity and reliability

In order for a research project to be worthwhile, the results must be both valid and reliable. Validity depends on the claims made by the research, and how well the claims made are supported by the evidence or results. There are several ways to examine whether or not this is the case.

Firstly, look at the sample size – how many results were scientists able to obtain? A study with only a few data points may still be accurate – but with a small sample size, it may not be possible to apply the results more generally. A study with a larger sample size reduces the likelihood of error and makes the results considerably more generalisable. When scientists design an experiment, they may undertake a sample size calculation – to help them work out how large their sample needs to be to give them statistically significant results. Is there any evidence that this has been performed in the study you are examining?

Secondly, look at the number of references to other publications that the researcher has included. What is already known about the topic? How has this influenced the design of the research project? If there are references to other scientific papers, look at where these were published, and how the research in these references was designed. Does this appear to reinforce or undermine the researcher's own project?

Think about where the researchers have published their study. Is it a reputable scientific journal? If so, it is likely to have undergone a process called peer review. This is when a group of experts examine the research, checking it for inconsistencies and making sure that the method, results and analysis appear to have been performed correctly. If there are concerns about any of these processes, the paper may be rejected. Peer review is a very important part of making sure that scientific research is conducted and analysed properly – if the project does not appear to have been peer reviewed, ask yourself why this is the case, and if any conclusions drawn from the study can be trusted.

Have the researchers provided all the raw data from their experiments, or do they simply quote extracts of the data? If all the raw data is not provided, it is much easier for researchers to extract or misquote data to back up their own conclusions.

Similarly, look at when the data was collected – is this recent, up-to-date research, or does it use old data? Older data is not necessarily less reliable – but if there is more recent data, its results may be more relevant. Look at the information about the authors – who are they, and what are their qualifications? Who has funded their research, and does this represent a possible conflict of interest? If there was funding from an external source, it should be mentioned in the paper – and researchers should also declare any potential conflicts of interest, such as if they were employed by whoever funded the research, or if they are currently working in any field which might influence their analysis of the data.

Reliability is about the extent to which the research can be reproduced. Reliable research should produce the same results when repeated by another researcher using the same methods, that is it should be **repeatable**. Typically, researchers will test for reliability by carrying out their test in duplicate or triplicate. If the data is similar after many repeats, then there can be strong confidence that the data is reliable. Figure 3.26 below highlights some key queries to consider when assessing a source of information for reliability and validity.

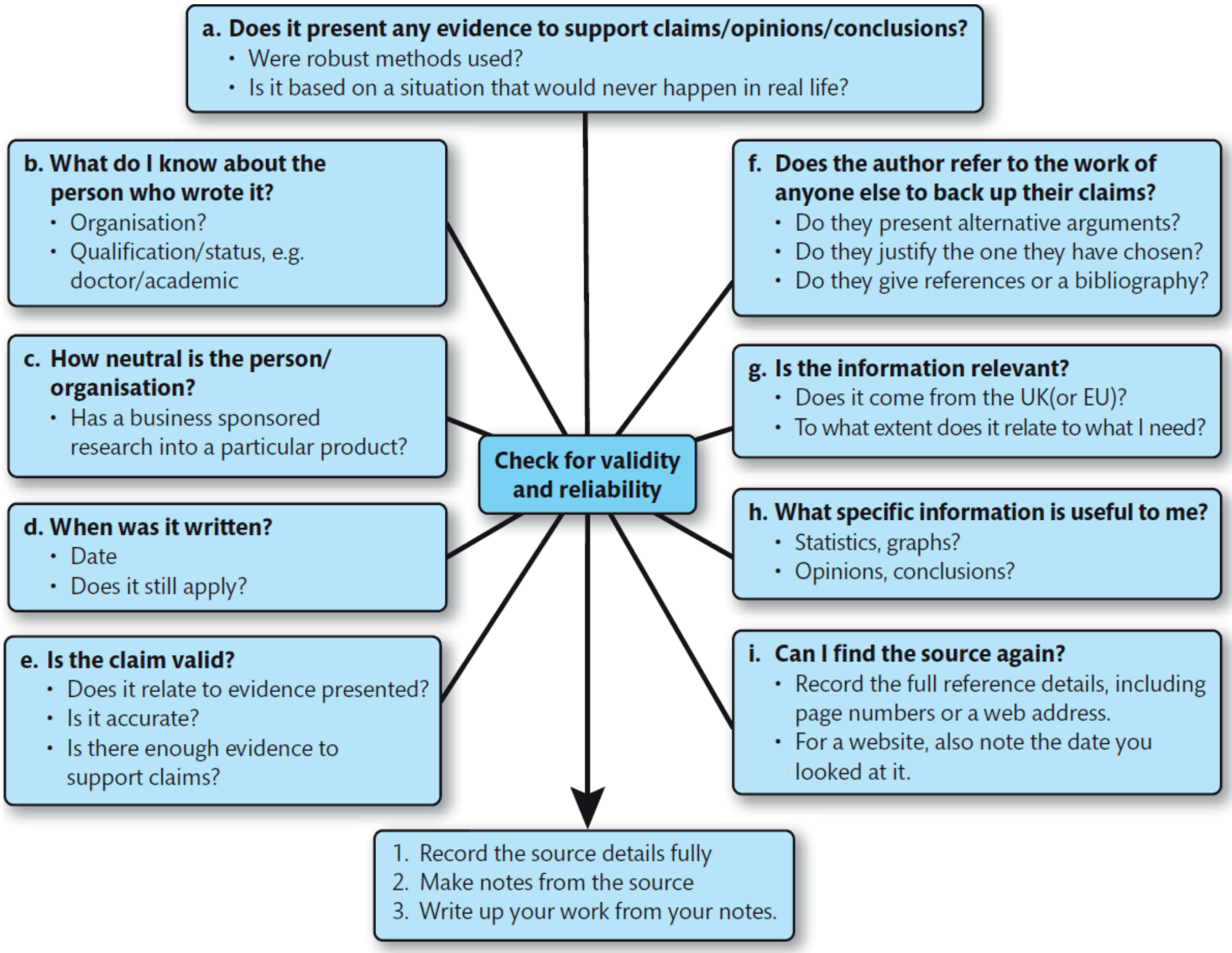


Figure 3.26: Evaluating a source for reliability and validity

Validity of conclusions and providing evidence

After researchers have analysed their data, an important outcome is for them to draw it all to a conclusion. This includes describing any links or relationships found, whether the results and data support the aims of the research and making any comments on recommendations or improvements. This usually takes the form of explaining whether the graphical or statistical analysis of the data matches the predictions made at the beginning of the experiment, considering any limitations associated with the methodology.

Some questions to support drawing conclusions could be:

- Is there a link or relationship between variables? i.e. no correlation, strong correlation, positive correlation, negative correlation.
- Do the results support the hypothesis? If not, have they explained why? If it does, how large was their sample size – could the experiment be carried out on a larger sample size?
- Do other research projects seem to match these conclusions? If not, where could the difference have come from?
- Are anomalous readings and errors identified and explained? How were they dealt with?
- Were there any experimental problems? i.e. any difficulties with the equipment used.
- Are there any improvements outlined? What could be done to extend the research further?
- Have the researchers clearly identified the strengths and limitations of their research? They should explain the nature of the limitations and suggest how they might be reduced in the future

Assessment activity 3.3

Look at the research you undertook in Unit 2. Swap your project with a classmate, and use the information you have learned above to critically appraise their research in terms of:

- references to existing information
- processing and analysis of data
- statistical testing (if appropriate)
- validity and reliability
- further areas for research.

C Scientific Reporting

There are many different ways of finding information on health issues. In this section, we will look at how various types of media tend to present that information, and how sometimes information may be misrepresented, misreported, or simply ignored in order to support or further a particular viewpoint.

C1 Understand how health issues and initiatives are reported in different media and for different audiences

Reporting medium

The two headlines in Figure 3.27 below are both reporting on the same study – but they each give a very different viewpoint.

Like 16M Thursday, Jun 6

Daily Mail AUSTRALIA

Home | U.K. | U.S. | News | World News | Sport | TV&Showbiz | Femail | Health | Science

Latest Headlines | Zika Virus | Depression | Cancer

Statins 'may be a waste of time': Controversial report claims there's NO link between 'bad cholesterol' and heart disease

- For decades doctors have prescribed statins to reduce the risk of heart attacks and strokes caused by 'bad' cholesterol in the blood
- But now a team of scientists say taking the pills may be a waste of time
- They found no link between high LDL cholesterol and heart disease

By BEN SPENCER MEDICAL CORRESPONDENT FOR THE DAILY MAIL
PUBLISHED: 09:03 AEST, 13 June 2016 | **UPDATED:** 18:55 AEST, 13 June 2016

Flawed cholesterol study makes headlines

A controversial study has argued that if you have a high LDL (bad) cholesterol level when you are aged over 60, you will live longer, there is no increased risk of cardiovascular disease and that statins will have little effect. But can we trust these bold claims?

The researchers, led by Dr Uffe Ravnskov at the University of Lund, Sweden, looked at 19 existing studies which considered the association between 'bad' LDL cholesterol levels and the overall risk of death in people aged over 60. They concluded that 92 percent of people with a high cholesterol level lived longer, and called for a re-evaluation of the guidelines for cardiovascular prevention, "in particular because the benefits from statin treatment have been exaggerated."

Figure 3.27: Two headlines about the same study into cholesterol-lowering drugs called statins, one suggesting that the drugs "may be a waste of time", the other claiming that the study itself is "flawed".

When faced with conflicting information like this, it can be very difficult to know which source to trust. This has become even more difficult with the rise of social media, and the huge amount of information (some of it helpful, some of it less so) that is available on a daily basis via smartphones, computers, televisions, radio and the written word.

When looking at any scientific information, no matter where it is reported, it should be considered critically, using the guidance below as a starting point.

Target audience

Information aimed at scientists or healthcare professionals is, by necessity, detailed and highly specific. It is likely to contain lots of scientific terms, many of which may not be easily understood by the general public. It may contain raw data, graphs or diagrams, but is unlikely to give much explanation of scientific concepts, as the authors will expect that anyone reading the information will already possess a high level of scientific knowledge. This sort of information is usually published in scientific journals, which are not always easily accessible or available to the general public.

Information aimed at the general public may report on the same issues as those covered in scientific journals – but the language used is likely to be simpler. Any use of scientific terms is likely to be clearly explained, and raw data is much less likely to be published. The information may be condensed and summarised to make it shorter and more approachable. The term "general public" tends to mean that no prior level of scientific knowledge is required to understand the article. Information aimed at healthcare users (or patients) is likely to summarise the information clearly, explaining any scientific terms used and providing sources for its information, which may be links to research papers or national guidelines.

Scientific information aimed at political representatives is likely to have been written by somebody who wishes to lobby for a change in policy. Similarly, scientific information written for the general public, information aimed at political representatives and politicians is likely to have been simplified and condensed from the original scientific research. Any complex scientific terms and ideas are likely to have been simplified or explained, and raw data may not be included. Information prepared for politicians is very likely to have an underlying agenda and may have been developed to meet a particular objective.

Where has the information come from?

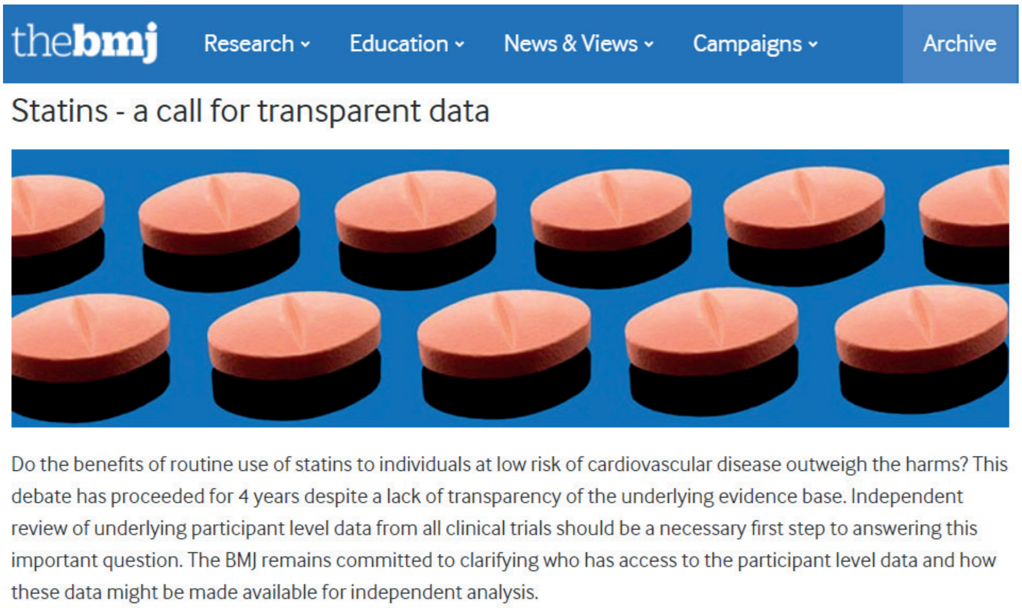


Figure 3.28: A British Medical Journal (BMJ) article **examining the evidence for and against statin use**

The most reliable sources of information usually come from peer-reviewed scientific journals. These journals will tend to publish the original research papers in full, following a complete peer-review process, to ensure that the information presented has been gathered using appropriate scientific methods. Sometimes, journals will collect together different studies on the same subject and present them as an editorial piece, or an analysis of the existing data. You can see how this relates to the debate about statins in Figure 3.28 above.

Articles in specialist, peer-reviewed journals may provide the most accurate information, but they are not always easily accessible. Many journals require a paid subscription, and some are not available to people who are not involved in healthcare or research. Even if a research paper can be easily accessed, it may be written in highly technical language. This may make the research difficult to read or process for people who are not used to examining scientific research.

Health science magazines also publish scientific data but will often condense the findings of research articles down into a more reader-friendly format. They may present some (or all) of the raw data, or make it easily accessible, and will often summarise the researchers' key findings and conclusions. This makes complex research much easier to understand, but also increases the possibility of reporting bias from the writer of the article. Figure 3.29 shows an example of this type of resource, and how headlines in this format are often presented.

Figure 3.29: Health and science magazines will often report on scientific research and recent discoveries – but beware of bias from reporters covering the story

Newspapers and non-specialist magazines will often print stories about healthcare-related issues. Sometimes these will feature recent research, or changes to national or international guidelines on disease treatments. Sometimes they may feature stories about individuals or groups of people affected by a particular health condition. These articles will usually break the scientific concepts involved down into more simple language so that they can be more easily understood by the general public. When using a newspaper or magazine as a source, it is very important to make sure that you can support the claims made in the article with scientific evidence. This might be provided in the article – but you might have to look elsewhere for it. Even broadcasting media can be guilty of choosing examples that give an attention-grabbing story rather than an accurate scientific picture – again, look at the type of programme and the people involved in its production. Reality TV is likely to be much less reliable than a serious documentary, for example.

Social media and internet-based resources can seem like a useful way of obtaining scientific information quickly – and sometimes this is true. It is very easy to access the most up-to-date research and find huge numbers of scientific papers with the touch of a button. However, it is also very easy to find unreliable information – which can often seem, at first glance, like a reliable source. When analysing information found online, it is more important than ever to ask yourself about the source and potential bias in what you have found. Using an academic search engine can help to provide information from appropriate sources. You should avoid using information gained from social media, unless you can find and verify the source of the information independently.

Presentation and reporting of information

Detail and accuracy of sources of information

To some extent, this will depend on who the article is aimed at, where the search for the information took place and the keywords used to look for information, to name a few variables. The internet can produce enormous amounts of sources of information that come from a variety of places, some reputable, some not as reliable.

Generally, some immediate conclusions can be made about the accuracy of a potential source of information based on the level of detail given in the report. For example, if the article appears to be aimed at scientists or healthcare professionals, is the article quite lengthy, do the authors clearly link to other studies, and cite their sources? Do they present their data in a raw format, as well as clearly explaining how they analysed it to reach their conclusions?

If the article is aimed more at the general public or non-specialists, have scientific terms been removed and replaced with more common place terminology, do the authors provide clear links to other sources of information? How much information from the report is available – has it pulled out some selected 'key' data points only and not provided the full article? Do the authors describe how they have arrived at their conclusions?

Use of language

The writing style and level of a source of information will depend on who it is aimed at. Scientific reports and research papers aimed at specialists and other scientists will often use long paragraphs containing detailed scientific information. Using the correct words to describe an item or procedure is vital in the scientific community to ensure everyone understands the purpose of the experiment and the outcomes. There are a lot of words used in science that do not translate well into articles aimed at the general public. Typically, in reports meant for the scientific community, a lot of technical knowledge, and language, is assumed to be known and is used throughout the article.

Where technical terms are explained, or substituted, it tends to be for the benefit of the general public who are assumed to have little or no knowledge about scientific terminology and processes. Articles aimed at the general public will also usually be broken down into shorter paragraphs.

Visual representations of results

The quality and detail available to the reader from visual representations of results will vary greatly depending on where the information was sourced. In scientific publications, the raw data will be provided so the reader can directly view the data that influence the graph, table or diagram. Diagrams/charts/graphs are likely to be labelled clearly, with the axis clearly labelled with the variables being tested and the units of measurement noted. Scales or percentages will be consistent, and patterns found in the data will be highlighted, with anomalies/skewed data trends evident.

In visual representations for the general public, the amount of information will be stripped back, and the raw data is unlikely to be available. Depending on who is presenting the information, the format of tables/graphs/diagrams is likely to change – where the government is presenting information in a news conference, for example, the number of graphs and data points presented, and what they represent, may be significantly more than what appears in the media.

Bias in reporting

In the UK, there are expectations on researchers that they conduct and present their research in a way that avoids errors in their methodology, the presentation of their data, and the analysis and conclusions drawn from the research. Scientific experiments and research go through a number of processes from ethical committee approval at the beginning to peer review prior to publication, to ensure that sources of bias and potential errors are removed and that the research cannot be misused in anyway. A researcher failing to consider possible bias in their research would be unethical, although it does sometimes happen.

When researching scientific sources of information, consider whether the author has written and had published any other articles, this may provide insight into whether they have a particular agenda they have focused on. Also, consider if their methodology was likely to produce only one expected outcome, and that was in line with the proposed hypothesis, and who funded the research – how often they have funded that particular author's research could also provide evidence of bias if it seems that the results of multiple research studies are aligning to the values of those who fund it.

Bias can easily be translated into the presentation of graphs, tables and statistics. It can be just as easy to insert bias into representations of qualitative data as well.

Some key considerations when you're looking at data in sources of information could be:

- Has the author/authors used an exaggerated scale on an axis, so it exaggerates a difference that is actually very small?
- Alternatively, have they used a small scale to underrepresent a difference in the data?
- Has any data been omitted? This could be an attempt to hide, or divert attention from, anomalies, resulting in the reader making conclusions that support the author's point, rather than the conclusion from the study.
- Has the data selected been skewed to demonstrate only one side of an argument or conclusion, usually it supports the author's perspective?

When selecting a source of information, it's important to note that the medium it is presented in is likely to affect the degree of bias presented to the audience. Some sources who report information have an agenda that they want to promote, this may or may not align with the intended results and conclusion of the research.

Evidence-based information

Scientific research regularly influences significant decisions made by the government on health and social care needs and services. The focus of research is that the evidence base for decisions on policy, practice and provision must be based on facts which also allow for new learning, knowledge and understanding.

When reviewing sources of information, it's important to distinguish fact from matters of opinion. In fact-based research, all sides of an argument are likely to have been considered, with the evidence the research has produced used to support logical reasoning and arguments. The author will use this approach to bring together their own, new conclusions as to how the research can be used to benefit others and the scientific community. While it may not be entirely free from opinion, in comparison to some reporting mediums, scientific reporting is likely to be of higher quality and value to all due to the manner in which results and conclusions can have a direct on the health provision for the nation.

Theory into practice

Look at the three articles that follow, starting on the next page, and use the skills you have learned about analysing scientific reporting to work out how reliable and accurate each of these articles might be. Each article contains the hyperlink to the original in the title.

Check your knowledge

As you examine each of these sources, think about using the following template to help you decide on the reliability and accuracy of the reporting.

Read each article several times, making yourself familiar with the text.

Annotate each article, highlighting the importance scientific issues clearly.

Find out more about each publication – noting the audience for each, and the content of other articles they have published.

Pick out any scientists or institutions mentioned in the text, and look them up to find out more about their reliability, and other research they may have taken part in.

Analyse any data given in the articles. If possible, look up where this data came from. Look at sample size, length of study, source of funding, etc.

Look up secondary sources – use keywords from the articles to find similar scientific studies. Do they support or refute the claims made in the article? Assess the reliability of these secondary sources using the same techniques as you use for the primary sources.

Make a table, comparing and contrasting the articles.

1. Which of these articles do you feel gives the most reliable information? Why is that?
2. What secondary sources have you found to support the claims made in the articles?
3. Have you found any sources that appear to refute the claims made in any of these articles?

Article 1 – Antibiotic resistant superbugs 'will kill 90,000 Britons by 2050'

OECD says superbugs could kill 1.3m people in Europe unless more is done to tackle the issue

More than 90,000 people in Britain will die over the next three decades unless action is taken to halt the rise in antibiotic-resistant superbug infections, a report has warned.

The Organisation for Economic Co-operation and Development (OECD) estimates resistant infections could kill about 2.4 million people in Europe, North America and Australia by 2050 unless more is done to tackle the problem, which it describes as "one of the biggest threats to modern medicine".

This includes about 1.3 million deaths in Europe and 90,000 in Britain.

Simple hygiene measures such as hand washing and more conservative prescribing of antibiotics could prevent some of the deaths, the authors said. The report said enhanced rapid testing to ensure patients are given appropriate drugs could also help overcome the looming crisis.

There are growing concerns about the increasing number of infections that have evolved resistance to first-line drugs, leaving a dwindling number of treatment options available. The problem of resistance is growing even more rapidly in low- and middle-income countries.

The report warns that southern Europe risks being particularly affected, with Italy, Greece and Portugal forecast to top the list of OECD countries with the highest mortality rates from antimicrobial resistance.

Resistance to second and third-line antibiotics – used as backup to treat infections when common antibiotics do not work – is expected to increase over the coming decades, it says.

The report comes after health officials in England launched a campaign to try to prevent people from asking for the drugs when they do not need them.

Public Health England said antibiotics were essential for treating serious bacterial infections but the drugs were frequently being prescribed for coughs, sore throats and earache, which usually improve without the medication.

The health body's latest campaign reminds people that if they are feeling unwell "antibiotics aren't always needed".

Tim Jinks, head of the Wellcome Trust's drug-resistant infections priority programme, said: "This new OECD report offers important insight into how simple, cost-effective surveillance, prevention and control methods could save lives globally.

"Drug-resistant superbugs are on the rise worldwide and represent a fundamental threat to global health and development. This report provides yet further evidence that investing to tackle the problem now will save lives and deliver big payoffs in the future."

A short-term investment to tackle superbugs would save lives and money, the OECD said, estimating that halting the rise of resistant infections would cost just $2 (£1.50) per person a year.

Article 2 – Antimicrobial resistance: a real threat to the future of healthcare

On European Antibiotic Awareness Day, Dr Mike Durkin, NHS England Director of Patient Safety, writes about the threat of antimicrobial resistance and what needs to be done to respond to this threat to the future of global healthcare.

Each year, 18 November marks European Antibiotic Awareness Day, an annual European-wide initiative to raise awareness of how to use antibiotics in a responsible way that will help keep them effective into the future.

Evidence of the use of antibiotics can be dated back to ancient Greek and Egyptian societies. However, in the modern era of mass medicine we are facing a very real threat to the effectiveness of these important drugs. As bacteria adapt and find ways to survive the effects of an antibiotic, the bacteria become 'antibiotic resistant' and the drug no longer works. The more an antibiotic is used, the more bacteria become resistant to it.

This is a major threat to the delivery of healthcare across the globe and requires us to act now to ensure these wonderful elements of medical science can be preserved, not just for generations to come but for use in our own lifetimes.

A major part of this year's European Antibiotic Awareness Day is the Antibiotic Guardian Campaign, which calls on everyone in the UK, the public and medical community, to choose one simple pledge about how they'll make better use of antibiotics and help save this vital medicine from becoming obsolete. I've made my own pledge 'to incorporate antimicrobial stewardship and resistance as a quality measure within my commissioning pathways', and strongly encourage others to choose their own via the Antibiotic Guardian website.

The awareness day is used to promote important messages to patients, healthcare professionals and commissioners about the responsible and appropriate use of antibiotics and the need to prevent the spread of infections. It is also part of the UK 5 Year Antimicrobial Resistance Strategy 2013 to 2018, which focuses on antibiotics and sets out actions to slow the development and spread of antimicrobial resistance.

Antimicrobial resistance (AMR) to antibiotics is spreading, and there are few prospects for new antibiotics to be developed in the short term. Some bacteria have now developed such high levels of resistance that antibiotics of last resort are the only choice of treatment available.

Without effective antibiotics to prevent or treat associated infections, some routine surgical operations and cancer chemotherapy will become very high-risk procedures or even be unavailable due to the increased likelihood of resistant infection.

Healthcare workers have a vital role to play in preserving the power of antimicrobials and in controlling and preventing the spread of infections that require antibiotic treatment. The more we can do to prevent infections and control their spread, the more we will reduce the need for antibiotics and can limit the opportunity for antimicrobial resistant strains to develop.

Antibiotic prescribing and antibiotic resistance are inextricably linked; overuse and incorrect use of antibiotics are major drivers of resistance. However, where infections do occur, we need to diagnose them quickly and use the antibiotics we have appropriately, particularly in the urgent treatment of life-threatening conditions such as sepsis. There are a range of tools and guidance available to assist healthcare providers and their staff around infection prevention and control and antibiotic prescribing. Links can be found below and on our AMR web page.

For commissioners, such as NHS England, it is essential that we are doing all that we can to drive improvement in infection prevention and control practices and antimicrobial stewardship programmes that reduce health care associated infection and antimicrobial resistance.

Commissioners must ensure that they have access to specialist infection prevention and control advice and that they work closely with local authorities and Public Health England centres which provide a wealth of local intelligence on services, such as timeliness and completeness of mandatory surveillance and voluntary reporting of antibiotic susceptibility data.

Again, details of resources to support commissioners can be found at the end of this blog and on the AMR web page.

And for patients, it is important that antibiotics are only taken as prescribed, never saved for later or shared with others. Antibiotics should be used in the right way, the right drug, at the right dose, at the right time, for the right duration. It is also important never to demand antibiotics from your doctor. Many antibiotics are prescribed and used for mild infections when they do not need to be. All colds and most coughs, sinusitis, otitis media (earache) and sore throats often get better without antibiotics.

Antimicrobial resistance is an issue that affects us all and we all have a part to play. To repeat my earlier plea, please do take the time to contribute to this year's European Antibiotic Awareness Day by making a pledge via the Antibiotic Guardian Campaign website.

Article 3 – Antimicrobial resistance is a major threat to public health

There is an incoming tide of concern about the problems of antimicrobial resistance. For several years alarm has been expressed in the United States, and the past 12 months have seen two World Health Organisation meetings prompted by increasing anxieties about the role of antimicrobials in animal husbandry; a report by Britain's House of Lords on antimicrobial resistance; and a report from the US Institute of Medicine on emerging infections. This week the Danish Chief Medical Officer, Einar Krag, has called together colleagues from the European Union and their advisers for a conference on "the microbial threat" to "assess the strategies to prevent and control the emergence and spread of antimicrobial resistant microorganisms." Is all this activity warranted? We believe it is: in the words of the House of Lords' report, "Resistance to antibiotics ... constitutes a major threat to public health and ought to be recognised as such more widely than it is at present." This issue of the BMJ is helping to broadcast this message.

The causes of these problems and gloomy portents are not difficult to find. In the past 50 years people in both the developed and developing worlds have accepted antibiotics as their right— to obtain a prescription at the first sign of a trivial infection or treat themselves with a handful of cheap antibiotics. We cannot conceive a return to the pre-antibiotic days, yet the unbridled use of these agents in man and animals is inexorably propelling us in that direction.

Most antibiotic use is in two areas: in humans in the community, and in animals for growth promotion and prophylaxis (see table). The data in the table suggest that up to 75% of antibiotic use is of questionable therapeutic value. What seems less controversial is the long-term risk of spraying fruit trees in some parts of the world with antibiotics and adding 50-60 kg of an antimicrobial to each acre of salmon farm.4Bacteria have evolved very sophisticated means of exchanging DNA, both within their own genus and species and across them. The widespread use of antibiotics will tilt the delicate balance between us and the bacteria.

There seems to be an inevitability about this problem. Society demands easy answers to its health problems. The increasing resistance problems of recent years are probably related to the use of increasingly broad-spectrum agents (cephalosporins and fluoroquinolones) and crowding of the most vulnerable members of society in day care centres and nursing homes. These problems are compounded by the worldwide phenomena of pressure on health care systems for greater efficiency, with higher bed occupancies and stretched nursing and medical care. Added to this are pressures to allow over the counter use of antibiotics in western countries so as to reduce healthcare costs. To effect change much will be required by the medical profession, politicians, the pharmaceutical industry, and not least patients.

Without doubt antibiotic prescribing in humans and animals must be prudent, but by how much must antibiotic use be reduced (10-50%?) and to what extent will this affect antibiotic resistance in different bacteria? Will we see a return to more susceptible populations or just keep the current problem in check? Some see the problem as particularly gloomy.3 There are suggestions that as resistant bacteria increase and the available antibiotics decrease transmission from inpatients to the larger population will increase and become a problem to the general public.

Certainly, the veterinary profession will be required to change practices, and we commend the House of Lords' views on the control of valuable agents in animal husbandry. There are some encouraging signs that this may be occurring: at least in developed countries, fish farming is using new techniques such as immunisation instead of antimicrobials. The Swedish experience in reducing the reliance on growth promoters shows that progression can be made without reducing production. Initial problems in the form of increased morbidity and mortality in pig and poultry production were overcome by enhancing the rearing systems.5 There is a need to keep a sharp eye on the development of resistance in animals, but not at the expense of inaction.

Secondly, both patients and doctors must reduce their expectations. Antibiotics are commonly prescribed, mainly for the respiratory tract, where the vast majority of infections are caused by viral pathogens. The pressures on both patient and doctor are easily understood: an anxious parent, a sick child, and a doctor faced with diagnostic uncertainty. The solutions are not straightforward. Patients must be educated that most such infections do not require antibiotics—that they may actually be harmful to them and their families (through their effect on beneficial bacteria in the body) and to society at large (through encouraging resistance). All this requires considerable effort and time, not easily achieved in a five-minute consultation. The American Academy of Paediatrics has made a start in giving guidance to parents. Advances in rapid diagnosis will help to remove uncertainties.

The coming years will undoubtedly see the introduction of strict clinical guidelines on antibiotic prescribing. At present there is a tendency to concentrate on which antibiotic to use rather than question whether an antimicrobial is useful at all. More firm guidance is also required on the optimum length of treatment. In many parts of the world simple cystitis is still treated for 5-7 days and the more common chest infections for up to 14 days. The drug regulatory authorities therefore have their part to play in insisting that relevant clinical trials support the licence of an antimicrobial.

There is much discussion worldwide about surveillance schemes for antimicrobial resistance.7 The major problem is gaining useful denominator data—that is, how to obtain an accurate picture of resistance in a community, be it in hospital or general practice. In hospital it is moderately straightforward, since ward-based surveys can be undertaken, but in general practice we have little accurate information.

As resistance rates of common pathogens can vary greatly over short distances, such surveillance must be undertaken both nationally, so that meaningful broad-based policies can be devised, and locally, so that relevant clinical guidelines can be developed.

Greater insights are required into how resistance genes spread, especially in the community, where there is a paucity of information. Infection control procedures in child and elderly care units require enhancing. Scientific funding bodies across the European Union should realise that if we are to understand the levers which control antibiotic resistance more fundamental research will require funding. The House of Lords report highlights the problems of funding research in this area of medicine, which in the past has mainly come from the pharmaceutical industry.

Finally, the pharmaceutical industry, which until recently has been ahead of the resistance race, will also be well advised to increase its commitment to antimicrobial research. Indeed, now that several bacterial genomes have been sequenced, there are signs that this is occurring.9 In this issue, we trust that these and other matters have been confronted. We wish the European Union medical officers' conference well. The problems they are addressing are real and can be approached only by concerted action as bacteria respect no country's borders. The past decade has seen the progressive intercontinental spread of methicillin resistant Staphylococcus aureus and penicillin resistant Streptococcus pneumoniae, and there are concerns about increasing resistance of Salmonella typhi. Parochial approaches are therefore doomed to failure.

Use of antibiotics

Where antibiotics are used	Types of use	Questionable use
Human use (50%)	20% Hospital	20-50% Unnecessary
	80% Community	
Agricultural use (50%)	20% Therapeutic	40-80% Highly questionable
	80% Prophylactic/growth promotion	

Assessment activity 3.4

Use one of your recent science experiments (either the one conducted in Unit 2, or an experiment conducted at a different time). Adapt the report of this experiment to make it fit for reporting in various different media:

- social media (for example a blog post)
- television (as a short extract on the news)
- science-based magazine aimed at people with at least an undergraduate degree in a scientific field.

Think about the target audience for each of these different types of media. Plan your use of language and style appropriately. Think about using visual elements such as graphs, or even photographs, to keep each piece engaging.

Make sure you use an appropriate style for each piece. You are much more likely to use a more informal style of writing in a blog post, for example.

What elements of this did you find the most challenging? Which media format did you find trickiest to write for? How could you change this in the future?

Further reading

www.bbc.co.uk/news - the website for the BBC's news reporting, on all aspects of national and global news – including health and scientific news

www.cdc.gov – the homepage for the Centre for Disease Control (CDC) containing information about disease outbreaks worldwide, as well as advice on travel and healthy living

www.cochranelibrary.com – The Cochrane Library provides access to large numbers of reviews and meta-analyses of scientific papers, aiming to provide accurate, up- to- date information to help healthcare professionals make evidence-based decisions

www.newscientist.com – The New Scientist is a modern science-based magazine, publishing articles of interest on many different scientific discoveries

www.nhs.uk – the homepage for the National Health Service, containing information on health and disease, medication, and healthcare organisations

www.nice.org.uk – the National Institute for Health and Clinical Excellence – an organisation focusing on evidence-based healthcare, which helps to determine health policy and practice in the UK

www.who.int – the website for the WHO, giving information on health and disease globally, as well as healthcare initiatives championed by the WHO and its affiliates

Think future skills

Nadia Phillips: Public Health Doctor

"I started working in public health after two years as a junior doctor in the NHS. I've always been interested in epidemiology, and how we can use public health data to track and control outbreaks of disease. Of course, infectious disease control forms a significant part of our day- to- day job, but looking at non-infectious diseases like cardiovascular disease and diabetes is also hugely important – and trends will often take much longer to become evident in non-infectious diseases, making it even more important for us to consider why rates of disease might be changing in different areas of the country.

I spend a significant proportion of my day looking at disease reports and data gathered by public health investigators or reported by local health authorities. If I identify any patterns suggesting an outbreak of disease in a particular area then I might need to visit that area with an investigative team, to interview medical staff or patients with the disease and try to isolate a cause.

I have to produce written reports on the outcomes of my investigations, so I need to make sure that I can write concisely, accurately, and informatively in order to sum up my findings.

Excellent communication skills are an essential part of my job, as I spend quite a lot of time talking to people, both healthcare professionals and members of the general public. I need to have good investigative skills, too – knowing which questions to ask during an investigation and being able to think logically about common causes for disease outbreaks. In addition to these person-centred skills, I also need excellent data analysis skills, to be able to break down raw data and look for emerging trends".

Focusing your skills

Using your understanding of science reporting is crucial for a job like this. In addition to writing reports on disease outbreaks, you might be asked to produce an article for the local paper explaining about an outbreak of disease, or a press release outlining precautions taken by local public health officials.

Many jobs in healthcare require good communication skills, and you would need to be able to tailor your explanations to a wide variety of different groups – from expert healthcare professionals to members of the public who may have very little understanding of the issues you are discussing. Being able to analyse scientific evidence and present it in an easily understood way is an important part of this job role.

Getting ready for assessment

This section has been written to help you to do your best when you take the assessment test. Read through it carefully and ask your tutor if there is anything you are still not sure about.

About the external assessment

The external assessment will last for three hours and there are a maximum of 60 marks available. Learners will be given a scientific article and are expected to analyse and interpret it within the context of the health issue being reported.

Remember you should attempt to answer all the questions.

Sitting the external assessment

Listen to and read carefully, any instructions you are given. Marks are often lost through not reading questions properly and misunderstanding what the question is asking.

Most questions contain command words. Understanding what these words mean will help you understand what the question is asking you to do.

Command word or term	Definition – what it is asking you to do
Bias	Inclination or prejudice in a way considered to be unfair.
Discuss	Consider the different aspects in detail of an issue, situation, problem or argument and how they interrelate.
Economic issue	Related to the best use of limited, or scarce, resources.
Ethical issue	Ethically related aspects that may have affected how research was carried out.
Explain	Requires identification of a point and linked justification/exemplification of that point. The answer must contain some linked reasoning.
Health initiative	Identified in the article and related to the impact it has on the health issue.
Health issue	Issue or problem that has been identified, which is often open ended and has multiple potential solutions.
Implication	Effects or consequences of an action or decision that may happen although not explicitly stated.
Influence	The capacity or power to have an effect on the development, actions, behaviours or opinions.
Issue	May be used on its own to describe the subject that the article is describing.
Media	The means of mass communication through a reporting medium.
Primary research	Research compiled directly from the original source, which may not have been compiled before.
Qualitative data	Descriptive data, such as data drawn from open-ended questions in questionnaires.
Quantitative data	Data in numerical form, which can be categorised and used to construct graphs or tables of raw data, such as data drawn from results of experiments.
Referencing	Acknowledgement of sources of information used within an article.

Command word or term	Definition – what it is asking you to do
Reliability	The extent to which an experiment, test or measuring procedure yields the same results on repeated trials.
Research methods	Refers to how the research described in the article was carried out, for example through quantitative methods such as analysis of numerical data or qualitative-based observations.
Secondary sources/ research	Published research reports and data, likely to be based on analysis of primary research.
Social issue	An issue that influences and is opposed by a considerable number of individuals in society.
Suggest	Use your knowledge to propose a likely solution to a problem.
Target audience	A specific group at which the article is aimed.
Technical language	Specific terminology directly relating to the subject matter presented in the article.

Work out what question you need to answer and then organise your time, based on the marks available for each question. Set yourself a timetable for working through the external assessment and then stick to it.

If you are writing a longer answer, try and plan before you start writing. Have a clear idea of the point your answer is making, and make sure this comes across in everything you write, so it is all focused on answering the question.

Exam tip

- Arrive in good time so you are not in a panic.
- Remember you cannot lose marks for a wrong answer, but you cannot gain any marks for a blank space!
- Try answering all the simpler questions first then come back to the harder questions. This should give you more time for the harder questions.